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Bridging the Gap Between What is Praised and What is Practiced: Supporting the Work of Change as Anatomy & Physiology Instructors Introduce Active Learning into their Undergraduate Classrooms

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Bridging the Gap Between What is Praised and What is Practiced: Supporting the Work of Change as Anatomy & Physiology Instructors Introduce Active Learning into their Undergraduate Classroom

by

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Dedication

To my daughter, Taylor Aiko Marie Thorn

and my husband,

Mack Jess Thorn

Acknowledgements

During my study at the University of Texas, I have come to see that every manifestation is a cooperative effort. This dissertation is no exception. I would therefore like to acknowledge the people without whose support I would not have started or completed this research. I give my heartfelt thanks:

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Bridging the Gap Between What is Praised and What is Practiced: Supporting the Work of Change as Anatomy & Physiology Instructors Introduce Active Learning into their Undergraduate Classroom

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When college Anatomy & Physiology instructors begin using active learning in their classrooms, what do they experience? How do their beliefs about teaching and learning change? What obstacles do they encounter and how do they respond? How do their responses influence future decisions regarding the use of active learning? This study documented the experiences of seven instructors from diverse types of institutions as they began using active learning in their classrooms. Conceptual change and social cognitive motivation theory provided guidance for the 15-month project. A classroom-situated professional development framework that included goal setting, planning and doing active learning and formative assessment, and reflecting on experiences was used.

Multiple data sources (verbatim transcripts from emergent and semi-structured interviews, observation notes, surveys, written correspondence, instructional materials, and student surveys) and research methods allowed rigorous exploration of the research questions.

A number of important findings emerged from the study. Data indicated that instructors struggled with a lack of instructional, pedagogical and clinical content knowledge, student resistance, personal and professional risk-taking issues, and widely shifting attitudes toward active learning. Data also suggested a developmental progression in beliefs about teaching and learning as instructors implemented active learning, and the progression shared similarities with reports of preservice teacher development documented in the learning-to-teach literature. Initially, instructors' beliefs shifted from knowledge transmission and intuitive theories to constructivist theories; however there was marked variation in the intelligibility, status, and endurance of the new beliefs. Data also allowed identification of two distinct conceptual change experiences. Analysis of instructor beliefs within and between the change groups strongly suggested that causal attribution constructs either facilitated or precluded belief development, conceptual change, and a more encompassing and sophisticated definition of active learning, and supported the emergence of an Attribution-Based Conceptual Change Schematic. The findings have significant implications for both change-desiring instructors and faculty development staff. The findings allow faculty to familiarize themselves with the obstacles and response patterns that may shape their own change experiences and allow development staff to design empirically

grounded learning opportunities that may facilitate the development of beliefs about teaching and learning and promote faculty conceptual change.

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CHAPTER 1

Focus of Inquiry

Who should build the bridges necessary to connect research and practice?… As it stands now, the task is the responsibility of no one…
Maryellen Weimer, 2002

PURPOSE

When college Anatomy & Physiology instructors commit to using active learning in their classrooms, what kinds of experiences do they have? How, if at all, do their beliefs about teaching and learning change as they implement active learning? What, if any, supports and/or obstacles do instructors encounter as they implement strategies to promote active learning? If they encounter problematic classroom situations, how do they respond and how do their responses influence decisions regarding future use of active learning in their classrooms? This study documented the experiences of seven instructors over a 15-month period as they planned and implemented active learning in their undergraduate classrooms. Their experiences form the foundation of this study.

RATIONALE

The reform vision for college science education calls for fundamental changes in the way science is taught in undergraduate classrooms. *The College Pathways to the Science Education Standards* (National Science Teachers Association, 2001) states that if instructors wish to foster deep, conceptual understanding in their students, then “student activity, or active learning, needs to supplant the more traditional lecture approach to teaching" (p. xvi). However, it will not be enough to tell instructors to stop lecturing and start using strategies to facilitate active learning. Such an approach is problematic on several levels. First, there has been no consensus in the literature on how to define "active learning" in college classrooms (Pressley & McCormick, 1995). While some researchers use active learning to non- specifically describe what students do in the classroom, others use the term to describe what instructors do. Second, given the traditional training of most college science faculty, a call to engage students in the learning process and to organize the presentation of information around themes and conceptual clusters of problems may be only vaguely understood at best, and more likely, misunderstood. Third, just as student learning is a process of conceptual change that requires eliciting and building on prior knowledge structures, learning to facilitate student active learning is a conceptual change process that requires instructors to activate, and in many cases, make long-held intuitive beliefs about teaching and learning explicit, construct new knowledge, develop new skills, and revise teaching and learning philosophies. Fourth, although recent research has identified and reported college instructors' conceptions of teaching (Kember, 1997; Martin & Balla, 1991; Samuelowicz & Bain, 1992; Gow & Kember, 1993) on a continuum ranging from "knowledge transmission" to "learning facilitation", little if any attention has been given to eliciting and identifying instructors' specific conceptions as they engage in the use of teaching strategies designed to foster student engagement and active learning. Finally, although the *Standards* document calls for the use of conceptual change professional development (p. 46) there are very few examples of conceptual change professional development programs at the post-secondary level, and those that do exist (Ho, 2000; Ho, Watkins, & Kelly, 2001) have been grounded in theoretical assumptions of the original conceptual change theory rather than in empirical data, and without consideration of the motivational constructs that surely impact conceptual change. If faculty developers are to successfully support science instructors' endeavors to create classroom contexts that facilitate student active learning, an empirical base of knowledge that documents the range of instructors' conceptions and change experiences is critical in order to design meaningful learning opportunities that are structured on the epistemological foundation of constructivist learning theory that "begin where instructors are", build on exiting conceptions in meaningful ways, and anticipate possible change experiences.

PILOT STUDY

The primary experience that shaped this research was a National Science Foundation funded project to improve the quality of undergraduate physiology teaching by developing and then providing college instructors with access to thematic curriculum modules. (Silverthorn, April 2000; *Integrative Themes in Physiology (ITIP), Development of Active Learning Materials for Physiology and Functional Anatomy: Collaboration between the Human Anatomy and Physiology Society (HAPS) and the American Physiology Society (APS)*). First-year studies were designed to gather instructor feedback as they site tested the effectiveness and adaptability of the modules. The rationale for the study was that a lack of instructor planning time and limited access to current scientific and educational resources served as barriers to the introduction of active learning in A & P classrooms. Training in the use of active learning was conducted through HAPS update seminars and workshops (HAPS Annual Meeting, 2000) and curriculum modules focused on the theme of *Gradients & Conductance* were made available for volunteer instructors to site test.

Three important findings emerged from the first year studies. First, over the course of the first six months of the study, it became clear that instructors were not site testing the curriculum modules. Given the inadequacy of speculating on why site testers were not evaluating the modules, interviews were conducted to determine what was going on. The interviews revealed that most instructors felt it necessary to ease into the business of using active learning in their classrooms, and despite the fact that they had volunteered to evaluate curriculum, believed that the task was not realistic. Although several of the volunteer instructors had reviewed the modules for potential use, they had concluded that the material was either not compatible with their course or their teaching practice, or did not meet their students' needs.

In light of instructors' reactions, the study focus shifted to identify the critical issues that faculty encountered as they began the process of using active learning in their classrooms. Specifically, the focus became an exploration of "What goes on when instructors volunteer to introduce instructional strategies that encourage active learning into their classrooms?" This revision was made with consideration of research literature on best practice in educational innovation which suggests that teacher change is best supported by a voluntary orientation rather than a mandated set of activities (Richardson, 1990). Data collected during interviews revealed that the use of active learning had been impeded by: limited knowledge of how to implement active learning, a lack of support at the institutional and departmental levels, lack of time, and student resistance to active engagement in the classroom. However, despite struggles to implement active learning, interview data suggested that some of the instructors were beginning to think differently about their roles in the classroom. The following statement by Briscoe (1991) was critical in proposing and implementing the research that was to ensue: "Because all new knowledge is filtered through the framework of beliefs which the teacher already possesses and is adapted to fit those existing frameworks, simply giving the teacher new curriculum or suggesting changes in practice may not result in the desired outcomes. Clearly, if a teacher is to create and maintain change in practices he or she must have an acknowledged, legitimated, and experienced the rewarding role in creating the knowledge to facilitate these changes."

LIMITATIONS

This study is limited by five factors. First, data gathered from instructors is both self-reported and retrospective. As such, important information may be forgotten, inadvertently omitted, or reported inaccurately. Second, while instructors' self-reports of their teaching practice may well be a close approximation of actual practice, particularly when methodological trustworthiness is enabled, it is certainly reasonable to argue that the self-reports given by instructors in this study may not reflect their actual practice. In fact, Menges & Rando (1989) urged that educational research should gather classroom data through direct observation. However, since the focus of this study was primarily on the beliefs, conceptual change, and the perceived experiences of introducing active learning into undergraduate classrooms, only limited classroom observations were conducted. Third, because of the contextual elements of each case study, the findings are only generalizable in a naturalistic way. Robert Stake (1978) has clarified this type of generalization by comparison to the rationalistic generalization of scientific discourse. Where scientific generalization is law-like and propositional, "naturalistic generalization" is empirical and based on personal, direct and/or vicarious experience. Stake suggests that (p.5), "… it is reasonable to conclude that one of the most effective means of adding to understanding—for all readers—will be approximating through the works and illustrations of our reports the natural experience attained in ordinary personal involvements." Fourth, surveys administration by instructors to collect information on the pre and post attitudes and thematic content understanding of their students was inconsistent. Although all but one of the instructors collected both pre and post data, a variety of incentives (bonus points, food rewards) were offered across classrooms, and timing of survey administration was diverse. While some instructors set aside reasonable time for students to complete the surveys, others asked students to complete the surveys out of class or after finishing a classroom assignment or exam. Further, the results of the content test are not comparable since instructors were teaching different physiological systems to either first or second semester students. As a consequence of these inconsistencies, the primary value is data triangulation with instructor beliefs, and an exploration of student beliefs. Finally, despite methods and a willingness to identify and document researcher biases, the findings and interpretations in this study are unquestionably shaped by researcher subjectivities.

SCOPE OF STUDY

A review of the literature that focuses on how college science instructors go about introducing active learning into their classrooms reveals that this subject has received little study. As such, a limited number of studies are relevant to this report. Relevant studies and theories that guided the research will be reviewed in Chapter Two.

Chapter Three outlines the design and methods employed to execute the study. The chapter includes a detailed discussion of how the data was generated, analyzed and reported. It details how participants were recruited and describes the procedures used in data analysis. Chapter Three also discusses the quality criteria used to establish trustworthiness and authenticity of the study.

Chapter Four presents the case studies of the instructors who participated in this study. The case studies are presented individually, and in the interest of space, two long studies and five condensed cases are included. "Purposive sampling" at the onset of the study and "thick description" of each case is attempted to enable observers of other contexts to make tentative judgments about applicability of observations for other contexts.

Chapter Five contains a discussion of the common and contrasting characteristic beliefs and experiential patterns that emerged across the instructors. Characteristic beliefs are developed and supported by direct quotes from interview transcripts and compared and contrasted with literature where possible. Finally, the common experiential patterns are compared and aligned with theory in order to generate an empirically based conceptual change process schematic that describes the experiences of the A & P instructors in this study.

Chapter Six describes what has been learned from the study and presents ideas for future research. As in any naturalistic study, the obligation for demonstrating transferability of the findings to other instructors teaching in other contexts belongs to those who would apply it to the receiving context.

CHAPTER 2

Literature Review

OVERVIEW OF GUIDING THEORY

This research was guided by a constructivist theory of learning, which holds that knowledge—rather than being transferable-- is uniquely constructed by individuals based on their interpretations of experiences and interactions with others. Both the nature of the individual's prior knowledge as well as contextual factors determine the nature of new knowledge structures. An implication of constructivist learning theory is that teaching faculty instructors hold personalized, experience-based conceptions about teaching and learning that play important roles in the classroom instructional practices they use and the decisions they make (e.g., Hewson & Hewson, 1987). Constructivist learning theory underlies conceptual change theory. The notion that learning is a process of conceptual change has gained acceptance in educational arenas as means of countering students' alternative conceptions (e.g., Champagne, Klopfer, & Anderson, 1982; Chickering & Gamson, 1987) and has recently been proposed for use in professional development frameworks at the post-secondary level.

The proposed research, unlike others conducted to date, is based on a "hot" model for conceptual change (Pintrich, Marx, & Boyle, 1993) that extends the traditional cognitive model with motivational and contextual mediators.

Constructivist Learning Theory

Constructivist learning theory explains how people form new ideas or concepts based upon their current and past knowledge. Within the field of education, constructivism is linked to the child development research of Piaget (1971), who believed that learning can best be explained as an active experience between the learner and objects or people in an environment and implies the process of creating mental structures instead of merely absorbing information. As formulated by philosophers, cognitive psychologists, and educational researchers, constructivism is open to different interpretations. Regardless of the diversity of views about the underlying assumptions of constructivism (Vygotsky, 1986; von Glaserfeld, 1993; Driver, 1989; Guba & Lincoln, 1989) the theory has had a major influence on both research and practice in science education.

Two tenets underlie constructivism. First, knowledge is not fixed and cannot exist in a complete form outside the learner. Rather, knowledge is constructed through experiences and resides in individuals. The implication here is that knowledge cannot be transferred in discreet information packages. Moreover, although instruction can facilitate the construction of knowledge, learning is not the direct consequence of instruction. Second, knowledge construction is an interpretive process and new information is given meaning in relationship to a person's prior knowledge. Knowledge construction includes both concept modification and reorganization of knowledge structures. As people learn, conceptions of phenomena change and the world is seen differently. The acquisition of information in itself does not bring about such change, but the way in which information and thought processes are structured does. Thus, from the constructivist point of view, learning is about conceptual change, not just the acquisition of information. Although learners construct their own knowledge, social agreements about meaning tend to limit how new experiences are interpreted or perceived in any given situation. The implication is therefore that knowledge is situated and informed by the central roles of language, culture, social setting, and physical contexts (Brown, Collins, & Duguid, 1989; Vygotsky, 1978).

Conceptual Change Theory

The idea of conceptual change was introduced into education as an analogy drawn from the history and philosophy of science (Kuhn, 1970). Kuhn introduced the concept of a paradigm to describe a set of assumptions that scientists held about reality. On one hand, paradigms were seen as beneficial because they allowed scientists to interpret data, elaborate theories, and solve problems in a consistent manner. On the other hand, a tenacious nature made them problematic because they tended to function like closed systems in which all new data merely confirmed what was already known. Since the introduction of the paradigm concept and subsequent theories of mental models in cognitive psychology, conceptual change theory has expanded considerably, from a way of exploring scientific thinking, to a way of thinking about how learning can be improved.

Conceptual change theory is grounded in the tenets of constructivism and the idea of conceptual conflict and has been applied to student learning in a variety of disciplines. Generally stated, a learner's strongly held existing conceptual framework serves as a filter for interpreting all new experiences. When new knowledge and prior knowledge are compatible, learners are able to assimilate the new knowledge into their existing conceptual framework. However, when new and prior knowledge are dissimilar, conceptual conflict occurs. Conceptual conflict has a number of possible outcomes, including: the new information can be rejected; the new information can be incorporated so that the learner simultaneously holds conflicting beliefs; either the existing framework or the new information (or both) can be modified to reduce conflict; or, the faulty components of the prior knowledge structure can be elicited and replaced with ideas that more closely approximate the accurate ideas. Certainly when meaningful learning is desired, the latter outcome is the most desirable—but also the most difficult to achieve due to the tenacious nature of existing conceptions.

One of the most influential theories in learner conceptual change, particularly in the biological sciences, is the conceptual change theory proposed by Posner, Strike, Hewson, & Gertzog (1982). The theory explains the process of accommodation--the process of knowledge restructuring where faulty components of the existing knowledge structure are elicited and replaced with ideas that more closely approximate those of sophisticated understanding. Posner et al. defines accommodation as: "the substantive dimensions of the process by which people's central, organizing concepts change from one set of concepts to another set, incompatible with the first" (p. 211). The authors' central commitment is that conceptual change is a rational process concerned with ideas. Learners comprehend and accept ideas because the ideas are judged as intelligible and rational based on available evidence. This "cognition only" model of conceptual change has been referred to by some subsequent researchers as the "cold" model.

The cold conceptual change model has two dimensions. The first is a set of conditions that support conceptual change. Initially, the learner must perceive and attend to information, begin processing and trying to understand the information, and be confronted with conceptual conflict. The conflict triggers conceptual change only if the learner becomes dissatisfied with the old conception, and the new conception is seen as plausible, intelligible, and fruitful. An intelligible concept is one that is understood and internally represented by a learner. For a concept to be plausible, the learner must find it potentially believable and consistent with personal experiences. Finally, to be fruitful, the learner must be “aware of, generate, or understand novel practical applications or experiments which the new conception suggests (Strike & Posner, 1985, p. 21). Strike & Posner (1992) emphasize that the conditions are *not* a sequential set of steps, or a "magic ritual" (p. 159) that learners correctly execute for successful accommodation. Rather, the conditions unfold in a gradual and non-linear fashion. Whether or not accommodation occurs is dependent on the second dimension of the theory--the learners' conceptual ecology. The conceptual ecology originally included prior knowledge and cognitive artifacts (i.e., anomalies, analogies and metaphors), but was elaborated in the revisionist theory to include (albeit, non-specifically) emotional factors.

The conceptual change model that frames the proposed research is the "hot" conceptual change model proposed by Pintrich et al. (1993). The model elaborates on the conceptual ecology dimension of the cold model in order to address why learners who have requisite prior knowledge don't consistently activate the knowledge and engage in meaningful learning. The researchers' central claim is that cognitive engagement is a choice made by learners and the choice is a function of motivational and contextual mediators. These researchers critiqued the cold model as "useful for investigating the general cognitive competence of compliant subjects in an experimental setting where they are provided with a relatively clearly defined problem or task" (p. 168) but believed the model lost its utility when applied to students working on unstructured problems in real classrooms.

As described by Pintrich et al. (1993), the learners' cognition establishes the conditions for learning. Cognitive factors, such as perception, attention, thinking, learning, and problem solving, interact with contextual factors and motivational constructs, such as, goals, theory of intelligence, personal interest, value, importance, self-efficacy, and control beliefs, to make learning possible. The dynamic and interdependent nature of the cognitive, contextual, and motivational factors provides an explanation for why learners may not always engage cognitively and therefore may not always learn.

Social Cognitive Motivation Theory

Motivation is a pivotal concept in most theories of learning. Whereas behaviorist theories of learning tend to focus on extrinsic motivation (reward), cognitive theories focus on intrinsic, goal-seeking acts. Although there are a number of cognitive aspects of motivation, four theories are particularly relevant to conceptual change: self-determination as a probable prerequisite for change; values regarding what is important and expectations for success (value expectancy); goal orientation and the impact of goals on behavior; and, the explanations people use to explain success and failure (attributions).

Self-determination theory (Deci & Ryan, 1985, 1987) is one means of linking the concepts of motivation and conceptual understanding. When applied to educational contexts, this theory suggests that people are most likely to be cognitively engaged and motivated when they believe they are in control of the choices they make and can competently execute the tasks before them. Conversely, people are less likely to be internally motivated when they believe that their choices are being controlled or forced by threats, deadlines, or evaluative situations that undermine their confidence to successfully accomplish a task.

From the perspective of expectancy value theory, another means of promoting cognition that leads to motivated behavior comes when people believe they can succeed (high expectancy for success) and when they place value on the outcomes of the task (Ormrod, 1995). Research has demonstrated that expectancy may be influenced by prior successes and failures as well as the anticipated effort necessary to succeed (Dweck, Goetz, & Strauss, 1980; Dweck & Elliott, 1983). Although more subjective in nature, activities may be valued because they are seen as a means to a desired goal or not valued when the effort or risk required to complete the task exceeds the worth or benefit of the task.

The mastery orientation theory proposed by Dweck & Leggett (1988) provides a useful framework for differentiating people who persist in the face of difficulty versus those who abandon tasks under difficult situations. The model describes how individuals' conceptions shape the goals they set for themselves, and how their goals influence patterns of cognition and behavior. Research supporting this theory demonstrated that individuals engage in two kinds of response patterns and two different goal orientations when confronted with challenging work. They either took on the challenge while maintaining a focus on strategy and effort (a mastery-orientation where the learning goal to increase competence and understanding) or they focused on performance aspects of the task and gave up on the challenge (a performance goal orientation where the goal is to gain positive judgment, avoid negative judgment, or outperform others). Evidence increasingly suggests that an individuals' goal orientation sets a strong influence on their interpretive framework and their response to failure. In general, research has shown that a mastery goal orientation is associated with stronger cognitive engagement and the increased use of deeper processing strategies (Pintrich 2000).

Attribution theory is concerned with how an individual "comes to attribute events to one or more of their possible causes" (Ross & Fletcher, 1985). In line with constructivist accounts of cognition, attribution theory is a phenomenological theory of motivation (Pintrich & Schunk, 1996). Precedence is given to the individual's construction of reality, not necessarily reality per se. However, the accuracy of an attribution is not important in order for an attribution to have psychological and behavioral consequences. Certain kinds of circumstances, such as negative feedback or disconfirmation of expectations, can prompt individuals to attempt to figure out what is happening and why (Weiner, 1979, 1986). Attribution theorists suggest than an individual's level of performance on a certain task can be attributed along three causal dimensions: stability, locus, and control. The stability dimension refers to how stable an attribution is over time and ranges from stable to unstable (with unstable implying that conditions are unpredictable and can vary from one time to the next). The locus assigned to an attribution separates internal factors (within ourselves) from external factors. For example, while some people believe that the outcome of their action is contingent on what they do (hence making an internal attribution), others feel that the outcome of their action is contingent on events outside their personal control (an external attribution). Finally, the control dimension refers to whether an individual believes that his or her behavior can influence or change the outcome of an event. Since attributions have been shown to have important consequences on cognition, risk-taking, expectations for success, and affect, it has been suggested that differing attributions may predispose individuals to different kinds of change experiences (Ormrod, 1995). For example, when individuals consistently attribute the outcome of their actions to external factors they are unlikely to change their behavior in order to achieve greater success.

RELEVANT LITERATURE

Definitions of Active Learning

There is a lack of consensus in the literature on how to operationalize "active learning" (Pressley & McCormick 1995; Bonwell & Eison, 1991). Generally, active learning defines what students are doing and is most often defined as "students doing things and thinking about the things they are doing" (Bonwell & Eison, 1991). The *Standards* define active learning as student activity (National Science Teachers Association, 2001, p. xvi). This broad definition seems to include students engaged in focused listening, short writing exercises, applying content to solve real life problems, thinking about process skills in addition to knowledge acquisition, and exploring the learning process.

Less often active learning is a general term used to describe teaching techniques. Johnson & Malinowski (2001) defined active learning as "any teaching style that maximizes student participation in the learning process" (p. 172). However, after running a summer workshop on active learning with geography and engineering faculty, Johnson & Malinowski surveyed workshop participants to find out how they defined active learning. The responses gathered were categorized into four groups. The largest number of responses fell into the categories of: getting students actively involved in the learning process, getting students engaged with the subject material, and making students responsible for their own education. However, several responses fell into a category that defined active learning as "an environment, not a technique".

Teacher Beliefs and Conceptions

"Beliefs" and "conceptions" are frequently used interchangeably in the research literature with terms such as values, attitudes, judgments, opinions, ideologies, perceptions, conceptual systems, preconceptions, dispositions, implicit theories, personal theories and perspectives (Pajares, 1992). As such, it is often confusing to differentiate beliefs and conceptions from knowledge. In a study of teacher beliefs, Nespor (1987) extended the work of Abelson (1979) to describe four features that differentiate beliefs and conceptions from knowledge. Nespor asserted that beliefs, unlike knowledge, call into play the existence or nonexistence of presumptuous entities, such as stable or uncontrollable learner characteristics about ability or maturity. Second, beliefs may incorporate a view of an ideal or alternative state that contrasts with reality. Third, beliefs are strongly associated with affective and evaluative components stemming from personal experience; and finally, beliefs are distinguished from knowledge by their episodic structure, or association with particular, well-remembered events. Nespor also suggested that beliefs are bound into networks that may contain inconsistencies and may be quite idiosyncratic.

Calderhead (1996) summarized the research on teacher beliefs and identified five interconnected areas in which instructors hold significant beliefs: assumptions about students and how students learn; beliefs about the nature and purposes of teaching; beliefs about what the subject domain is about, what it means to know the subject, or to be able to effectively participate within the subject domain; beliefs about how one learns to teach; and the beliefs instructors hold about themselves, particularly in relation to their teaching role. Although the interconnected areas Calderhead summarized are based on K-12 studies, and post-secondary researchers (e.g., Becher, 1989; Kember, 1997) have cautioned against the transfer of school research findings because of differences in values, traditions, and disciplinary training, the findings seem worthy of consideration, particularly when considered from a developmental perspective, such as that presented by Patrick & Pintrich (2001).

Studies on beginning preservice teachers' beliefs about students have shown that they tend to believe that student intelligence (ability) is fixed and that motivation is trait-like and largely outside of the control of teachers (Dweck & Leggett, 1988; Holt & Reynolds, 1992; Weinstein, 1989). Accordingly, many beginning preservice teachers speak rather dualistically about able or less able students and motivated or unmotivated students and, as a consequence, attribute students' learning failures to either low ability or insufficient motivation. Beginning preservice teachers' conceptions of how students learn have been shown to be implicit and largely formed through their own experiences as school students. While teaching is seen as a process of information telling and following a set of prescribed tasks, learning is seen as a process of receiving information, practicing, and remembering (Blumenfeld, Hicks, & Krajcik, 1996; Borko & Putnam, 1996; Calderhead, 1996). Further, beginning preservice teachers have been shown to hold unexamined views of their own development as teachers, presuming that formal learning is not especially relevant and that teaching is something that anyone can do through instinct and by tapping into one's own experience (Book, Byers, & Freedman, 1983) and gleaning a few managerial tactics from observations of other teachers (Calderhead, 1988).

Somewhat further along the developmental continuum, while engaged in subsequent teacher-education programs, teachers' espoused beliefs have been shown to shift away from control-oriented belief systems that emphasize order and discipline toward the constructivist-based models of teaching and learning on which their programs are established. However, despite the use of sophisticated language by preservice teachers, researchers have reported incomplete constructivist or co-existing and incompatible belief systems during observations of lesson and task planning sessions (Hollingsworth, 1989; Hicks & Blumenfeld, 1995). Studies on teachers' beliefs about students show some changes from the earlier developmental state. Rather than believing that student ability is fixed, teachers often believe that student ability is determined by the maturity level of students, the home environment, or by societal problems such as watching too much television (Calderhead, 1996; Pultorak, 1996). Motivation apparently continues to be viewed as a trait-like characteristic of students and largely outside of the control of teachers (Holt-Reynolds, 1992).

Rather than being exclusively implicit, preservice teachers' conceptions of how students learn have been shown to take on a mixed composition of old, implicit conceptions and co-existing new beliefs. Holt-Reynolds (1992) documented preservice teachers' conceptions of active learning and found that while the teachers advocated the use of active learning, they did so in order to provide an interesting variation to motivate students, and continued to justify the use of lecturing with comments such as, lecturing is a good way to "pass out a lot of information in a short time" (p. 237). Moreover, when observed during planning sessions, researchers noted that "students' prior knowledge" was interpreted to be only the information that had been formally presented in previous classroom lessons. (Hicks & Blumenfeld, 1995). Apparently preservice teachers did not envision that student learning was occurring outside the classroom environment and consequently gave little consideration to how prior knowledge might influence the learning of new information.

Once out of their teacher-education program and into their own professional teaching careers, novice teachers apparently turn their attention away from constructivist notions of teaching and learning, revert to transmission beliefs, and redirect their attention to issues of classroom management (Hoy & Reese, 1977). Studies on teachers' beliefs about student ability suggest continued attribution to uncontrollable factors outside the teachers' control such as innate maturity levels. Kilgore & Ross (1993) conveyed the attributions of a first-year teacher struggling with teaching as: limited student ability. The teacher explained that the 4th grade students, "knew that they were dumb" and that she couldn't change the way that they were (p. 280). Motivation apparently continues to be viewed as a stable student characteristic, but one that can be increased by providing fun and interesting learning tasks (Calderhead, 1996). Interestingly, beliefs that classroom teachers hold about subject domains may be inconsistent between classroom contexts and between different content areas within the same subject domain. Elbaz (1983), for instance, found that an English teacher viewed

English as a creative literature-based endeavor in one class, but presented a system of linguistic rules for students to master in another. Curiously, the beliefs held by beginning preservice teachers of their own development as teachers seems to permeate the belief systems of teachers at all levels. Even very experienced teachers, seen to be highly competent by their peers, have often been found to hold “fairly restricted and simple accounts of the processes involved” in their own professional learning (Calderhead, 1996).

College Instructors’ Conceptions of Teaching

There have been a number of studies that have focused exclusively on college instructors’ conceptions of teaching. In general, these studies bear out the existence of a continuum of teaching orientations ranging from a focus on information transmission with the teacher at center stage and an interactive learning approach focused on student understanding. In addition, while some researchers have reported transitional-type categories bridging the two broad orientations, other have found no empirical support for transitional categories.

Kember (1997) compiled the results from over ten studies addressing instructors’ conceptions of teaching and summarized the findings into five categories: imparting information, transmitting structured knowledge, student-teacher interaction, facilitating understanding, and conceptual change/intellectual development. He then reduced these categories to a model based on three distinct instructors’ orientation to teaching. These were “teacher-centered/content-oriented” and “student-centered/learning -oriented ” with a category in between, which he described as transitional. Included in Kembers’ comparative study was a study by Prosser, Trigwell & and Taylor (1994), who found that most of the first-year physics and chemistry science teachers whom they worked with were focused primarily on transmitting information to their students so that could acquire the necessary information. Study interview excerpts indicated that teacher-focused, content-oriented instructors believed it was their responsibility to help students develop the knowledge and skills needed to pass the examinations. Such instructors were focused on "covering the syllabus" and dictating notes for students to transcribe. Conversely, instructors with a student-focused, learning orientation were much more concerned with confronting students' preconceptions for the purpose of shifting preconceptions toward a more scientific point of view. Using interviews and then a questionnaire with college teachers, Gow & Kember (1993) identified two teaching orientations, which they labeled "learning facilitation" and "knowledge transmission". On the basis of a factor analysis they described learning facilitations as, conceiving of teaching as "a facilitative process to help students develop problem solving skills and critical thinking abilities'' (p. 28). In practice, this orientation was characterized by interactive class sessions and lectures, and personal/motivating interactions with students. The knowledge transmission orientation was characterized by maintaining a focus on subject matter through the articulate and accurate presentation of the subject matter with a goal of preparing students for professional careers.

Using interviews and constant comparative analysis, Samuelowicz & Bain (1992) proposed five conceptions of teaching in the sciences and social sciences, including variants of a knowledge transmission, teaching centered system and variants of a learning facilitation, learning-centered system: imparting information transmitting the knowledge and attitudes of the discipline; facilitating student understanding of the course content material; changing students' world conceptions; and supporting students' learning. The conceptions ranged from a focus on knowledge and the instructor as the disseminator of the knowledge to an interactive collaboration with students aimed at fostering conception understanding. Martin & Balla (1991) described a continuum from teacher content delivery to student activity/experience in three general categories. The categories were described as presenting information, encouraging active learning, and learning facilitation. A subsequent cross-disciplinary study of twenty college teachers suggested seven different categories of conceptions (Dall'Alba, 1991). These categories were: presenting information; transmitting information from teacher to student; illustrating theory to practice application; concept and principle development through interaction with students; developing students' capacity to be experts; exploring perspective-situated understanding; and, facilitating conceptual change.

Conceptual Change Professional Development

The application of models of conceptual change to conceptions of teachers has received far less attention than research on student conceptions. Although a few researchers have qualitatively described teacher conceptual change (Stofflett, 1998) and have analyzed the importance of structuring tertiary professional development programs around what is known of academics conceptions of teaching and learning (Biggs, 1989; Entwistle & Walker, 2000; Hativa, 2000;

Kember & Kwan, 2000; Trigwell & Prosser, 1996; Kember, 1997), very few studies have actually reported the outcomes of faculty development using a conceptual change approach. Stofflett (1998) reported the impact of a one-on-one, semester-long mentoring relationship with a graduate teaching assistant who had completed a summer session graduate-level science methods course and was frustrated over an inability to transfer what had been learned in the methods course to teaching practice in a discussion section of a large introductory science course. Videotaped teaching sessions provided the basis for weekly reflection with the researcher/mentor to determine the extent to which conceptual change was enacted in the classroom and factors that facilitated or hindered the instructors' perceived ability to apply knowledge of constructivist-based teaching to practice. Stofflett reported evidence of text-based conceptual change constructs for dissatisfaction, intelligibility, plausibility, and fruitfulness in interview transcripts but noted that fruitfulness was limited to situations where the instructor was familiar with the content information was being taught. Aside from content familiarity, other factors reported to impede application of constructivist based teaching included lack of planning time and interaction time with students (because of the instructors own commitment to her graduate coursework), unsupportive supervisors and a confusing accusation of incompetence despite exam statistics that indicated that the TA's students had outperformed students in other discussion sections, overenrolled classrooms with students sitting on the floor, and excessive content and vocabulary for students to learn. In addition, student factors—"lackadaisical" attendance, inadequate preparation for class, and an attitude that the course instructors would intentionally "trick" them with wording of exam questions—also impeded use of constructivist based instructional practice. The TA's affect, which became increasingly negative over the course of the semester, also impeded use of constructivist based teaching. Specifically, the researcher cited declining self-efficacy for constructivist based teaching, frustration, self-confidence in content knowledge, unhappiness, and a fear that interactions with supervisors would involve "attacks and impositions". The primary factor reported to support the use of constructivist based instructional strategies was the mentoring relationship, which promoted positive affect, alleviated negative affect, challenged the instructors beliefs about teaching and learning, and her understanding of the traditional distribution of power within the university context.

Ho (2000) and Ho, Watkins, & Kelly (2001) are among the few if only researchers to report the outcomes of a relatively short duration conceptual change faculty development program that consisted of four, three-hour sessions scheduled in four consecutive weeks (one session per week). However, the programs' impact was assessed over three years--instructors were interviewed one year prior to, once during the project, and once, one year after the program to evaluate change. The program was ground in the conceptual change theory reported by Posner et al. (1982). The four-phase program, focused on creating self-awareness and clarifying personal conceptions, challenging instructors' to realize the possible inadequacies in their existing conceptions and exposing them to alternative beliefs as a model for improvement, and a commitment building process. The effectiveness of the program was determined on three levels: through instructor interviews throughout the study, by administering pre- post-perception and learning approach surveys to student in the courses taught by the instructors. Interview transcripts were coded on six dimensions including: expected learning outcomes, knowledge (content, real life); attention to student's conceptions, teacher-student interaction, learning responsibility, and control of content (teacher controlled, student controlled). Ho et al. (2001) reported detectable "conceptual change or conceptual development" in two thirds of the participating instructors (defined as showing positive changes in their conceptions of teaching) and indicated that students had reported significant improvement in the teaching practice of the instructors. Ho et al. (2001) concluded that their study provided "evidence that a development in teaching conceptions can lead to improvements in teaching practice and in student learning" (p. 165).

CHAPTER 3

Methodology

RESEARCH QUESTIONS

The following research questions guided the investigation and therefore the selection of research methods: (1)? (4) If they encounter problematic classroom situations, how do they respond and how do their responses influence decisions regarding future use of active learning in their classrooms?

Paramount questions in the design and methods decisions of social science research are, "What is the research for?" "What kinds of data will facilitate understanding" and, "What techniques will allow collection of the desired data types?" Given the nature of this research, which seeks to document classroom-situated experiences, the study was conducted in an interpretive case study design using mixed methods (concurrent use of qualitative and quantitative methods) for data collection, analysis, and interpretation. The design choice finds support in the works of Yin (1984) and Stake (1995) who advocate that research questions, situated in contexts where little or no control is intended or desired, are best explored with case study designs. Moreover, Gallagher (1991) posits that interpretive research provides science educators with a powerful tool for examining the strategies and thinking of science teachers and for documenting the details of teaching in contexts that render depth and meaning to the events of interest.

According to Yin (1984), a case study is defined as:

> An empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used. (p. 23)

Yin advocates multiple case study designs, "as one would consider multiple experiments—that is, to follow a replication logic" (p. 48), and cautions against generalization by the researcher to larger populations. Stake (1995) asserts that, rather than generalization, "the real business of case study is particularization" (p, 8), where the goal is coming to understand the uniqueness of the case through a process of progressively reducing the breadth of the inquiry.

The framework used to support instructors as they began to implement instructional strategies to promote active learning in their classrooms was the Critical Issues Framework (Loucks-Horsely, 1998). The framework consists of a planning sequence that includes goal setting, planning, doing, and reflecting—guided by consideration of the teaching context, emergent critical issues, and instructor knowledge and conceptions. Overall, the framework allowed a research design to emerge from a dynamic process of "thoughtful, conscious decision making" (p.16) driven by instructor needs and choices.

Based on work by Schon (1983, 1987) instructors were asked to engage in two, "reflection-in and reflection-on-action" activity cycles during the project. One cycle was to be implemented after baseline data was collected, and the other was to follow at the instructor's convenience. For each cycle, instructors were asked to plan an active learning session around the theme of gradients and conductance (curriculum modules were available, but instructors were free to choose, develop, or modify any classroom activity for their students, implement the session, ask for student feedback, and reflect on their experience.

PARTICIPANTS

The selection of research participants was based on the technique of purposive sampling (Lincoln & Guba, 1985), which seeks both typical and divergent data to maximize the range of information collected. Study participants were selected from a pool of 18 instructors who had volunteered to evaluate activity-based curriculum modules in a longer-term project.

As background on participant purposive sampling, the process of selecting the longer-term study participants began at the HAPS Annual Meeting (June 2000, Charlotte, NC). Instructors interested in using and evaluating the curriculum modules were asked to add their name to a centrally posted sign-up sheet. Fifty-one instructors volunteered (29 males and 22 females). Thirty-six instructors from the volunteer list (18 males and 18 females) were invited to participate in the study. Invited participants reflected the organizational diversity of undergraduate teaching faculty with membership in HAPS, held a master's degree or a Ph. D. in science, and were currently employed as Anatomy & Physiology instructors at a postsecondary institution. During the following three months, the number of participants declined from 36 to 18 (10 females and 8 males), as instructors re-evaluated and prioritized their fall semester activities. On the primary criteria of interest (institutional type), a total of five instructors, from the pool of 18 volunteers was invited to participate in this dissertation study and two additional instructors volunteered for participation as well (Prof. A and C; both females).

The Human Subjects Review Board at the University of Texas at Austin requires that researchers obtain the written consent of each participant prior to their participation in a research project. Consent forms that met the established requirements of The University of Texas were distributed to each participant. One copy was signed and returned to the researcher and the participant kept the second copy. The consent form is included in Appendix A, and signed consent forms are in the researchers possession.

Table 1 details how the participants met the primary criterion of interest (institution type), as well as the secondary and tertiary criteria (years of teaching experience and active learning experience). The willingness and ability to articulate thoughts and concerns, which had been identified during the longer-term project, were also taken into consideration during the selection of the dissertation sample. All participants, with the exception of Prof. C, were members of the HAPS organization. The number of participants chosen from each type of institution corresponded to the demographic composition of HAPS members. Given that nearly half of the HAPS members in attendance at the Symposium were from two-year colleges, half of the participants in this study were also affiliated with two-year colleges. Four participants were instructors at community colleges/vocational schools, two were teaching in a University or a Professional setting, and one was teaching at a four-year college. Six of the participants were Ph.D. scientists and one held a Master's degree in science. Five of the participants were female and two were male. Three of the participants had been teaching for five years or less, two had been teaching between ten and 15 years, and two had been teaching more than 20 years. Four of the participants reported that they had no experience using instructional strategies to promote active learning and three reported having tried active learning but found that their attempts did not always produce the desired results.

Table 1 Participants and Criteria of Interest

Instructor	HAPS Member	Community College	University or Professional Program	Four-Year College	College Teaching (Years)	Active Learning Experience
A	X	X			10	Little
B	X	X			15	Little
C			X		1	None
D	X		X		4	None
E	X			X	5	Little
F	X	X			35	None
G	X	X			20	None

DATA COLLECTIONS AND ANALYSIS

Data were collected for 15 months for all seven participants. The data, primarily qualitative, served to explore and document how instructors went about introducing active learning into their classrooms, what supports and obstacles they encountered, how their beliefs about teaching and learning changed, and whether there were patterns in the experiences described. Survey data from students in participants' classrooms were collected at the beginning and end of the project. The student data served as a point of triangulation to compare student attitudes across institutional types, instructors perceptions of their students to students self reported beliefs and to document the impact of the active learning experiences on student attitudes and conceptual understanding.

Qualitative Procedures

Naturalistic inquiry methods (Lincoln & Guba, 1985) were used for qualitative data generation and analysis. These methods are particularly well suited for the collection, analysis, and documentation of primary data oriented toward describing and understanding phenomena within situational contexts. The methods permit in-depth study of participants and yield rich, interpretive accounts of experiences. The axioms that guide naturalistic inquiry methods make the researcher's role specific. The first axiom--multiple constructed realities--necessitates a holistic investigation that seeks to collaborate with and represent the participants' points of view as a mosaic that captures complexity, rather than a neat, sterile picture. Because of differences in use of language between the researcher and the participants, this axiom guides the researcher to collect data from a variety of sources and in a variety of ways to develop the participants' assumptions, operational meanings, and ultimately an understanding of the participants constructed reality. The second axiom, which affirms the mutual influence that the researcher and participants have on each other, requires that the researcher finds ways to identify and document her own biases, expectations, and preconceived notions so that the flow of pertinent information is not inhibited. This axiom guides the researcher to develop a Researcher as Instrument statement, maintain a reflexive journal to document the process of decision making, check interpretations with participants, and work with peer debriefers who continuously challenge emergent themes and interpretations to ensure that participants' perceptions are properly represented in case study reports. Purposive sampling, prolonged engagement, triangulation, member checking, peer debriefing, a reflexive journal, and thick descriptions were procedures used to establish the quality of this study (Lincoln & Guba, 1985; Erlandson et al., 1993).

Primary sources of data were verbatim transcripts of interviews with participants. An average of six, 45-min interviews (both face-to-face and telephone) with each participant were conducted. Supporting data included observations, correspondence, and documents (instructor surveys, journal entries, field notes from classroom or HAPS workshop observations, and course manuals and syllabi).

Interviews

An interview is "a purposeful conversation between two people that is directed by one in order to get information" (Bogdan & Biklen, 1982, p. 135). In naturalistic inquiry, the major purpose of an interview is to learn to see the world from the eyes of the participants. "Interviews allow the researcher and respondent to move back and forth in time; to reconstruct the past, interpret the present, and predict the future" (Lincoln & Guba, 1985). The interviews that were conducted with the instructors who participated in this study truly moved through time. Instructors not only conveyed their present experiences with active learning, they reconstructed past events as learners of science, and recalled the influences on and development of current perceptions of students as well as perceptions of teaching and learning. Assembling the flow of meaning from each participant was remarkably similar to trying to assemble an old jigsaw puzzle found in the bottom of a closet, in a damaged box with lid slightly ajar-- indicating the potential for missing pieces.

All seven participants were interviewed at least once in person. A cassette tape recorder was used to record the interviews. All informants were also interviewed on multiple occasions by telephone. These interviews were recorded using a telephone recording control device. All interviews were transcribed and hard copies kept in designated binders.

In addition to tape recording, notes were taken during each interview to create a running outline; frame participants word choice, identify questions, and list ideas that required elaboration. Each interview began with an open invitation to "tell me what's going on…with you and the active learning project". Additional questions emerged as the interviews progressed. The following transcript excerpts illustrate how each of the participants responded to the initial interview question:

> Researcher: Tell me what's going on with you and the active learning project.

Prof A: Well, maybe I'll start with describing the program and the students…and…oh…. you sent the email that asked about what had re-stimulated my interest in active learning and what my goals were for the project…

Prof. B: Well…it's been a tough semester for me so far. Part of me gets real hooked into this and just gets so upset…but I think it's just critical that I engage with these students so that I can feel what the other [participants] are describing on the Listserv…sometimes…by God…it's no wonder people say, 'Forget active learning!' I know you probably don't want to hear that.

Prof. C: Do you want me to brainstorm or do you want to ask me specific questions? Well, I just had a thought so I'll do that before I forget it…I've been so disappointed when students don't put together the relationship between them not knowing a concept, doing an active learning exercise, and then knowing the concept afterward…it's like they aren't appreciating the value and how much faster this way of teaching can be sometimes…

Prof. D: Well, it's going pretty good. I can't complain…everything is up and running for the course…the Web pages are up…and I just gave the first quiz and problem solving exercise…they like the group quizzes…well you may not be familiar with what I am doing. What I do is I give them a 10-qusetion individual quiz on the reading assignment. I collect the grading sheets for those and while I am running those through the scanner, they are taking a group quiz…15 questions…the two or three hardest questions off of the individual quiz…the questions on the team quiz are higher level thinking that the individual ones are. The individual ones are more factual recall. And then they get to discuss what they want to put down as an answer…

Prof. E: We haven't started the semester yet and so I haven't finished my syllabus yet…I've done the schedule…so my thought is that I am going to streamline things because last semester I almost killed myself with all the different things I was doing…. I'm just going to scale back in that I have been doing too many things that students were graded for…so they were…at like almost every class session they would come in and we'd do some sort of [question and answer time] and then one, if not two major problem solving things…and I think it was too much. It was too much grading on my part and it was too much extra stuff on their part. I think really it was too much output on their part and not as much time for input and I felt like they were frustrated…especially in the beginning because

> they had no idea what this whole thing was…even though I tried to explain it…and after the first exam they kind of got the hang of it…but it was so much and they didn't have the time to absorb and process information.

> Prof. F: Well…I haven't really had a chance to look through the material that you sent out by email. But so…let's go…what's on tap? I'm trying a lot of little things…a year ago…as soon as we got into this I may have mentioned that I rescheduled my classes so I don't have separate labs…they meet two hours at a time…and when I want to do a little lab work I do it and when I want to do a little lecture I do it…sort of what some of the physics people are doing and they call it the studio approach. Have you heard about this?

> Prof. G: It's going pretty good… I…we did an ECG lab this week…. and I always have them do that and take their pulses in three different positions…and then I teach them to do standard deviation and standard error of the mean …So it's real nice to be able to introduce them to statistics and it shows that the heart has to make some pretty dramatic adjustments when they first stand up….

Beginning with the second round of interviews, challenge questions were added to the structure of interview. Participants were asked first to respond to the open-ended question and as conversation slowed, challenges were worked into the questioning. For example, the following challenges were extended to Prof.'s F, and G:

> Prof. F: Now I have often thought on my next exam…just have a question or two…"Do you feel you learned the subject using this approach?" or something like that….a simple yes or no might provide some information. I don't know whether that is a way to do it or not….

> Researcher: Well does yes or no get what you want? What about asking something they couldn't answer with yes or no?

> Prof. F: Ah…yeah, okay.

> Researcher: Sometimes…I'm interested in comparing my expectation for learning with what they actually think they learned.

Prof F: Yeah and you know what? I have a feeling that my students might say, ”We are not sure what we learned.” And if that is the case then it needs to be looked at again and modified…and that is a good point…. yeah….

Researcher: Okay, let me make sure I got this…so the next time you do an activity, you would reconsider group size?

Prof. G: right…yeah group size definitely. I also want to be clearer …and I either need to give them very specific directions about what needs to come out at the other end…or I need to let them do it their way, and accept what comes out. So…it was a minor thing but I don’t want to repeat that.

Researcher: So either be very explicit about what you want and tell them that…or be flexible about the logistics and encourage that?

Prof G: Well yeah but I don’t know…you can give me feedback here…do you need to have your particular objective spelled out? I mean it didn’t bother me that they were frustrated because they were thinking it was a review type thing…but I didn’t intent it to be that…I just wanted to know if they could take what they knew so far and try to make something of how it fit together…should I have told them that?

Researcher: If you were a student in the class would you want to be told?

Prof. G: Yeah…I think so.

Researcher: I’d for sure want to know…I’d want to be a partner in what was going on and what I was expected to be doing.

These excerpts detail the questioning techniques used to generate data during the interviews. Each interview began with an open-ended focus question and additional questions were asked in order to clarify and expand points previously discussed. One complete interview transcript has been included in Appendix B. The remaining transcripts are in the researcher’s possession.

Observations

Observations, like interviews, range from being unstructured to very focused. Whereas interviews allow the researcher and participant to travel back and forth in time, "observation allows the researcher to discover the here-and-now interworkings of the environment via the use of the five human senses" (Erlandson et al., 1993 p. 94). The power of observation is elaborated by Guba & Lincoln (1981):

> [O] bservation…maximizes the inquirer's ability to grasp motives, beliefs, concerns, interests, unconscious behaviors, customs, and the like; observation…allows the inquirer to see the world as his subjects see it, to live in their time frames, to capture the phenomenon in and on its own terms…(p.193)

Because six of the seven participants taught at out-of-state institutions, observations for most were limited either to their participation in HAPs workshops (Prof.'s B, D, E, and F), on the rare occasion of a visit to the vicinity of the researcher (Prof. G; teaching as a guest lecturer), or observation through a triangulation researcher (Prof. B). Prof. C was the exception. Because of her regional proximity, she was observed on a regular basis throughout the project. The most useful format was to observe (and tape record for later transcription) a classroom session, formulate a series of observation-based questions and ask for responses in subsequent interview. For example, following a classroom observation that focused on the concepts of osmolarity and tonicity (short lecturing with questioning and small group problem solving), an interview excerpt revealed that Prof. C was integrating her knowledge of classroom strategies, students' responses, with what she was reading of research literature. It is doubtful that this account would have been revealed had it not been for the questions formulated during observation:

> Researcher: What did you think about students' reactions to the problem set today?
>
> Prof. C: Well… they enjoyed it…they've been saying to me already…."Oh, we love your class" and that makes you feel so good….that was of course before they got their quiz [laughing]….it may have changed a little bit…but I had to make them get a little more serious…but I think they are enjoying it…my profound statement is going to be that this is somewhat like a marriage…like when something goes wrong or doesn't go the way you expected it to, you have to just say, "Well now….this is what I am going to do…we're together." And I expect for things occasionally to happen that are not exactly what I thought would be ideal….and that's okay….that's just the way things happen…..instead of going, "Oh my gosh! I can't believe my students didn't like this!"
>
> Researcher: Okay…then if you were to make a statement, you would say that teaching undergraduate science is like a marriage?
>
> Prof. C: [Laughing] Well no….I would say that trying to incorporate active learning in the classroom…that kind of a commitment is like commitment in a marriage where you have to be committed to it….you have to have faith that it will work or else….every time something happens…you get to nick pick it because you look for either the failures or looking for the successes….and you have faith that it is going to work…okay…this is profound [laughing] this is coming from someone who has never been married….and doesn't actually know….but from what I have read in theory….hypothetically….but really…people approach things in different ways….it's just whether you are an optimist or a pessimist about it. So far I've been an optimist and I've had moments of pessimism and I just keep shoving them aside….and so far I've been very pleasantly surprised with how well this works in two ways….one, to get the students enjoying the class…and really using the material in class and two, in uncovering the difficulties they are having. This is better than any teaching technique I've found so far…this is new for me….in the classroom before they leave…for me to find the problems that they are having….and address those….or address those the next day….somebody says…."Oh, I tried to do this in the classroom and I didn't….and….why did this go this way….?" And I think, "Ahhh, I forgot to tell them….why this goes this way…."

> Researcher: So let's think about….
>
> C: I know I am reading all of this too….that this is how it works but I'm experiencing this stuff now and going, "Ahhh, this is great! It really does work"

Correspondence

The correspondence data collected for the study included informal invitations to participate in the study, interview scheduling, requests for documents, and activities related to member checking. Correspondence took place via e-mail messages and traditional letters mailed through the United States postal service. Appendix B contains selected correspondence samples. All other correspondence has been archived and is available upon request.

Documents

Documents are any of a broad range of written records, as well as any data or materials made available by the participant. Documents used included a teacher survey inventory, that addressed beliefs about teaching and learning and strategies used teaching journal entries, field notes from classroom observations and course manuals.

The teacher inventory, designed to explore the way that academics go about teaching in a specific content area (Trigwell & Prosser, 1996; Permission granted for use Trigwell, 2000; Appendix C) was used throughout the project with the intention of tracking quantitative changes in beliefs and strategy use. Participants completed the five-point Likert scale inventory in written form four times over the 15-month period, and were asked to respond verbally to the survey question and elaborate on responses after the project semester was completed (Appendix C).

Data Analysis

Data analysis is the process of bringing order, structure, and meaning to the mass of collected data. It is messy, ambiguous, time-consuming, creative, and fascinating process. It does not proceed in a linear fashion; it is not neat. [It is a] search for general statements among categories of data…

Marshall & Rossman (1989, p. 112)

Data analysis in naturalistic inquiry is an ongoing process—it begins the first day of data collection, and involves an inseparable relationship between data collection and data analysis—as data are collected they are analyzed, and data analysis often necessitates revisions in data collection procedures, which, in turn yield new data that are then subjected to new analysis. To a large degree, the interactive process is governed by the intuition of the researcher and includes a continuous form of self-questioning. Entries from the researchers reflexive journal include stream of thought processing oriented around questions such as: "What did I learn from [Prof. B] that will shape my questions for [Prof. G]?" "How are [the participants] similar; how do they differ?" "Why are there differences in reflective ability between [the participants]? What questions might prompt [Prof. B] to go beyond her initial perception?"

The data collected for this study were analyzed using a variety of naturalistic tools and they were examined multiple times. The first step in the analytical process involved looking for the range of variation in the instructors' descriptions. For each participant, the next step involved breaking the interview data into sections that contained common themes. Once sectioned, the data "chunks" were labeled using codes that clearly identified each section's theme. Finally, a list of emerging themes was compiled by listing the codes ascribed to the section chunks. In order to confirm results, this process was repeated multiple times (separated in time), each time creating a list of emergent themes. Lists were then compared and if differences occurred, the process continued. A combined list of themes was reviewed with peer debriefers and revised in accordance with debriefers' recommendations.

In the peer debriefing process the themes were tied back into instructors' experiential descriptions at various points in time to identify how the descriptions were changing over time. It should be noted that the attempt to identify change in individual instructors, in relation to the categorical description, was problematic. The problematic nature of this process has also been conveyed by McKenzie (1999). In trying to look for changes in beliefs across a set of transcripts for a participant, different aspects of the experiences come into focus. Because participants don't report their experiences in a linear fashion, the interview transcripts become experiential reports that extend backwards and forwards in time. Second, as categorical descriptions are separated from context, the participants' ways of experiencing are partially lost. The process becomes one of recording extended chunks of categories across time. Appendix D contains an interview sample that has been chunked, coded, and sorted. Index cards containing categorical descriptions across time are in the researcher's possession. A list of emergent themes is included in Appendix D.

Conceptual change analysis was conducted using the method and construct definitions proposed by Stofflett (1998). Interview transcripts and written correspondence documents gathered throughout the project were analyzed for each conceptual change construct—dissatisfaction, intelligibility, plausibility, and fruitfulness—separately. The construct definition and indicators for each construct are briefly described:

Dissatisfaction: Statements that suggest a reduction in the status of a traditional transmission conception of teaching and learning. Evidence (positive indicators) for dissatisfaction include direct statements that indicate a dissatisfaction that knowledge can be transferred in discrete packages from the instructor to the learner (e.g., "Just because I said it didn't mean they would learn it") and statements that include examples of mental disequilibrium (e.g., "I don't know how….", I don't understand….", "I'm confused by…."). Evidence against (negative indicators) dissatisfaction include confirming statements about the effectiveness of traditional lecture or information transmission to produce student learning (e.g., "My students learn best when I lecture".)

Intelligibility: Statements that suggest an understanding of constructivist learning theory. Evidence for intelligibility include direct statements that suggest understanding of the importance of eliciting prior knowledge, making connections between old and new information, and of stressing conceptual or thematic learning with an emphasis on transferring knowledge to novel problem solving situations. Evidence against intelligibility include statements about the transmission nature of learning, direct statements that constructivist terminology is devoid of personal meaning, or statement of constructivist terms followed by inconsistent descriptions of what the terms suggest.

Plausibility: Statements that suggest an increase in the status of a constructivist conception of teaching and learning and the intent to use instructional strategies to facilitate student active learning and knowledge construction in future teaching. Evidence for plausibility include statements that personal meaning has been made of constructivist terminology and a commitment to implement instructional strategies to promote constructivist pedagogy. Evidence against plausibility include statements that indicate a declining status or doubts in constructivist pedagogy, and/or reverting to traditional teaching methods following a problematic classroom experience.

Fruitfulness: Statements that provide evidence of use and continued future use of instructional strategies to facilitate active learning and constructivist learning.

Member Checking Level One

The first level of member checking occurs when the researcher questions or asks for elaborations of ideas during an interview. The following interview excerpts illustrate member checking at the first level during telephone interviews.

> Prof. A: My concern is…that I want to know whether the activity really helped them understand…so I mean I think to really know I'd have to ask each one verbally if they had a visual image of what we did and can they relate that to what they read in the book or talked about during discussion…did it give them something to hang their hats on…

Researcher: So are you talking about doing interview sessions?

Prof. A: Well I guess that is what I am talking about…I mean sometimes I'd like to be able to ask…but you know that would take a lot of time and I just don't want to go there! So I'm just talking…but I am just going to let it go…

Prof. B: …And so I agree to go through [the section on connective tissue] and one hour and 15 minutes later I finished with connective tissue and muscle and nerve. And I said…that is how I feel that given any opportunity they can't…if I don't say it, they don't know it. And isn't that funny because they are not good listeners…so what is this?

Researcher: Wait…is it correct if I am speaking for you here, "If I don't say it, they don't know it."

Prof. B: Yes. There is something about coming to class and this is stunning to me, it's like they think my job is to paraphrase the book and that is the only job that they feel the teacher has. So yes, "If I don't say it, apparently, they don't know it.

Researcher: So just a minute ago you said [a question that students respond to at the beginning of class by writing their answer on an index card] is not really active learning. Why?

Prof. C: Well yeah…that's just kind of a quiz…

Researcher: Okay so what's your standard for active learning? I'm not sure I'm seeing the distinction?

Prof. C: Yeah…why am I not calling that active learning? See if they did it in the middle of class….

Research: So timing is an issue?

Prof. C: Well no…so, I'll talk out loud because I'm not sure why I say it that way…so if I…well…if they are just answering a question or solving a problem…and they…. turn it in…it doesn't seem…I don't know why I said that.

Researcher: So I am asking you how you are defining active learning.

Prof. C: Well I'm questioning that now too…why I would say it's not active learning because if I did it later in class and we had the opportunity to go over it and they got feedback to adjust what they were thinking…that's active learning. But if I don't make some class time to address their responses or let them address responses with each other, then I don't know how valuable it was other than to just test whether they knew something…I'm not sure…that is more for me to see where they are…whether the majority of them have the knowledge…it's a way for me to see if we need to spend more time if a lot of them are still not getting something…does that make sense?

Prof D: Well I look at it more as me teaching them or trying to get them to think in a way so that they are basically not cheap…I guess I don't know exactly how to describe it…There are two things that I think about them as human beings and as professionals…so in the context of my purpose here at the college I'm basically teaching them how to critically evaluate something because that is what they are going to be doing.

Researcher: And by cheap do you mean a surface view of thing…more depth…when you said cheap?

Prof D: Cheap? When did I say cheap?

Researcher: You said...teaching them to think in a way so that they aren't cheap?

Prof. D: S-H-E-E-P….baaaaaa.

Researcher: Got it. Good thing I asked.

Prof. E: So on the first page…everybody did the first page together.

Researcher: What's there to do? I don't see any questions.

Prof. E: Well there's question 3…and it has three parts.

Researcher: I don't see anything like that.

Prof. E: I'm sorry! Page 2 is page 1...because page 1…yeah and then they turned in page 3.

Researcher: So the first page with problems is really page 2…and there's that question with three parts. Am I there?

> Prof E: You are! Okay. So they were confused because of the drawing of the capillary …oh oh…that wouldn't be on yours! I'll tell you what to draw….we want to show a capillary with a magnitude of 1 going in and 37 going out. Got it?
>
> Researcher: Got it.
>
> Prof F: The computer program worked great! It was a thrill to teach the way that I think teaching out to be done. [Students] get the facts on their own, use the facts when they work with the program…and my job is to help them figure it all out.
>
> Researcher: Right.
>
> Prof. F: Now that was even more…the benefit was even more pronounced in the afternoon when the class went through the program…but that had been my first try writing such a program and it was a flop!
>
> Researcher: The first program you wrote?
>
> Prof. F: Right the one on the immune system.
>
> Researcher: But that's not the one you wrote for the [project activity], right?
>
> Prof. F. No…right…I was just thrilled at how well the program I wrote for the project worked, so I pulled out an old program and it didn't work nearly as well…well it was a flop…because it didn't have any questions…
>
> Prof. G: This semester I have one high school student and the rest are sophomores…most of them…they have been here three years
>
> Researcher: Sophomores…so they are 19 or 20?
>
> Prof. G: Oh no! They are in their 30's and 40's. I have very few traditional students…like you are probably accustomed to. Mine have a sophomore ranking but…oh gosh…one guy must be 50 but most are probably early 30's.

First level member checking is critical—it allows confirmation that the reality I was constructing and describing was aligned with the participants' perceptions. I member checked throughout each interview to get as close as I could to understanding what participants were trying to tell me. I also member checked at the end of each interview.

Member Checking Level Two

The second level of member checking takes place after the interview and requires the researcher to check her understanding of emergent themes and ideas with the informant to confirm they are accurate. One participant's level two member checking interview occurred in person. The other six level two member checking occurred via e-mail correspondence. The following table was presented to Prof. C for comment:

Table 2 Prof. C: Level Two member checking

Goals	Problems	Perceptions of Students	Active Learning
Keep advanced students motivated to participate but not leave other students behind. Get students to see the value of active learning.	After a formal assessment I shift to the lowest common denominator in an attempt not to leave some students behind. I think this action lessens the motivation of the more advanced students. I've heard second-hand that my classes have too many activities and can be a waste of time. Scheduling makes it almost impossible to completely align lab and lecture material. The way I have awarded points for in-class active	They will take advantage and work less hard if I "give" them information. They will generalize that all active learning is a waste of time if they experience one activity they don't value. They need me to keep them on track by giving them explicit directions on assignments that are due despite the fact that they have this information in the syllabus. They will choose their	Active learning exercises are done midpoint to the end of class—with the purpose of challenging students to see if they understand material covered in class. A necessary component of active learning is instructor feedback. To make good activities you have to know something cool about physiology and that is hard when you are a new instructor. Some students like active learning but

	learning has not worked well. My pre-semester planning time was eaten up by an unanticipated office and lab move.	level of participation based on grades. They are motivated largely by grades. They may show physical anger during activities. They cram before an exam. They sometimes ask totally disconnected questions. If they don't keep up, they find active learning to be a negative experience.	some hate it and think it's busy work. Students are more likely to value active learning if they are shown the potential benefit of the activity or information to future careers. Once students form an opinion that active learning is not valuable, it's hard to change their minds. When using active learning it's important to lay the ground rules early. Using active learning can be a faster way to teach—especially for common concepts that students repeatedly miss on their own. Good active learning exercises stimulate curiosity and a little confusion in students. Students are motivated to solve good problems
Instructor's Role	**Class Flow**	**Changes**	**Questions**
An effective instructor does not leave students behind. Instructors can encourage students to create a habit good studying	I use a PowerPoint outline (large font; 4 lines/slide) during class. The format gives me the flexibility to add or delete topics. I begin with a summary of the objectives for the day and then do a series of 15-minute lecture segments divided by	I'm more natural (I don't feel as canned) as I did when I first started doing the exercises. I've gone back and forth with the difficulty of the questions I pose during the class. This semester I'm going toward more structured	How do I fairly award point for learning activities? How do I motivate students without grades? Can I encourage preparedness by posing questions

	exercises to break things up. The purpose of the exercises is to give students time to stop and work with the material to find out if they understand it. At the end of the class, I summarize what's due next time (like homework, lab and/or reading assignments). Because of the lab/lecture/discussion format, it can get pretty hairy.	activities and more difficult questions based on my own impressions of what seems to work and indirect student feedback. I recently had a favorable experience with "coached practice" and felt okay about sacrificing some additional class time to really model how I read and interpret graphs for students. I'm changing the way I award points for exercises in response to my observations that students strategically choose the activities they do based on grades. My former grading system allowed some student who chose activities strategically to outscore students who consistently participated in all activities.	related to the required reading?

The discussion with Prof. C that followed review of the table follows:

> Researcher: These are some of the themes that keep coming up in our interviews. Whenever you talk about a problem or students or your role, I transfer the comment in a summary form to this table. So now I need you to look through the table and just react to it.
>
> Prof. C: Oh…that's interesting. [Laughing] Whooo….I'm stuck on instructors role because it makes me laugh….because I guess I used to say that and now I just say, "Naah….just leave them behind!"

Hmmm…okay…………………………so what do you want me to look at?………………………Do you just want me to see what I think about this?

Researcher: Yeah and I mean you can react to it…you can say, "Maybe I said this but this is what I meant….or yes maybe I said that but not in this context". Like when you said just now that you were laughing at instructor's role because now you just leave the students behind….you could just respond to some of the statements in that same way.

Prof C: Yeah so that is a change….but you know what? When you reminded me of my goals and then said I had addressed them…man that was really cool because I had forgotten about that…so I liked that you kept track of this because that really blows me away.

Researcher: But how would you address goals that you forgot about?

Prof. C: I know…I didn't even think about it...and yet…if it was something that was bugging me and I verbalized it…it's almost like that was a counseling session for me because if I could get to the point where I could say it to you….what was bugging me….then that was the point at which I could start to address it…to solve it.

Researcher: So the awareness drives a new behavior?

Prof C: Yeah and even if I don't keep it in the forefront of my awareness…the point at which I became able to verbalize it and clarify what the problem was the turning point for when I start solving it….as soon as I complain about something is the point at which I….well hopefully…..[laughing]…my sister would not agree with this statement….but as soon as I complain about something I quit complaining about it and start solving it….. [laughing]

Researcher: That's good. See and…I'm thinking that you are moving away from that first problem statement too...

Prof. C: Yeah…I think so…but that may be a function of weeding out the activities…dumping the ones that are failures or tuning them to make them better…

Researcher: Almost like you get your own repertoire built up….your own notebook of music that you can look into and go….'oh I haven't played this one in a while…"

Prof. C: Yeah! Add a few and you subtract a few. Uh! And aligning lab and lecture material! [The lab director] and I have worked together on this and it's made a huge difference…and actually I'm solving this problem too because I go to the TA meetings for the lab and I talk to them about what I am doing in the lecture and then in lecture, I try to bridge or pre-load…or whatever you want to call it… the lab activities and tell students, "This ties into what you'll be doing in lab…." And I encourage the TA's to make connections like, "Well you know in class…. when you did this…" I mean it does take some time….a couple hours a week but it is so worth it.

Yeah…[reading the summary]…. this whole thing of awarding points in class for active learning…I still haven't solved this one. I changed the way I did it…and I am having a whole new set of problems…. my problem is keeping up with the points! It's so time consuming. I'm started doing it thinking it would be a motivator but now the students are self-motivated…. and now it is just getting in the way to worry about points and it's become nothing more than checking attendance. It also isn't working out to have them always turn a card into me so that I can assign points because sometimes I want them to hang onto their cards and thinking about how they would change their answer…or if it's a quiz, I want them to take the quiz home and work on it or talk to their friends if they didn't know how to do it. I think it just makes for a better learning experience.

And then like…yeah the "coached practice" with graph reading…we do that and then there's really no way to take them up….mostly I can just walk around and help them and that works fine….but they don't get credit for it because I don't take it up….so what do I do with points for that? They end up doing exercises that they don't get credit for…

Prof C: This is so much work that you do on these summary tables…oh my gosh….I like this though…

Researcher: You do?

Prof. C: Yeah I like the table. I've never thought about our conversations as little individual pieces…..WHAT'S THIS?!!!!….show physical anger during activities?….My heavens DO I DO THAT?"

Researcher: No! You said the students may do that….

Prof C: [laughing]…OHHHH…Whew! [laughing]…..

Researcher: Sometimes I wonder to if I lead you to say certain things…and I want you to tell me, "Hey! That's what you think! Not what I think!" Would you do that?

Prof. C: Well sure but I don't see anything so far. I think this does a pretty good job so far…. everything is like, "Yeah"…. I mean some of it I had forgotten….but some of it is still really true. Like I have students that are…they don't come to class prepared but they like to hear themselves talk…and they are talkative and articulate and they have no facts to bear and they waste a little bit of our time…but I don't mind….because, I like them….and I know it's just them feeling how it feels to speak out….I mean it's different for them just to talk out in a big class!

[reading] Yeah….I don't really do the objectives that much anymore although they still get a handout of the objectives…..every time we do a section.

Researcher: What do you mean a section? Like a system?

Prof. C: Yeah…like an organ system, they get the objectives for that organ system….I've tried to break the exams up so that they cover one whole organ system….because it makes more sense to me to have all the information for cardiovascular and then all the information for respiratory on one exam…and then they get the objectives for that system…and even though there is a lot of overlap….it is kind of nice actually because I can point out to them that they need to understand pressure flow relationships….and I still write the objectives and I get better all the time at doing that….I do them as a checklist because what I intend for them to do with that is…at the very end take the objectives….you might expect the objectives to be what you get at the beginning….I mean I want them to have them in hand…but what I really think the value of them is…in the end to go through the list and check that they can accomplish certain things…can you calculate clearance of inulin? Of creatinin? Can you calculate the filtered load of any solute given these two values? Can you tell by listening to me what I am teaching now?

Researcher: [laughing] Yeah--so it's like a post-learning check list?

Prof. C: Yeah.

Researcher: How did you learn to write objectives?

Prof. C: That I got from the HAPS…. no the APS site…. they have the curriculum objectives site…. so if you go to the APS, they have education, medical curriculum…I think it is under undergraduate…but it is their medical curriculum objectives…. and they have objectives there for medical education so I actually use those…but they also talk about objectives and how to write objectives…and how to write them as an action rather than understand this thing….and it has worked real well for me….I would not have necessarily thought of that….but it is so helpful in terms of informing my teaching because now I see …I realize that I'm teaching them to be able to do something….even if it is understand this thing….but it is still be able to use it in some way in the end….some end result…rather than just some ambiguous….thing…because how do you really know if you understand something?

Researcher: Yeah…just telling someone to understand doesn't tell them anything about what level they should be understanding…what is with that word? Understand…to stand under….?.

Prof. C: I do that all the time though with physiology words…breaking them into components.

Actually, it's something that would be good to share with the other [participants]. I think they would like this idea actually. It gives…. the students something to hang onto…. and it addresses that question…. "Will this be on the test?" So now they get this list of action objectives and that is basically telling them that when they take the test they better make darn sure they can do all those things!

Researcher: You know, what you are doing has a name? You are aligning objectives…what you think they should be able to do …with your teaching….and then with the assessment…they are all aligned on the objectives.

Prof. C: I guess…yeah……I mean I am not sure I planned it that way but I guess maybe it works out that way….I guess maybe that is why I like the objectives…..and when I write an exam…when I write a good exam….then I can pull out the objective list to write the exam…and when I don't do that that is when I write my bad exams…like I have exams that are really good and I have exams….that I feel like don't really match what we were doing…..

Researcher: And I suppose if the way you operate is sort of…once I have the awareness then I begin to solve the problem…if you've got a list of objectives…then you probably start looking for problems that align with those….you probably go…whoa that's right in there with that objective!

Prof. C: Yeah…oh yeah…if I tell them that they need to be able to calculate filtration given excretion….then I try to give them a problem that is exactly like that in class…even if it is a simple problem…and it also helps me not skip the simple stuff ….even if we just go through it quickly….I gave them a problem like that that they turn in an index card….you know and…60 out of 61 students got it right….and that told me …good….we are done with that and we can move on….so…and…they know when they sit down with the objectives they can go, "check….I did that. I know how to do that and what kind of problem I might get…." And I think that helps them deal with the anxiety.

Researcher: Anxiety over testing…?

Prof. C: Right….because they are sitting there….you know we are doing these active learning things…and they think, "Oh my god! Anything like this could be on the test….and I don't even know……" And then they spin off with anxiety. But when they can sit down with the objectives they go, "Ahaaaa this is what I have learned to do….and I still need to work on…" You know?

Researcher: And you know this question over here? How do I motivate students without grades….? You're doing that!

Prof C: Yeah? [laughing]

Researcher: How are you doing that?

Prof. C: [laughing] …

Researcher: You have given them some control of the situation…they know what they have to know….this objective list. And when you give control…. to a learner…it is intrinsically motivating…. because if you are in control of something…you feel like, "I can handle this." And rather ….the other end of the continuum is a student who goes, "Oh no matter what happens….I always study the wrong stuff….she'll always test what I don't study…blah blah…"

Prof. C: [laughing]

> Researcher: "I have no control" is a hopeless feeling and not very…motivating..
>
> Prof. C: Umhuh…I have some students who really use those objectives and I have some who don't. They can choose to use them or not. If they do use them…it can help them and if they don't use them….that's their choice.
>
> Another change is that the second semester students are reading now. It was like…they went through all of that last semester and they figured it out by the end…. but more than that they decided to jump on it this semester…and the mean on the last exam was an 82…. 83…. and I was happy with that…. I want all of them to make A's…. I mean I want a big chunk of the class to be having so much success that they can't stand it. And it was a hard test…beefy questions!
>
> Researcher: Gratification!
>
> Prof C: You know, it is good to have this conversation…I like this…this is the kind of thing [the table] that you can do that I can't do for myself… really…and it is so cool.

Second level member checking is a very important part of data analysis because it gives participants the opportunity to "test categories, interpretations, and conclusions" (Erlandson et al., 1993, p. 142). Each participant in this study was provided with a summary that depicted emerging themes and asked to check and correct the listing. Case study writing was started as soon as the second level of member checking was complete.

Member Checking Level Three

The third level of member checking requires the participant to read and approve the case study prior to its publication. Each participant was given a significant portion of his or her case study to check and correct. This final level of member checking gives informants another opportunity to confirm, enhance, or dispute the findings of the researcher. An example of Level Three Member Checking from Prof. A follows (first part of a three-part response):

> Here are my first responses. I may have to continue this in a few separate emails, depending on my time. It was interesting reading the document. And I hate to say it, it reminded me of several things I had forgotten!
>
> In your info about the college, some of your numbers seem surprising and ought to be checked…..maybe that counts lots of continuing ed, community service part-time and non-credit students. We are at about 1700 FTEs winter quarter. 50 full time faculty sounds okay, but 200 adjunct??? sounds too many. If there are indeed that many, it sounds misleading. Our regular day programs are nearly always run by full-time faculty, the adjuncts teach the evening and community service courses. We as a school are very committed to not overloading with adjuncts.
>
> Refer to "Nursing Foundations"…differently [specified].
>
> Re-word your explanation of grades in the program: Students must earn a minimum of a C grade (C- not acceptable) in order to progress to the next class. [More specifics included]
>
> Re-word your section on advancing to a AD RN program. Students have always been able to transfer their nursing courses from here to a community college to enter the 2nd year of a RN program. What is different now is our Anatomy/Physiology is also transferable to (at least some) community colleges. The curriculum revision you mentioned only applies to the A/P course. Previously, students had to retake A/P at the community college, and take some additional pre-requisites, before they could transfer their nursing courses. Now they still may need to take some additional pre-requisites, but at least a/p doesn't have to be repeated.
>
> My comment about being isolated from other faculty...did I really say "I assume that holds for must of us in the program."? Looking at that now, I don't think that's true….I think there is a lot of interaction…but maybe I'm feeling differently about it now.
>
> ”Fundamentals of Nursing sequence", should be "Foundations of Nursing."
>
> As for attrition rate: add "typically" 19-20 finish. (This quarter I have 21!) The "overall" attrition you mention isn't over the whole progam, but

> over the biology courses (cell bio and a/p). I think about 30% is more accurate. We now enroll 28 in cell bio, and I usually am down to 19-20 by the end of A/P. I really am not sure what the overall nursing program attrition is at this point.
>
> Section on Instructors Prior Experiences: The definition of learning "how to cross a hurdle when confronted with one" doesn't sound like something I would say. Did you present some choices of different definitions? I don't remember where that definition came from.
>
> That's enough for now. I'll try to write some more over the weekend. It is hard to reference where in the text I am commenting. If you can't follow me, let me know!

Researcher as Instrument

> *All we can work for is that our vision is not too skewed by our own subjectivities. And that means work for most of us. But this work is of a different class from that of striving to reach the impossible goal of pure objectivity. The trouble is that, as participant-observers, it looks as if we are trying to do just that. That is, as qualitative researchers, we must educate and re-educate ourselves to practice detailed observation without reading in our own answers, our own biases. That process entails becoming increasingly more aware of our own 'eyeglasses', our own blinders, so these do not color unfairly both what we observe and what we detail in writing. With all the striving to observe fairly and with all the self-awareness and introspection this demands, we are still subjective people doing a subjective job.*
>
> (Ely et al. 1997, p. 53-54)

In naturalistic inquiry, although the researcher may use a variety of instruments to collect data, the researcher is the most important instrument involved in the interactive process of data collection and analysis. The process of data collection and analysis "merely follows the normal process by which humans solve their daily problems. As soon as data are obtained, tentative meaning is applied to them. When new data are obtained, meaning is revised (Erlandson et al., 1993, p. 39). Because naturalistic research is considered a co-construction between the researcher and the participants, it is important to separate their voices. The voice of the researcher of this study is detailed in a "Researcher as Instrument statement" (Appendix E). It was prepared prior to data analysis.

Quantitative Procedures

Survey Tools

Two student surveys, developed prior to the project were distributed to participants to administer as pre and posttest. A content information survey was designed to explore changes in students' understanding of gradients and conductance in respiratory, cardiovascular, and renal systems. Questions that represented common misconceptions held by college-level students, from a variety of knowledge categories (ranging from remembering to analyzing), were included on the survey. A majority of the survey questions were provided by Joel Michael, Ph.D. (June, 2000).

An attitudes and demographics survey was administered. It was designed to explore changes over time in eight belief constructs —self-efficacy for learning anatomy/physiology, learning preferences (lecture, in-class problem solving), failure attribution beliefs, goals (mastery, performance), beliefs about the instructor's role in the classroom, learning strategies, beliefs about assessment, and beliefs about how much was learned in the class. Survey tools are included in Appendix C.

Data Analysis

The unit of data analysis for each of the surveys was each instructor's class. Scoring for the 25-question, multiple choice content survey (both pre- and post-test) was expressed as the percentage of the number of students who correctly responded to questions categorized to represent four levels of knowledge—Category 1: Remembering; Category 2: Understanding, Category 3: Applying; and Category 4: Analyzing. Three content experts who were members of the pilot, curriculum project advisory committee, categorized questions.

The student attitudes surveys (28 questions; five-point Likert scale) were analyzed using descriptive statistics and dependent samples t-tests (t formula for correlated data; two-tailed test). Items that composed the eight constructs of the attitude survey were corrected for negative wording and averaged for both pre-test and post-test groups. Pair wise comparisons between pre- and post-test data were made.

All statistical analyses were conducted using the SPSS statistics computer program. Alpha levels were set *a priori* at the .05 level indicating that the probability of the result being attributable to chance was 0.05 or 5 out of 100. Therefore, if statistical tests showed a t value equal to or smaller than the table value listed at the set coordinates, the results would be considered attributable to chance alone, and therefore not significant. If statistical tests showed a t value that met or exceeded the table value, the null hypothesis is rejected and the results would be considered attributable the intervention (one semester of instruction that encouraged student active learning) and, therefore, significant.

QUALITY CRITERIA

Trustworthiness and Authenticity

The quality of a naturalistic inquiry is judged by two sets of criteria: trustworthiness and authenticity. While trustworthiness assesses the quality of the research product for the research community and speaks to methodological adequacy, authenticity gives status to the separate realities of research participants and thus speaks to the rigor of representing participants' constructions (Lincoln & Guba, 1985, 1989; Erlandson et al., 1993).

Trustworthiness

The researcher establishes trustworthiness by demonstrating that the study is rigorous and relevant. Establishing trustworthiness enables a naturalistic researcher to reasonably claim methodological soundness that parallels that used by a traditional researcher. There are four important criteria to be met in establishing trustworthiness: credibility, transferability, dependability, and confirmability. The relationship of each of these naturalistic criteria to traditional inquiry methods are summarized in Table 3, which is adapted from Lincoln & Guba, 1985) and Erlandson et al., (p. 133).

Table 3 Establishing Trustworthiness: A Comparison of Terms

Criterion	Conventional Term	Naturalistic Inquiry Term	Naturalistic Technique
Truth Value	Internal validity (i.e., control and randomization)	Credibility	Prolonged Engagement Triangulation Peer debriefing Member Checks
Applicability	External Validity (i.e., randomized sampling)	Transferability	Thick Description Purposive sampling
Consistency	Reliability (i.e., odd-even correlation of test items, test-retest or parallel forms correlation	Dependability	Reflexive Journal
Neutrality	Objectivity (i.e., intersubject agreement)	Conformability	Reflexive journal

Credibility is the truth-value of the study. The truth-value reflects the researchers' confidence that the data and findings accurately reflect the participants' perceptions at the time data were generated. In this study, credibility was established through prolonged engagement, triangulation, peer debriefing , and member checks. Transferability is the applicability of the study findings to other contexts or with other participants. Since the naturalistic researcher believes that no context is identical to another, transferability is the responsibility of the reader of the study. In this study, transferability was established by the use of thick description and purposive sampling. Dependability demonstrates the criterion for consistency. The naturalistic researcher strives for "trackable variance" (Guba, 1981), realizing that repeated application of the study/instrument to the same participants under the same conditions will yield similar measurements, but that reality shifts may also contribute to inconsistencies. Confirmability shows evidence that the findings are the product of the participants' views, not the biases of the researcher (Lincoln & Guba, 1985, p.290). Both dependability and confirmability are communicated through an "audit trail"— a "record-keeping system that provides for thick description of both the inquiry context and the inquiry process" (Erlandson et al., 1993, p 149.)

Prolonged Engagement

Prolonged engagement increases credibility because it allows the researcher time to process information, events, and participants being studied. It requires that the researcher be involved long enough to learn the participant's context, test for distortions, either of the researcher or the participants that might creep into the data and for establishing trust (Lincoln & Guba, 1985). Distortions of the data include personal distortions where the researcher is an outsider and introduces out of context values and expectations, so that the data contributed are not entirely accurate. Participants may also distort the data by reporting misinformation they may have collected "through the grape vine" and by reporting information that they believe will please the researcher. Finally, prolonged engagement provides the researcher an opportunity to build trust and develop a rapport, demonstrate that confidences will be honored, and that the interests of the participants will be honored as much as those of the researcher (Lincoln & Guba, 1985).

The data types used for this study were gathered over a period of approximately 15 months. During this time, participants were interviewed, and then it took approximately six months to transcribe, chunk and code, analyze data, member check, and write the case studies. Following the approval of the case study, each participant shared reflections on their case.

Triangulation

"Triangulation derives from celestial navigation" (Stake, 1995, p. 109) and represents a means of inferring location by using two visible or know points as references. In naturalistic research, triangulation is used to establish meaning rather than location, but the approach is the same. Stake (1995) elaborates: "We assume the meaning of an observation is one thing, but additional observations give us grounds for revising our interpretation." Triangulation of emerging themes and interpretations is achieved by gathering data from different sources, gathering different data types, and by using different methods or investigators (Erlandson et al., 1993). The use of five different data types, and two researchers (for one case study) triangulated this study. The data types used include personal interviews with all participants, written correspondence, and written/verbal surveys jointly discussed with all participants, observation of five participants, and data from students in the classrooms of six of the participants. These data types were checked against each other in order to confirm findings and highlight, but not resolve, disparities.

Peer Debriefing

Peer debriefing is an important and powerful technique used in naturalistic research to increase the likelihood that credible findings and interpretations will be achieved. It is a process whereby a researcher receives searching questions and feedback about various aspects of the case studies that might otherwise remain implicit. Peers take on multiple roles. They not only play the devil's advocate by critiquing the researcher's methods, themes, data analysis, interpretation, and organization; they provide the researcher with opportunities for venting and clearing the mind of feelings that may be standing in the way of good judgment and sensible next steps (Lincoln & Guba, 1985), I invited three graduate students familiar with naturalistic inquiry to be my peer debriefers. We meant monthly, or more often when needed. They gave me feedback and challenged my ideas as I collected, organized and analyzed the data, prepared the case studies, and wrote the dissertation. Their comments and suggestions are noted in my reflexive journal. Selected minutes of peer debriefing meeting have been included in Appendix F.

Reflexive Journal

A reflexive journal—an introspective diary kept by the researcher to document aspects of self (including biases, values, interests, and insights) and methodological decisions made and the reasons for making them--fulfills every aspect of trustworthiness in a naturalistic inquiry. It is essential. According to Erlandson et al. (1993) a reflexive journal provides information about: how decisions are reached, how interviews are scheduled and conducted, which questions need to be member checked, and how emerging themes come to light. A review of my journal reveals how I developed my focus questions, my feelings about the study as it progressed, my thinking process, questions that needed participant follow-up, interpretations that I asked my peer debriefs to challenge, reflections on meetings with committee members, reflections and connections with other empirical studies, emergent coding schemes, and transcription and member check status. Sample reflexive journal entries are located in Appendix G.

Thick Description

It is uniformly agreed that case studies should be written with detail and clarity, and should communicate the participant's beliefs and attitudes to readers. The idea of 'thick description' may be best conveyed by comparison to the 'thin description' used by writers intending to convey partial, summary renderings of situations, seen through the researcher's rather than the participant's eyes, without conveying the possible intentions and meanings behind the actions" (Denzin, 1983). Alternatively, 'thick description' includes mood, language, signs of emotion, and actions of the participant as well as one's own emotions as the participant-observer (Ely, Vinz, Downing & Ansul, 1997, p. 341). The purpose of using thick descriptions is to promote an active role for the reader, to "bring the reader vicariously into the setting the researcher is describing" and thereby pave the way for shared constructions (Erlandson et al., 1993, p. 24). Thick description is used in a naturalistic inquiry to aid the reader—to facilitate transferability—to enable "observers of other contexts to make tentative judgments about applicability of certain observations for their contexts" (Erlandson et al., 1993, p.33). Lincoln & Guba (1985) argue that the researcher should provide sufficient data so that anyone who reads the report can potentially apply the findings to their own life. Readers of the case studies included in this study are invited to enter them vicariously through the thick and rich descriptions provided.

Timing

Lincoln & Guba (1985) propose that naturalistic studies follow a three-phase plan. In accordance with their proposal, this study was divided into three phases: (1) Orientation and overview (six month baseline data collection period; (2). Focused exploration and data collection (ten month project semester); and (3) member checks (throughout the study) for data confirmation and closure for case study writing and dissertation preparation.

During the orientation and overview phase the application for Human Subject Exempt Status was completed, potential participants were identified and invited to participate in the study, and the driving research question was refined to, "What happens when seven, traditionally-trained, A & P instructors, voluntarily implement instructional strategies to facilitate active learning in their undergraduate courses?"

The focused exploration phase was spent interviewing (and when possible observing) informants, transcribing interviews, chunking and coding data for analysis, coordinating the collection of student data, and analyzing student data.

Finally, member checking was devoted to preparing transcript summaries for email "check and correct" with individual participants to ensure thematic saturation while confirming and disconfirming emerging individual themes. The conclusion of this study was achieved by writing the case studies, completing thematic analysis, and by preparing the dissertation for publication.

Authenticity

The researcher enables authenticity be meeting the criteria of: fairness, ontological authenticity, educative authenticity, catalytic authenticity, and tactical authenticity.

Fairness

Fairness is enabled to the extent that participants' different constructions and values are solicited and represented in a balanced and even-handed way by the researcher. Fairness demands that the informed consent obtained at the beginning of the research must be continuously renewed and that an open process is available for participants to appeal when they believe their constructions and or values have been compromised. In this study, fairness was enabled through ongoing consent for participation, confidentiality, and through three levels of member checking with open negotiation of findings.

Ontological authenticity

Ontological authenticity is demonstrated through participant testimony that their constructions and understandings are enhanced or have become more informed as a result of participation in the study. Ontological authenticity was established and documented for all participants except Prof. D who did not suggest that an increased awareness due to study participation.

Educative authenticity

Educative authenticity requires evidence that the participants learned about the viewpoint of other participants in the study. Although some of each participants' data was shared (anonymously) by the researcher in Listserv discussions, evidence that all participants experienced educative authenticity is not available. Those that expressed evidence of educative authenticity included Prof.'s A, B, C, and E.

Catalytic authenticity

Catalytic authenticity refers to the extent to which decisions and action are facilitated by the study. Prof. A, B, C, E, F, and G demonstrated a willingness to make decisions and develop plans to use their expanded constructions and learning gained from the study as a basis for action.

Tactical authenticity

Tactical authenticity requires that participants demonstrate change action or are empowered to act. Tactical authenticity was determined for Prof. A as she began participation in another grant-funded active learning project, for Prof. B as she began development of materials to assist in the preparedness of first semester students, for Prof. C as she honed alignment and bridging between the lab and lectures, for Prof. E as she developed learning objectives to align instructional components, and for Prof G as she organized a faculty discussion group to discuss teaching and learning issues.

SUMMARY

The primary qualitative research methods used in naturalistic inquiry were drawn from Lincoln & Guba (1985). Purposive sampling techniques were used in order to maximize the range of experiences and increase the range of information and range of thick and rich description. Information for this study was generated from four types of qualitative data: interviews, surveys, correspondence, and documents. Quantitative data, generated from student surveys, was used as a point of triangulation with instructor beliefs and to document the impact of the active learning experience on students' content understanding and attitudes. Checking and coding data, member checking, a Researcher as Instrument statement, lists of emerging themes, and descriptive statistics were used for data analysis. Prolonged engagement, triangulation, peer debriefing, a reflexive journal, and thick and rich descriptions established the trustworthiness of this study. Even-handed representation of constructions (fairness) was enabled throughout the study by member checking and continuous informed consent. Authenticity criteria were derived from participant testimony.

CHAPTER 4

Findings

The case studies presented in this chapter were built upon and enriched with data collected from face-to-face and telephone interviews, e-mail correspondence, observations (where possible), surveys, and course packets and syllabi.

The cases of Prof.'s A and B, which represent the most diverse experiences described in this study are presented in an extended format while those of Prof. C, D, E, F, and G are presented in a condensed form. Each case provides information about the college and course, the students, distinguishing features of the instructor, prior knowledge information (experience as a science student), teaching strategies, beliefs related to teaching and learning, a motivational profile, a summary of the project activities used, supports and obstacles reported, and change profiles. Because the instructors' reports of change differed significantly in some cases from the interpretation of the researcher, change is presented as: instructor self-reports, data-based changes in beliefs about teaching and learning, and evidence of conceptual change. Since the focus of this study was instructors, descriptions of student change are used primarily as points of triangulation.

PROFESSOR A: TECHNICAL COLLEGE A & P INSTRUCTOR

> The whole nursing program is really based on active learning…it's something of a mindset around here and a large number of courses incorporate teaching strategies that encourage active learning…accreditation has demanded that we look closely at student outcomes...when students leave our program they have to demonstrate that they have acquired both measurable clinical skills and soft skills, such as the ability to communicate and work as part of a team.

Pre-Project Information: A Snapshot

Baseline data were collected over a five-month period. Two, 30- minute telephone interviews, three written surveys, numerous email exchanges, the course syllabus and workbook, and the college website served as data sources.

College, Program, and Course

The Technical College's institutional mission identifies a learning community dedicated to educational excellence in academic skills instruction, educational retraining and improvement, and student success through quality instruction using instructional technology and alternative teaching methods. Prof. A concurred that the educational philosophy of fostering lifelong and independent learning through instructional strategies that promote student active learning permeates the college atmosphere and is reflected in all programs. "We [the instructors] are encouraged to modify and adapt our courses" in accordance with the college vision which is supported by initiatives to promote innovative instruction in each program. Without question, Prof. A felt very supported to participate in this research project

The college provides instruction to enable its student population to gain employment and be quality workforce participants. Approximately 50 full-time faculty provide instruction for over 50 certificate and degree programs, which reflect current and emerging labor market trends. A small group of adjuncts teach the evening and community service courses. Prof. A explained that the college has been very committed to not overloading with adjuncts. Students are required to meet capstone competencies for all programs degrees/certificates and are supported to do so through a variety of initiatives that provide services responsive to diversity and learning issues. Partnerships with business and educational organizations support student transitions to employment or advanced educational experiences.

Practical Nursing (approved by the State Department of Health and the Nursing Care Quality Assurance Commission) is a full-time, five-quarter program (or nine-quarter, part-time) that prepares students for taking the National Council Licensure Examination for Practical Nursing. Program admission requirements are minimal, and include a computerized, reading/comprehension/mathematics placement test. The program requires that students complete courses in biology, communications, psychology, occupational math, and a three-quarter sequence in Nursing Foundations, which includes clinical practice as well as nursing theory, pathophysiology, and pharmacology. All courses are taught using strategies to promote active and cooperative learning. With reference to the grades students are required to make, Prof. A explained: "They have to earn C's…a C- is not acceptable…in order to progress to the next class, and must earn a score of at least

80% …that's a B-… on each written exam in the Nursing Foundation courses…retakes are possible." Once students have earned a program certificate and passed the Board Exam, they are licensed, and either begin a career as an LPN, responsible for standard nursing patient care—monitoring vitals, emergency procedures, IV fluid therapy and injections, specimen collection, and patient education--or can transfer their nursing courses (and with a recent curriculum revision, A & P course transfer is now possible) from the Technical college to a community college to enter the second year of an RN program. Prof. A is confident that the Nursing Program does a good job in preparing and effectively assessing students clinical knowledge and skills competency, but is somewhat hesitant to draw conclusions related to assessment of the soft skills. Although the faculty recognize the importance of developing the skills of independent learning, effective communication, and the ability to work in a group she's not convinced that these skills are effectively assessed. She stated, "Let's face it…those are hard skills to develop outcomes for and actually assess and to feel confident that students are leaving with".

The A & P course is the second science course that nursing students take. It is sandwiched between a new, introductory Cell Biology course and the Foundations of Nursing sequence and is taught each quarter. The class meets five days a week in three-hour blocks (clock hours at the vocational school are distributed into blocks of time). Prof. A characterized the course as "fast-paced and high-pressured" due to the large amount of content material that had to be covered.

The Students

Students in the nursing program as older, primarily in their late 20s and early 30s, with a sprinkling of students 60 or older, or younger than 20. About 80 percent are women who also work part-time jobs to support families and kids. Prof. A categorized a good number of her students as academically under-prepared and overwhelmed with the demands of course work, jobs and families. She empathized, "They come to class and really don't have the background knowledge or study skills to give it their all…then with everything they are juggling…. it's a tough life and sometimes I'm really not sure how they do it". In terms of attitudes toward learning, Prof. A placed her students into two groups. The largest group is career-focused, motivated, understands the importance of a foundation in A & P, and is determined to do what ever it takes to be successful. A smaller group has, "sort of a vague idea that, nursing seems like an interesting thing to do", don't see the relevance of the course content, and tend to project their negative attitude to other students. According to Prof. A, students in the second group don't generally make it through the program.

Approximately 28 students begin the Cell Biology course, 24 students move on to A & P, and 19 or 20 finish (30% attrition over the biology course sequence).

The Instructor

Prof. A has been the only Human A & P Instructor at the College for the past ten years; however, change is charted to bring another A&P instructor on board to support a new, health technologies program. Prof. A reflected on her interactions with other college faculty, stating that although there were organized faculty gatherings and good rapport among instructors in various programs, instructors tended to stick with their own programs. She elaborated, “Even though we all tend to stick with out own programs, there is a lot of interaction and comradery among the faculty”.

Project Participation: A Snapshot

Project participation data were collected through three, 45-minute telephone interviews, one 90-minute personal interview, four written surveys, a course syllabus and workbook, and numerous email exchanges.

Instructor’s Prior Experiences

Prof. A received her undergraduate degree from a small, Liberal Arts College and her Master’s degree from a large, Research University. Science courses at both institutions were taught in a traditional lecture format. Prof. A recalls considering herself a very successful learner in both environments and being very satisfied with her instructors’ teaching strategies:

> Many of the instructors I had in college used straight lecture and the course grade was based on how well students did on tests. There wasn’t any group work, little or no opportunity for discussion, and if there was a lab component, it was pretty cook-bookish….because we weren’t required to do more than memorize and parrot information back on tests…and because I was really good at that…I remember believing that I learned a lot from lectures. And, since I didn’t know there was more to learning than memorizing and parroting information, I wanted to be lectured to. I wanted a clear and organized, factual lecture.

Prof. A said that her current teaching style was influenced by a number of factors, including: a new definition of learning that emerged sometime after her undergraduate experience, knowledge of how she learns, and an outstanding instructor outside of academia. When asked what it might be like to be a student in her class, Prof. A laughed and then confessed: "If I were a student in this class, I would hate the instructor!" Although she considers herself to be very approachable and personable in her interactions with students, she admits that as a student, she wouldn't have wanted to have to draw something or convince the instructor that she understood the material by applying it to some situation. "I know I would have had a hard time doing what I ask my students to do!"

Although she was educated in traditional lecture settings, Prof. A was quick to express her current dissatisfaction of the traditional lecture instructional strategy. She elaborated: "When I redefined learning as knowing how to cross a hurdle or obstacle when confronted with one….it was just so clear that lecturing falls short. It doesn't allow students to build life-long learning skills". Prof. A stated that in order for students to develop the mindset of a life long learner, they have to be challenged in the classroom to become familiar with the real nature of learning. She said that it is up to instructors to provide classroom challenges--despite what students say they want to experience in the classroom--which is usually lecture.

Another influence on Prof. A's teaching was a developing knowledge of how she learns best. Knowing that she needs to access and see information in different formats, she said that she now uses strategies that encourage students to take the information apart and organize it in different ways, like into charts, tables, concepts maps and pictures.

Another factor that likely contributed to Prof. A's teaching style, was the influence of a non-academic instructor—her Lamaze instructor. After considerable reflection directed toward academic instructors who may have influenced her teaching, she commented that she couldn't think of anyone. However, she continued in a surprised tone:

> I thought of someone who influenced my teaching…she was my Lamaze instructor…our teaching styles are similar…she used group discussions to draw experiences from the students and then wove the experiences together to make her main points…she helped everybody make their own connections….she was lively, talked a lot, and affirmed what people said even though she might not have agreed with them.

Teaching Strategies

Prof. A has structured her class for the past several years with a self-authored workbook that is divided into learning modules. Students purchase a general A & P textbook to use as a learning resource.

The class flow and teaching strategies Prof. A described included: (1) An introduction conducted in one of two formats depending upon the level of difficulty of content material; (2) Small group discussion generally focused on workbook questions, with the recent addition of one active learning exercise per quarter; (3) Instructor-guided wrap up and summary; (4) End of module tests.

When straightforward content material was addressed, the introduction was held to a minimum (five minutes to half an hour) and consisted of a "back-and-forth, question-answer kind of dialogue" that either summarized the previous days learning or highlighted the main points in new material. Although Prof. A has expected students to come to class with their reading done and workbook pages completed, she believes the introductory period is essential. "These guys are beginners and as they go through all the material in the book they really need a little direction." To illustrate the flow of a typical introduction, Prof. A described how she would guide a situation where students had just finished studying the nervous system and were beginning the endocrine system:

> I might begin by drawing a parallel between the control function of both systems, largely building on what students have already learned about the nervous system, and continue by asking students to list familiar aspects of the endocrine system. After collecting typical responses, like thyroid disorder, the pituitary gland, sex hormones, growth hormones, diabetes or insulin, I would try to incorporate the responses into the bigger picture of endocrine control. My point in doing this is I want students to understand that things that they are already familiar with are connected to the new concept.

On occasion, though not very often, Prof. A has structured the introduction as a straight lecture. "I do value a good, well-organized lecture, particularly when I know the subject is one that is consistently problematic for students…in those cases, I have just told students that I am going to lecture first and they will do the workbook exercises after my lecture."

After the introduction, students have generally worked in small groups for an hour and a half. Although the time is designated for productive discussions, Prof. A admits that more often what happens is that students get together and look for piecemeal information to get the assigned workbook questions answered. In order to keep students on track—which amounts to making sure that they are doing the things that they should be doing—Prof. A circulates around the room and encourages students to reword their responses, draw pictures, and connect new information to what they already know. "My students really need a learning environment that is structured and they need me to keep them on track….if I don't they are both figuratively and literally out to lunch", she laughs.

Although group work is a common and therefore anticipated component of the nursing classes, it is not always smooth sailing. Prof. A elaborated:

> There are personality conflicts…and they whine about group work, especially when the people in their group don't come prepared. The biggest complaint I hear is that it's, 'the blind leading the blind'…and the most common question I get asked is, 'how do we know if we got the right answer?' The complaining comes and goes but they know they've got to do the group work…it's not negotiable.

As far as providing answers to the workbook questions, Prof. A said she doesn't like to respond to the general question, "Is this right?", preferring instead to suggest strategies that might help students get past the places where they are stumped. She does however; respond to specific questions that students come up with after effortful discussion, but always tries to frame her responses within the big picture of physiological process and application of the material. Prof. A added that while she no longer provides a key to the workbook questions because of the "copy and memorize" approach to learning it seems to promote in her students, she does post answers to the most critical workbook questions so that students know they have the right answers and are more confident about their thinking processes as they prepare for exams.

Prof. A explained a recent change to her strategy for forming groups based on a discussion with other instructors in the nursing program: "I used to let my students choose their own groups but there is a feeling that random grouping should be used to discourage cliques from forming and to help students develop the ability to work with a variety of people." Although the change seemed reasonable to Prof. A, it has been the source of potential frustration for everybody involved. "Students may be frustrated because they don't get along with the people in their groups….I'm frustrated because I know the value of group work and see that the discussions aren't as effective as I know they could be."

The tail end of the class has been spent in a large group discussion focused on material that the small groups have identified as confusing. She explained:

> Since I have an idea of which concepts are difficult for students, I try to pull the threads together by combining their questions with what I know I want to emphasize and show them how the stuff fits together. I also try to straighten out key errors in their thinking and bring closure.

Beliefs Related to Teaching and Learning

Prof. A's defined the instructor as an experienced guide. As she described what this might look like in the classroom, the following descriptors emerged: The instructor is someone who: is more experienced than students, can and does serve as a guide, knows which physiological concepts are difficult, can check to see if students have information right, weaves information together for students, and encourages students to resolve and challenge answers to workbook questions. Detailed excerpts of Prof. A's beliefs are listed in Table 4.

Although some elements of an interactive teaching system were present—the instructor as facilitator, guide, and challenger—there were elements of an information transmission system as well. For example, it can be implied from Prof. A's descriptors that the instructor is the presenter of information and the authority on whether an answer is right or wrong, and it is the instructor rather than the students, that integrates (weaves) information into the big picture.

Prof. A defined learning as, “more than memorizing and parroting”; rather as, “knowing how to cross a hurdle when confronted with one.” Her description of what students do in order to learn was, “they need to work both independently and in small discussion groups to connect their existing thought patterns to new information.” However, as Prof. A described recent classroom experiences, she made many comments that reflected her beliefs about her students, which seemed to indicate a limited ability to engage in learning. Students were primarily referenced as a single group (“they are”, “these guys”), although at one point, four groups were identified based on confidence and motivation: “those that are vocal and confident” and “those that are less vocal and less confident” “those that are motivated by their career goals” and “those who aren’t motivated”. In general, students approached learning: with poor study strategies, without having prepared for class, by quickly losing sight of the big picture instead focusing on piecemeal information to get the workbook questions answered, and, without challenging each other to explain answers unless prompted to do so. She indicated that when students were provided with an answer key, they would adopt a learning strategy of “copy and study” rather than engaging in purposeful learning.

Prof. A also made a number of references to students’ needs. For example, students needed to: have the stage set, be encouraged to work through challenges to figure things out, be provided with a structured learning

Table 4 Prof. A: Beliefs Related to Teaching and Learning

	Pre-Project	Post-Project
What is learning?	Knowing how to cross a hurdle when confronted with one	Learning is still crossing hurdles but the process is often clumsy
	More than memorizing and parroting	Forming a structure where information is tied together, misconnected pieces are pulled out, and accurate connections are added
	Putting together the pieces from a wide variety of resources (ranging from reading to discussion to activities), assessing and integrating new information into thought patterns	It requires hashing through material and sticking with the frustration
	How will active learning be implemented	
Who are the students?	People in their late 20's or early 30's who are enrolled in the nursing program	Many really want to understand processes and will work hard to do so
	People that are beginners and have a low tolerance for frustration	Many enter the class in a nebulous state They are easily confused and have a low tolerance for frustration
	Are academically under-prepared	All have individual preferences for the way they like to have learning situations structured
	Are overwhelmed with course work, job, and families	Some don't realize how much interpretation goes on in science and don't understand that models are used to demonstrate principles
	They have poor study strategies	Some don't want to discover information--they really want to be told
	1. Determined to be successful are focused on a career goal, motivated understand importance of A&P	
	2. Vague goals, negative attitude, don't value	
What do students do?	Approach learning in a piecemeal fashion and lose sight of the big picture	Most will take responsibility for their own learning by reading and understanding the basic information on their own
	Do their homework, work in groups, participate in group discussions and hear what other people have to say	Construct and manipulate models
	Get stumped over questions	Give feedback on what they learned and what is confusing
	Sometimes come unprepared to class	Give feedback on how to improve an activity
	Don't generally challenge each other unless prompted to do so	Tell group members that the reason they are taking a long time is because they really want to understand
	Adopt ineffective learning strategies	Make connections between the reading and the activities
	Whine about group work	Get anxious if they don't know if they have something right
	Want to bond with their own group	
Who is the instructor?	Someone who is more experienced than students and knows which physiological concepts are difficult	A combination guide/weaver/information resource/encourager
What does the instructor do?	Takes what students say and puts it into the big picture	Makes learning expectations explicit
	Talks about systems and how they link; compares systems	
	Sets goals and points out key things to students	Uses class time to elucidate the more difficult areas
	Sets the stage and talks about how new information links to what students already know	Helps students through unclear parts of an exercise
	Asks students to think about associations	Reviews fundamental concepts with students prior to an activity
	Assigns groups	Tries to set up activities so students can discover information on their own and go through the activity at their own speed
	Circulates among groups	Collects and tries to interpret formative assessment
	Ensures students have resources and know how to use them	Incorporates questions from learning exercises on tests
	Keeps students on track	Uses feedback to identify which content is not being understood and addresses the content again with students
	Makes sure students get the right answers	Uses insight from formative assessment to initiate dialogue with other instructors
	Summarizes information	Constantly talks about the importance of making connections with students
	Writes and gives tests	Incorporates "lessons learned" on how to improve activities the next time activities are used
	Answers students questions	
Instructor Student Relationship	An experienced guide and people that need to be kept on track	An experienced life-long learner and people learning the skills of life long learning

What is the Purpose of the Class Meeting	For hitting the highlights and discussing concepts that are difficult for students	Elucidate the more difficult concepts
	Groups figure out what things they need more help with	Ask and answer questions and find connections
	Instructor summarizes and pull the threads all together	Reinforce what's been learned from the book and from group members
What does instruction look like?	Introduction in question-answer dialogue to summarize previous learning and highlight the main points in new material; Group work focused on workbook questions; Instructor-guided summary	Class format is similar but facts and material presented is tightly related to a main concept, content that is extraneous and simple in nature is being cut from the course, the instructor creates more opportunities for questioning and challenging student ideas and seizes opportunities to model behaviors she wants students to learn
What is Evaluation/Assessment	"Did students get what the instructor was trying to get them to see?"	"It should be to determine whether students have changed their perspective and understanding of material but I haven't successfully put it into practice."
	Are students meeting the goals set by the teacher?	

environment, be given direction and kept on track, and have information and instructions that they misinterpret corrected.

Based (presumably) on her perceptions of students' approaches to learning and their needs in the classroom, Prof. A defined her own responsibilities in the classroom as: assembling piecemeal information for students so they know how new information links to what they already know, circulating among students as they compare workbook answers to encourage them to resolve differences and re-explain information, encouraging students to make connections, "pulling all the threads together" to show students how information fits together; reinforcing the big picture and straightening out thinking errors, directing students to diagrams or book pages when they are stumped, setting goals so that students know what they need to accomplish, assigning groups, making sure students have the resources they need and know how to use them, and designing and giving tests.

Juxtaposing stated teaching and learning beliefs to Prof. A's description of her teaching strategies, it seemed that the mixed belief system played out in the classroom, where the impact of the traditional system may have had a somewhat stronger status (instructor is assembling the piecemeal information).

When asked to speculate on how instructor responsibilities would change when active learning was used, Prof. A speculated that the instructor would then also be responsible for observing students to see if "wheels were turning in students' heads" and if "lights were coming on" and making sure that students were getting the right answers.

Goals and Motivational Beliefs Impacting Change

The goals Prof. A articulated (Table 5) included a desire to: break the routine format of discussions with activities to engage students and encourage conceptual learning and process thinking, develop some activities, exchange ideas with other instructors, fine tune outcomes, develop some assessment tools for evaluating the impact of classroom teaching activities on student learning and soft skills, and "just get personally inspired".

Prof. A articulated a belief in an incremental theory of ability about herself (to implement active learning) and students' ability and attitudes. During pre-project data collection, she reflected, "I'm always interested in improving my teaching and student learning" and "If I implement even one new idea, and students' understanding of one concept improves, it's a success". Prof. A spoke frequently about how student attitudes were gradually changing (they were more cooperative, willing to stick with trying to figure it out) in response to small changes she made in her instructional strategies. Throughout the project, she continued to set goals focused on improvement. She also indicated a disposition toward risk-taking in the classroom and expectancy for future success in her expression to gather ideas for thought-provoking questions and new kinds of activities, rethink the course content with a focus on themes, share student feedback related to student misconceptions with the Cell Biology instructor, and persuade two colleagues to participate in an upcoming research study.

Table 5 Prof. A: Motivational Profile

Nature of Competence/Theory of Intelligence:	
	I'm thrilled that when students have difficulty on an activity they come up to me and say they need to study more and work harder to learn this
	I'm always interested in improving my teaching and student learning
Goal Statements:	
	Break the routine format of discussion with activities to engage students and encourage conceptual learning and process thinking
	Exchange ideas with other instructors
	Fine-tune student outcomes
	Move away from just using standard tests and develop some reliable assessment tools for evaluating the impact of classroom teaching activities on student learning and soft skills
	Develop some of my own activities
	Just get personally inspired
Mistakes:	
	When I've pushed students on (to cover more content), I've passed up, and they've missed, opportunities for in-depth learning experiences
What is Failure? Student-oriented	
	A majority of the class seemed to be able to differentiate terms, but there were a few that still said they didn't understand the difference between depolarization, repolarization, and hyperpolarization.
What is Success? Student-oriented	
	If I implement even one new idea, and students' understanding of one concept improves, its' a success.
Attribution for Success:	
	Student negativity has improved since I've started making the central ideas explicit and identifying the elaborations as such [Internal, Unstable, Controllable (Instructor Ability and Effort)]
Attribution for Failure:	
	I haven't been able to put teeth into rethinking goals and objective this semester. I haven't had a slot of time to devote and it's not something I feel I can do in short sitting periods. I need to really give some thought and effort to this after the semester is finished. [Internal, Unstable, Controllable (Instructor Ability and Effort)]

Statements related to success and failure, were consistently focused on students (rather than the instructor) and indicated adaptive patterns of attribution. For example, at the mid-semester point, she indicated that although she was committed to learning as much as she could about improving her teaching, she hadn't been able to put the effort into rethinking her goals and objectives. In this example, she attributes failure to herself (internal), to a temporary and unstable condition (the semester is crazy right now but things will settle down as it draws to an end and I will have a sizable chunk of time to commit), that she can change through her own effort and ability (controllable).

Project Activities

A perceived lack of creativity for designing new activities prompted Prof. A to reflect on two activities that she had downloaded from the ITIP website and had already tried in the previous quarter: the Membrane Potential Activity and the Cardiovascular Concept Map (Appendix H). She felt that since both activities had provided students with concrete opportunities to explore abstract concepts and students had enjoyed doing them, she decided to use the familiar activities again. "Besides, " she added, "I can't come up with anything else…and really would like to try them again with a few modifications".

The modifications that Prof. A made to the membrane activity included "setting the stage" for students before the activity by reviewing fundamental concepts related to membrane structure, not stopping at suggested intervals for whole group discussion, and omitting the closure portion of the activity because of time constraints. Overall, Prof. A was pleased with students' level of engagement. She commented on two glitches; one, that students had found the instructions for moving ions through the paper membrane model confusing and she had spent a considerable amount of time clarifying; and two, that a couple students had finished the activity but had not been able to differentiate depolarization, repolarization and hyperpolarization. However, Prof. A had been impressed by the engagement of a learning-disabled student who was making connections to potassium disorders and asking questions. “It was unusual because she’s usually very quiet in class and doesn’t ask questions. I was quite surprised that she knew enough to ask that question.”

Prof. A got feedback on the activity by listening to students as they worked through the activity. She also asked for written comments about the most important thing they learned, the most confusing part of the activity and suggestions for improving the activity the next time around. She also administered a short quiz immediately after the activity and added a few questions to the next exam.

With regard to feedback, Prof. A reflected:

> The most surprising thing for me was that a number of students were quite taken by the fact that the concentration gradient was not the only issue they needed to consider. They were just very amazed at this electrical gradient—which I hadn’t thought was any big deal. It was as though they had discovered a whole new concept *or* felt that they had been lied to previously or something!

Prof. A was also surprised at how amazed students were that they could use something as simple as a number line idea to calculate the membrane potential difference. They were also amazed that they were using a model cell membrane, rather than a real cell membrane, because they wouldn’t be able to see movement of ions through the membrane of a real cell. "I think students must not realize how much interpretation goes on in science--when we understand a physiological process and then make a model to try to show how it works. That was something else I thought they already understood." Prof. A also commented on the candid nature of some of the feedback, such as, "For this activity to have been less confusing, I could have been more prepared!" She was not surprised, however that a few students—just a few-- felt they needed more lecture so they wouldn't have had to stop and ask questions.

Although Prof. A concluded that getting student feedback had given her new insight into student thinking and she had been pleased with performance on the post-activity quiz and the exam questions about membrane potentials, she was perplexed that she had not been able to interpret all of the comments and was left wondering how the activity impacted student learning. "It seems that in order to really figure out whether the activity gave students something to hang their hats on, I'd have to ask each student to relate what they learned in the activity to something we discussed from the homework or reading ". Prof. A was quick to add, "That would take a lot of time and I just don't want to go there."

A month after doing the first activity and collecting student feedback, Prof. A commented on four significant realizations, prefacing the information with, "I don't know why it took me so long to figure this out." First, it had become obvious to her from the feedback and watching students more closely, that they were going about learning in at least two very different ways—both of which seemed effective. One group preferred to hear, read, and memorize information before doing an activity. Without the opportunity for advance preparation and some general assurance that they were on the right track, Prof. A felt that anxiety and ambiguity seemed to interfere with their ability to learn. She added, “Once they’ve done some preparation they are more than willing to engage with the activity”. The other group of students seemed to be willing to start with the hands-on learning and find their way through—using the activity in a similar way to how the other group was using hearing, reading, and memorizing—yet, when they were finished with the activity, they wanted to discuss what they discovered to get the reassurance they got what they were supposed to out of it. “I think both groups want access to both kinds of opportunities—but they want different structuring.” Second, when it occurred to Prof. A that the learning preference information was right there in the feedback and observations, she realized that she had approached feedback collection with the belief that she, “might find out something interesting here”, rather than, “here’s a way to find out *what I can do* to improve student learning!” With the new action-oriented belief, her third realization was that it was important to share the feedback that had surprised her—the discovery of an electrical gradient—with the Cell Biology instructor. “He responded very favorably to the information and indicated he would think about how he might better clarify that concept in his teaching”. Fourth, by tuning into the questions that emerged during the activity and in the feedback, Prof. A said she was presented with a challenge to reconsider her own content/process understanding. She explained:

> The question about potassium abnormalities made me realize that, I’ve always accepted the textbook explanations of the consequences of

> potassium imbalances. Now that I have the visual image of ion movement from the CD program, I'd like to go back and try to make better sense of the situation for myself and prove it to myself.

She continued, "I tell you! This whole process has really increased my confidence in my own teaching *and* learning abilities."

Prof. A's second activity—the cardiovascular concept map—was also implemented with a few modifications. She sized the materials down (from index cards to 1" x 3" labels; and from newsprint to standard size paper) to make the task seem less daunting and told students they were responsible for reviewing pertinent information before coming to class. She explained that she intended for them to use the activity as a self-assessment tool. "I wanted them to know that this was a way *they* could check to see how well they were understanding the material…it was a tool for them…not something that would help me!" She also made her expectations for map construction explicit by telling students what the start and finish points were, and indicated that maps should show branching and interconnections between concepts. (The last time she had used the activity students had tried to construct linear maps). She also allowed students to choose their own group size and members since the previous class had complained that working in larger groups made it difficult to reach consensus. A formative assessment component similar to that used with the first activity was also added. At the end of the class session, Prof. A collected the concept maps, screened them for common errors, and placed post-it notes next to the mistakes so that students would have feedback. Questions related to the activity were also added to the next exam.

Prof. A commented that the activity was again, “not a cinch for students”, but that students’ attitudes were much better this time through. “I’m learning that nothing is as obvious to students as I think it is going to be! They were confused and got stuck as they tried to hash out which terms were related and how to show cause and effect relationships.” Despite the challenging nature of the task, the feedback was fairly positive. Prof. A elaborated:

> I think 17 out of 20 students made comments that that they valued the exercise and that they found it very worthwhile. Some of them flat-out said that the activity was helpful and made them realize where their understanding was weak. That’s exactly what I wanted to hear—that they found out what they still needed to work on.

Prof. A commented that she enjoyed and valued getting feedback the second time around because,

> I got a window into what students were getting and what they weren’t. It was just so obvious from the way they had made their map connections that there were five points—after-load, stroke volume, contractility, pre-load and the fact that both norepinephrine and acetylcholine could affect both the SA node and the muscle itself-- that they weren’t clear on and I was able to focus the next days discussion on those points…This is the first time that I’ve done feedback in such a complete way and it was interesting because even though I had collected index cards before, and I had graded maps before…but this was the first time that I did everything together and this is the first time that the trends in student thinking just jumped out!

She said that as she wrote the next exam she found herself going back to the concept map activity. In addition to the typical mechanistic questions, she added questions on the five points that students had been confused about. “I thought it was important to reinforce the material one more time.” She found that most of the students got the exam questions right.

Prof. A said that, although she found the activity/formative assessment very worthwhile, she was concerned about “wearing out a good thing”. Although it seemed to improve understanding, she felt that the process would likely get tiresome for students and anticipated using it only “here and there”.

Perceived Supports and Obstacles

As the project began, Prof. A felt her greatest obstacles (Table 6) were a shortage of class time, under-prepared students, and her own motivation to complete an entire quarter of active learning. She elaborated:

> The biggest problem I face in the classroom is that my students never seem to have the time to let things sink in as much as they need to. They never seem to really get to the point where they see the implications of what we are learning…and when I think about how things go every quarter….about a month into it, things get hectic and crazy and I put my interest in active learning on the back burner…

Content coverage emerged as both a program and course obstacle. Prof A. said that while the program certification requirements dictated the need for fast-paced coverage, content posed an issue at the course level because of the immense body of knowledge, and difficult concepts that she felt nursing students needed to be familiar with.

In addition to motivation to sustain when things got hectic, Prof. A stated that other instructor-level obstacles were, the time it takes to plan and implement activities, and lack of knowledge of formative assessment. Since she hadn’t seen a need to use formative assessment before (it would duplicate what she already did), she wasn’t clear on the rationale or the procedure. She also was quite

Table 6 Prof. A: Perceived Obstacles Over Time

	Pre-Project	Post-Project
Academic Community		
College	Professional development funding is not always available	Professional development funding is not always available
Program	Fast-paced content coverage is necessary because of the need for students to meet certification demands and pass the Nursing Boards	Students need to meet certification demands
Course	Not enough time for students to let things sink in	**Time for activity follow through for student understanding**
		Encyclopedic textbooks don't support conceptual learning
		Can't locate a textbook written from a nursing perspective
	Too much content	Too much content
Instructor	Not creative when it comes to thinking up new activities	Not creative when it comes to thinking up new activities
	Limited knowledge and no experience using formative assessment	**Hard to break out of the comfortable mold of information dissemination**
	Limited value associated with formative assessment	**Old beliefs are tenacious**
	Questionable ability to maintain active learning once the quarter gets hectic	**Lacks knowledge of how to assess for conceptual change**
	It takes time to plan and implement activities	**Lacks knowledge of instructional alignment**
Students	Many students are under-prepared and have poor study skills	**Angry note from student**
	A few students are unmotivated	
	Many students are juggling school, jobs, and family demands	
	Most students have a low tolerance for frustration.	
Professional Organizations		

concerned about her perceived lack of creativity and ability to translate an abstract idea into a concrete plan for an active learning exercise. She commented,

> I'm not sure how to get started…what I should do…how to think about this. I mean I just have sort of a pie-in-the-sky kind of idea of what might be useful for my students….for something I'd like to try, but not anything specific...you know, concrete…and I'm not sure how to get started. Aside from the supports of alignment with the college vision, small class size and the project curriculum/start-up package/Listserv, Prof. A also described a support at the neighboring University:

> I thought I had died and gone to heaven when I discovered the Consortium at the U that hosts summer workshops for all the community colleges in the state. The first one was on anatomy and physiology…so it was a gathering of science instructors and it was wonderful! I couldn't believe it! It was just fantastic to be able to compare ideas and what people are doing…

Overall ten supports (Table 6) distributed throughout all categories and 13 obstacles (no obstacles in the academic community or professional development categories) were mentioned at the beginning of the project. Interestingly, very few of original obstacles were reported as the project progressed. The one exception was Prof. A's perceived lack of creativity—which continued to be a frustration. Although time and content remained course obstacles, the descriptive nature changed significantly (described in the next section; Project Impact Information, Self-Reports of Change).

Another salient change was the removal of all previously mentioned student-related obstacles. The only emergent student obstacle was mention of a rude unsigned note from a student. Prof. A explained, "The note said I had to change the way I taught…I didn't back off active learning and it seemed to work out fine". Emergent course-level obstacles were focused on textbooks and the

Table 7 Prof. A: Perceived Supports Over Time

	Pre-Project	Post-Project
Academic Community	Encouragement from the neighboring University Consortium	**Invitation to participate in another national research project that is promoting active learning.**
College	Active learning is aligned with the college mission and vision	Active learning is aligned with the college mission and vision
	Active learning and group work are components of most courses, college-wide	Active learning and group work are components of most courses, college-wide
Program	Active learning is used in all of the Nursing Program courses	Active learning is used in all of the Nursing Program courses
		Faculty are supportive of each other
Course	Small class sizes allows lots of instructor-student interaction	Small class sizes allows lots of instructor-student interaction
		Grading system supports active learning
Instructor	Familiar with the "nuts and bolts" of two ITIP modules	**Increased confidence from doing, sharing and reflecting**
		Realization that planning time and level of effort is reduced the second time activities are used
		Encouraged by improved student engagement, attitudes and cooperativeness
		This is a fun way to teach
Students	Most students are goal-oriented and motivated	**Improved attitudes due to modifications (formal assessment)**
	Most students value a solid foundation in A & P	Most students value a solid foundation in A & P
Professional Organizations	ITIP curriculum modules	**ITIP Listserv discussion focused on grading**
	Start up packet with research papers	**ITIP Listserv discussion focused on viewing student resistance as negative motivation**
	The Listserv	**ITIP Listserve exchange of activity ideas**
		HAPs Update Session that showed the student responses to active learning
		HAPS Informal Interactions
		Project requirement to use formative assessment/ITIP document that explained the rationale for doing formative

problematic nature of using an "encyclopedic textbook" to support conceptual-type learning. Prof. A explained that, "the way the textbook emphasizes the facts rather than concepts…seems to result in a need for more lecture…because students have to struggle so much just to get through the book". Moreover, a search for a conceptually organized text with a nursing perspective had yielded nothing.

Instructor-related obstacles changed significantly as well; while formative assessment issues had shifted to become supports, obstacles related to summative assessment and instructional alignment emerged. Prof A commented that although she knew that assessment should "reveal changed conceptual understanding" she didn't know how to make that happen aside from doing pre- and post-concept testing. However, she felt that observing students group discussions represented a realistic means of monitoring for conceptual change. She also elaborated on a "potential disconnect" between her goals (objectives) and assessment: "I am concerned about making my goals clearer to myself and being sure that I am really evaluating students based on those goals." Although she had always felt (and even said) that her content goals and assessments were aligned, she commented, "I am not really sure they are. I state my goals, but I don't always follow up on them and I don't have a way to put some teeth into making sure." She expressed particular concern over the assessment of the soft skill objectives.

Prof. A added that the discomfort of "breaking out of the mold of teacher as information disseminator" seemed to provide the momentum for her ability to identify more and more instructor-related obstacles. "But" she added,

> I just have to keep telling myself that if I really believe that students need to take responsibility for their own learning…and they have to in order to become life long learners…then I have to keep working to break out of my mold and learn to be a facilitator who helps students learn how to access information on their own…and helps them learn how to stick through the frustration and gain confidence in their own ability. If I'm asking them to be life long learners…I have to be willing to do the same.

Prof. A. commented repeatedly on the supports that naturally emerged from the process of using active learning and formative assessment in the classroom. She spoke enthusiastically about finding more models and activities so the "engaged learning" would happen more frequently. She also commented that she found improved student understanding and test scores supporting; and was thankful for the realization that planning time really is significantly reduced when activities are used a second time. Support from other biology faculty, project materials, HAPs update sessions and informal interactions at the HAPS meeting, as well as her established grading system (which required student attendance but awarded no points for activities), were also listed as supports. The final support Prof. A spoke of was a recent invitation (and her acceptance as a team leader) to participate in another long-term research project to study active learning. "It's going to be a chance to learn more about improving science teaching around the principles of active learning….and I thought…'Oh gee…let's go for this!" Overall 19 supports (distributed throughout all categories) and 12 obstacles (primarily at the course and instructor levels) were mentioned throughout Prof. A's project participation.

Impact of Project Participation

Three separate categories of change beliefs are provided: self-reports of change, databased belief changes, and theory-based conceptual change. The impact on student content learning and attitudes is also briefly presented in this section.

Self-Reports of Change

Prof. A made a concerted effort to articulate the overall impact of the project on her teaching. Perhaps the substantial effort stemmed from her ongoing frustration with her students to grab onto information in a piecemeal fashion rather than tying it back into the big picture, or perhaps the effort was naturally in line with Prof. A's outstanding ability to "weave" and reflect on her thoughts. Whatever the rationale, her perceptions of the impact of project participation on her changes fell into three major areas: level of commitment, content-related issues, and instructor responsibilities.

Level of Commitment

Prof. A's action of committing herself and two colleagues to another long-term project speaks volumes about the value she assigns to active learning as well as to collegial interactions. She commented that although she didn't really know how she felt about "fooling around with this" because it would mean more data collecting and some week-end work for orientation, she said she was excited about and committed to participation and continued use of active learning in her classroom.

Content-Related Change

Prof. A identified two separate but connected content-related issues. The first was a restructuring of her own conceptual understanding of anatomy and physiology. She credits the thematic ITIP curriculum modules and "all the talk about themes" at her first HAPS meeting for supporting this change. She laughed as she elaborated:

> It's so funny because at first, I thought the theme of gradients and conductance sounded really *boooring!* But now it just seems like that theme…and other really important themes like signaling between cells, and feedback mechanisms and structure and function—those are the foundational concepts in biological systems! Now I have started to think along the lines of the major, umbrella-type themes that come up over and over in A & P.

As an extension of her changing conceptual framework and her recognition of the thematic nature of A & P, Prof. A said that content coverage had become less of an issue for her. She credits the project requirement to use formative assessment for this change, because when she combined her awareness of the knowledge explosion in the sciences with the insights into student thinking she had gleaned, she concluded that improved student learning required that students needed to: hear a consistent learning goal, have ample time for learning, and be given more time for understanding. She surmised, "I'll tell you for sure….it became very clear that I needed to let some things go!" Prof. A said that this is the first time in her teaching career that she had cut planned content material. She explained,

> I simply said, 'I cannot to do this. I have to give up something'. And you know what? That's okay because I'm realizing that I can cut content when I ask myself, 'What are the skills and concepts that my students really need to master and ground their nursing practice in?' I have a rationale that I can apply. If it's foundational it stays. If it's something that students can look up on their own later, it can go…. I am realizing that it doesn't matter so much whether I cover certain content…what matters is that I cover the themes in enough different places…in relation to content…that students understand the theme.

Although she made the cut, Prof. A admitted that it wasn't an easy decision. First she thought about paring it down, then she thought about making it into a lab, but as it turned out, she just plain let it go. She said that when the content was cut, she told students that because she had made the decision to do activities that would help them understand important concepts, she was now making the decision to cut some other content so that they could spend the time they needed to really understand. Prof. A reflected that the changes played out in an unexpected way: because she was gaining confidence in her teaching (due to theme recognition and insight into student thinking), she was able to develop a strong rationale for content prioritization, which supported the decision to cut content, all of which ultimately improved her students' potential to learn, by giving them the opportunity to experience depth of content. Prof. A demonstrated the tenacious nature of her "old mold" when she added with an embarrassed laugh, "I should tell you I added the content back into the syllabus for next quarter! But we'll see what happens…".

Instructor Responsibility

Prof. A said that over the last year, she had challenged herself to think more about her role in the classroom based on her changing beliefs about her students. Three insights had "become pretty clear". The first was related to the role of questions in the classroom. She elaborated, "I do much more questioning now than I used to, either through explicit techniques or setting things up so that students question each other." She stated that questioning is not only an instructors' responsibility, students need to show that they have accepted responsibility for their own learning by asking questions of each other and the instructor to express what they are learning. Although Prof. A had previously labeled her teaching style as an interactive kind of dialogue/lecture, she reflected that at times it was probably more of a one-way than a two-way dialog.

The second insight was related to the critical role of objectives in reducing student negativity. She said that by learning through formative assessment that students were genuinely confused about the connections between ideas, she decided to "back pedal":

> I've changed my thinking …and the way I structure information. I've decided that it's really important to be explicit about what I expect students to know. I don't limit my teaching just to what's assessed, I am just much more concerned about making sure that students know the difference between main ideas and elaborations. So now I tell them which are the main ideas and which are the examples that supports the main ideas. I want them to see the main idea and how having an example makes the main idea more meaningful Students seem to appreciate the change because now they have a clear picture of what they are responsible for understanding and they can prioritize their study time. It's definitely reduced the negativity in the class.

When asked how this approach was different than "teaching to the test", Prof. A responded that her intention was two-fold: to help student identify the central ideas, and examples as extensions of the central ideas, so that they could structure future learning and make new connections in a similar way; and, to provide a more concrete structure to decrease the feeling of being overwhelmed and increase their feeling that they could "do well on the tests", which is something they must do in support of their career goal.

The third insight was her role in modeling behavior that she wanted students to learn. With the addition of the active learning exercises, Prof. A said she realized that there are more possibilities for students to ask questions and "they ask some really good questions!" Rather than becoming uncomfortable with not knowing *all* the answers, she said it just made sense that she modeled what it meant to be a life-long learner. "They need to realize that people don't always have all the answers and can't be expected to have all the answers." So, now when a question that she has never thought about comes up, she just tells her students, "I don't really know…but here is a reasonable estimate….and here is a path to how we can find out….I'm a lifelong learner too".

Data-Based Changes in Beliefs about Teaching and Learning

Learning

Although Prof. A's definition of learning may not have changed from "knowing how to cross a hurdle when confronted with one", certainly there were indicators that suggested a different image of the hurdling process—clumsy and bungling rather than coordinated and agile. For example, "Sometimes it's so difficult for me to watch students hash through material that I think surely they must already know…but they don't" and "if students are going to learn the skills of a life-long learners then they have to figure out on their own how to stick through their own frustration". Specifics of the formative nature of the learning process were also relayed: "It's a process of forming a structure where information is tied together…misconnected pieces are pulled out and accurate connections are added."

Students

Prof. A's starting comments referenced students as a group of people with inadequate approaches to learning and many low-level, generalized needs. During project participation however, it became much more common for Prof. A to reference her students as individuals engaged in appropriate learning approaches and with very specific needs. For example, after doing the first activity, she commented: "They wanted to spend the time they needed to understand what they were doing" and described productive student-student interactions and integrating information from the textbook into the framework of the activity. She also commented on student needs being: to hear a consistent learning goal, time to follow through with the content of an activity and make connections, and "…to be given opportunities to figure out where the gaps are in their understanding…they need to be *given* ownership of their learning".

Throughout the continuation of the project, several beliefs about students emerged that seemed inconsistent with Prof. A's transformed belief system;

rather, the beliefs were more aligned with her original baseline beliefs, which depicted students with problematic and generalized needs. An example of such a belief was: "My students are in a nebulous kind of state…they're confused, and have a low tolerance for frustration." Quite unlike the baseline belief however, this statement (and other seemingly inconsistent beliefs about students) was followed by reflection ("I was remembering what it was like to be a student and what I might have needed from an instructor if I was confused") followed by a description of her response to the perceived need. She elaborated, "I felt like I really needed to put some teeth into what I was observing". Her response (Self-Reported Change; second insight) was that of "backpedaling" (reflecting), making learning objectives explicit and structuring the presentation of information so that main ideas and elaborations were apparent to students.

Instructor

Prior to the project semester, Prof. A described herself as a guide. As the project got underway, she elaborated with weaver, information resource, and encourager. With regard to instructor actions, she started with descriptors that focused on clarifying, giving, and summarizing information. Near the end of the project semester the descriptors were less directive ("expects students to read and understand basic information on their own", elucidates, helps students, and "tries to set up activities so students can discover information on their own").

Near the end of the project, Prof. A described events that were spontaneously leading to a dynamic process of reassessing her fundamental assumptions about learning, a critical transformation of her belief system, and reference to classroom instructional strategies that reflected the transformed belief system. The text of Prof. A's extended description is presented in segments to draw attention to her line of reasoning:

> I don't remember the source, I think I heard something at a workshop about the myths of teaching…and it really sunk in with me. One of the myths is: *Because I said it the students know it;* and the other one is: *Students need me to say it in order for them to learn it.* For the longest time, I think I must have really believed that these statements were truth! So at first, it was a slap in the face to hear them labeled as myths.
>
> But as I reflected on them it became pretty clear they really are myths, because when I thought about the first statement--I thought, 'Hey!
>
> Students don't pass my tests and they ask the same questions all the time'. If they had gotten it when I said it, they would pass the tests and they wouldn't have had to ask the questions, right?
>
> Then I think about myself as a learner and it gets even more humbling. I know that now as I'm in a seminar and I am learning new information…I'm thinking along and thinking along…and then I have a question and I know I am asking what they just said but I was sidetracked with processing or evaluating the new information or I was thinking about something else at that moment and I didn't get it! Just because somebody said it doesn't mean I get it!
>
> As far as the second myth goes, there are lots of different ways students can get information besides me saying it. The explanation doesn't have to come from me. I certainly don't need to have somebody tell me to learn! As long as I make my expectations clear and set the learning goals and objectives, students can get the information from a small group discussion, or from the text, or an activity or experience, as well as from a lecture.

Instructor/student relationship

Prof. A's relationship with students changed from—guide who keeps students on track—to an experienced life-longer learner and people learning the skills of life long learning.

Purpose of the Class Meeting/What does Instruction look like

There was a shift from an information transmission purpose--for students to ask questions and for the instructor to summarize—to more of a clarifying and reinforcing purpose.

Evaluation

Evaluation was an area that Prof. A was beginning to consider toward the end of the project. At the beginning of the project, she had indicated that assessment was to determine if students "get" what she was trying to get them to see. Near the end of the project, she indicated that it should be more about determining if students' perspectives and understanding of material had changed, but stated that at this point she didn't know how to accomplish that.

Conceptual Change

To determine if Prof. A demonstrated the criteria for conceptual change, statements of dissatisfaction, intelligibility, plausibility, and fruitfulness were searched for. Statements that satisfied the criteria of each category were located in interview transcripts.

Evidence of Dissatisfaction

Direct statements of discontent or mental disequillibrium were searched for to determine if Prof. A had become dissatisfied with her former method of teaching. Just prior to the project, reports of dissatisfaction were focused on alignment. Not only was she dissatisfied with her own philosophical alignment with the Nursing Program, she was also dissatisfied with the alignment between her own beliefs and practices:

> My interest in moving beyond lecture is in part related to the educational philosophy of the nursing program, which is to foster the development of lifelong and independent learners. Students need to "learn how to learn", be responsible for their own learning and actively engaged in it…not passive recipients who are dependent on the instructor for information and motivation.
>
> When I redefined learning as knowing how to cross a hurdle or obstacle when confronted with one….it was just so clear that lecturing falls short. It doesn't allow students to build life-long learning skills…in order for students to develop the mindset of a life long learner, they have to be challenged in the classroom…and that is up to instructors…

Two months into the project, she described a classroom event (that had occurred during the previous quarter) that had led to disequillibrium between her expectations for student learning and actual student learning:

> We had just finished going over all of the cardiovascular unit in class… and I decided to have students get into small groups and use the cardiovascular mapping activity as a kind of review kind of activity. There are terms that they have to connect …show relationships between…and so… I really expected that it would be a cinch for them….and I even second-guessed myself as they were getting into groups…I thought, 'This is going to be way too easy….why are we even doing this?' But they had *more* trouble…and *more* arguments while doing that activity….and came up with some of the strangest cause and effect combinations… it ended up being a much different experience for them….and me….than I had

> expected. I learned that just because we have covered information in class, doesn't mean the students get it!

Near the end of the project, Prof. A described disequillibrium, when she compared what she had heard at a workshop (the Myths of Teaching; Data-Based Changes in Beliefs About Teaching and Learning) to both her students' and her own learning process. Statements of dissatisfaction expressed at the end of the project were again focused on alignment; but this time related to the alignment between objectives and assessment:

> I've become quite concerned about making my goals clearer to myself and being sure that I am really evaluating based on those goals. Sometimes it's a matter of….I say I am…but I am not really sure that I am. Or I say these are my goals but I don't always follow up on them. Sounds good but…You know? Yet I have thought about them a lot…so I am very aware of this…and you know at some point I need to put some teeth into it…come up with a way to know.

Evidence of Intelligibility

For evidence of intelligibility, statements that indicated understanding and internal representation of constructivist teaching and learning beliefs (long-term knowledge construction, knowledge application to solve problems, extension or modification of preconceptions) were searched for. Although some statements of instructional know-how were noted at the beginning of the project ("I am familiar with the nuts and bolts of a couple of the curriculum modules"), statements of intelligibility were more common later in the project. For example, toward the end of the project, Prof. A compared a previous instructional strategy to a current (less content is more) strategy, concluding that students benefited from the opportunity to explore a concept in depth:

> [since I've come to understand the thematic nature of A & P] and have gained the confidence to leave some content out of the course and included a couple of good activities that encouraged student to process and really think about the information…I think they have benefited from not being pushed to cram everything in—like I have required them to do in the past.

During the following month she simultaneously compared her previous definition of "classroom dialog", to a more current one and demonstrated understanding and internalization of eliciting and building instruction around students' ideas:

> I have always said that my classes are [conducted] in a dialogue format and that I've developed conversations with students about the topics we are studying. I think I'm realizing that the conversation can't just be a one-way street. They have to take some responsibility for what they are learning. They have to be able to ask questions and express what they are understanding.

Lack of intelligibility was noted near the beginning (conceptual understanding and formative assessment) and again near the end of the project (assessment for conceptual teaching):

> One of my goals is to promote conceptual understanding…but I don't think I always know the best way to accomplish this….
>
> I'm not sure about getting feedback from students after an activity. It's not something I typically do…it seems like more of what I already do in the classroom…I'm not sure about the rationale….
>
> I agree [with a statement that, assessment should be an opportunity for students to reveal their changed conceptual understanding of the subject]… but I haven't figured out yet how to make that happen. I'm not sure that is realistic for me….I don't know…I can't figure a way to

> structure an assessment situation to really show that. Would I have to do a pre- and post- test?

Evidence of Plausibility

For evidence of plausibility, statements of belief in constructivist-based instructional strategies, consistency with experience, and an intention of use in future practice were searched for. Certainly, evidence of intent is initially suggested by Prof. A's decision to volunteer and commit to project participation, and belief in/intent is indicated in her primary goal ("…to…break the routine format of discussions with activities to engage students and encourage conceptual learning and process thinking"); however, the conditions of plausibility are not met because she reveals her lack of understanding (intelligibility) of how to go about promoting conceptual understanding.

Toward the end of the project, there is strong evidence of plausibility in anticipation of the upcoming quarter, as Prof. A commented on course planning:

> With the formative assessment, I'm planning on using it a couple times ….and really I'm more interested in whether [students] improve their understanding of the content rather than if they like or don't like the activity…I will probably leave that question off next time. The bottom line for me is finding out whether they are understanding the content.
>
> I'm going to try the syringe activity next…[described in a Listserv discussion]…it's a really good idea on how to get students to understand flow through a narrow vessel versus a wider vessel.
>
> Getting feedback has given me some ideas for how to improve the activity next time around…like follow up discussions…or maybe some Web-based interactive videos…or questions about how the process would be different [than the model] if it were occurring in a living organism.

> I will do more mapping and this kind of thing…it's very worthwhile because the students have to deal with the information in a very concrete way. They have to put those cards together and it is really a test of how well they understand the material…and to hear them self-assess that, 'Oh I need to study this more'…that's a good [laughing]…very good thing.

Evidence of Fruitfulness

Confirmation of Prof. A's ability to understand, project, and apply her changing beliefs to classroom practice served as supporting evidence of fruitfulness. The primary constraint on application of constructivist practice was a perceived lack of creativity to generate her own activities—however—since awareness and understanding were part of her thought process, activity generation doesn't preclude fruitfulness. Strong evidence for fruitfulness is conveyed in the following passages:

> When I first started teaching…I was so much in the lecture mode…and I didn't…and it took me a while… I still go back and forth…and sometimes I catch myself thinking…this is ridiculous…I just need to do a little at a time and see what works and go with that…just stay open to trying and staying committed to students' learning, as well to my own learning. I will continue to go for it! Not only is learning to teach this way a goal worth pursuing it's much more interesting to teach this way than to lecture…it really is fun…as I think about doing more…thinking about coming up with some good lead questions….and having students make predictions…and have them stop and discuss an application with their neighbors…and looking for ideas for activities….

> I got together a team of three instructors to be a part of another active learning grant from NSF that requires us to develop ideas and revise parts of our courses to be more engaging. I will be the contact person…When I heard about it, I thought, 'Let's see if we can do this!' Here let me read from the brochure we got….the real work lies on your shoulders as you strive to develop, implement, and revise new approaches to teaching and learning in your course.

Student Change

Changes in content understanding and attitudes toward teaching and learning were determined from pre and posttests of students in Prof. A's class.

Thematic Content Learning

With the limitations (described in Chapter One) on this data in mind, students' understanding of gradients at four knowledge levels were: a 10% improvement in questions at the remembering level, a 22% increase in questions at the understanding level; a 6% increase in questions at the application level, and a 14% increase analyzing, and an overall increase (all categories) of 15%.

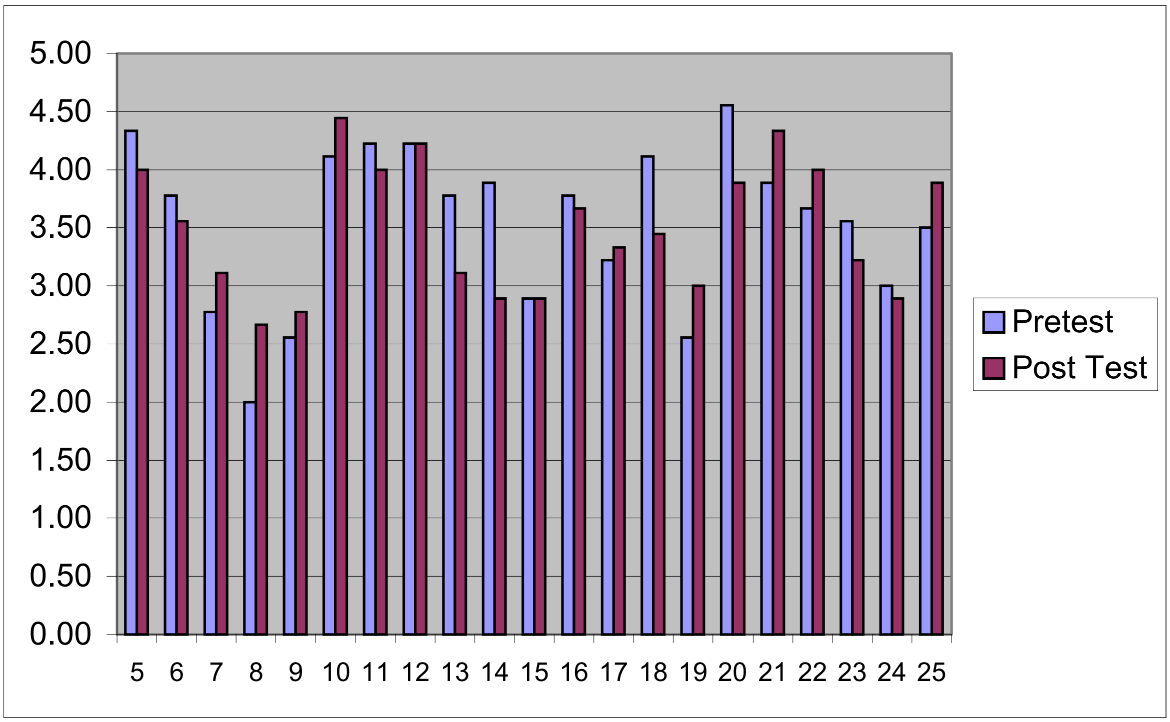
Attitudes about Teaching and Learning

Over the course of the project semester, data suggest that Prof. A's students experienced four significant changes: they were less inclined to believe that in-class problem solving activities were a good way for them to learn information; they were less inclined to see "making mistakes" as a useful part of the learning process; they were less inclined to believe that an important responsibility of the instructor was to challenge students to think, and they were less inclined to use learning strategies like putting information into their own words, reorganizing it into diagrams or maps, talking about it with a classmate, or trying to use it to solve a problem. Since all of the significant attitudinal changes were negative in nature when viewed in an isolated manner, a holistic interpretation based on responses to all related survey questions was conducted.

When Prof. A was asked to explain what might have been going on with students, she commented that she believed they were just exhausted at the end of the semester and were in need to a break. She commented, “They worked really hard all semester long and frankly…they were just ready to have it be over….take a breather.” Her explanation seemed plausible when the data from all questions were viewed holistically (Figure 1).

In support of Prof. A’s explanation, although students were significantly less inclined to believe that the instructors’ role was to challenge students to think (question 14; 3.9 to 2.9), they were more inclined to believe that the instructor should use class time to provide different examples and explain difficult concepts in new ways (question 10; 4.1 to 4.5) rather than simply presenting the information in the textbook (question 7; 2.7 to 3.1). Further, students continued to value feedback from the instructor over the course of the semester (question 16; 3.7 to 3.6) and their assessment of the purpose of class tests seemed to reflect a realistic understanding of the importance of memorization of fundamental information (question 19; 2.6 to 3.0) as well as an understanding of the necessity of being challenged to think about concepts in novel ways (question 24; 3.0 to 2.9). Although the data may in fact support Prof. A’s explanation--by the end of the semester students were more inclined to want more explanation of difficult concepts rather than challenged to figure concepts out on their own—the data also

Figure 1 Prof A: Student Attitude Changes Over Time



Questions 5-25 are located on the student attitude survey located in Appendix C suggests that despite being "exhausted", students remained focused on working at the level of difficult concepts rather than simplistic textbook information.

Further supporting Prof. A's explanation, although students were less inclined to study by putting information into their own words, reorganizing, talking about material with a classmate, or trying to use it to solve a problem (question 20; 4.6 to 3.9), they were still more inclined to use the aforementioned study strategies than they were to read information over and over (question 15; 2.9). Further, not only did students' learning preference toward in class problem solving decline significantly (3.8 to 3.1), their belief that hearing a lecture and taking notes was the best way to learn, also declined (3.8 to 3.5). One might speculate that by the end of the semester, students may have decreased their tendency to attribute learning to the teaching method alone; rather they may have attributed learning to some other factor like their own level of effort (preparing for class). This speculation is supported in part by data from question 25 which suggests that students were more apt to hold themselves responsible if they were having trouble understanding information in the class (4.0 to 4.4); however, contradicting the speculation, students' tendency to blame the instructor for trouble with understanding also increased (2 to 2.6) over the course of the semester.

Although making mistakes was significantly less likely to be viewed as a useful part of the learning process by students (question 18; 4.1 to 3.4), other questions that addressed elements of goal orientation suggested an increased tendency toward a mastery goal orientation. For instance, students were more inclined to look at the progress they made over time (question 22; 3.6 to 4.0) as a means of evaluating their learning, and more inclined to believe that understanding information was more important than getting a good grade (question 21; 3.9 to 4.4). Their belief that they worked hard in class primarily to get a good grade remained stable over the course of the semester (question 17; 3.3). From a practical perspective, valuing both understanding and grades should be expected given that most of these students must receive a required grade in order to move on in their studies and ultimately attain their goal of a health-related career.

Also suggesting a practical perspective, students believed that both memorization and challenges to thinking were important aspects of testing in anatomy and physiology. Students in Prof. A's course, increased their belief that the purpose of tests were to determine whether information had been memorized (question 19; 2.6 to 3.0). Similarly, students believed that tests should serve as a learning tool and should challenge students to think about concepts in ways they might not have thought about before (question 24: 3.0 to 2.9).

Although students did not recognize a gain in their topical knowledge at the end of the semester (question 23; 3.5 to 3.3), confidence in their ability to learn basic information remained high (question 5; 4.3 to 4.0) over the course of the semester as did their confidence to integrate material to understand how systems interacted in the body (question 12; 4.3).

In summary, a holistic examination of the data indicated that at the end of the semester, students were more inclined to want to work at the level of examples and difficult concepts than "covering textbook information", were more inclined to favor the use of study strategies to promote information integration rather than simply reading information over and over, and were slightly more focused on understanding information than on getting a good grade.

Students' belief about the utility of mistakes may be an area worthy of further investigation by Prof. A. While the data may suggest and end-of-semester desire to make fewer mistakes in order to attain a desirable end grade, it may also be indicative of a sense that there is a larger risk than benefit in making mistakes, that the classroom is not a safe place for taking risks, or some other unanticipated explanation that students might clearly articulate. Other areas worthy of further investigation, are why students attributed increased blame toward the instructor, and why they did not recognize a gain in their topical knowledge. While the attribution for failure may be a means of self-worth protection, it is unclear whether the latter data suggests a need to help students improve their ability to self assess or whether students perhaps began the class with an unrealistic (high) assessment of their knowledge.

Summary of Beliefs

An overview of Prof. A's beliefs about teaching and learning, motivational profile, perceived supports and obstacles over time, and change profiles are summarized in the Table 8.

Table 8 Prof. A: Summary of Data

Beliefs								
	Learning	**Students**	**Student Action**	**Instructor**	**Instructor Action**	**Class**	**Assessment**	
Pre	Putting together pieces; hurdling	Two groups: one goal-oriented, one not; Most are academically underprepared and have poor study strategies	Piecemeal learning; marginal effort; ineffective learning strategies	Facilitator (general)	Directive - Summary role (Talks about, compares, points things out, sets the stage, assigns groups, answers questions, summarizes)	Hit highlights; instructor summarizes	Did students get what instructor wanted them to get?	
Post	Piecing and connecting; clumsy; persevere	Individuals with preferences for the structure of learning situations	Make connections; take responsibility for learning	Guide/weaver/ resource/ encourager (personalized)	Explicit expectations; learning coordinator (elucidates difficult areas, reviews, structures activities for opportunity, collects feedback; incorporates lessons learned into instruction)	More conceptual focus; more questioning, challenging, modeling	Changed understanding	
Motivation								
	Goals	**Intelligence**	**Mistakes**	**Success Attribution**	**Failure Attribution**	**Failure**	**Success**	
	Engage students and encourage conceptual learning and process thinking	Instructor malleable	Useful learning opportunities	Internal, Unstable, Controllable (Instructor Ability and Effort)]	Internal, Unstable, Controllable (Instructor Ability and Effort)]	Student-oriented	Student-oriented	
	Fine tune student outcomes	Students malleable						
	Develop some reliable assessment tools for evaluating the impact of teaching on learning							
	Develop activities							
	Get personally inspired							
Obstacles and Supports								
	Academic Community	**College**	**Program**	**Course**	**Instructor**	**Student**	**Professional Org**	**Total**
Obstacles Pre	0	1	1	2	5	4	0	13
Obstacles Post	0	1	1*	4*	5*	1*	0	12
Supports Pre	1	2	1	1	1	1	3	10
Supports Post	1*	2	2*	2*	4*	1*	7	19
	* Modified or changed							

Change								
	Self-Report	**Change Event**	**Data-Based**	**Conceptual**	**Tries to Adopt Student Perspective**	**Student Attitudes**	**Student Content**	
	Personal: Increased commitment to active learning	Invitation from researcher; doing active learning/gained confidence	Learning: Yes	Dissatisfaction: Strong Evidence	Yes: "I was remembering what it was like to be a student and what I might have needed from the instructor if I was confused."	Learning Preferences: Less inclined to believe that in-class problem solving is a good way to learn	Remembering: 24 to 34% = 10%	
	Content: Restructuring of instructor conceptual understanding	Thematic organization of ITIP curriculum modules. Reflecting on how I think about content	Students: Yes	Intelligibility: Strong Evidence		Goals: Less inclined to see "making mistakes" as a useful part of the learning process	Understanding: 29 to 51% = 22%	
	Content: Rationale-based content trimming	Doing active learning; HAPs workshops; Reflecting on why I teach what I teach and what will be most useful to students	Student Action: Yes	Plausibility: Strong Evidence		Learning Strategies: Less inclined to reword/reorganize /apply as a study strategy	Applying: 21 to 26% = 6%	
	Instructor Responsibility: More questioning	Doing active learning/ Reflecting on my role in the classroom	Instructor: Yes			Instructor's role: Less inclined to think the instructor should challenge students to think	Analyzing: 22 to 36% = 14%	
	Instructor Responsibility: Objectives/Clear expectations	Doing active learning; Monitoring student resistance/taking perspective of what I would need if I were in their place	Instructor Action: Yes				Total: 24 to 39% = 15%	
	Instructor Responsibility: Skill modeling	Reflection on how someone learns to be a life long learner	Class: Yes					
			Assessment: Yes					

PROFESSOR B: COMMUNITY COLLEGE A & P INSTRUCTOR

> The college is one of a number of independently governed community colleges that are not connected…other than how the crow flies… but all belong to the State College system. The college caters to commuter students and there aren't any entrance requirements… and we are picking up students that are terribly under- prepared learners…

Pre-Project Information: A Snapshot

Baseline data was collected over a five-month period. Two, 60-minute telephone interviews, five, 60-minute personal interviews, four written surveys, numerous email exchanges, the course syllabus and the college website served as data sources.

College, Program, and Course

The Community College's mission statement describes a learning organization committed to educating lifelong learners to support career and skill training through innovative academic programs, teaching excellence, and high quality student services. The evening/weekend Nursing Program is highlighted as one of the most unique and largest programs at the college. Although program completion most often leads to a certificate of completion, nursing students may also pursue a transferable associate's degree.

Prof. B commented on her perception of departmental teaching context:

> The department requires 30 plus contact hours with students per week and pays us two-for-one for labs…we do a lot of night teaching which makes for odd hours…I also have committee responsibility… and have to attend departmental morning meetings once a week….there is no down time for creativity or for collaborating. You just do it. We always just DO. We throw handouts to students when they are still hot off the machine…. by

> the end of the week you can't even say your name…. [Within the period of a year] we've had a strike…our dean quit abruptly and the administration has been in flux…. there's also a controversy here about faculty sitting in on other faculty's classes for the purpose of peer review…it's a tight rope because of a Union issue…

A & P I and II serve allied health students. There are two course prerequisites: general biology and chemistry. Students enrolled in each, four-credit-hour A & P course attend two, 50-minute lectures; one, 50-minute seminar; and three, 50-minute labs per week. Day and evening classes are offered to accommodate student work schedules. Prof. B indicated that unlike many courses where the lecture drives the structure of the course, the labs provide the course framework. The goals of both courses are to provide students with solid background knowledge in Human A & P and to provide learning opportunities to help students develop skills that will enable them to become independent learners and problem solvers

A & P I is a large class, in excess of 100 students. In terms of content, anatomical positions and terminology through the nervous and endocrine systems are taught. The course is considered by many to be the "ultimate weed-out course" with attrition rates between 30 and 60%. Both semesters are characterized as "fast-paced and full of new vocabulary". Since A & P II is the continuation course, the class size is about half the size of the first semester course. A & P II begins with study of the cardiovascular system, and moves through the lymphatic/defense/immune system, respiratory system, and urinary, digestive, and reproductive systems.

Because of the fast-paced nature of the course (and in the interest of respecting classmates) Prof. B's syllabus states that students should "refrain from noisy, distracting behavior such as rummaging through backpacks, talking to [their] neighbors, and coming in late".

The Students

Information distributed by the College indicated that a "diverse" community of students (just over ten percent of the students are "of color") are served and supported by campus organizations. Prof. B again provided a different perspective on the students as well as the support services:

> Student diversity is mind-boggling. We have everything from high school drop-outs to fast-tracking LPNs…there is also a huge population of [non-native students] representing Hispanic, Vietnamese, Somalian, and Mung ethnicities that reflect the regional immigrant populations…and although there are English as a Second Language (ESL) support-type classes, there is no safety net…no required screening… so if students think they can make it through classes based on their own self-assessment, they can go ahead and register We have many first- generation students…who are working days and they commute to campus for the evening classes ...without seeing the library or knowing much about the collegial or support opportunities. Communicating with students outside of class isn't possible because they aren't required to have email accounts….

Although most of the students in the nursing program are in their 20s and 30s, Prof. B indicated that there are also a large number of high-school options students (16-year-old students rated in the top third of their high school class, who can elect to take college classes and the state pays their tuition and books) and a few second- or third-career students (40 to 60+ years of age).

Prof. B has taught A & P for about ten years. She is the only full-time member of a three-member teaching team. Prior to the project start, Prof. B taught the lecture, a temporary adjunct taught labs, and a part-time instructor taught the seminar. She indicated that interactions within the teaching team were tense due to different personalities, content expertise, and teaching beliefs. She described one member of the teaching team as intelligent but lacking in clinical experience and not committed to ”the day-to-day grind of teaching”. Prof. B’s impression of the third team member was that she catered to the students’ urgings to make the course easy (students commented that the lab tests required them to discriminate between a right answer and three unlikely answers), and has established herself as the “cool” one in the department. Although the team indicated they were interested in active learning, Prof. B felt their preference was to be, “very traditional tell the students what they need to know and then test them on it” instructors. She felt largely unsupported to make changes in the classroom and to participate in the project.

Project Participation: A Snapshot

Project participation data were collected through four, 60-minute telephone interviews, two 90-minute personal interviews, four written surveys, a course syllabus and workbook, and numerous email exchanges. In addition, a 30-minute telephone interview with a triangulation researcher, and review of materials to support first-semester students, contributed to this case.

The Instructor’s Prior Experiences

Prof. B received her undergraduate degree from a Community College and State Research University, and a doctorate from the same university. She started college as an older, married student with children and an expanding educational goal. She explained,

> I was first generation college…with a family that didn't understand my motivation…and grimaced…when I decided a two-year degree wasn't going to be my long term goal…then flipped when in the middle of nursing school I had this revelation that I was never going to be comfortable as a nurse…I just knew it wasn't going to work. I did a Bachelor's in science and then aspired for a Ph.D. in Cell Biology.

After completing her Bachelor's degree, Prof. B began graduate school, only to discover that she had been "ripped off " by her undergraduate education. She explained,

> After I got my B.S., I went on to take a medical microbiology class that was research-based and I could not answer the questions…. I would just know the book and know the information…backwards and forwards…like I had typically done before…but the instructors would give me a C- because I simply could not reason things through….

She described the experience as a "thump on the head" and a life-changing experience. "I had been trained to follow the directions …not to reason". When she spoke of her undergraduate instructors, she described with a laugh, that they were, "folks that conducted lecture while jingling the change in their pockets…and talked all about content and weren't concerned if students understood what was going on or not….fact after fact….with very few exceptions".

She recalled an incident where her graduate-level instructors reinforced her belief that she had been under-prepared, by setting her back in her oral prelim exams. They didn't feel that she had provided a satisfactory response to an experimental design question. After trying again and completing her prelims, she recalled having both huge teaching and research roles and knew through comments she heard, that teaching was secondary to research. Prof. B's decision to pursue a teaching rather than a research career, seemed to have been shaped primarily by a belief that her research style ("a shot-gun approach") would not render her competitive for extended research funding. Although she claimed to have liked her teaching responsibilities, her passion was clearly for the subject and her desire to impart the value and excitement of the subject to others.

Although Prof. B was aware that her experiences as a student might impact her teaching beliefs and strategies, she alluded to the potential only once and with a great deal of discomfort. She commented,

> I have been dragging a lot of this [experiences as a graduate student] with me…and have had a terrible time letting go of it…and unconscious perhaps…certainly not conscious….I think that if I went through hell…then that's what it is ...an education has to be tough or it has to be serious…based on how I was drug through a knothole backwards several times…..

After finishing her doctorate, she said that she was notified of an adjunct teaching position at the local community college. She got the job and began teaching. She recalled, " I was teaching under somebody…and I did what I did, because I had to… I had no say in anything". When the position later became full-time, Prof. B began to think about how to carve out her own niche as a teacher. Although she felt she had a good understanding of her students (because she had been a community college student and "knew where they were coming from") she realized that she had never been exposed to teaching techniques and that she "was out of the loop" when it came to knowing how to teach. As she attended conferences to "bone up" on teaching, she found that the more she listened to the experts, the more turned off she was. It seemed to her that "everything in education went through cycles…directed by pop psychologists."

Nearly all of Prof. B's comments about education had a strong overtone of dismissal. For example, during pre-project data collection, she stated that she didn't need to have a teaching philosophy, and later in the same interview made her opinion of objectives clear,

> I hate objectives. That's not my personality. I absolutely abhor sitting down and writing those things. They dive me crazy. To me it is obvious without the objectives and it is so mundane to sit there and do that. I hate that part of it. I want to bypass all the…stuff… If I write objectives, I will be held to them and then I can't be spontaneous. To me it feels like entrapment. I know you are supposed to do this but they feel inhibiting to me… I don't think that way.

One gets the feeling after prolonged interaction with Prof. B that her rejection of educational knowledge is a firm display of her allegiance to the "hard sciences", avoidance of the label of "educator" and therefore avoidance of a reality described by her graduate professors: "those who teach are not living up to the expectations of the degree". When describing interactions, Prof. B indicated that her relationship with educators tended to be adversarial. She described her perspective of educators who had lead a state-sponsored, Center for Thinking and Learning (CTL) session focused on the "less is more" theme:

> The CTL types can empathize with scientists to a certain degree but scientists are different…. CTL types don't understand the importance of content and details in science…. so when they get into talking about how to adapt classes and they [tell you to teach less content]…well that is fine for sociology…. and psychology classes…where you can throw out a model or skim something…but you can't throw out the leg or the heart to save time! You can't do that!

Prof. B also expressed doubt that methods and theories generated by educators were based on empirical data. She elaborated:

> It just kills me that these people say they have data to prove…. but they don't look at the assessment data or their assessment tools carefully. It drives me nuts! [For example], our CTL did all these assessing things…and they would say that, 'Our study suggests that.' And all the scientists there would say, 'Where is the data?' And they would say… 'Well we really have it all put away and we are going to get it out over the summer and crunch the numbers but our impression is….' my god if you want to turn a group of scientists completely into raving lunatics then come to a meeting and say you are going to quantify something but then don't have any data to back it up…. So that whole thing just has turned me so off so for three years I didn't go to another CTL meeting.

Prof. B recalled that her commitment to begin searching for teaching methods that were scientific, worked for the long term, and were based on observations was a response to a "new subset of students that began to appear in the classroom". She said she knew immediately that they weren't from her era and didn't value the joy of learning; rather they were there "to fill up a seat as they moved toward a career goal". They had poor retention, lacked basic academic skills, and their desire to be "super humans"—going to school, working, and parenting— diminished their ability to learn. Since she had been using traditional lecture to teach, she questioned whether changing what she did might improve student learning. She became interested in finding out more about the active learning methods being used by other scientists because she felt the approach might allow her to do something differently to "impact these people… that are …fed on video games…". To find out more about active learning, she attended the HAPs 2000 meeting (and a workshop, "Active Learning in

Lectures"), a workshop for case study writing, and a workshop for creating an environment for active learning.

Teaching Strategies

Professor B described the flow of her class sessions as "interactive lectures". She elaborated:

> I hand them out my lecture notes. I always begin class by asking what questions they have…and usually it's about what is on the test or where is some paperwork that they are supposed to have. So, I am in the front of the classroom and I make overheads of my lecture notes and I'll say, "We'll begin our discussion here about the skin." And we go through reviewing some of the anatomy of the skin and I ask them to list the layers…as a reinforcement of the main ideas. Then, I start to give them some kind of bone to chew on…like I'll ask them what is happening in each layer or where they predict that mitosis would be occurring…and they can't predict where mitosis is occurring…they've read about it but they ….they can't understand…. then we take the next part where there is something about the dermis…. and we kind of approach it in the same way…. what do they understand? What is giving them problems…and we talk about some skin condition somebody has…and I try to encourage that they relate this to the skin conditions they are familiar with…that's pretty much the standard approach.

She described her grading system as one that gave points for everything students do, except attendance which was not a required element, and that grading resulted in, "a normal distribution…heavy on the low C's… some B's …and fewer A's than B's".

Beliefs Related to Teaching and Learning

Prof. B's beliefs about teaching and learning are summarized in Table 9. She defined learning as, "Related to motivation and a person's ability to have insights and connect with things" and "something that everyone has the potential to do". Her descriptions of learning indicated that she believed it was an

Table 9 Prof. B: Beliefs Related to Teaching and Learning

	Pre-Post	Post-Project
What is learning?	Related to motivation and the ability to have insights and make connections	
	Requires working in teams	
	Something that everyone has the potential to do	Hanging on to some knowledge and different than short term memory
	Requires an ability to think independently and on one's feet	If someone has learned they know more than they did before
	Requires a willingness to buckle down and pull up ones' bootstraps.	It requires pulling information together from different inputs
	Learning is accompanied by excruciating feelings	It takes time for information to be absorbed into long term memory
		Learning is accompanied by the feeling that it can be survived with proper preparation
Who are the students?		Underprepared
		Have unrealistic course expectations
		Are part of a "click and point society" who have difficulty manipulating real objects
		Watch too much television
	People with poor: foundational academic skills, attitudes, and organizational skills	People who are unable to accurately self-assess their own level of knowledge
	Career goal oriented	Have misconceptions about information related to the human body
	Overwhelmed with school, family, and work situations	Underestimated the importance of information retention in passing next-level professional tests
	Immature and lack a strong rationale for wanting to become nurses	Maintain the belief that the textbook is the content authority, the instructor's job is to paraphrase the textbook, and that understanding is possible only when they can hear or read something
	Have a sense of entitlement and consumerism	Very dependent on the instructor
	Have unrealistic expectations of what it takes to succeed in the course or nursing	Become anxious when stretched to do difficult tasks and learning
		Those that are motivated to learn, are talented and committed
What do students do?	Fixate on taking notes during class	Student learning can be characterized in one of two ways:
	Expect the instructor to give them the bottom line	1) Those that complain there is too much information to integrate, memorize what the instructor says, want the bottom line, sit in lab reading their textbooks rather than working with lab materials, and can't get a C in the course
	Unwilling/unable to make predictions based on content understanding	2) Pass the class.
	Won't complete pre-lecture homework assignments	Most students ask questions that are far below the level the instructor is teaching to
	Expect to exert the least effort for the greatest reward	Most students say they do not want to be told that their verbal responses are wrong
	"Pitch fits" in class	Validate and appreciate the importance of content and terminology
	Don't take responsibility for learning	
	Will "dig a ditch to China" for bonus points	
	Tell the instructor she is unsupportive and negative about their ability to succeed in the class	
	Blame the instructor for difficulties	
	Inattentive	
Who is the instructor?	A content expert with clinical experience/facilitator of learning	A content generalist who transmits information, encourages content and skills integration, and manages student negativity.
	Passionate about the content	A basic scientist who is trying to figure out how people learn and is applying some of what is learned but doesn't always know what should be done.
	Is a hard scientist	Understands the unrealistic expectation of knowing all the answers to students' questions but prefers to know most of the answers
	Is able to explain the unexplainable	Has developed an awareness of student perceptions and has become reacquainted with what it is like not to know
	Is extremely confident in knowledge of anatomy; less so with physiology knowledge	Often feels alienated from students
	Familiar with what students are experiencing because of her own experiences as a student	Has experienced the value of questioning students to find out what they know prior to instruction but knows that the constraints of time, student attitudes and instructor knowledge/personal energy, and the risk of altering a successful curriculum outweigh the potential benefits
	Is very disconnected from what the young females in class are going through	
	Is frustrated with the degree of diversity in the classroom	
	Enjoys the opportunities created by a diverse classroom	
	Is largely intuitive and spontaneous	

What does the instructor do?	Personal: Uses a scientific teaching method that works over the long-term and is based on observations; Focuses on "reaching" students so that they can be successful; issues reality checks to students; is in control; runs class at a fast pace to get it all done; is demanding, rigorous, and writes hard tests;	Personal: Emphasizes a "tightly-scripted" delivery of foundational-level content plus some current theoretical content; gets things covered and done
	Adopted: Engages students in interactive lecture; creates discussion opportunities; makes a study guide to focus students' reading; teaches students how to use tools; gets student preferences by taking student polls	
	Alternate: Doesn't write objectives because they are unnecessary and a form of entrapment; Uses textbook objectives to respond to student demands for objectives; Designs tests in a manner that makes it difficult for students to predict what will be on the test and "doesn't teach to the test"; wishes students were required to pass an academic skills pretest in order to enroll in the course; goes through the textbook chapters and takes down lecture notes to give to students	Alternate: Minimizes student negativity by making the learning process doable for students by giving them a complete set of notes from the textbook, underlining everything in the notes and lab manual that students are responsible for knowing, and helping students see that "even though they are not "A" students, they know more than when they started. Tries to involve students in some discussion. Has difficulty paying attention to how students' understanding is changing.
Instructor Student Relationship	Expert and underprepared students	Travel guide and prepared travelers
What is the purpose of the class meeting?	To cover information	To cover information
What does instruction look like?	Interactive lectures: asks students for questions, reinforces main ideas, and applies information	Interactive lectures: asks students for questions, reinforces main ideas, and applies information
What is evaluation/ assessment?	The purpose is to give a grade	The purpose is to find out if students can read, have memorized terms, and can integrate terms and information from lab, lecture and seminar

excruciating process. On separate occasions, she described learning as, hard, painful, like being pulled through a knothole backwards, and going through hell.

When asked to describe who the instructor was, Prof. B said that the instructor should be a combination content expert with clinical experience and a facilitator of learning. As she explained what this might look like in the classroom (over two interviews, one-month apart), contrasting descriptors simultaneously emerged, presumably representing either different belief systems, situational attitudes, or both.

Prof. B's conceptions about an instructor's role in the classroom were mixed between two systems: a personalized one that highlighted the instructor as the authority whose primary concern was covering the content (e.g., uses a scientific teaching method that works over the long-term, focuses on reaching students so that they can be successful, is in control, runs class at a fast pace to get it all done); a second adopted that focused on interacting with students (e.g., engages them in interactive lecture and discussion, makes a study guide to focus students' reading, teaches students how to use tools). An alternate system also periodically that seemed to function to accede student demands or reestablish instructor control. The alternate system also contained an element that suggested a strong preference for spontaneity rather than predictable behavior. For example, she stated that: "My behavior in the classroom can't be put in a container"; "I like spontaneity. I don't like things too calculated", "I am an impulsive person by nature", "I don't want to think about everything I do in terms of some kind of form or model", and "I'd rather just do what I do by the seat of my pants. I know that sounds funny…but that's what I like".

While speaking of the instructor's role in the classroom, Prof. B expressed frustration with her perceived difficulty to interact effectively with students. She explained that she struggled with feeling alienated (she recalls feeling this even as a teaching assistant in graduate school), because she had always felt that students saw her as a "gatekeeper who intentionally frustrates them by not giving them the key". She explained that a feeling of alienation from the younger women in the class seemed to stem from what she perceived to be anger. She explained, "They seem to have this attitude of, 'Don't frustrate me!' 'You didn't tell me I needed to know that!' and 'That's not in the notes!'" Her concern was that the "rumbling" brought the whole class down and created an unpleasant classroom dynamic. Although she felt that she was not effectively reaching these students, she was at a loss for what to do.

Juxtaposing stated teaching and learning beliefs to Prof. B's description of her teaching strategies, it seemed that the information transmission belief system was the primary driver of her classroom practice (although I did not have the opportunity to observe her teaching). Elements of the other systems may have gained status in laboratory teaching, or in response to situational emotions related to "being up" or feeling challenged. Although there is a reference to questioning and dialog with students during lecture ("I give them some kind of bone to chew on… I'll ask them [to] predict [where] mitosis would be occurring"), no evidence was provided to describe subsequent interactions. Rather, Prof. B commented: "…. they can't understand…"

Prof. B's description of what students should be able to do in order to learn was, "They must be able to think on their feet", "they have to work in groups or teams", and "they have to be independent thinkers". However, as she described classroom events, her comments about students seemed to preclude the aforementioned abilities. She described her students generally as a group of immature people with poor foundational academic and retention skills, who were overwhelmed by job, family, and school responsibilities.

> Although she referenced a small group of good students that would "buckle down and pull up their boot straps", she stated that economic and social factors acted on most students, "something like lampshades dimming their level of brightness". For instance, she said "…it is hard to be bright in A & P when you are the mom of four kids and fever is raging and there isn't any milk in the refrigerator." She perceived that her students had attitudes of entitlement mixed with consumerism and didn't have good reasons for wanting to become nurses. For example, students thought they deserved an A just for coming to class, and "they are the consumer….and they want it their way…and what they want is less [content] for their money." Prof. B spoke with disbelief when she reflected that, "this is the only consumer group I know of that wants less for their money!" She said that the reasons students gave for wanting to become a nurse showed little reflection. She elaborated, "I hear people say they want to become a nurse for reasons ranging from, 'I woke up this morning and wanted to be a nurse'…to, 'I am a nice person.'

When describing what her students did in the classroom when they were involved in learning, Prof. B's comments were directed toward a single group ("they" or "these people") who: fixated on taking notes, wouldn't do pre-lecture assignments, flipped to the back of the book to get answers, didn't take responsibility for classroom learning but would dig a ditch to China for bonus points, blame others for their problems; wouldn't give their attention to the instructor, and expected everything to be handed to them.

The Context for Participation

Prof. B participated in the project while teaching A & P II—immediately following a semester (A & P I) where active learning strategies had been planned but abandoned. When pressed to describe the events that led to abandonment, Prof. B gave the following account of how her students "pulled the pin" as she laid the groundwork for active learning:

> I had just come back from all my traipsing around picking up all my new so called good ideas…and it was the first class of fall semester and I was doing what I was told I should do…which was lay the groundwork for the class. My intention was to be supportive and give students sort of a reality check for what the class would be like. I did a whole two-hour lecture on class success and talked about the challenges to the class and how study skills are important and told them that if they woke up one day and saw something on TV and decided to become a nurse… they probably had no idea of what it meant to be a nurse…and I gave them Bloom's taxonomy and told them all about my educational experiences and I saw them glaze over. So I told them to just stop and write down what they were thinking and what they were feeling. Then a few volunteers formed a focus group and they went through what everyone had written…and it was just eyeeyeeye…had no clue! I had had the opposite effect that I had wanted! The students said I was speaking to them in a demeaning way…that all they could hear was that I thought they weren't capable…some had felt that my sentences and word choice were inflammatory…some felt scared…some were bored and said they'd heard that kind of speech before and just wished I'd get on with lecturing. When I asked the focus group what I could have done differently, they said they didn't know…but that it was negative and….they thought students would just rather figure it out on their own. And you know what? I came to the same conclusion! Setting the groundwork for active learning doesn't work.

The incident was followed by a series of student complaints to the administration, meeting of the recently-formed focus group to discuss what students liked and didn't like, a "blow-up that involved the Dean of Science, the Vice President, and the Dean of the Nursing", and ultimately, to a semester of traditional lecture. Quite to Prof. B's surprise, she had received unwavering support from her Dean throughout the confrontational situation.

Prof. B recalled the events of the past semester frequently, and on one occasion said that she would, "rather pick xxxx with the chickens that ever go through that [kind of experience] again". She indicated that she would not risk doing active learning again with the first-semester students because the material would be way over their heads (she referenced the ITIP Membrane Potential activity) and there would be "too much grousing and complaining". She vowed to never repeat the first-semester dynamic, "even if it meant that [she] had to go in and be a dictator and….keep control". Having said this, she began her participation.

Prof. B chose to continue with project participation because she felt it was critical for her to, "engage with students so that she could feel what some of the other participants were describing on the Listserv". She felt that because she was teaching A & P II—which tended to select for the better students who had accumulated insights on how to be successful--active learning would be doable.

Goals and other Motivational Beliefs Impacting Change

The primary goal Prof. B articulated (Table 10) was to "find better teaching methods". When asked to elaborate the generalized goal, she said that better teaching methods would allow her to reach her students, which meant that

Table 10 Prof. B: Motivational Profile

Nature of Competence/Theory of Intelligence:	
	I don't have the ability to change things efficiently. It seems I am trouble shooting things that wouldn't have been trouble if I'd left them alone. [pre]
	I want students to learn the material well enough to retain it but they don't…they just don't…no matter what I do. [pre]
	All the teachers here are saying this is the biggest "box of rocks" we have run into in a long time. In my opinion it's related to having no entrance requirements and picking up students that are totally under prepared. It's just the type of students that are appearing. [pre]
	The second semester students have acquired some insight into how to be successful. [post]
	A few of the students are intelligent; they have the brainpower to perform on tests. Others are high risk…they haven't developed…they have no clue…they are floundering..in way over their heads. [post]
	I can't write objectives because I don't think that way [pre and post]
Goal Statements:	
	I want to find better teaching methods to reach students [pre]
	It's critical that I engage with these students so that I can experience what the other participants are experiencing. [pre]
	I want to network with peers and outside the community college. [pre]
	I want students to learn material well enough to retain it so they can do well on the boards. [pre]
	I want to get students to construct their own knowledge base and to put the information in the context of what they know [post]
	I want some of this to be more understandable to students when they are done with the course [post]
Mistakes:	
	Trying to lay the groundwork for active learning was a mistake and I will never do it again. [pre]
What is Failure?	
	When I fail I think I should just go back to lecturing and then students are responsible for the notes and they do much better [pre]
	The students resistance to active learning makes me feel very inadequate.[pre]
What is Success?	
	When something works and I can look at students and know they understand it better. [post]
Attribution for Success:	
	I feel as if I'm learning...there are times when the universe aligns periodically and I must be in some major alignment [pre] [External, Unstable, Uncontrollable {Chance Event)]
	I cannot predict how something will come out because I don't have a ouijee board or crystal ball [post] [External, Unstable, Uncontrollable {Chance Event)]
	The second semester students did well with the dissection because they are better prepared academically.[post] [External, Unstable, Uncontrollable (Student Preparation)]
	The second semester students have somehow gained an awareness of how to be successful in the class. [pre and post] [External, Unstable, Uncontrollable (Student Awareness)]
Attribution for Failure:	
	Other people have told me that active learning isn't working for me because I don't make my expectations clear enough but when I tried that that didn't work either. That brought the whole house of cards down. [pre] [Internal, Stable, Uncontrollable (Instructor lack of ability)]
	Because of the terrible underpreparedness of my students, I must use an approach other than the lecture method to reach them. [External, Stable, Uncontrollable (Student Ability)]
	I don't stand a chance to succeed with all the backstabbing. [pre] [External, Stable, Uncontrollable (Student Behavior)]
	Students misinterpreted my intention to help them lay the ground work [pre] [External, Unstable, Uncontrollable (Student Interpretation Skills)]
	All teachers got blasted last semester with evaluations…its' as though all students were in sync and

	irritable last semester.[pre] [External, Unstable, Uncontrollable (Chance Event)]
	When active learning doesn't work it rekindles something about me interacting like I'm forgetting something or perceiving something about their level. I've forgotten what it's like not to know.[post] [Internal, Stable, Uncontrollable (Instructor lack of ability)]
	I'm teaching to a degree of difficulty I didn't teach to early in my career, and now I don't always know what is reasonable [post] [Internal, Stable, Uncontrollable (Instructor lack of ability)]
	Active learning doesn't work well with my students because they don't listen well and they are very dependent. They also don't have good learning skills [post] [External, Stable, Uncontrollable (Student Characteristics and Skills)]
	What I am trying to accomplish must be at odds with students' reactions [post] [External, Unstable, Uncontrollable (Student Reactions)]
	Priority is for comfort and control over student interaction "If I don't ask questions, then I don't open Pandora's' box and I don't have to deal with what flies out of the box"

they would learn the knowledge and skills that would allow them to: pass their professional exams, be effective health care providers, think independently, and appreciate that health care requires a commitment to life-long learning. Although not directly stated, a belief that learning is a result of instruction is implicit in Prof. B's goal elaboration. Other goals included wanting to experience what other participants were experiencing, networking with peers outside the Community College, and wanting students to learn material well enough to retain it and do well on their boards. Toward the end of the project, she expressed two new goals. She wanted students to construct their own knowledge base, and she wanted some of the course content to be more understandable to students when they finished the class.

Prof. B seemed to articulate a belief in a fixed theory of ability in herself (to implement active learning) and students' ability and attitudes. During pre-project data collection, she reflected, "I don't have the ability to change things efficiently" and "I can't write objectives because I don't think that way". Regarding student ability, throughout the project Prof. B spoke of her students seeming inability to learn and retain information. A fixed theory of intelligence also came through in statements about the small percentage of intelligent students who "had the brainpower" to perform on tests. Prof. B's statements related to failure were consistently focused on herself (rather than the students) and indicated maladaptive patterns of attribution. For example, prior to the project start, she indicated that because of the, "terrible under preparedness of my students, I must use an approach other than lecture method to reach them. In this example, she attributes failure to her students (external), to a stable student trait (a terrible under preparedness that stands little chance of changing), that she has no control over (uncontrollable). The external/stable/uncontrollable pattern of attributions emerged regularly in Prof. B's explanations. Another common pattern was external/unstable/uncontrollable. For example, also prior to the project she commented: "All teachers got blasted last semester with evaluations." In this statement, failure is again attributed to external factors outside of Prof. B, a temporal state or chance happening (unstable) and again is uncontrollable because—who can control chance?

Prof. B's statements related to success were focused either on students or herself and again indicated maladaptive patterns of attribution. For example, the external/unstable/uncontrollable pattern emerged in her explanation of recent learning: "I feel as if I'm learning…there are times when the universe aligns periodically and I must be in some major alignment. Prof. B attributes her success to factors outside of her control--an external, unstable factor (chance). These belief statements triangulate with her fixed theory of intelligence. Since her own ability is fixed, success must be due to something outside of her—hence, the consistency in the external locus. Several exceptions to the pattern were found, as in the following statement: "I'm teaching to a degree of difficulty I didn't teach to early in my career, and now I don't always know what is reasonable." Here, the attribution is internal, but again stable and uncontrollable (there is something about my ability/perception that doesn't allow me to know).

Project Activities

Prof. B's planned course of action deviated somewhat from the suggested, two-activity and feedback plan. Although she renewed her commitment to project participation and to interact with students and get feedback on lab activities (her teaching responsibilities had been extended to include labs because team instructors had taken on additional teaching assignments), she indicated that she would also be developing a system to track correlations between success in A & P and Nursing School[1] and planning the development of a system to convey course expectations and improve the success of first-semester A & P students.

The first lab activity of the semester was one that Prof. B had used before. The activity called for student teams to dissect a whole sheep heart, identify key structures of the heart, and insert dissecting pins and name labels into the structures. Students were given a diagram of heart structure and a heart model to help make identifications. In contrast to the last time she had used the activity—where students had been given an already dissected half-heart—she said that she

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[1] Conversations based on program review experience among instructors of A & P, seem to suggest that external, Nursing Program reviewers have found that students' A & P course grades are positively correlated with performance on Nursing Board exams.

instantly noted that students learned more from the dissection and had a better, three-dimensional understanding of anatomical structures and relationships than they had in the previous semester. Although she didn't collect written formative feedback, and post-quiz results didn't particularly reflect improved learning, she felt that "students understood much better" based on conversations she overheard.

Although she didn't acknowledge it as a change, Prof. B also described a modified grading system where she gave students credit (they were given a "plus" in the grade book) rather than points for the activity and the ability to respond to questions as she circulated around the lab. She described with elation, one student who had missed the opportunity for a "plus", came to her and asked if she could work a little longer and then try again to explain the structures and respond to questions. Prof. B. exclaimed, "Oh this was music to my ears!"

Four weeks into the semester, Prof. B began a lab session by asking students to respond in writing to three questions: 1) What is the topic of today's lab? 2) Name two of the five tests that you'll be performing today, and 3) What one question do you have about this weeks' lab? She commented on her rationale for beginning a lab with feedback collection: "I've always been kind of curious to know if they are reading their lab manuals before they come in…I have told them one hundred million times that they should…and if they are coming to lab unprepared they might just as well stay home." Prof. B spoke with amazement as she summarized her thoughts after reading the student responses,

> This has just made my whole day…because I am not thinking like they are at all! They knew the lab was about blood and most could name the tests

> but the third question….I can categorize the responses! The first group is having technical difficulties…they get disturbed by a few typos or mislabeled figures…and that's helpful because it's easy to fix…the second group is having logistical problems…they aren't sure how to make dilutions or use a pipet…and the third group is just out in the ozone someplace! Stunned is a strong word…but some of these questions are the kinds of questions that [elementary-age students] would ask…[describes how comments aren't relevant to the lab]…this question about why we don't use monkey blood instead of sheep blood so that it would be more similar to human blood…. is just….doesn't she understand the concept of mammalian blood?

She went on to describe that:

> ….this experience has rekindled something about me interacting with them…that I'm forgetting something…like I am not validating something or perceiving something about their level…I've forgotten what it is like not to know…and when you do something new…you pull all your associations in…this is just mind-boggling.

Immediately following the experience, Prof. B said that the pre-lab questioning technique would become an essential component of her classroom practice because it was the only way she knew of to figure out if her expectations were reasonable. She continued, "…maybe what is happening in class…with the negativism and alienation….is that I've gotten bored with the material and I'm expecting them to do too much …"

Perceived Supports and Obstacles

Over the course of the project, Prof. B shared her perceptions of the supports (Table 11) and obstacles (Table 12) to implementing active learning. Thirteen supports and 35 obstacles were mentioned prior to the start of the project semester. Prof. B stated that the three biggest obstacles to active learning use were under prepared students, negative student attitudes, and the 17-week semesters which she felt were too long to sustain high effort and energy.

In addition to the semester length, other college-level obstacles (there were no supports) were identified as the open admissions policy, inadequate technology to support project participation, an unsupportive administration, a questionable administrative attitude toward active learning, a Union policy that prevented instructors from doing peer observation, and inadequate ESL screening. Departmental-level obstacles (there were no supports) included: an unsupportive

Table 11 Prof. B: Perceived Supports Over Time

	Pre-Post	Post-Project
College	Adequate technology to support project requirements and student learning	Adequate technology to support project requirements and student learning
	Supportive administration	Supportive administration
		Connection with Academic Department colleague
Department	Supportive administration	Supportive administration
		Development of system to convey expectations to first semester students
	ITIP supplies found	
Course	Successful image; Students do well on Nursing Boards	Successful image; Students do well on Nursing Boards
	Student diversity poses no problems. All students must leave the class having worked toward the same educational goals.	**Modified grading system (point system replaced by +'s)**
Instructor	Familiar with and uses active learning strategies	
	Familiar with research literature supporting active learning	
	Motivated to find better teaching strategies to reach students	Motivated to find better teaching strategies to reach students
Students	A small number of second semester students are well prepared and motivated and will be able to do active learning	**Some second-semester students are motivated and can do almost anything.**
Professional Organizations	Informative HAPS meetings and workshops	**ITIP network support**
	Motivating ITIP Listserv discussions	Motivating ITIP Listserv discussions
	Case studies in science workshop	**ITIP site visit**

Table 12 Prof. B: Perceived Obstacles Over Time

	Pre-Post	Post-Project
College	Open admissions	Open admissions
	Long semesters	Long semesters
	Questionable administrative support for active learning	Questionable administrative support for active learning
	Dean of Nursing (involved in previous semester student conflict) sided with students and has recommended that the difficulty level of A & P tests be reevaluated.	**No coordinator for the Nursing Program**
	Inadequate technology	
	Union policy precludes peer observation	
	Optional ESL services for foreign students	Optional ESL services for foreign students
Department	Excess requirements for student contact hours/teaching/committees	Excessive departmental requirements for student contact hours/teaching/committee work
	Questionable commitment to quality teaching and learning	Questionable departmental commitment to quality teaching and learning
		No reward for curriculum revision/course improvement
	ITIP supplies moved and temporarily lost	
	Professional development funding is available only every other year	Professional development funding is available only every other year
Course	Requirement for heavy content coverage to prepare students for Board exams	Requirement for heavy content coverage to prepare students for Board exams
	Limited time	Limited time
	Student diversity precludes being able to meet all students needs	Student diversity precludes being able to meet all students needs
	Strained team teacher relationships	Strained team teacher relationships
	High attrition (30-60% in the first semester)	High attrition (30-60% in the first semester)
	Balances were stolen from the new science facility	
Instructor	Hesitancy to participate in Listserv discussions	**Deleterious and tenacious nature of past experiences/beliefs**
	Tried but abandoned outlining/concept mapping; Doesn't like small group work	**Lack of knowledge about student content knowledge**
	Little collegial interaction or support	**Shortage of class time precludes curriculum flexibility**
	Alienated from students	**Students in crisis require excessive attention; instructor can't do justice to more capable students**
	Does not write course objectives	Does not write course objectives
	No teaching methods training	No teaching methods training
		Lack of skill in responding to students' incorrect verbal responses
	Thematic nature of content is unclear	Thematic nature of content is unclear
	Confusion about active learning	Confusion about active learning
	Perceived loss of well-being	
	Dissatisfaction with changes made to date	
	Exhaustion and hopelessness	
	Increasing student alienation	
	Perception of weak organizational skills	
Students	Most lack foundational knowledge, study skills, realistic expectations, and motivation to do active learning	**Half of the second-semester students are in crisis.**
	First-semester students are incapable of doing active learning	
	Limited knowledge of learning supports available at college	**Students can memorize but can't synthesize information.**
	Some second-semester students don't have the foundational knowledge or motivation to do active learning	
	Students have high anxiety in test situations	Students have high anxiety in test situations
	Unrealistic course expectations: overcommittment to jobs/ families/other course work; frustration and negativity	**Students are too dependent**
		Students don't know how to ask relevant questions
		Student negativity
Professional Organizations	State CTL doesn't meet the needs of science instructors	State CTL doesn't meet the needs of science instructors

administration, excessive requirements for student contact hours/teaching/committee work, a questionable departmental commitment to quality teaching, professional development funding (funding was available only once every two years); and support staff that "move and lose" instructor materials (the project start up packet and student surveys). At the course level, there was one support—the course had established an image of success because passing students went on to score extremely well on the Nursing Board exams. Five obstacles were given: a traditionally high attrition rate, the requirement for heavy content coverage to prepare students for Boards, strained relationships and little communication between the team teachers, student diversity, and limited time.

At the instructor-level, three supports and four obstacles were reported. Prof. B felt that her strong motivation was a support, as were her knowledge of active learning strategies and the research literature that supports active learning. She felt somewhat hesitant to participate in the project Listserv discussions because of an unpleasant past experience on another Listserv (obstacle). Other obstacles included: little opportunity for on-site collegial interaction, feelings of alienation from students, and a lack of fondness for "some of the techniques felt to support active learning" (such as, small group work, concept mapping, and outlining).

In addition to under prepared students (student-level obstacles), Prof B also felt that "working students" presented two obstacles to using active learning: generally they were not knowledgeable of learning support services that were available to them, and as a result of not having realistic expectations of the course, they had a tendency to over commit to jobs, families, and other course work However, she did believe that a small number of motivated students would be able to do active learning (support). Finally, at the level of professional/organizational support, she had experienced informative HAPs meetings and workshops and anticipated that more would follow, but felt the State CTL would be at best, no support, at worst, an obstacle.

Although most of the same supports/obstacles were reiterated at the beginning of project participation, there was a net gain of three supports, four obstacles, and numerous shifts between categories. Prof. B's belief about departmental and college-level administrative support had changed from an obstacle to a support because of the backing she had received during the semester that she had abandoned active learning, but there was now friction with the Dean of the Nursing School who had sided with the first-semester students and had recommended that the difficulty level of the A & P tests be reevaluated (obstacle). A move into a brand new science facility ("it's excellent…and wired") eliminated the previous departmental technology obstacle, but the theft of balances from the new facility had added an obstacle at the course level. Two opposing beliefs related to student diversity (diversity poses no problems because all students must leave the class having met the same educational goals—versus--diversity poses severe constraints in the course and many student needs must go unmet) were expressed, and the critical support role of the project community was acknowledged. Of particular salience, the three baseline instructor-related supports had been omitted and eight new obstacles had emerged. The obstacles expressed a perceived lack of: general teaching knowledge and skills, knowledge about active learning; knowledge of how A & P content knowledge could be organized thematically, and, confidence and energy. Prof. B. also indicated that she had been dissatisfied with the changes she had made to date. Her elaborations follow:

> "I am not clearly getting the picture of what needs to be happening in this paradigm and I don't know which questions to ask…I'm not satisfied with the changes I'm making and don't seem to have the ability to predict what will be helpful and what won't.

Prof. B spoke of two, student subgroups at the beginning of project participation: A small group who were well-prepared and motivated (support); and, a larger group who lacked foundational knowledge, study skills, and the motivation/commitment to do active learning (obstacle). She believed that most of the students in both groups would demonstrate high anxiety in test situations. Prof. B's reflection on the first-semester students (within the context of the first-semester; not the first semester students who were now second semester students), remained firm, yet broadened to a more generalized belief: first semester students had been incapable of doing active learning (because they were under prepared and had poor attitudes) and all first semester students would be incapable of doing active learning in the future.

As the midpoint of project participation approached, Prof. B began to refer to her student population (second-semester A & P students) as two groups: "those in crisis" and "the few motivated students who can do almost anything." While the motivated students were seen as a support, an emergent obstacle was that in her role as instructor, she was so focused on the students in crisis that she was not able to do justice to the other group of students. Overall, student negativity remained an obstacle. Prof B believed this was due to a feeling of over-confidence (acquired from passing the first semester course), which had lulled students into taking on more responsibilities, and ultimately to negativity because they were unable to keep up with their course work. Emergent student-level obstacles were: students' inability to do more than memorize (they were perceived as incapable of synthesis); students' over-dependence on the instructor, and an unwillingness to listen, ask questions, or stretch themselves.

During the project, Prof. B spoke frequently of the time spent developing the system to convey expectations and improve success of the first semester students. Because she felt that the system would ultimately improve the conditions of the course, the development time was listed as a support rather than an obstacle. Another course-level support identified was her modified lab grading system, where a point system was replaced with a symbol (plus or minus) system.

Prof. B also described a new support, a relationship with an adjunct instructor who had begun sitting in on her classes and providing feedback. She was pleased with the feedback he had provided because it validated her own observations: that students weren't listening and were too dependent on her. Three new obstacles also emerged in the instructor category: the detrimental impact of past experiences on change efforts, a perceived inability to recall and respond appropriately to a student perspective, and a perceived inability to be flexible with the curriculum. Prof. B elaborated on each obstacle:

> I'm seeing how hard it is to break what you were brought up on…when you are a product of a certain way, that's where the comfort is;

> I have trouble remembering what it is like…not to know;
>
> I'm not sophisticated enough to respond to a piece of a sow's ear [students' incorrect verbal responses] with a silk purse [a response that is encouraging and corrective in nature]; and,
>
> I can't be flexible when I know students need to know all of this for the Boards.

Overall, 13 supports (in the categories of college, course, students, and professional organization) were identified and 28 obstacles (at all levels) were mentioned throughout the project.

Triangulation Researchers' Perceived Obstacles and Supports

Several months into project participation, Prof. B requested that a member of the ITIP community come to observe and provide feedback on her program/departmental/class/ student context. The individual spent three days observing and interacting and served as a point of data triangulation ("triangulation researcher") for this case. The researcher confirmed strained interactions between the teaching team members. The researcher speculated that instructors were either verbally slighting each other in the presence of students, or were not challenging inappropriate student comments made toward the other instructors.

Classroom observations and informal interviews with students confirmed much of the information Prof. B had provided in interview sessions. However, the researcher did not have the opportunity to observe one of Prof. B's lectures or labs due to a review session in the lecture and a practical exam in the lab.

However, it seemed to the researcher that the other instructors were in fact using very didactic teaching strategies. The researcher made the following comments:

> I spoke with a number of students who said they had taken the class previously [with Prof. B] and hadn't done well enough to get a passing grade… so the students were retaking the lecture with [one of Prof. B's team members]. One student told me, 'I'm doin' really well with [the team members' class]. I really like her lecture. She goes real slowly and writes everything down and she follows the book.'

Following a classroom observation of the instructor referenced in the above excerpt, the researcher continued:

> WELL [she] did teach the way the students had described to me. Not only did she follow the book, she READ to them from the book and then she would insert things…so she had the book open and the students had their books open and they were basically following what she said…and she was literally reading….I was reading along with her…and then she would stop and insert a funny story [about previous work experience]…so she is very engaging in that sense…and she is telling students flat out what they need to know … I didn't see her tests but I can't imagine that she could ask them to problem solve because that would have so alien to what she was doing.

In addition to classroom observation, the researcher met with the Dean of Clinical Sciences (who had supported Prof. B during the previous A & P I semester when she had abandoned active learning) and the teaching team. After a lengthy discussion on the goals, objectives, and curriculum for the program, the researcher commented:

> I am going to suggest to the Dean that somebody needs to be appointed as a coordinator for the program…there isn't one currently…and there needs to be a concerted effort to discuss and identify the primary objectives and the minimum content for a [semi] uniform curriculum [across instructors] within the bounds of academic freedom

The researcher commented with amazement that when she observed the different instructors' labs, each had a separate sequence of activities: Prof B. had students doing an anatomy activity, one instructor had no activity, and the other instructor was having students work on some sort of a [cookbook] lab that required students to add drops of solutions to wells, while the instructor did the dilutions for students.

The researchers' final comment related to obstacles for implementing active learning was that there was no indication that administrators were aware of the complicated process and time required to align curriculum and teaching activities to support a more learner-centered approach. "There is really no reward and little support for Prof B's efforts."

Impact of Project Participation

Three separate categories of change beliefs are provided: self-reports of change, data-based belief changes, and theory-based conceptual change. The impact on student content learning and attitudes is also presented.

Self-Reports of Change

Prof. B's perception of her changes were related primarily to more knowledge about strategies, students, and assessment and different beliefs about assessment and course impact. Her change statements are summarized below.

<u>More Knowledge</u>

Prof. B. felt she had more knowledge and a better understanding of the difference between providing information to students and giving them notes to memorize for the test. Her knowledge of tools (reading/comprehension, biology/chemistry pretests, learning styles inventory) that could be provided to first-semester students for them to self identify whether or not they were likely to be successful in the course, had also increased. She felt that she had improved knowledge about what students were thinking and how they were perceiving the content material (through individual, written feedback), and how they perceived the learning environment (through comments from the focus group). She also felt that she had become less factually oriented and was better able to prioritize information that would be important for student to know when they entered a clinical setting.

Changed Beliefs

Regarding assessment, Prof. B stated that she had changed her belief about what the purpose of testing was and had changed the way she went about writing tests. Previously, she said she believed that assessment was for giving a grade. Now, she felt the purpose of *her* assessments were to find out if students: could read; had memorized terms; and, could use and integrate terms and information from lab, lecture, and seminar. Prof. B, explained, "My tests are heavy reading…I don't think anybody should continue on that can't read because reading is critical to success in nursing school. She also indicated that she no longer "wrote tests right out of the notes just like everybody else did …and like what was done to me"; rather, she wrote tests to evaluate whether or not students were able to integrate information.

Prof. B said that she had also changed her belief about what students should be able to do after they've completed her class. "I used to think the most important thing that they gained in the class was that they were able to pass assessments. I am moving away from that idea toward thinking that they should know something about ethics and social and public health issues."

Data-based Changes in Beliefs about Teaching and Learning

Prof. B's evolved definition of learning downplayed the active, personal construction and motivation components (pre-project definition); emphasizing instead, information integration and retention. She defined learning as, "Hanging onto knowledge…it's different than short-term memory…it requires pulling information together from different inputs and absorbing it into long-term memory." Although the first-semester support system for students that Prof. B was developing (researcher was provided copies of the product and supporting material) still suggested that learning was perilous, the tone was somewhat more optimistic—with an emphasis on, learning is something that can be survived if one is adequately prepared. The analogy Prof. B made when describing learning was: the instructor as guide and students as prepared travelers.

Prof. B. described the instructor as someone who paraphrases the information in the textbook (because students expect this) and structures information so that students can put it into a framework of anatomy and physiology knowledge. She felt the instructor was someone who encouraged integration of new content and skills with personal knowledge, and introduced students to current research findings so they know what's going on in science. As she explained what this might look like in the classroom, a set of blended descriptors, best described as a teacher-centered system, focused on information transmission/content and skills integration/student negativity management, emerged. She described the instructor as:

> Someone with a background in basic sciences who has scrambled over the last ten years trying to figure out how people learn and has tried to apply some of these things, but doesn't know how to do these things well;
>
> Someone who should know most of the answers to questions students pose but is honestly still uncomfortable not knowing everything.
>
> Someone who knows she is a generalist and can't be expected, and is open with students, about not knowing everything; and
>
> Is alienated from students at times and stunned by the low level of questions they ask, but has become reacquainted with what it's like not to know.

When asked what she thought her changed beliefs indicated, Prof. B responded, "I suppose they show where I came from and where I am going", but added that she was at a loss to describe the destination. One gets the distinct impression after prolonged interaction with Prof. B that her changed beliefs are the result of--either conscious or unconscious--risk/benefit analysis. Although she has experienced the value of questioning students for their preconceptions and is now fully aware that she is not teaching to what they are thinking; she feels that the constraints of time, student attitudes, instructor knowledge/personal energy, and altering a historically-successful curriculum, outweigh the potential benefit of significant change.

Prof. B's conceptions about an instructor's role in the classroom seemed to have been integrated into one system. The information transmission system that highlighted the necessity of a "tightly-scripted" delivery of content had been coupled with a student management system that focused on minimizing negativity by trying to make the learning process doable for students. Prof. B elaborated on the system, saying that when she walked into a classroom she was keenly aware of the ticking clock and "it's like I have the sensation that things have to be covered and have to be done". Her continued descriptions indicated the coupled belief systems. She described giving students her complete set of notes, underlining everything in the notes and lab manual they were responsible for knowing, helping students see that "even though they are not A students they still more than when they started", and trying to involve students in some discussion without paying "any attention to how students' understanding is changing". When asked about how she prioritized her roles in the classroom, without hesitation she said: "I want to be able to keep it more tightly scripted so that I can feel more in control. Sometimes that is more important to me than knowing what student know or don't know."

While continuing to speak of her role in the classroom, although Prof. B expressed dissatisfaction over her interactions with students, the dissatisfaction had shifted from "the class" to one-on-one situations. On separate occasions, she spoke at length of interactions—different in nature--with two individual students who were experiencing learning challenges. Her interaction had been reserved and thoughtful when she had observed one student working alone in lab who was "floundering on labs and quizzes". She had offered suggestions, while wondering what her response, "in the active learning paradigm should be". Her reaction had been defensive when a second student had come to office hours because she was unable to find information in the textbook on a current topic that Prof. B had covered during lecture. According to Prof. B, the student,

> Came and spent a half hour in my office telling me that [the topic] wasn't in the textbook and she didn't know where to read anything more about it and she said she felt that if I was going to introduce topics like this that didn't follow the chapters…and if the topics weren't in the glossary…she accused me of not knowing what was in the textbook…I must have blown a blood pressure that was 200/100 because not only did she challenge what I was doing because it didn't fit her expectations about what a teacher should do…which is regurgitate the chapters…that what I was doing was something she couldn't read about…but I have told the class that there are topics that I will discuss and test on. She intended to offend me…was challenging me! I will never forget this! I told her perhaps this wasn't the right teacher or class for her and perhaps somewhere else would be more comfortable. She made me take a stand…I was furious…

When challenged to consider that the student may not have known how to locate references outside the textbook to find out more about the topic, and may have inadvertently been seeking help and guidance, Prof. B firmly responded that the student had deliberately come to office hours to attack her authority.

Juxtaposing stated beliefs about teaching and learning to descriptions of Prof. B's teaching strategies as well as descriptions by observation (provided by the triangulation researcher; described previously in Supports and Obstacles), suggests that the mixed belief system plays out in classroom practice. The comments from the triangulation researcher are paraphrased:

> She has an easy way with students and is personable in one sense…but rigid in another. She polls them at one time to find out how they'd like assignments sequenced, and then she'll have them do out-of-class group work and insist on four people per team. When I talked to students…they have families and so many logistical issues and said that getting together with three other people was such a drain.

With regard to researcher perceptions' of the driving belief system:

> There is a sense that the instructor wants to do everything…and that she keeps adding and adding to what students are responsible for…and she has some really well-done problems [that require students to construct their understanding]…one in particular that was great [2], but she's not getting rid of anything! There is so much that she covers. As a consequence, the constructivist elements are there but there's so much… that the problem sets have to be done out of class along with a lot of other homework. Students also are responsible for investigating and comparing current issues…but those assignments are enough to satisfy a stand-alone seminar class…. and are really quite peripheral to the foundational material.

The researcher commented on a challenge made to Prof. B about the amount of material that students were responsible for learning:

> When I confronted her on what students are responsible for she said, 'I just can't let go of the old model. I'm trying to embrace the new, but I can't let go…I can't convert'. And she's very much aware of where she's at in all of this. She told me that she had spent too many years thinking that all of this is important…to suddenly just get rid of it.

The researcher concluded that, "…maybe she is a person that really wants to do [active learning] but she is too tied into her role to convey content and she just can't let go of any content…which keeps the other from happening…".

Unlike Prof. B's phase-one beliefs which referenced one, large student group, she directed comments either toward first-semester students or second-semester students. The beliefs about the first-semester students (who were now referred to as, "the group that saw the glass as half empty") were exclusively unfavorable, similar in nature to the baseline beliefs. The second semester students ("the group that sees the glass half full") were described in a more

[2] The problem: After covering cell organelles, students are given a three-dimensional diagram of the milk gland cell and asked to identify all the organelles and specify their function. Then they read through a paragraph about what the cell does and they write about how that applies to the representations in the figure.

positive light, despite the fact that all had been students during the first semester with the exception of a couple of transfer students. This group was described as being able to think on their feet, locate challenging anatomical structures and make statements that reflected an ability to compare and contrast, and answer questions that required integration of information from lab, lecture, and seminar.

As Prof. B described classroom events, her comments about students seemed to align with a less challenging definition of learning. Although she continued to reference a small group of good students, she stated that most of her students were too dependent and not willing to stretch themselves. When asked to describe what students do in class to learn, Prof. B's comments were directed toward two groups of students: 1) those that complained about too much information to integrate and memorize, wanted the bottom line, sat in lab reading their textbooks rather than working with lab materials, and couldn't even get a C in the class, and 2) those that were motivated to learn, talented and committed, and did well in the class.

Conceptual Change

To determine if Prof. B demonstrated the criteria for conceptual change, statements of dissatisfaction, intelligibility, plausibility, and fruitfulness were searched for.

<u>Evidence of Dissatisfaction</u>

Direct statements of discontent or mental disequillibrium were searched for to determine if Prof. B had become dissatisfied with her traditional beliefs about teaching and learning. Pre-project statements that seemed to convey knowledge of the problematic nature of lecture were found, but the statements were transitional and lacked a perceptual or experience-based element:

> I know that lecturing is not conducive to fostering the skill set needed by today's health care workers... it doesn't allow me to reach students and I know they don't retain the material…their preference would be to finish a chapter and then take the test immediately…so that tells me they don't even want to try to retain it or think that's important…and I know that they really don't have strong listening skills…it's all about short term memory to make it through.

In contrast, during project participation, statements of satisfaction with the traditional belief system were common:

> When I lecture and hold my students responsible for the notes, they learn better.
>
> I have to say it [to students] in order for them to know it.
>
> I want to be able to keep it more tightly scripted so that I can feel more in control. Sometimes that is more important to me than knowing what they know or don't know.

No consistent, experientially based statements of dissatisfaction were identified.

Evidence of Intelligibility

For evidence of intelligibility of constructivist teaching, statements that indicated understanding and internal representation of constructivist teaching and learning beliefs (long-term knowledge construction, knowledge application to solve problems, extension or modification of preconceptions) were searched for.

Interestingly, intelligibility statements were found only outside of Prof. B's telling of classroom events as illustrated in an interview exchange:

> Interviewer: So what are teaching sessions for if they are not to give students a good set of notes?
>
> Prof. B: Teaching sessions are a place where the instructor facilitates…helps students construct their own knowledge base using several different inputs at the same time…. experiential versus conceptual….

Much more common, and within the descriptive context of her own classroom experiences, were passages that indicated *lack of intelligibility*:

> Students want me to paraphrase the text and read them the notes…yet when I say…"No"… I am there to facilitate their learning…there is a part of me that doesn't know what that means. I am very confused…. what they say they want me to do is what I experienced…I know what that means.
>
> I'm not sure about the restructuring of existing knowledge…. what I do is focus on comparing what students knew when they started the class to what they know now. So, for instance they might have known something about the foot but now they know some of the bones of the foot…so I want to show them they know more in a short about of time.

No experientially based statements of dissatisfaction were identified.

Evidence of Plausibility

For evidence of plausibility, statements of belief in constructivist-based instructional strategies, consistency with experience, and an intention of use in future practice were searched for. Evidence of intent is suggested by Prof. B's decision to volunteer and commit to project participation, but intent is diminished by goal statements that do not address improving student learning and statements that suggest a lack of intelligibility and implausibility.

If taken out of the context of the total project experience, two potential instances of plausibility were found. Both instances occurred in the laboratory, and both were related to activities that were directed at satisfying project requests. In both cases, Prof. B described a feeling of immediate gratification and described future plans for both activities:

> [Pinning the heart] worked really, really well. Having them work in pairs doing the dissection and locating structures using a key and models and labeling…it really turned their ability to think three-dimensionally around 180 degrees…and in fact, I am planning on writing that up for an activity suggestion…it was so simple and cheap and they were so proud of what they accomplished especially when I asked them questions and they had to think on their feet…it's a tough exercise.
>
> [Getting feedback from students] was a great thing because it gave me a much better perspective of where these people are at…and sometimes I forget where they are starting…I thought when I swore to myself when I was a student that I would never forget what it was like to know…I thought I wouldn't forget…but I did. I was telling [one of the other teachers] about this and how great it was and I am planning on doing it again…asking them to share their ideas about how muscles move bones next week….

Interestingly, towards the end of the project as the status of Prof. B's traditional belief system increased (perhaps in response to a feeling of lack of control and continuous discomfort), statements of *implausibility* of constructivist teaching became common. Although Prof. B indicated that she had experienced the value of collecting student feedback and knew that students entered the course with "some of the strangest ideas" and knew that learning improved when she was "more in tune with what they were thinking", she commented:

> I can't blame it on time, but when I am in the trenches...I'd rather not open Pandora's Box to tune into what they are thinking…if I open the box then I have to do something about it…I'd rather teach to what I've planned so that I can keep the lecture more tightly scripted so that I can feel more in control….That is more important to me than knowing what students know or don't know…. It's hard to break what you were brought up on. When you are a product of a certain way, that's where the comfort is.

In response to administrative and personal concerns, she also began to question whether learner-centered teaching was a fit at the College and a fit for her personally. She commented:

> Ever since I moved to this kind of teaching [learner-centered], students flock to the other [lecture] classes that are available. Should I go back to writing everything down, testing them on their ability to recall what's in the notes, and give them the bottom line? I think I would get more sleep and have less anxiety. I am getting to the point that I am too worn down to care….and there's certainly no reward in this… I am tired of being the dragon at the gate of their nursing career.

Implausibility of the constructivist definition of learning also became apparent as Prof. B's dissatisfaction with her traditional belief system began to dissipate. She dismissed an earlier observation that she had made—that students still repeated their strange ideas and misconceptions after hearing a lecture containing accurate information—when she commented:

> I have to say it in order for them to know it… There is something about coming to class…students think my job is to paraphrase the book and they feel that is the only job the teacher has…they believe that if they don't hear me say it, they don't know it.

Interestingly, disengagement with active learning was implied when Prof. B indicated her desire to participate in the development of an on-line A & P course. She admitted that although she was the biggest opponent of on-line learning in the department and her opposition was based on a strong bias, she elaborated, "it would be a good experience for me" and would ultimately decrease contact time with students".

Evidence of Fruitfulness

No evidence of fruitfulness (perceived ability to understand, project, and apply a constructivist cognition to actual classroom practice) was found. As with plausibility, Prof. B speculated that "time" was the factor constraining her ability to consistently plan for and "pull active learning off" in her classroom. "[In order to do this better] I would have to shift and reconstruct my paradigm…to do that, I need to take some time off and think about this and come back with a different approach."

Student Change

Changes in content understanding and attitudes toward teaching and learning were determined from pre and posttests of students in Prof. B's class.

Thematic Content Learning

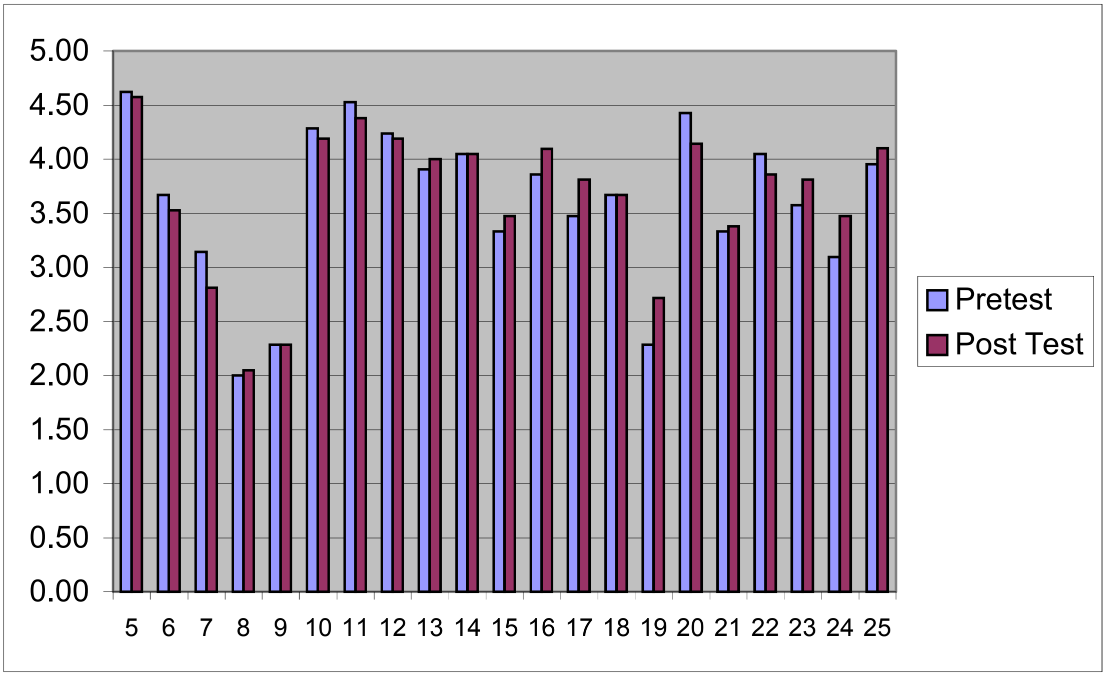
With the limitations (described in Chapter One) on this data in mind, students' understanding of gradients at four knowledge levels were: a 1% improvement in questions at the remembering level, an 8% increase in questions at the understanding level; a 5% increase in questions at the application level, and a 9 % increase analyzing, and an overall increase (all categories) of 1%. When asked to speculate why the increases in content understanding were only marginal, Prof. B indicated that students took the content test after completing a two-hour exam and she was, "just happy that *marginal* increases were shown." She elaborated that other than a few bonus points; there was really no incentive for students to try to do well on the test.

Attitudes about Teaching and Learning

Over the course of the project semester, data suggest that Prof. B's students experienced two significant changes: they were more inclined to believe they work hard in the class primarily to get a good grade; and they were more inclined to believe that the purpose of class tests was to determine if they had memorized the information. Since the significant attitudinal changes suggested movement toward a performance goal orientation (working hard with a focus on getting a good grade) and such an orientation is known to impede meaningful learning (Dweck, 1986), a holistic examination of the attitude data was necessary to determine if responses to other survey questions supported the interpretation (Figure 2).

With regard to goal orientation, there is not strong support for interpreting movement toward a performance goal orientation. Contradicting this interpretation are data that suggest that students valued mistake making as a part of the learning process over the course of the semester (question 18; 3.6 stable). Movement toward a performance goal orientation would have been supported had this belief declined significantly over the course of the semester. Other survey questions that addressed goal orientation suggested little or no change over the

Figure 2 Prof B: Student Attitude Changes Over Time



Questions 5-25 are located on the student attitude survey located in Appendix C course of the semester. For example, despite a slight decline, students continued to evaluate their learning by looking at the progress they made over time (question 22; 4.0 to 3.8) rather than comparing their performance to other students in the class (question 9; 2.3 stable), and had the same inclination to believe that understanding information was more important than getting a good grade (question 21; 3.4 stable). Although student responses suggested somewhat higher motivation to work for a grade rather than understanding (question 17; 3.8 versus question 21; 3.4), from a practical perspective this may not be unreasonable given their situation. Students must value understanding and grades when they are required to earn a given grade in order to move on in their studies and ultimately attain their goal of a health-related career.

With regard to the purpose of tests, not only did the strength of the belief that tests should determine whether students have memorized information increase (question 19; significant increase from 2.3 to 2.8), the belief that tests should challenge students to think about concepts in novel ways also increased (question 24; 3.1 to 3.5). Certainly the tendency to believe that tests should challenge thinking was greater than the tendency to believe that tests should measure memorization success. Increases in both beliefs may suggest that students are gaining an appreciation for the complimentary roles of memorization and novel thinking in the learning of anatomy and physiology.

Although student learning preferences for lecture/note taking (question 6; 3.6 to 3.5) and in-class problem solving (question 13; 3.9 to 4.0) changed very little over the course of the semester, data suggest a preference for in-class problem solving activities over lecture/note taking (4.0 versus 3.5). And, although students were less inclined to study by putting information into their own words, reorganizing, talking about material with a classmate, or trying to use it to solve a problem (question 20; 4.4 to 4.1), they were still more inclined to use the aforementioned study strategies than they were to read information over and over (question 15; 3.4 stable).

With respect to what students thought the instructors' role was in the classroom, throughout the semester students demonstrated a strong belief that the instructor should: challenge students to think (question 14; 4.0 stable), and use class time to provide different examples and explain difficult concepts in new ways (question 10; 4.3 stable) rather than simply presenting the information in the textbook (question 7; 3.2 to 2.8). Data collected through question seven seem to support Prof. B's claim that students believed that the instructors' primary responsibility was to present textbook information. However, the data also suggest that this belief declined (albeit not to the point that it became statistically significant) over the course of the semester. Further, student valuing of instructor feedback increased over the course of the semester (question 16; 3.8 to 4.1).

Although student beliefs about whose fault it was when understanding was difficult remained relatively stable over the course of the semester (question 8, instructor's fault; 2.0 stable versus question 5, student's fault; 4.0 to 4.1), data suggest a strong tendency for students to attribute the difficulty to themselves and seem to recognize their responsibility to work harder to remedy the situation. Finally, students did recognize a slight gain in their topical knowledge at the end of the semester (question 23; 3.5 to 3.7) and confidence in their ability to learn basic information remained high (question 5; 4.5 stable), as did their confidence to integrate material to understand how systems interacted in the body (question 12; 4.3 stable).

In summary, a holistic examination of the data indicated little if any movement toward a performance goal orientation. At the end of the semester, students were more inclined to want to work at the level of examples and difficult concepts than "covering textbook information", were more inclined to favor the use of study strategies to promote information integration rather than simply reading information over and over, and were more inclined to believe that tests should challenge thinking rather than measure memorization success.

Summary of Beliefs

An overview of Prof. B's beliefs about teaching and learning, motivational profile, perceived supports and obstacles over time, and change profiles are summarized in Table 13.

Table 13 Prof. B: Summary of Data

Beliefs	Learning	Students	Student Action	Instructor	Instructor Action	Class	Assessment
Pre	Two sets of beliefs: 1. Personal - something everyone can do; requires thinking on feet and willingness to "buckle down"; excruciating 2. Adopted - Have insights make connections; requires working in teams	Underprepared and overcommitted people (poor: foundational academic skills, attitudes, and organizational skills)	Inattentive, blaming, don't take responsibility for learning; act with a sense of entitlement; Low/no learning actions described	Two sets of beliefs: 1. Personal - content expert with clinical experience (passionate, confident) 2. Adopted - facilitator (disconnected, frustrated)	Three systems: 1. Personal - knowledge transmission, authority 2. Adopted - learner engagement 3. Alternate - Regain control; student appeasement	To cover information (Lecture)	To give a grade
Post	One belief set: Personal - Hanging onto and pulling knowledge together from different inputs; knowing "more"; time dependent	Two groups of students: 1. First semester - Underprepared people 2. Second semester- people who motivated, talented, and committed but don't have good self-assessment skills, have misconceptions, don't understand the value of content retention, dependent, anxious	Two sets of actions: 1. First semester - Complain there is too much information and only want the bottom line 2. Second semester - Pass the class; ask low-level questions; don't want to be told they are wrong; validate and appreciate the importance of content and terminology	One set of beliefs: Personal - After constraint and risk analysis has found balance as a Content generalist (transmits information, encourages content integration, manages student negativity), who is learning about teaching and learning	Two systems: 1. Personal - knowledge transmission, authority 2. Alternate - Regain control; student appeasement; involve students in discussion	To cover information (Lecture)	Test reading skills, memorization, and integration of content from lab, lecture, and seminar

Motivation	Goals	Intelligence	Mistakes	Success Attribution	Failure Attribution	Failure	Success
	Find better teaching methods to reach students [pre]	Instructor Fixed	Although informative, won't do again	External, Unstable, Uncontrollable (Chance)	Internal, Stable, Uncontrollable (Instructor Lack of Ability)]	Instructor oriented	Student Oriented
	Engage with students so I can experience what other participants are experiencing [pre]	Students Fixed		External, Unstable, Uncontrollable (Chance)	External, Stable, Uncontrollable (Student Behavior)]		Activity Oriented
	Network with peers outside community college [pre]			External, Unstable, Uncontrollable (Student Preparation)	External, Unstable, Uncontrollable (Student Interpretation Skills)]		
	Want students to learn material well enough to retain it to do well on boards [pre]			External, Unstable, Uncontrollable (Student Awareness)	External, Unstable, Uncontrollable (Chance)		
	Want students to construct their own knowledge base and put it in the context of what they know [post]				Internal, Stable, Uncontrollable (Instructor Lack of Ability)]		
	Want some of the course content to be more understandable to students when they are done [post]				Internal, Stable, Uncontrollable (Instructor Lack of Ability)]		
					External, Stable, Uncontrollable (Student Characteristics and Skills)]		
					External, Unstable, Uncontrollable (Student Reactions)]		

Obstacles and Supports

	Academic Community	College	Department	Course	Instructor	Student	Professional Org	Total
Obstacles Pre	0	6	4	6	13	6	1	35
Obstacles Post	0	6*	4	5	6*	6*	1	28
Supports Pre	0	2	2	2	3	1	3	13
Supports Post	0	3*	2*	2*	1	1*	4*	13

* Modified or changed

Change

Self-Report	Change Event	Data-Based	Conceptual	Tries to Adopt Student Perspective	Student Attitudes	Student Content
More knowledge of teaching strategies	Doing active learning	Learning: Yes	Dissatisfaction: No Evidence	No-but remembered what it's like not to know	Goals: More inclined to believe that they work hard in the class primarily to get a good grade.	Remembering: 64 to 65% = 1%
More knowledge of self-assessment tools	Self Learning/Colleague Interaction	Students: Yes	Intelligibility: No		Testing Purpose: More inclined to believe that the purpose of tests in the class is to determine whether students have memorized the information	Understanding: 52 to 60% = 8%
More knowledge of students content understanding	Doing formative assessment	Student Action: Yes	Plausibility: No			Applying: 41 to 45% = 5%
More knowledge of student perceptions	Organizing student focus group	Instructor: Yes	Fruitfulness: No			Analyzing: 27 to 36% = 9%
Improved instructional strategy	Rethinking rationale behind applicability of content	Instructor Action: Yes				Total: 41 to 49% = -0.7%
Purpose of assessment changed	Self Reflection	Class: No				
Purpose of class changed	Self Reflection	Assessment: Yes				

PROFESSOR C: THE RESEARCH UNIVERSITY A & P LECTURER

> As a lecturer at a Research University it's possible for me to go a whole year without anybody checking up to see how I am doing or how my students are doing. Research is what's valued and researchers are the gods of everything. It's ironic to me that researchers… who are problem solvers at heart…don't see it as their responsibility to help the undergraduate students they teach to become problem solvers. I don't understand why they don't approach their teaching in the same way they approach their research…as something they have to figure out…apply some creativity…some innovation…incorporate what's known about learning…push some boundaries.

Pre-Project Information: A Snapshot

College, Department, and Course

- Quality teaching is not something that stands out as a focus at the institution or within the department.
- At the departmental level, the idea of teaching and learning seems to be that if an exam is given and students spit back information, they've all learned.
- There is little if any communication between schools or departments and even somewhat of a disconnect between physical scientists and life scientists.
- Although the workshops offered by our Center for Teaching Effectiveness are very helpful and open to all instructors on campus, the Teaching Resource Center, which conducts workshops on developing skills and strategies in the classroom, excludes Lecturers.

- A & P II is the second semester of a two semester course taken by about 125 sophomores and juniors planning allied health careers. The four-credit hour course is a made up of three hours of lecture, one lab, and one discussion per week. Prerequisites include A & P completion and I of biology, chemistry, and physics.
- Because of the large number of lab sections, it's a challenge to synchronize the content material in the lecture and labs. Despite the tightest scheduling possible, still may experience somewhat of a disjointed feeling.

The Students

Prof. C's students are traditional, full-time students in their early 20's. If they work, it's typically a part time job or volunteer position at a hospital or clinic. Since the second semester students have already completed the first semester course, also taught by Prof. C, they have a pretty good idea of what physiology and active learning is about —which isn't to say that they did going into A & P I. Prof. C commented, "as first semester students, many of them entered the class with the expectation that they were going to memorize every bone and muscle in the body", and some felt "knocked for a loop" with the process nature of physiology and being active in class. Prof. C explained, "It's like they come prepared to name the chess pieces, and I tell them we are going to play chess". As first semester students, only a small percentage keep up with the assignments, but by second semester a majority of them are more on the ball and improving in their attitude toward doing activities in class.

The Instructor

Five features distinguish Prof. C from the other instructors in this study. One is that the discussion sections and labs of her course are taught by graduate teaching assistants, who generally don't have any teaching experience, let alone any experience with active learning. Prof. C explained,

> It's as if they share the student perspective that the instructor should give students everything they need, so…as I'm using strategies to foster student independence, they are in the discussion sections working against my efforts by telling students everything—almost as if they are attempting to make up for what they think I'm not doing.

The second distinguishing feature was that just prior to the project start Prof. C saw the need to create learning objectives for her students to support their independence and lower their level of frustration related to not knowing what they were supposed to be learning. She located and modified learning objectives from the APS medical curriculum objectives. Although she believed that some of the objectives were too complex for her students, she indicated that there were many that were right on target and others that just "needed tweaking" to put them at the appropriate level. She explained what she particularly liked about the APS objectives,

> They have given me a different frame of mind in terms of thinking because they are written as actions rather than as statements. So a traditional objective would be something like: Students will understand cell structure. But, these objectives describe what students should be able to do. For example…instead of the 'students will understand' format, these say something like…students can describe the composition of the cell membrane, diagram the cross section and explain how the distribution of phospholipids and proteins influences the membrane permeability of ions, hydrophobic, and hydrophilic compounds.

Third, more so than other participants in this study, Prof. C faced obstacles at the institution and departmental level, which required a constant and attentive awareness. For example, prior to the project semester, she became acutely aware of her research colleagues' perceptions of how one climbs the academic ladder of success and how her use of active learning might impede movement much beyond the first rung. She explained,

> [This process has] been interesting for me because as I've started to share small successes with my researcher peer group…who also teach…and tell them what I am trying in the classroom and seeing changes in my students…and every time I bring up the subject…and I know that my focus on learning not my own polished presentation of the content is coming through…it seems like I get…either ridiculed or treated with skepticism. The comments they make to me start off as sort of making fun and then get worse…they say that …the more I value teaching the less I deserve a job… other than Lecturer. They say that I don't deserve a place in academia because I don't teach the right way! So by valuing student learning and developing instructional strategies to improve learning, I've devalued myself in the eyes of my colleagues.

Further, within her department, there is a heavy reliance on end-of-semester evaluations for judging the effectiveness of lecturers, and little consideration or incentive to use evaluations to support anything other than the basis for retention (good evaluations) or dismissal (poor evaluations). Moreover, there is a culture that views lecturers as expendable resources.

Fourth, Prof. C coins personalized, descriptive terms for the strategies she uses in the classroom to promote student learning. She routinely talks of "bridging" the lecture/lab/discussion curriculum, "coaching and modeling" the skills she wants her students to develop, and creates situations to facilitate "cue-based" problem solving and improved student retention.

Finally, following her project participation, she simultaneously received a harsh reprimand from the Chairman of the Department to "not do active learning if you are not good at it!" and received a student nomination for a university-wide, "Greatest Impact Teaching Award". Regarding the reprimand she commented, "It was awful." Regarding the award nomination, she said, "I hadn't heard of it until I was nominated…the women that nominated me said that in the years at the University, I was the instructor who had the greatest impact…pretty cool…yeah…that's pretty cool."

Project Participation: A Snapshot

Project participation data was collected in nine, 60-minute personal interviews, one, 20-minute phone interview, five classroom observations, four written surveys, course syllabi, class objectives, and numerous email exchanges.

Instructor's Prior Experiences

Prof. C received her undergraduate degree and Ph.D. from separate Research Universities. Her college coursework was fairly traditional with lots of lecture, but there were opportunities for discussion. When recalling her undergraduate experience, she indicated that one of her strongest areas of discontent was with her own approach to learning: she was too quiet and wouldn't contribute to discussions. As a graduate student she remembers taking courses offered by the medical school. "Man! Those lecturers used those little bitty typed words on a slide just crammed full of information. You couldn't even see what was up there much less know what a person was getting at!" When asked to recall teachers who may have impacted her own teaching, she recalled her high school biology teacher:

> When I took Biology…I felt like the world had been revolutionalized! She had this phenomenal respect for biology and she imparted that to me…it was funny because before that I had thought that chemistry and physics were real science but biology was not…but she challenged me to discover the complexity. She was the first one to present the idea that not everything is known…and that biology was fascinating and it wasn't just facts like I had thought before….it was hypothesis and experimentation….it was a tough course and when we worked in the lab we didn't always know what the outcome would be …she pushed the students hard to do things that we wouldn't have done on our own…and I valued what I was doing and I was good at it!

Teaching Strategies

Prof. C characterized the flow of her class as "going over some material and then stopping to work with it." She generally began class with reference to two or three of the learning objectives, meant to serve as guidelines for what students should be thinking about during the class session. At the beginning of her project participation, she had just added reading quizzes to the beginning portion of the class that students got points for answering. She elaborated: "If students have done the reading and paid attention to the main points…and they can give a very general verbal explanation, then they will be successful".

During the class, she presents material using about six, PowerPoint slides. She prepared the slides with very large font and a maximum of four lines of text per slide. Prof. C likes the PowerPoint approach because she can put up a question that everybody can see, so it reduces the tendency for students to ask: "What did she ask? What was the question?" PowerPoint also reduces the amount of paper she hands out in class. "If I want students to work with a graph, I just put it on a slide". The slides are used in an alternating fashion with "cue-based activities". Prof. C explained that it's important for students to know that when they get problems in class, the problems are connected to the material they are learning. She commented that students start to realize that the problems are not "out of the blue". By anticipating the connectedness of problems and lecture students change the way they approach problems from an attitude of, "I have no idea where to start", to "Okay…this has to be related to what we are doing today…what are the connections?" During the first couple weeks of class she assists students by providing prompts such as, "Okay now…you just learned something about this…what are the connections? After a short period of time, however she no longer says anything…"They know how it works and they know they have to find the connection." She extends the strategy to her exams. Just prior to an exam she tells students: "Some of the problems on the test will seem unfamiliar at first…and you're right…you will not have seen these exact problems before…but you've seen something similar. So if you feel stumped, start thinking in terms of…what connections can I make?"

Beliefs Related to Teaching and Learning

Elements of both an information transfer and interactive classroom were present in Prof. C's pre-project beliefs about teaching (Appendix I). Salient features of her beginning belief system included a belief that learning required the acquisition of behavior patterns and opportunities to repeat and practice the patterns. The belief was expressed prior to the project start as she struggled to put into words what she knew about learning. As she articulated her beliefs, she drew frequently from her academic and practical neurobiology experiences, and extended the knowledge into the classroom. She elaborated, “The behavior patterns that students have to acquire are things like good study habits and problem solving”. From her own personal experience as a learner, she also defined learning as a process of gathering and integrating facts from different sources followed by “understanding sequences, logical patterns, points of comparison, problem solving, and making conjectures”. Prof. C had somewhat contradictory ideas about her role in the classroom. She believed that the instructor needed to act strict to keep things in control and keep a positive attitude. The instructor also needed to train some basic behaviors, like keeping up with reading and homework, while trying to balance the classroom so that it was a place that was safe for students to take risks and want to participate.

Her beliefs about students were generally positive (they are likeable and interesting people to be around) but her explanations of what they did in the classroom were grouped into: what they should do, and what they did do. Ideally, she felt that students should learn the material at a factual level before coming to class, work with their classmates to get comfortable talking about ideas, and always be thinking about what other people are saying while thinking about their own explanation. However, in reality she felt that they: got frustrated and sometimes angry if they felt like they were “left hanging” without knowing the right answer, had a hard time sorting through what they were supposed to be doing, read and memorized facts and diagrams but didn’t think logically about the information, determined their level of participation based on what grade they would get, didn't have sophisticated reading strategies, and loved to talk about ailments of friends and family members.

Juxtaposing Prof. E's stated beliefs (and classroom observations) to her description of her teaching, the mixed belief system, with an emphasis on giving students opportunities to apply facts to problem solving, while remaining quite formal and reserved, was enacted in the classroom during the first phase of the project.

Goals and other Motivational Beliefs Impacting Change

The goals and other beliefs related to motivation that were articulated by Prof. C are listed in Table 14. Of particular salience, her goal statements and explanations of success and failure were all learner-oriented, and excerpts from interview transcripts suggested that Prof. C applied a malleable theory of intelligence to both herself and students. For example, she did not perceive that students' discomfort and poor ability with problem solving was a fixed, inherited ability; rather, she perceived that their ability was low because they hadn't been taught how to problem solve and hadn't had much practice. She also commented frequently on her own improvements in making activities more effective and learning more about what different kinds of activities are likely to accomplish. Her interpretations of success events were consistently internal, unstable, and controllable ("To go well, there has to be organization and spending a lot of time learning this stuff forward and backward and thinking of questions that will help students make connections…it's a lot like running a marathon), and

Table 14 Prof. C: Motivational Profile

Nature of Competence/Theory of Intelligence:	
	I'm learning how to do make the activities more effective and am learning more about what different kinds of activities are more likely to accomplish. It's a process of learning.
	Students aren't comfortable with problem solving because they haven't been taught how to do it and haven't had any practice.
Goal Statements:	
	I want students to acquire relevant facts, integrate the new information with what they already know, solve novel problems, improve their confidence, and get comfortable talking about ideas.
	I want to help students better understand the parts in physiology and how they fit together and help them being to see how systems function as a whole rather than seeing each piece in isolation.
Task Choice:	
	Challenging tasks and benefit (student learning) outweigh risk (instructor discomfort)
	"Trying less structured activities is scary for me. But I'm realizing there are times that less structure makes a better learning exercise and gets more students involved in participating. Also, students like to be able to generate ideas and solutions related to their own questions. So it's scary….that's okay..."
	"Using active learning strategies is risky because you are not meeting students expectations. You are not telling them everything…and students may become critical of you...they may think either that you don't know the information or that you are not willing to give them the information...that somehow you are not doing your job. That bothers me a bit but I'm going to have to live with it."
Mistakes:	
	When something goes wrong with an activity or doesn't go the way I expected, I just have to ask myself…'Well now…?' It's a lot like marriage...you make a commitment and have faith it will work...and you uncover the difficulties and compromise and learn.... I expect for things occasionally to happen that are not exactly what I thought would be ideal and that's okay…that's just the way thing happen...it's part of my learning process.
What is Failure?	
	If students miss getting an understanding of the basic facts and relationships.
What is success?	
	My success is determined by whether my students are learning.
	Students are getting bolder about answering questions, they're getting better at problem solving and putting information together in maps or outlines…and those are all measures of success.
Attribution for Success:	
	"It's coming together. I'm doing active learning and a lot of reading about the research that supports it and it's great…I'm thinking, "Ahhh…this is great! It really is working"'. [Internal, unstable, controllable (Instructor Ability & Effort)]
	"To go well, there has to be organization and spending a lot of time learning this stuff forward and backward and thinking of questions that will help students make connections…it's a lot like running a marathon." [Internal, unstable, controllable (Instructor Ability & Effort)]
Attribution for Failure:	
	Some students won't get into groups and I've suggested that they should, or at least join up when they have worked through the problem…one woman with a negative type personality did what I said and got into a group and she was directive and her group was so dissuaded by her attitude...whoaa! I had no idea it might play out like that. I need to be putting some thought into helping some of these folks build social skills...so I can handle it different next time. [Internal, unstable, controllable (Instructor Ability & Effort)]

interpretations of failure events were either external or internal, unstable, controllable ("I had no idea [a group learning situation] might play out [with conflict]…I need to be putting some thought into helping some of these folks build social skills so I can handle it different next time").

Prof. C also indicated a disposition toward risk-taking in the classroom. For example, she commented:

> Using active learning strategies is risky because you are not meeting students' expectations. You are not telling them everything…and students may become critical of you…they may think either that you don't know the information or that you are not willing to give them the information…that somehow you are not doing your job. That bothers me a bit but I'm going to have to live with it.

Project Activities

Prof. C used a multi-part respiratory case study in her classroom for the project activity (the case is in the researcher's possession). She had used the case study before but hadn't been pleased with the educational impact it had, so she "did it really differently this time around". First, she made the case more manageable by spreading the component parts out over three days of lecture. Previously, she had assigned the case as an out of class assignment, given student two weeks to do it (and indicated they could work in groups), held a class discussion on the case, and collected the cases for grading. Despite the fact that students seemed to like doing it and then discussing it in class, "It was pretty obvious that they either didn't spend the time on it and did it at the last minute, or they couldn't break it down into the component parts on their own, or they just didn't know how to relate it to what they were learning". She commented that the case had low impact during the class discussion. She elaborated:

> We were talking along and we got to the questions that asks, 'Does carbon monoxide cause hyperventilation?' In class, when they learn about the regulation and…the stimuli that regulate ventilation rate…they must not have recognized that they were learning information that directly applied to that question…because during the discussion…they answered …'YES' and I would say, 'tell me why you think that'…. they would say, 'Well I saw it in a movie once that so and so was breathing this way [panting]'…so almost all of them thought that yes…you would hyperventilate…even though in class if I said, 'If the partial pressure of oxygen is normal …will you hyperventilate?'…And … 'Is partial pressure of oxygen normal in CO poisoning victims?'…And they say, 'yes'…but they couldn't take the next step on their own….

"This time", she explained, "I would lecture a little and then say…'Okay, pull out your cases and let's work on the first two problems'." Prof. C said it worked much better this way because, even though her students are getting much better at graph reading, the hemoglobin curves are still difficult for them to understand ("they just get muddled by these curves") and it helped to be able to go through the information together in class. She also believed that by using the case as "cue based problems" students were able to make solid connections. Prof. C said she was also finding that by assigning two or three problems at the same time during a class session, the problem of students working at different paces is largely removed.

Prof. C's formative assessment consisted of asking students to explain how the case problems helped them learn and putting questions related to the case on the respiratory exam (which they did remarkably well on). She explained how she looked at the feedback while flipping through the index cards:

> I look for a couple of things…. a general balance of how many pros and cons…and then for the cons, I look for specific comments. If they don't take the time to write down something specific, I figure they are just whining. So if there are specific comments about clarity of questions or something that I can change, I pick up on it. Also if there are a bunch that say that it didn't really address any concern or clarify their understanding then…maybe it's something I need to rethink. [Focusing on a card]. See this one…the activity contradicted what we learned in lab…this is really valuable because there's a big point of confusion here…and I need to look at what the connection to lab is and see where this person thought she found a contradiction…these kinds of comments really are helpful for being able to set up really valuable learning experiences next time.
>
> [laughing] Some of these comments just make me feel good…when they say they love application exercises…I'm glad they are getting what they feel are the right set of circumstances to learn and they are seeing the value…here's a student who wanted to do the case all at one time…I don't agree…here's a student who it 'helped put a picture in her head'…see that tells me that she is probably a student that likes to have all the pieces there before she starts…and she likes being able to assemble it…somehow this process matched her way of understanding.

Perceived Supports and Obstacles

Prof. C shared her perceptions of the supports and obstacles she encountered while implementing active learning (Appendix I). Prior to the project semester, twelve supports and 29 obstacles were mentioned. At the level of the academic community, Prof. C referenced one obstacle as the general structure of the educational system that placed so much emphasis on grades and testing that by the time students got to college they operated based on how they'd been rewarded—"by expending effort for the grade…not for learning". Overall, Prof. C reported seven college-level and two department-level obstacles. These included: little concern for the quality of student learning, little communication between academic units, having to move the physiology labs a week before classes began, undervaluing of lecturers (compared to researchers and maintenance staff), heavy reliance on end-of-semester evaluations to judge teaching effectiveness, the departmental procedure of giving lecturers a syllabus from a previous semester and telling them to 'teach this', and lab scheduling issues. At the course level, Prof. C reported the issue with graduate teaching assistants, too much content, and "large class sizes make it hard to learn students names". Consistent with her attribution style, Prof. C reported her biggest (and most numerous) obstacles at the instructor level. All instructor-level obstacles were related, in one way or another, to a lack of instructional knowledge.

During the project semester, two old obstacles (reliance on end-of-semester evaluations and an outdated perception of teaching and learning by many faculty) remained and five new obstacles had appeared. The new obstacles included over-enrollment (doubling of class size) agreed upon between the department and Nursing School, the ineffectiveness of teaching assistants despite weekly meetings, and a harsh reprimand from the Chairman of the Department, who was acting on a complaint from a disgruntled student who said she "wasn't getting the information she was supposed to be getting". Prof. C also commented on a conversation that a faculty member had engaged her in saying that the faculty member told her, "If you end up with a semester of bad reviews and if you want to be employed the next semester you are going to have to make your class really really easy for a semester just to bring your evaluations up…if you make sure that everybody makes an A on the exams…you evaluations will skyrocket for a semester and then you will be back on track for becoming a senior lecturer".

Quite surprisingly, toward the end of the project, only two obstacles were mentioned at the instructor-level. Prof. C still didn't feel that she knew how to get the most out of formative assessment and after the reprimand from the Chairman was puzzled over how she would balance challenging students and supporting them, "to keep them happier…more satisfied….so that there weren't any complaints."

Throughout project participation, Prof. C commented on a number of new supports including regular meetings with a small group of instructors who were all interested in quality learning, a restructured grading system that seemed to reduce students tendency to choose participation based on point value, improved coordination between lab and lecture, the reading quizzes, learning which activities were keepers and which were duds, improved confidence, "cue-based" activities, "bridging" strategies, an improved understanding of how student minds encounter concepts in physiology ,and improvements she saw in student thinking and confidence. The value of the support she received through the ITIP group was also mentioned throughout the project. At the end of the project semester, Prof. C had reported 27 supports and 15 obstacles.

Impact of Project Participation

Three separate categories of change beliefs are reported: Self-reports of change, data-based belief changes, and theory based conceptual change. The impact on student content learning and attitudes are also summarized as points of triangulation.

Self –Reports of Change

Prof. C's perceptions of the project impact fell into two main change areas: beliefs about teaching and active learning and instructor responsibility. The events she believed facilitated the change are included in parentheses.

<u>Beliefs about Teaching and Active Learning (Doing active learning and reflecting)</u>

Prof. C identified two belief changes: one was that effective teaching had "more than one face"—it had two or three; and, active learning was not about doing activities, it was the implementation of a system of instructional strategies.

Prof. C explained that she had previously viewed teaching as having one face: content knowledge. "In order to direct these activities and respond to students you have to know the content...and you have to know it better than you would if all you did was lecture." Although she still believed that content knowledge was important she also believed it wasn't enough. "If I just stood there and spouted information that wouldn't be effective teaching". She elaborated:

> You have to have the 'know how' face. You've got to know how to interpret themes within the content, how to break the themes down and explain the pieces in lots of different ways… and know how to design activities to address the common misconceptions that students have. You also have to figure out how to get students to recognize they have the misconceptions once they've been ferreted out, and know how to provide opportunities for them to work through their old and new conceptions…at their comfort level…and ability level…you have to know how to interact with people.

As she considered the comments she received from students, she added another face:

> There's also encouragement…helping them become aware of different kinds of learning and pushing them and making them see that they can do things that are harder than they thought they could do…and it must transfer to other parts of their life because one student told me she's just better at everything she does now…I've gotten thanks for making it a tough class…for making it interesting…oh and for helping them learn the value of working in groups….

The second belief change was specifically about active learning. When Prof. C began teaching she said she thought active learning was a "good idea" and good way to keep students awake. "Because there is so much content in physiology, I really liked the idea of students being responsible for learning the basic facts on their own and then using class time to work on problem solving…which is the way the class had been set up…that I walked into…and ended up teaching." She said that since she enjoyed interacting with students, she looked forward to asking questions and doing activities in class. Other than some media-inspired beliefs, she wasn't terribly tuned into the whole active learning thing.

At some point in her own learning process, she started to think about the defining characteristics of active learning. Just because students were asked to do something in class, it wasn't necessarily active learning, "if there wasn't any learning going on". Active learning then came to be activities that had the purpose of challenging students on some level to see if they understood a concept or idea. Active learning also had to have a feedback component. Students had to get feedback from somewhere that let them know how they were doing and to what extent they were understanding.

She explained her changing viewpoint further, stating that when she began; active learning was an activity and the "most important part of the activity was knowing something cool….a cool disorder…to get students interest." She continued:

> I still think some of the best activities are based on a real disorder of some kind, but just as important as the activity is how it's implemented and how students are able to manage it. But there's a balance…it's not just activities. Students have to have help setting a framework or structure to build their knowledge on….especially when they are just starting…or for that matter every time they start something new. They have to be shown how to build this framework. It's not either or…it's not active learning or lecture…it's a balance of providing the supports they need to start integrating all the knowledge and skills we encounter. There's even a difference what works for my first semester students versus the second semester students…they need different kinds of structures and grading systems. There's also the need for the instructor to tie the knowledge gained through activities into the exams and to bring the knowledge from the lab into the lecture. Everything in the class needs to be structured with some activity-based learning objectives. You can't just tell students to be active learners, you have to get them on board with what their responsibilities are and then set up supports so you can transfer the responsibility over to them. You have to help them with motivation by giving them the assurance that there are concrete things they have to know…and can know…to do well in the class and that they can control what path they take in the course …

<u>Instructor Responsibility (Doing active learning, CTE workshop, Interviews, Chairman reprimand)</u>

For Prof. C. this change was related to responding to the different faces of effective teaching. While she felt that helping students build a framework and helping them learn facts were very important (she coined a term, "preloading" to describe preparation for effective learning), she said that providing opportunities for their ideas to be questioned was just as important. She elaborated:

> It's up to the instructor to provide opportunities for students to work in groups and let them interact in…enough of an open environment where they have enough open questions where they can pick up on the differences between their ideas and a classmates…and where they can talk about how they are studying…or something they've discovered or figured out…or how something is like what they learned in biochemistry. They end up validating or debating each other in a way the instructor can't. And the instructor has to set up opportunities for them to see how they've gone from not being able to do something to being able to do it. I think teaching is incomplete if students' ideas aren't getting questioned.

Relating to a changed image of effective teaching, Prof. C commented that at the beginning of the project, she felt it was pretty important to know the answers to most of the questions students asked but said she realizes now, it's unrealistic to expect that it's possible to be the knower of all. What is possible and much more valuable from a learning perspective is, "to apply my thorough understanding of the content and thought process and think my way out loud to a probable answer to their question".

In response to the reprimand, Prof. C also believed her responsibility had changed somewhat. "That deal put me in such a precarious situation", she commented. "How do I avoid this kind of problem in the future…what do you do when your bosses don't understand what you are doing or why you are doing it…don't give an opportunity to explain…and immediately side with a student?" Although she didn't plan to eliminate active learning completely in the classroom, she was in the process of developing what she called her, "consumer approach to education". She explained,

> I'm going to give students a fair number of facts in the classroom…but I wish I didn't have to do that because I feel as though they can get the facts on their own. That's the balancer though…. students feel more satisfied and comfortable with the whole process when they are presented with facts. I know they don't learn effectively by being told and they are not aware of the fact that they are not learning when they are given facts…but they feel satisfied. If they are feeling more satisfied than they are more amenable to doing the active learning exercises.

She explained that it's become clear to her that students need to be given challenges just outside their comfort level,

> the kind of challenge…where they look at the problem and say, 'I should know how to do this but I don't have a clue.' And they need to sit for a minute and flounder…and then given a piece to eliminate a possibility…and given another nudge…. until they go 'Yeah…okay…now I see' and they finish the problem on their own. Those situations are so valuable and powerful because it gives them the flavor of solving makes it so much clearer to them how they can think about this knowledge differently…without being told.

Data-Based Changes in Beliefs about Teaching and Learning

Prof. C's beliefs related to teaching and learning changed in the following ways:

Learning: From a definition that focused on behaviorist and mechanistic aspects of learning without context to one that included building levels of a knowledge structure and included mention of the desire and opportunities to learn.

Implementing active learning: From doing a cool activity to the system articulated in the previous section (Prof. C's articulates the process of implementing a system of active learning above). Perhaps the most salient feature of her changed strategy was the bridging she does to help students bring in prior knowledge and integrate information from lecture and lab.

Students: From statements that recognized students as individuals and recognized both their position of comfort and the progress they made in coming through A & P I, to people meeting the goals.

Student actions: From descriptors that focused largely on limitations (with a few exceptions) and undesirable skills (won't read, don't think, don't have, base engagement decisions on the grade) to descriptors that focused on capabilities (demonstrate maturity, are becoming, pick up a lot, develop, practice).

Instructor: From a guide and challenger to someone who has broadened her responsibility to creating a context and opportunities for learning.

Instructor actions: From descriptors that were somewhat directive (stresses, makes sure, keeps, uses) to those that suggested the setting up of opportunities for students to take advantage of.

Instructor/student relationship: From challenger/presenter of different perspectives and grade-motivated participants to a creator of context/opportunities and responsible students.

Class Meeting purpose: From representing topics and opportunities for students to work with material, to a situation that included more attention to assisting students with building knowledge frameworks

Evaluation: From a struggle with grades as motivators and assessing understanding, to a system where students knew the expectations for learning and used tests to determine the extent of their understanding.

Conceptual Change

Evidence of Dissatisfaction

Direct statements indicating dissatisfaction with traditional teaching beliefs and strategies were identified prior to project participation. The statements were focused on a previous definition of teaching and a personal teaching experience:

> …there are three different modes when you in front of a classroom… presenting, training, or teaching. The difference is not the material…because each of the modes can facilitate transfer of a large amount of information. Presenting is what is supposed to happen when you give a seminar…you organize and present your research. You tell them about the experiments… and the results…and then you put it all together into your interpretation of how this all works…so you've given

> them all kinds of information and helped them understand how it all fits together. Training is really showing people how to monkey a skill….Teaching is talking about the information that people need to learn …and focusing on that and putting it together for them...synthesizing it for them….that helps them understand…but now I am thinking how is teaching different than presenting?
>
> I must have been operating on the assumption that if I said it enough students would learn it….but…I have said in class 'peptide hormones have membrane bound receptors'…I've said it maybe 15 times in the last month…written it on the board…they've read it….it's over and over…so, I put it on the test…expecting everyone will get it right….do they? No. Over a quarter of them miss it. It's just devastating to me…it's like, 'What's wrong with this picture?' Then somebody will stroll into my office and say, 'This one about peptide hormones….you never went over that in class…'

Evidence of Intelligibility

Direct statements indicating an understanding and internal representation of constructivist beliefs about teaching and learning were found throughout the project data. Early pieces of evidence for intelligibility came as Prof. C extended a teaching metaphor (instructor as piano teacher):

> Before I said the instructor teaches the rules and the notes. Students memorize the rules and notes and learn how to play…and then students practice over and over again because practice makes perfect…now, I'm still the piano teacher but I need to make sure they play the music more in class instead of just watching me play and listening to me talk about the notes…and I need to stop giving them more and more music…and just keep the focus on the central concepts and the basic material so they can gain confidence with it.

Interestingly, lack of intelligibility seemed to increase just as the project semester began. She revealed lack of intelligibility with unfamiliar content material and said she felt like an "imposter doing active learning":

> When I'm not very familiar with the content, or when it was taught to me in a straight lecture format …I have no idea how to teach this in an active way. It's almost as I only see it as a list of terms…and I don't know how to get past that…listing mentality.

During the first project interview, as she described a disappointing classroom discussion[3] she stated:

> I'm losing touch with what I think active learning is…it's like the more I do it the more I don't know. I'm definitely coming up on the stage of not knowing [laughing]…. I'm even not sure if what I'm doing is active learning anymore…. I don't know if I am doing it right. Am I doing active learning when I give them problems that are more concrete versus the hypothetical ones…and what about when students come to class without having prepared and they can't participate…they are just sitting there at the same level…confused…that's not a learning activity…. what about if I don't follow it with feedback…so it's something they did but they don't know how they did? What are the defining characteristics of active learning? This is ridiculous…here I have this goal of active learning which is supposed to be a way of helping them engage with the material in the classroom and understand the material and now I don't know what it is…

Prof. C. extended the lack of intelligibility to the realm of science content knowledge coverage:

> Maybe I understood it as one way…the lecture way…. or the other way…the active learning way…. But, where's the balance? I think I'm wondering about active learning well maybe I'm hanging on to…I'm still leaning towards wanting the students to know the basic factual information. I mean I say that the goals are to be able to problem solve and things like that…but I don't want them to be a nurse if they don't know where insulin comes from and if they don't know what it does. And I want them to know the control pathways. I want them to know that glucose is the stimulus…when glucose goes up, insulin goes up…when

[3] Prof. C asked students what questions they had about the endocrine reading they had done. Since there were no questions, she told students to talk with the person next to them and make a list of the major themes within the system. Their responses were, "Very unsophisticated" according to Prof. C. Her disappointment was that students said they had all done the reading but they couldn't reduce what they'd read to an interpretation of themes. Moreover, they were unable to articulate the parts that made up the system and very few facts related to the parts or system.

> calcium goes up, parathyroid hormone goes down…that sort of thing…there are facts they absolutely have to know in order to think logically. The facts are one set of tools you have to have to do that. I guess… if at the end of the semester students hadn't learned the facts that would be one sign of a failure to me.

Evidence of Plausibility

As the semester continued, and softball season began, Prof. C demonstrated plausibility with an analogy:

> You know…it's not really that different than swinging a bat…when I'm playing softball…sure I've practiced and all… but there is still an element of …well…winging it. I just have to know I'll connect with the ball. In the classroom when I'm using active learning…it's more fluid than it used to be… and I have ideas in my head…. or a paper that they get or something that gives them some instructions and we just sort of take it on the fly…but I don't always know how it's going to go in the classroom but I am getting a better feel for it and kind of developing a bit of faith. Swinging a bat…you can practice and all that stuff…but you don't necessarily have to know all the components and have it totally right to be able to do it. You know I'm becoming more comfortable with active learning and more effective with it even if I don't know exactly what it means and what all the parts are and exactly how to do it. I'm fine with not knowing every specific and every directive…and I feel really good about my ability…

Evidence of Fruitfulness

Prof. C expressed fruitfulness in the following quote:

> One of the most important lessons learned for me is that you have to talk to the students a lot about why they are doing certain tasks and what you are hoping the task will accomplish…that's the big thing I want to keep in mind when I teach next semester. I will be doing more of that from the beginning the rationale behind what we are doing…whether it is making connections within a system or recognizing a theme that runs through a

> couple systems…. I need to be talking with them…. because it's us doing active learning.

Student Changes

Changes in thematic content understanding and attitudes toward teaching and learning were determined from pre and posttests.

Thematic Content Learning

With the limitations (described in Chapter One) on this data in mind, the following data summarizes gains in students' understanding of gradients at four knowledge levels: remembering, understanding, applying, and analyzing: an 23% increase in remembering, a 12% increase in understanding, 4% change in applying, a 25% increase in analyzing, and an overall increase (all categories) of 14%.

Attitudes about Teaching and Learning

Statistically significant changes in four of the belief construct categories were determined. At the end of the semester, students were less inclined to believe that hearing a lecture and taking notes was the best way for them to learn new information; students were less inclined to think the instructor's most important responsibility was to present textbook information; students were more inclined to believe that they had lots of useful knowledge about topics in the class; and, they were less inclined to believe it's the instructor's fault if understanding is difficult.

Summary of Beliefs

An overview of Prof. C's beliefs about teaching and learning, motivational profile, perceived supports and obstacles over time, and change profiles are summarized in Table 15.

Table 15 Prof. C: Summary of Data

Beliefs							
	Learning	**Students**	**Student Action**	**Instructor**	**Instructor Action**	**Class**	**Assessment**
Pre	Integrating information from different sources; then, understanding patterns, comparisons, and applying to solve problems	Individuals operating from a position of comfort; improve in skills; don't realize how to learn from an activity	Emphasis is on low effort behaviors and what they won't or don't do do - choose what they will participate in based on the grade; get frustrated about taking responsibility; don't have reading strategies to be able to identify themes ram before theses, make value decisions quickly, won't read the syllabus, don't think to consult references outside the text or question resource credibility	Someone who balances the classroom for risk taking and accountability gets frustrated but tries to keep her focus on finding the source of problems and improving	Adopts a student perspective; writes engaging activities that target a variety of skills; models thinking and making connections; suggests strategies for improvement and study skills; keeps students on track; states the value of content to careers; does not leave students behind	To address two or three topics, represent them in different ways and challenge students to work with material	An opportunity for students to see where they are at in their understanding; a means for instructors and students to figure out problematic areas; the motivator for learning
Post	Three levels of learning (facts, application, solving complex problems). "Effective Learning" requires a foundational set of skills, foundation, resources, motivation, and opportunities for engagement.	Individual working towards their goals by developing their intelligence and preparedness	Focused on higher effort behaviors and what they will do: Value application problems, provide helpful feedback; are becoming self-motivated, approach material in different ways and problem solving with more confidence.	Someone who sets up the right circumstances for learning and provides opportunities to interact with peers, apply information, and get feedback; Wants students to be successful and understand that they can use base knowledge to solve complex problems. Values taking on challenges and building confidence	Coaches student in skill building (meaningful reading, building a knowledge framework, making connections), solicits ideas, trusts students, uses problem sets to equalize working rates, facilitates, contextualizes problems, gets students on board with responsibilities and then transfers skills that students	Provide a structure and framework on which to build; give examples and elaborate; student interaction and learning how to use base knowledge to solve problems	To determine if students can accomplish the specified learning objectives
Motivation							
	Goals	**Intelligence**	**Mistakes**	**Success Attribution**	**Failure Attribution**	**Failure**	**Success**
	I want students to acquire facts, integrate information with what they already know, solve novel problems, improve confidence and get comfortable talking about ideas.	Instructor malleable	Useful learning opportunities	{Internal, Unstable, Controllable (Instructor Ability and Effort)]	{Internal, Unstable, Controllable (Instructor Ability and Effort)]	Student Oriented	Student Oriented
	I want to help students better understand the parts in physiology and how they fit together and help them see how systems function as a whole rather than pieces in isolation	Students malleable		{Internal, Unstable, Controllable (Instructor Ability and Effort)]			

Obstacles and Supports								
	Academic Community	College	Department	Course	Instructor	Student	Professional Org	Total
Obstacles Pre	1	7	2	4	10	4	1	29
Obstacles Post	0	7*	3*	1*	2*	1*	1*	15
Supports Pre	0	0	1	2	4	2	3	12
Supports Post	0	0	1*	5*	12*	5*	4*	27
	* Modified or changed							
Change								
	Self-Report	**Change Event**	**Data-Based**	**Conceptual**	**Tries to Adopt Student Perspective**	**Student Attitudes**	**Student Content**	
	Beliefs about Teaching: Teaching is more than content knowledge	Doing active learning and reflecting on comments/notes/thanks provided by students.	Learning: Yes	Dissatisfaction: Strong Evidence	Yes	Learning Preferences: Less inclined to believe that hearing a lecture and taking notes is the best way for them to learn new information	Remembering: fro 41 to 64% = 23%	
	Active Learning: Is not a single activity ; it's a system of strategies	Personal reflection and ITIP interviews on the characteristics of active learning. Why was I calling some things active learning and not others?	Students: Yes	Intelligibility: Strong Evidence		Instructor's Role: Students are less inclined to believe that the most important responsibility of the instructor is to present the information in the textbook to students	Understanding: from 41 to 53% = 12%: from	
	Instructor responsibility: Assisting with framework building and questioning	Doing active learning; talking with students and determining that making connections is not something they've learned to do yet	Student Action: Yes	Plausibility: Evidence		Useful Knowledge: More inclined to believe that they had lots of useful knowledge about topics in class at the end of the semester	Applying: from 36 to 40 %= 4%	
	Instructor responsibility: Modeling thought processes not reciting the facts	CTE workshop; Student responsiveness to "coached practice" of graph reading	Instructor: Yes	Fruitfulness: Evidence		Failure attribution: Students were less inclined to believe it's the instructors fault if understanding is difficult.	Analyzing: 26 to 51%= 25%	
	New awareness of departmental philosophy	Chairman reprimand and assessing former beliefs about departmental leadership	Instructor Action: Yes				Total: 35 to 50% = 14%	
	Consumer approach to education: Integrating a balancer (giving facts) to increase student satisfaction	Chairman reprimand and thinking about what my options were for creating more "satisfaction" in the classroom while still challenging students to apply the foundational material	Class: Yes					
			Assessment: Yes					

PROFESSOR D: PROFESSIONAL SCHOOL A & P INSTRUCTOR

> The college is very small…there are only 900 students and interestingly, many of them are either relatives of previous graduates or underclassmen…and a fair number belong to fraternities and sororities…it seems like everybody knows everybody. [Because of the relationships between students], the college has an institutional memory…there is a memory of how it once was [that is carried by the students] and what it should be…which is that teachers give students information to memorize for the exams.

Baseline Information: A Snapshot

- The college enrolls six-year professional students. The first three years are considered pre-professional, and the second three years are professional.
- The college has a new progression policy, which makes it so that students can't keep repeating classes. To make it into the third year of the program, students cannot have more than two D's on their academic record. With the new policy, the attrition in the first two years is around 40 percent.
- The A & P course format has undergone a number of changes in the last several years. Some of the change has been shaped by an institutional curriculum revision designed to accommodate transfer of students from community colleges directly into the third year courses. Although the course has remained a two-semester sequence, it has transitioned from A & P I and II with a focus on different systems each semester, to a beginning and advanced course that focus on all systems each semester but at different levels.
- The course instructional methods have also changed. Although one section is always traditional lecture, the other section has changed from a traditional,

lecture to a lecture with graded group homework assignments. Subsequently, individual and group exams and graded, take home essays/case studies have been added.

- Since students are registered for courses using a lottery system they are unable to select whether they want the traditional lecture section or the problem solving section.
- The learning objectives for the course were set by professors whose courses follow A & P so that students will be getting the information they need to be successful in future classes.

The Students

Students are required to have completed pre-professional courses (biology, two semesters of general chemistry, one semester of organic chemistry, and anatomy) prior to taking A & P. Although Prof. D believes that about a quarter of the students entering his course are well equipped to learn, he believes an equal fraction should not have graduated from high school. Overall, he believes that there has been a decline in the abilities of incoming students in terms of their reading comprehension, note taking skills, analytical thinking, basic math skills, and ability to attend to details.

The Instructor

Three features distinguished Prof. D from the other instructors in this study. One is that he didn't consider himself a teacher. He elaborated in a Listserv post:

> According to Webster, a teacher is one who instructs and teaching is the act of imparting knowledge or guiding studies within a particular subject. I AM NOT a teacher. Other than acting as a guide to someone within the field I do not do what most people consider to be teaching…. what I do is act as a guide, mentor, coach, and motivator. All of what I do is basically geared towards helping them learn, but I am not teaching them anything. I can show them how I do it or I can critique what they do but in the end it's all up to them.

Second, he believes the flexible approach he uses in teaching gives students, "a lot of room to do what they want to do". Unlike other instructors at the College he allows students to appeal test grades and doesn't require that they dress professionally to come to class. He believes that being strict in the classroom doesn't particularly promote learning. Rather, he feels it is important to "keep it an environment where students know that their primary job is…and that is learning."

Third, a search of transcripts for passages describing grading suggests that grades are a direct measure of learning and that grades reflect students' ability and leadership capability. The following comments are representative:

> The instruction that I provide improves the probability that student' grades will go up.
>
> Grades are a reflection of students' ability. If the grade goes up you know that retention has improved.
>
> Everything students do in class is graded and is used to calculate their final grade.
>
> When I am circling around in the class helping students I don't tell them the answers because the answers are graded.
>
> I do not let students form their own small groups. I've been down that road before and found that students break into cliques that to do give everyone an equal chance for success. When I form groups, I ask the

> instructor that had students before me to rank students by [approximate] grade…if I have 9 A students, I set up 9 groups. The A's are counted on for leadership in each group. Then I spilt the D's and fill in with the middle of the road people. I usually have to shuffle for personality because I can't put a quiet A with an extroverted D because the D will force everybody to go in his direction… and I also shuffle for gender. I want everyone to have an equal chance for success.
>
> You know if an activity or problem doesn't' work by the student grade. If they get 50 to 75%, it didn't work.

Project Participation: A Snapshot

Project participation data were collected through six, 30-45 minute telephone interviews, one personal interview, one audio-taped workshop presentation, four written surveys, course syllabi, class problems, and numerous email exchanges.

Instructor's Prior Experiences

Prof. D received an A.A.S. from a community college, and an undergraduate degree and a Ph.D. from a State University affiliated with a Medical College. When recalling experiences as a science student he noted with distaste the requirement for graduate students to take the same gatekeeper courses as the medical students. He recalled taking 19-credit hours per semester, doing lab rotations, bar tending weekends, and losing interest in his goals as he began to figure out how "the research thing" (grant writing, meetings, politics, back-stabbing, egos bigger than lab spaces) worked. Although he considered quitting, he continued—had a pleasurable research experience and then discovered teaching, which he loved. He ended up petitioning his advisor to be allowed to teach A & P at the local community college. The advisor agreed as long as the research did not suffer. Prof. D. said that although the research did suffer—the teaching was great. He elaborated: "I basically finished grad school only so that I could become a college professor. I had absolutely no intention at all of becoming a top tier research".

When describing the instructors who influenced his thinking about teaching, he referred to ninth- and 11th grade-English teachers. He elaborated:

> [One instructor] was non-judgmental, mellow, and fatherly. He liked to read passages in class and discuss them. He also held voluntary "book club" meetings after school two days a week. We would get together and discuss section of the Iliad, the Odyssey, The Bible…the purpose of the [informal and unofficial club] was to discuss books and share ideas and interpretations. I loved attending these sessions and discussion the books and their possible meaning with other students and teachers. [The other instructor] was a falsetto-voiced, mousy, frumpy…lady…who got me to have an appreciation for Shakespeare's plays….she also encourage me to read Dante's Inferno and Paradise Lost. She later admitted that I was probably too young for both and missed many of the key points in the works, but I did not mind…much later [I found out that both teachers had been let go]…apparently not the types the Principal wanted…

Teaching Strategies

Prof. D characterized his teaching as a, "hybrid approach to teaching that involved elements of team learning and Problem Based Learning". He also included case studies and elements of lecture. He commented that since he was trying his first semester of true PBL he hadn't yet found the proper balance.

Prof D explained that when students came to class each day they didn't know if they would be doing a problem or a team quiz. If they do a problem, the class goes through it step by step and he asks groups to speak out if they think they have the right answer to a particular step. He elaborated:

> They give their answer and then I'll ask if everybody agrees or disagree and if somebody disagrees I ask them to state their rationale. It's a directed thing on my part and I'm not really telling them the answer because the answer is graded …I want them to argue amongst themselves…if I see they are going way off I remind them of something and I'll talk for a little bit about more background.

Alternatively, the team learning format involves spending the first 25 minutes on a quiz and then afterwards students can ask the instructor questions, or if he thinks there is something that needs more explanation, he might give a mini-lecture. He explained that if he didn't do a mini-lecture then student could spend the rest of class time studying or preparing appeals to their test questions that they got wrong. He explained the appeals process:

> If students got a test question wrong and they disagree with the answer that I chose as the correct answer…if they think there should have been more than one correct answer for the question…I let them submit written appeals to raise their grades.

Beliefs Related to Teaching and Learning

Prof. D's held two sets of beliefs related to learning (Appendix I). The first highly personalized set, referenced when talking about classroom practice, defined learning as, "Like riding a bike" (you don't read about it, you just do it). In this belief set, learning could be forced or facilitated by quizzes or homework assignments. A second belief set explained learning by neurocognitive theory and required that the learner focus attention, actively process information, and focus on key points.

When asked to describe who the instructor was, Prof. D offered an explanation within the context of a description of a classroom event, as: "Someone who believes in his teaching methods…and would not…be happy as a teacher" if he stopped using the methods. When responding directly to the question, "Who is the instructor?" Prof. D replied that the instructor was a facilitator who helps people learn study skills, a new way of thinking, and a difficult subject".

Prof. D's conceptions about an instructor's role in the classroom were also distributed between two systems. Presumably, the first system was made up of descriptors related to what he seemed to practice in the classroom: provide instruction to improve student grades, give quizzes, prepare instructional materials, form student groups, and teach students what is important. The system was grade-based and involved guiding students without giving them the answers and circulating among groups to see if students were getting the right answers. The second system seemed to be composed of his perceptions of what a good instructor did: uses feedback to make modifications, gives students a voice and freedom, spends time helping students through the learning process.

Juxtaposing stated teaching and learning beliefs to Prof. D's description of teaching strategies and to an audio-taped workshop session, it seemed the system expressed in the classroom was an interactive style lecture, with a relaxed feel on the surface, yet a tense, authoritarian feel just under the surface.

Prof. D's comments about students in his classroom described under-prepared and grade-oriented learners with poor analytical skills that needed to be forced to keep up with what was going on in class. Descriptions of what students did in the classroom were focused largely on undesirable actions (cramming for tests, resisting problem solving, performing poorly on tests). Descriptions of students outside the context of his classroom (theoretical students) focused on individuals using desirable learning strategies (solve problems, engage in learning, apply information).

Goals and other Motivational Beliefs Impacting Change

The primary goal Prof. D articulated (Table 16) when asked about goals for the project was to, "Do anything and everything that I can do to improve as a teacher and continue learning what I find to be intriguing". Other goals were also focused on supporting his own learning and intrigue, and his desire to socialize with "people that somewhat share my beliefs about teaching and learning." Emergent classroom goal statements were generally directed toward students with emphasis on their dependency on the instructor. For example, he stated that he wanted to get students engaged in learning. When asked to elaborate, Prof. D said that he wanted students engaged "rather than just sitting there like vegetables expecting me to give them nutrients, " or "engaged so they would move away from being sheep."

Prof. D articulated a belief in a fixed theory of ability in statements about students but a malleable self- belief of intelligence. With regard to himself, he commented, "I'm improving in my ability to write problems and case studies. Regarding student ability, he spoke of students as poor problem solvers and "really bad" critical thinkers. A fixed theory of intelligence also came through in

Table 16 Prof. D: Motivational Profile

Nature of Competence/Theory of Intelligence:

We are seeing a decline in the abilities of incoming students reading comprehension, note taking, analytical thinking, basic math skills, short attention span and little attention to detail. About 25% should not have been allowed to pass high school. Only 25% are well prepared. [pre, post]
A students will get A's regardless of the teaching approach used because they have natural ability, motivation, and inquisitiveness. [post]

Students are poor problem solvers and really bad critical thinkers. [pre, post]

I'm improving in my ability to write problems and case studies. [post]

Goal Statements:

Get students more involved in their education rather than just sitting there like vegetables expecting me to give them nutrients. [pre]
I am interested in anything and everything that I can do to improve as a teacher and to continue learning what I find to be intriguing. [pre]
I want to get involved in something that would basically force me (or add additional motivation) to learn more about education theories and teaching methods. [pre]

I would love to have my students learn at least 50% of what is in the textbook (but this may not be realistic). [pre]

I want to get together with people that somewhat share my beliefs about learning and teaching. [pre]

Get students to move beyond being sheep [post]

Mistakes

No statements found

What is Failure?

Instructor/Activity failure, Student confusion: Students were confused because I hadn't told them or written in the directions for the activity how something worked.

What is Success?

The method I have developed is working because student averages are 75%
I just got my mid-semester evaluations back and it appears to be going well. Students gave the course a "B" and gave me a "B".

Attribution for Success:

"Right now the teaching approach I have put together seems to work" because students scored 75% on the exam.

Because students are very good at understanding the mechanism of action potential generation, I was able to go into more details--in fact, more detail than I had anticipated being able to give them.

Attribution for Failure:

The feedback I got on the first problem was that I wasn't specific enough in my descriptions. Students were confused but should have been able to figure that out. [External, Stable, Uncontrollable (Student Ability)]
If there is friction in a group and it is not working, it is almost always between a male and a female. [External, Stable, Uncontrollable (Gender Conflict)]

Some student groups become dysfunctional because I haven't found the equation for "proper balance" yet. [Internal, Unstable, Controllable (Instructor Inexperience)]

Because students are operating on the philosophy that teachers should give information to be memorized, classroom discussions do not work here. [External, Stable, Uncontrollable (Student Philosophy)]
I attempt to help students make connections but cannot always succeed because they have been educated under a "standardized testing paradigm" which teaches them memorization skills and other surface learning techniques. My approach is "patience and faith" (and repetition, prodding, cajoling, coaching, butt-kicking, butt-patting). [External, Stable, Uncontrollable (Secondary Education System; Standardized Testing Paradigm)]
Because of the skill deficits of my students, I must use an approach other than the lecture/exam method. {External, Stable, Uncontrollable (Student Ability)]
Because students struggle with basic cell physiology, I am only able to get through the concepts that they need and am not able to give them the details that I would have liked to. [External, Stable, Uncontrollable (Student Ability)]

statements about the small percentage of very good students who “will get A’s regardless of the teaching approach used because they have natural ability…”.

Prof. D’s statements related to failure were consistently focused on himself or an activity he had designed, and indicated maladaptive patterns of attribution. For example, prior to the project start, he indicated that because of the, “skills deficits of my students, I must use an approach other than the lecture/exam method”. In this example, he attributes failure to students (external), to a stable student trait (skills deficit that seems to be fixed), over which he has no control. The external/stable/uncontrollable pattern of attributions emerged regularly in Prof. D’s explanations of events. The most frequently expressed attribution was used to describe why he could not always succeed in helping students make connections in the content material. The failure attribution was a stable K-12 standardized testing paradigm that taught students memorization and surface learning techniques. He explained that the paradigm (“a sort of mobius loop that we are caught in and can’t get out of”) was unalterable because parents (who are only interested in grades) pressure administrators and school boards (who are only interested in pleasing parents and politicians) to devise curricula that emphasized knowledge required to pass standardized college entrance exams, so that students could score higher on tests, and get into their choice of college. He concluded that, “students pick up on this and they become interested in the bottom line (grades)”. Curiously, Prof. D did not acknowledge the focus on grades in his own classroom.

Prof. D's statements related to success were focused on himself, or being able to do something in the classroom, and again suggested maladaptive patterns of attribution. For example, an external/unstable/uncontrollable pattern emerged in his explanation of being able to go into much more detail in class than he had anticipated: "Because students are very good at understanding the mechanism of action potential generation, I was able to go into more details—in fact, more detail that I had anticipated being able to give them.". Prof. D attributes his successful delivery of lecture details to factors outside of his control--an external, unstable factor (action potentials are apparently one thing students are very good at understanding; in other statements he elaborates that students "struggle mightily with receptor mechanisms, cell-to-cell communication, and basic cell physiology).

Project Activities

Prof. D developed both activities he used during the project. Both were problems that students worked on during class (activities are in the researcher's possession). The first was a problem to design an intestinal cell that moved glucose from the intestinal lumen into the blood stream. Prof. D did not lecture prior to the activity, he only told students what a glucose transporter was and gave them a visual example of symport. He commented that the activity was very simple and that all students had to do was draw a gradient. Although Prof. D did formative assessment on the activity, he didn't have access to the feedback during an interview, so summarized what he recalled. He said he recalled that students liked working in groups because they got to discuss things and some of them felt they had learned better by talking to each other. Some people didn't like the problem because it wasn't structured and some didn't like the idea of their grade being determined by students who "weren't as good as they were". Further he recalled that some people had liked the problem because it was free form so there were several right answers. He explained,

> As long as it worked it worked…so if they used a potassium co-transporter instead of using a sodium co-transporter that was fine because I just wanted them to get the idea of the gradient. I just let them go with it and they liked that.

At the end of the problem, Prof. D said he told them how the system usually works and, again, students liked that. He said that they understood that the way that they had done the problem wasn't necessarily wrong. He explained,

> "They saw their system would work…but that's just not the way that it works as we know it so …they got the principle out of it and that is what I was looking for…. I wasn't looking for a right answer; I wanted to see if they understood the principles of ion gradients and transport.

A second exercise was conducted on "second messengers and G proteins…to demonstrate how G proteins work….and how second messengers work and that the same neurotransmitter/paracrine/hormone can have different effects on different cells based upon the type of receptor present ort the second messenger activated". Again, although Prof. D had collected formative assessment on student response forms, he had been too busy to look at them. His impression was that students had liked the activity but as always, they would have rather had " everything wrapped in a nice neat package with a bow on it" so that they didn't have to think. Moreover, he said that students felt he had done a good job. He commented that not only was it important to find out if students thought the activity was a good learning tool, it was also important to find out,

> about how the instructor coordinated it…handled it…so that there is feedback about how the instructor used the activity…which is sometimes even more than the activity….it's important to know how they thought you carried yourself through the process…were you a peer or did you act authoritarian….

Perceived Supports and Obstacles

Seventeen supports and 28 obstacles were mentioned prior to the project (Appendix I). Prof. D stated that the biggest (and most) obstacles to active learning were at the college and student level. At the college level, he listed the "institutional memory" that made change difficult, the dynamic that sets up if the student class leader is bad, the administrative emphasis on more A's, student satisfaction, and increasing enrollment. He also felt that the unavailability of a foundational course in study methods was an obstacle to introducing active learning. Supports at the college level included administrative support for active learning, a small college atmosphere, the curriculum revision, and a seminar to help students with note talking and reading comprehension. Obstacles at the student level were under prepared, grade-oriented students who wouldn't engage in discussion and were unwilling to modify their expectations. One support at the student level was the presence of a very few nontraditional students who liked active learning.

At the instructor-level, one support and two obstacles were reported. Prof. D felt that doing active learning meant that he got to spend more time thinking about physiology. Obstacles included: the potential influence of active learning on evaluations and the time spent preparing quizzes, activities, exercises and grading. Most of the same supports/obstacles were reiterated over the course of the project. There was a net loss of three supports, and a net loss of one obstacle. Prof. D was presented with an added obstacle at the student level as he determined that students didn't have the skills to formulate an argument and support it with evidence, nor were they old enough to reflect or have an inward eye.

Impact of Project Participation: A Snapshot

Three separate categories of change beliefs are reported: Self-reports of change, data based belief changes, and theory based conceptual change. The impact on student content learning and attitudes are also summarized as points of triangulation.

Self-Reports and Critical Incidents Promoting Change

Prof. D reported two areas of change and summarized the experiences or information responsible for the change:

<u>Change in instructor role: Findings from field of neuroscience and classroom observations)</u>

> I am much more interested now in discussing [information] with students rather than just lecturing to them. This is because basic neurocognitive theory states that the more sensory modalities you have focused on a task the more likely you are to make the transition to long-term memory.
>
> I don't think that the goal of encouraging students to restructure their existing knowledge is as appropriate as I once did because my students are at the age where they are still in the acceptance mode where if it is on TV

> or in the newspaper then it must be true. Rather than restructuring, my job is to change the way that they think and to teach them to critically evaluate.
>
> It's important for the instructor to build opportunities for debate into the semester. At the beginning of the semester, I take it easy and do problems that have solutions. Then after we have been at it for a while, if I have some faith that they know what they are talking about, I'll give them something that they have to defend or refute. An exchange with emotional attachments has a longer lasting effecting than an emotionally void exchange.
>
> I used to feel that I had to know the answers to all questions that students put to me and if I didn't know the answers to then they wouldn't respect me…now honesty is my policy now. If I don't know I say so…and tell them that I will attempt to find out.
>
> I used to think it was important to spend time questioning students ideas but now I just don't have the time to do this. {Even if I had the time] most of my students don't have any ideas on physiology to begin with. I think they might have some prior misconceptions taught to them in a high school anatomy or physiology…
>
> <u>Changed thinking about the role of assessment</u>
>
> I used to be more inclined to thinking that assessment at this level should be an opportunity for students to reveal their changed conceptual understanding, but it's not feasible for my students to reveal because they have a low ability to self reflect…. they are not mature enough to self evaluate…my emphasis is on covering information and meeting objectives.

Data-based Changes in Beliefs about Teaching and Learning

Learning: Prof. D extended his personal belief about learning to include critical thinking, and retained his neurocognitive definition of learning throughout the project.

Implementing active learning: There was a continued emphasis on writing cases and problems for students to do in and out of class. Classroom decision-making was based on what students said they wanted more or less of.

Students**:** Prof. D. continued to extend the unfavorable characteristics of students.

Student actions: Prof. D continued to extend the unfavorable strategies students used in learning and added that students had no capability to self-reflect.

Instructor: Prof. D maintained two distinct belief sets related to the role of the instructor. The personal belief set focused on maintaining his own happiness, gatekeeper status and defined the instructor as someone who helps students clear up their misconceptions. The adopted belief system focused on the instructor as a guide/mentor/coach who has transferred responsibility for learning to students.

Instructor actions: Accordingly, Prof. D maintained two systems of actions engaged in by the instructor. The first system was focused on what he actually seemed to be doing in the classroom (shows students how to maximize the potential to get better grades, makes writing assignments, writes case studies to grab students attention, forms groups, helps students learn without teaching); the second system was focused on adopted beliefs which described the instructor as teaching concepts rather than facts, pausing during lecture for reflection, and teaching students how to be successful at the next step.

Instructor/student relationship: Over the course of the project, Prof. D maintained a belief that the relationship between instructor and students is that of peers (one more experienced) relating to each other.

Class meeting purpose: Over the course of the project, an emphasis on information transmission was maintained.

Evaluation: Over the course of the project, Prof. D maintained a belief that grades gauge what students have been taught.

Conceptual Change

Evidence of Dissatisfaction

Although statements of dissatisfaction toward information transmission, the statements were mixed with conflicting statements of satisfaction. For example:

> Lecture is a horrible way to learn something. It's a great way to memorize and pull out little facts and snippets, and a good way to memorize figures but not very good for understanding.
>
> Sometimes lecturing is required to clear up misconceptions.
>
> Lecturing should not be the sole means of information transfer.

Evidence of Intelligibility

Although there were statements that suggested intelligibility of constructivist-based practice, the supporting rationale Prof. D provided when probed was representative of transmissionist-based or inconsistent logic. For example:

> I create a syllabus that is a contract with the student…. It contains the course outcome. …. The course outcome tells students, 'When I am done with you, if you have done what I told you to do, you will have this set of skills.'
>
> A pause or short break in the middle of class to reflect and compare notes seems to work very well for my classes. I tell them that this is a good time to identify their misconceptions and formulate questions.
>
> All of what I do is basically geared toward helping students learn…. I don't teach them anything… I can show them how I do it or I can critique what they do but in the end it's all up to them.
>
> In the method I use there's a relationship between teaching, grading and retention…my method increases students likelihood of getting a better grade, thereby increasing their ability to retain the material.
>
> Collecting feedback from students is important. I ask for anonymous feedback…if feedback comes from a good student, I address it. If it comes from a student who complains about everything, I might ignore it. I mostly focus on feedback I get from B and C students because it is the most constructive. It is constructive because C students are happy with a C but they would like to get a higher grade so they give me some pretty honest feedback on how I can improve things. B students want to be

> students so they give me comments that will help me make the exercises better.
>
> At the first of the semester, when case studies are new to most of the students, I start out real simple…Cases get more complex later in the semester…The first thing I want them to do is get familiar with how I write the case structure and what kinds of questions I ask and how I want answers to be structured.

Evidence of Plausibility

Although there seemed to be a strong belief by Prof. D that he was using techniques to engage students, there was not evidence that suggested students were engaged, or with their deficient skills sets, capable of being engaged.

Evidence of Fruitfulness

Although Prof. D speculated on future use of active learning, there was no evidence to suggest that student learning would be the focus.

Student Changes

Changes in thematic content understanding and attitudes toward teaching and learning were determined from pre and posttests.

Thematic Content Learning

With the limitations (described in Chapter One) on this data in mind, the following data summarizes gains in students' understanding of gradients at four knowledge levels: remembering, understanding, applying, and analyzing: a 21% increase in remembering, a 18% increase in understanding, 5% change in applying, and a 10% increase in analyzing, and an overall increase (all categories) of 13%.

Attitudes about Teaching and Learning

Students expressed four significant change categories. At the end of the semester, students were more inclined to believe that they work hard in the class primarily to get a good grade; they were more inclined to believe that the way they learn information is to read information over and over; they were more inclined to believe that hearing a lecture and taking notes was the best way for them to learn new information; and they were more inclined to believe that they had lots of useful knowledge about topics in the class.

Summary of Beliefs

An overview of Prof. D's beliefs about teaching and learning, motivational profile, perceived supports and obstacles over time, and change profiles are summarized in Table 17.

Table 17 Prof. D: Summary of Data

Beliefs

	Learning	Students	Student Action	Instructor	Instructor Action	Class	Assessment
Pre	Two sets of beliefs: 1. Personal - It is like riding a bicycle (don't read about it just do it); the ability to retain information; is facilitated by taking quizzes, doing assignments and take home cases 2. Adopted - Explained by neurocognitive theory; personalizing material; shifting from long to short-term memory; facilitated by focusing attention, actively processing what is happening at a specific minute, and focusing on key points	People who had A's in high school but now have C's and D's; under-prepared with poor analytical skills; stuck in a mindset that doesn't work; are test and grade-oriented; don't like being called by name and must be forced to keep up	Two sets of beliefs: 1. Resist problem solving; won't engage in discussion; Don't know what to study for tests; perform at 50 to 75% on problem solving; prepare appeals for incorrect test questions; cram for exams then do a data dump; use fraternity files to improve grades; are dishonest 2. Solve clinical problems, engage in learning, do group problem solving, apply information and draw pathways	Two sets of beliefs: 1- Personal - Someone who who believes in his teaching methods. If he were to stop teaching the way he believes is right than he would not longer be happy as a teacher 2: Adopted - A facilitator who helps people learn study skills, a new way of thinking and a difficult subject matter	Two sets of beliefs: 1 Personal - Provides instruction to improve the probability that student grades will improve; gives reading quizzes (forces students to keep up); prepares instructional materials; forms equitable groups based on grades; teaches students what is important Guides students through the learning process without giving answers (because answers are graded); circulates (answers questions to determine if they are right or wrong). 2. Adopted - Uses teaching methods out of concern for student learning; uses feedback to make modifications; gives students a voice and freedom; spends time helping with problem solving	Delivery of content/Going over what the instructor thinks the hardest parts of the chapter are	Grading is related to teaching and retention. The teaching method increases students likelihood of getting a better grade, thereby increasing their ability to retain the material; a way for the instructor to learn what students don't know
Post	Two sets of beliefs: 1. Coming up with an educated opinion; doing critical thinking; teachers facilitate by giving guidance, answers to questions, and getting out of the way ("less is more") 2. Explained by neurocognitive theory; is speeded by engaging multiple sensory modalities	People who are responsible for their own learning; "tasked with learning", who cannot learn from audio materials or text (VARK scores; want to be lead; not old enough to reflect; don't have a clue about physiology; bad critical thinkers; and will not ask for a classroom context in which they can learn better because they are afraid of anything new	Not capable of self reflection	Two sets of beliefs: 1. Personal- ensures that students learn the material in the gatekeeper course, provides students with opportunities to clear up their misconceptions; and chose teaching to make a difference among the C/D/F students 2. Guide/mentor/coach/motivator, who has objectives to meet, and believes it is the students job to learn material	Two sets of beliefs: 1 Personal - Shows students how to maximize the potential to get better grades; has students do writing assignments from science magazine articles to force them to take a position and cite evidence; spends time writing case studies to grab students attention and make them want to learn; forms equitable groups based on grades; helps students learn without teaching them anything, uses mini-lectures to emphasize important points (and clear up misconceptions) 2. Adopted - Points out controversy in the content area; focuses teaching on central concepts and models, rather than facts; provides a pause period in lecture for reflection; teaches students how to think critically and succeed at the next step	Delivery of content; application of concepts; critical thinking	Students are taught and then assessed on what they have been taught; a way to gauge how well students understand the material

Motivation

	Goals	Intelligence	Mistakes	Success Attribution	Failure Attribution	Failure	Success
	Improve as a teacher and continue learning what I find to be intriguing [pre]	Students: Fixed	Not addressed	External, Stable, Uncontrollable (Student Ability)	External, Stable, Uncontrollable (Student Ability)	Not addressed	Instructor Oriented
	Get students involved in their education (rather than just sitting like vegetables expecting me to give them nutrients) [pre]	Instructor: Malleable		External, Stable, Uncontrollable (Student Ability)	External, Stable, Uncontrollable (Gender Conflict)		
	Learn (forced) more about education theories and teaching methods [pre]				Internal, Unstable, Controllable (Instructor Inexperience)]		
	Have students learn 50% of what is in the textbook [pre]				External, Stable, Uncontrollable (Student Philosophy)]		
	Get together with people who share my beliefs and learning and teaching [pre]				External, Stable, Uncontrollable (Student Ability)]		
	Get students to move beyond being sheep [post]				External, Stable, Uncontrollable (Student Ability)]		
					External, Stable, Uncontrollable (Testing Paradigm of the educational system)]		

Obstacles and Supports

	Academic Community	College	Department	Course	Instructor	Student	Professional Org	Total
Obstacles Pre	2	10	1	1	2	12	0	28
Obstacles Post	2	9	1	1	1	13*	0	27
Supports Pre	0	7	2	2	1	1	4	17
Supports Post	0	7	2	2	1	1	1	14

* Modified or changed

Change

Self-Report	Change Event	Data-Based	Conceptual	Tries to Adopt Student Perspective	Student Attitudes	Student Content
Instructor Role: More interest in discussion versus lecture	Neuroscience research findings	Learning: No	Dissatisfaction: Conflicting Evidence; Dissatisfaction and Satisfaction	No	Goals: More inclined to believe that they work hard in the class primarily to get a good grade.	Remembering: 28 to 49% = 21%
Instructor Role: Less emphasis on helping students restructure knowledge and more emphasis on teaching them skills of critical thinking	Teaching experience has revealed students poor problem solving/ critical thinking ability	Students: No	Intelligbility:Conflicting Evidence; Statements of Intelligibility supported by Traditional Logic		Learning Strategies: More inclined to believe that the way they learn information is to read information over and over	Understanding: 43 to 61% =18%
Instructor Role; Include more opportunities for debate	Neuroscience research demonstrates that exchanges with emotions have a longer lasting effect	Student Action: No	Conflicting Evidence; Statements of Plausibility but No Reference to Learners		Learning Preferences: Students are more inclined that hearing a lecture and taking notes is the best way for them to learn new information	Applying: 41 to 45% = 5%
Instructor Role: Not as inclined to believe all the answers to students questions must be known	Personal policy change	Instructor: No	Fruitfulness: Conflicting Evidence; Statements of Fruitfulness but no reference to learners No		Useful Knowledge: More inclined to believe that they have lots of useful knowledge bout topics in the class	Analyzing: 26 to 36% = 10%
Instructor Role: Less time questioning students ideas	Observations show that students don't have any ideas	Instructor Action: No				Total: 35 to 48% =13%
Assessment Role: Less inclined to believe assessment should show changed conceptual understanding	Experience indicates that this isn't feasible because of students low maturity and low self-reflection ability. Need to meet objectives	Class: No				
		Assessment: No				

PROFESSOR E: COMPREHENSIVE, PUBLIC UNIVERSITY A & P INSTRUCTOR

> Even at an institution where teaching is highly valued…and research is a secondary emphasis …and even when the Dean is a proponent of active learning…there's a risk involved in using active learning strategies…seriously, I'm not sure how it will impact my ability to get tenure…but I don't want my students to come out of their undergraduate experience like I did…knowing nothing other than how to memorize and spit it back.

Pre-Project Information: A Snapshot

College and Course

- The College "has let in way too many students" so classes are currently overenrolled.
- The College is trying to organize year-around operations so that students can take summer session classes; however, they are not making technical support available (tech support staff are on ten-month contracts) so departments like Biological Sciences that rely on support for labs, aren't required to offer summer classes.
- The College's Center for Teaching Effectiveness is focused almost exclusively on the use of technology in teaching and is not devoted to teaching research and scholarship.
- The course is an upper-division, one-semester, Human A & P course that focuses on the systems integration and control of organ systems. The development of scientific thinking processes is emphasized.

- The course is an elective for bioscience majors and nursing students, but is required for kinesiology majors.
- Class meets for 90 minutes, twice a week. Labs meet once a week for three hours. The lab material is designed to complement the lecture, and is integrated into lecture.
- Prior to project participation, Prof. E taught the class using lecture, and students purchased outlines of the class notes. "My thought was that I wanted them to be able to think and listen and not have to write down every single word I said…so I gave them an outline and then they would write on that. I no longer do that because I no longer lecture that way."

The Students

Students are required to have had one year of college chemistry and one year of introductory college biology. Physics is strongly recommended. From a cultural diversity perspective, students represent Caucasian, Hispanic, Philippine, Asian, and African American groups. Most students are either juniors or seniors majoring in bioscience or kinesiology, or nursing students. Prof. E believes that her students "have a pretty good feel for what needs to be happening in class".

The Instructor

Six features distinguished Prof. E from the other instructors in this study. One is that she teaches a course that is largely elective and another instructor who uses traditional lecture teaches the same course. The elective nature of the course seems to allow for a strong sense of purpose:

> The focus is on depth of understanding of a few important concepts and teaching students a logical thought process. If they are going on to careers that will require lots of knowledge of physiology, they will take more courses—and they will enter those classes with very strong foundations".

Second, Prof. E has made a commitment to pursuing teaching and learning as her primary scholarly activity and has received funding from the National Science Foundation for an inquiry-based learning project to study student thinking. Third, when she finds a strategy that seems to work well in her classroom, Prof. E posts to the project Listserv. Consequently, many of the other instructors have either implemented or are planning to implement the idea of "blue book" quizzes, which are short, "three-question quizzes worth three points, given during the first five minutes of class," that ask students to apply the subject matter learned in the last class period. Prof. E explained that even if students don't get the questions right, they get a point for being there and turning something in. Also, during the pre-project interval, Prof. E also compiled a large collection of her "favorite active learning problems" and distributed them to the other instructors in the study.

Fourth, when faced with a classroom dilemma, she consistently applies a strategy of extending an analogy from her personal life to think differently (and more concretely) about the dilemma. The following quote demonstrates her thought process as she sorted through the piecemeal teaching strategy typically used in undergraduate classrooms and compared it to an active learning system that teaches thinking and content within a context that students can make sense of.

> I have a friend who is trying to learn how to play guitar…. and so another mutual friend, who is a self-taught guitarist offered to teach Paul how to play. So Paul started to going to Mark for lessons…but within a month he

didn't want to go back. He was sick of it. I asked him, "What's going on?" He said, "Mark won't let me play any songs." And I asked, "Why not?" and he said, "He keeps telling me that I have to learn the chords before I can learn the songs."

It just struck me that this is a perfect example of [the way we go about teaching]. Really, Mark is teaching the way we teach…he's telling Paul, "Look, you need to get all the parts down before you can go to the next step." But the problem with that is by the time you get to the song, the students have lost interest and they probably can't even remember half the chords because they learned to play them out of context. [With active learning] what we are doing is saying, "Okay I'll teach you a couple of basic finger positions…okay…now it's time to try a song! Now…understand you are going to mess up all over the place…but as you mess up, you are going to learn to talk to yourself and say, "Okay I messed up here…. because I really need to stop and learn this chord…okay…there it is…. now I can try again." This way totally makes more sense because there is a contextual basis for what is being learned. Not only does it make the learning more memorable…. but it is actually more realistic because in real life…when you run into a problem you have to solve…you're not going to have all the chords memorized…you'll know the fundamentals…and since you've been taught the skills of thinking and searching for information you need…then you are always going to be successful.

From Mark and Paul, I just learned how we try to do it so backwards. But that creates another problem at the college level because we have got students that have been doing it Mark's way their entire lives…. so getting them to accept learning the song before learning all the chords is terribly difficult. They are not comfortable with it…and they think that you are not doing your job as a teacher…. because they think the job of the teacher is to put their fingers on the frets and teach them the chords.

Fifth, Prof. E's response to reading project interview transcripts and summaries was unique. Rather than a standard response of, "Do I really talk that way?" Prof. E responded with concern:

It was very disconcerting to see how my language patterns emerge. I sort of let my thoughts guide my mouth…and what I thought was a fairly linear explanation, I see what comes through is that I go off on different tangents…or pop in with an example…and then a story crops in…it makes

> me aware that I need to think about whether the same kind of thing is happening in my teaching…

Finally, Prof. E received tenure during the course of the project semester.

Project Participation: A Snapshot

Project participation data were collected through six, 45-minute telephone interviews, one, 60-minute personal interview, four written surveys, course syllabi, class problem sets, and numerous email exchanges.

Instructor's Prior Experiences

Prof. E received her undergraduate degree and Ph.D. from a large, Research University. She reported that, "pretty standard teaching practices" were used by most of her professors. She elaborated that as an undergraduate, "the real kind of learning where the puzzle pieces come together never happened for me". This realization came to her during more conceptually oriented graduate level coursework that focused on understanding the rationale behind processes and equations. When describing the instructors who influenced her thinking about teaching, she mentioned her high school A & P teacher and a water polo coach:

> [My A & P teacher] was very unorthodox and extremely animated. He never used a text, rather a series of handouts/notes, and would often lecture while walking around the classroom on top of the lab tables. He would do creative things with us like have us read a story on overpopulation while we were sitting so physically crammed around a table that we could barely move! He honed our curiosity about everything from legislation affecting science to biological facts…and he loved to debate. It was obvious he enjoyed the class as much as we did.
>
> [My water polo coach] had a very big impact on me…obviously it's a different type of learning but water polo is a very intellectual game with lots of strategy so the learning was cerebral as well as physical. My coach actually had a law degree…and come to think of it…he was very

> unorthodox…he transferred offenses from basketball to water polo and it was so inventive! He always encouraged smart play over physical play and that idea has just become a part of whatever I do.

Teaching Strategies

Prof. E characterized her teaching strategy as mini-lectures with breaks for responding to student questions and group problem solving. Over the course of the semester the method was modified slightly so that fewer and shorter mini-lectures were given. The general class format included: a "blue book" quiz over information form the previous class session and a student-led end of quiz summary; a homework question and answer period; a short mini-lecture; individual problem solving (five minutes), then joining with a group to finish; a dialog-style summary of the problem solving; and reminders from Prof. E to do the homework and reading assignments for the next class session. Students were expected to complete reading assignments and workbook pages prior to coming to class, and understood that class time would be used to clarify unclear concepts, answer the questions they generated while doing the homework, and work on problems.

Somewhat inconsistent with her teaching philosophy, Prof. E used a time-consuming process to place students into small groups based on what she thought "would be good for them to experience". The process involved completion of a survey by students and then "hours of shuffling people" between groups to get "a pretty gung ho" (motivated) student in each group, someone with a good science background, and a mixture of males, females, and ethnic groups.

Beliefs Related to Teaching and Learning

Elements of both an information transmission and an interactive teaching system were present in Prof. E's pre-project beliefs about teaching (Appendix I). Salient features included a belief that, learning required a feeling of ownership and was dependent on having freedom, and being "equitable in the classroom" included making sure gender, ethnicity, and academic background were distributed by the instructor throughout small groups. Prof. E had contradictory ideas about whether facts or thinking processes should receive the most emphasis in her teaching ("The instructor is someone who believes it's more important to teach thinking…than facts" and "Someone who is responsible for giving students the facts.") and somewhat contradictory ideas about students, who were people who had control of where they went in the classroom yet needed to have a lecture before doing an activity.

Juxtaposing Prof. E's stated beliefs to her description of her teaching, it seemed that the mixed belief system, with an emphasis on student freedom was enacted in the classroom during the pre-project phase. Despite a desire to let students control the learning process, Prof E indicated that both she and her students were frustrated by the teaching system: She was frustrated that students weren't learning what she thought they should be learning, and students were frustrated because they didn't know what they were supposed to be learning.

Goals and other Motivational Beliefs Impacting Change

The goals and other beliefs related to motivation that were articulated by Prof. E are listed in Table 18. Of particular salience, her goal statements and explanations of success and failure were all learner-oriented, and excerpts from interview transcripts suggested that Prof. E applied a malleable theory of intelligence to both herself and students. For example, she did not perceive that students' initial struggle to apply concepts across systems was a fixed, inherited ability; rather, she perceived that their ability to make connections would improve as a function of experience and effort. She also commented frequently on her own improvements in conceptualizing and implementing activities and problem sets that targeted what it was she wanted students to learn. Her interpretations of success events were consistently internal, unstable, and controllable ("I am massively overworking myself trying to get the workbook pages done so that students get some guidance as they are doing their textbook reading…once I get some of these things in place it will be great….), and interpretations of failure events were either external or internal, unstable, and controllable ("If students are confused there are lots of possibilities…[unclear guidelines…too big of a jump….didn't do their workbook or didn't make the connections that I expected them to"].

Prof. E also indicated a disposition toward risk-taking in the classroom. One example is the opening quotation in this snapshot; another statement made prior to the start of the project semester also indicates a belief that the potential to improve student learning outweighed the risk of her own fear and discomfort.

Table 18 Prof. E: Motivational Profile

Nature of Competence/Theory of Intelligence:	
	I'm moving away from "writing cool activities" to learning how to make shorter activities that really target what I want students to learn.
	Students don't naturally make connections. They need to be reminded that they've seen a theme before, and here it is again. Once they've been reminded they can quickly learn and elaborate the concept.
Goal Statements:	
	I want students to learn the logically oriented thought process of physiology.
	I want students always to be asking questions about the content, "Does this make sense?"
	Teaching students how to think in this discipline is my goal. That's the best tool they can leave my class with.
Task Choice - Challenging Tasks and Benefit (Student Learning) outweighs Risk (Instructor Fear and Discomfort)	
	1. Blood Vessels and Blood Pressure: A three-part problem
	2. Draw a nephron and osmotic fluxes in the kidney
	"Giving up control in the classroom is the most terrifying thing I have done professionally." But if I want students to have ownership of their learning, there is no alternative.
	Even at an institution where teaching is highly valued, there's a risk involved in doing active learning…. seriously…I'm not sure how it will impact my ability to get tenure….but I don't want my students to come out of their undergraduate experience like I did...knowing nothing other than how to memorize and spit it back.
Mistakes:	
	When things go wrong I try to do what I can…which at the time usually amounts to putting on a band-aide. Once I have time to think about what happened I try to learn something , "pay attention to the criticism and use and know that next time it will be better because of this experience".
What is Failure? Student-oriented	
	If students don't build a stable foundation in physiology…if they wind up with crumbly building blocks that won't hold them up in the future.
What is Success? Student-oriented	
	My success is determined by whether students build a strong foundation
	Success is when we've completed an activity in class...and maybe there was some confusion...but everybody comes out of thinking, Yeah...that was a worthwhile experience.
Attribution for Success:	
	"I am massively overworking myself trying to get the workbook pages done so that students get some guidance as they are doing their textbook reading…I am rethinking my syllabus so that learning objectives are explicit…oh my god….I know once I get some of these things in place it will be great....but it's a ton of work. [Internal, Unstable, Controllable (Instructor Ability and Effort)]
Attribution for Failure:	
	I had a terrible time with student resistance. They let me know in no uncertain terms that they hated group work. When I tried letting them make their own groups, rather than orchestrating that for them, it was like the difference between night and day! [Internal, Unstable, Controllable (Instructor Effort and Ability)]
	If students are confused there are lots of possibilities. Maybe the activity didn't have clear guidelines or maybe I asked them to make too big of a jump. Maybe they didn't do their workbook, or didn't make the connections that I expected them to. [Internal, Unstable, Controllable, (Instructor Effort and Ability)] [External, Unstable, Controllable (Students didn't do homework)]

She commented, “Giving up control in the classroom is the most terrifying thing I have done professionally…” but necessary if students are to have ownership of their learning.

Project Activities

Prof. E developed two, gradient-oriented worksheets/problem sets that she implemented in her classroom (Appendix H). Both activities addressed anatomical structure and osmotic fluxes: the first activity corresponded with study of the cardiovascular system and addressed blood vessels and capillary exchange; the second corresponded to the renal system and addressed the exchange processes of the kidney. Prof. E explained the flow of the second activity:

> I did a bit of an introduction because the system is complicated. First I had them recreate drawings of the nephron because I expect them to be able to figure out what’s going on by looking at the structure. Then I explained that there were forces in this system that they had seen before [first activity] and explained that their job was to describe how the system functioned given a hypotonic volume load and then an isotonic volume load. And, based on what I’ve learned [from the first activity] it makes a world of difference to give them numbers to work with so that they can talk in terms of relative magnitudes of things. Then…basically that was it…they took it from there. I told them they needed to figure out what changes were occurring at the different structures…at the glomerulus, in the distal tubule collection duct, and what’s going on in terms of final urine production. Then, the last thing they had to do was design an osmotic diuretic and explain the characteristics it would need to have. During the whole time I was just sort of circling around in the room and answering some basic questions. They really do have enough background information that they can figure this out…and I tell them that…. and ask them to think back to the other activity. Then we went over what they had figured out together at the end of class and I asked them to write down anything that still wasn’t clear to them so that we could address it in the next class.

Prof E said that the formative assessment was helpful to her because the most common question was one that she thought had been adequately clarified. “A lot of them really didn’t understand how the diuretic worked mechanistically”. She indicated that a little more time was spent during the next class period talking about diuretics and subsequently students had done “very well” on the exam that addressed the subject. In subsequent reflections she elaborated,

> The thing that jumps to my mind…is that it’s sort of shocking to me that students don’t make the connections on their own. I had to remind them that what was occurring at the glomerulus was a similar process to what they had already seen in capillaries. I think because we were in a new organ system and maybe because the numbers I gave them were different…it was very necessary for me to remind them…until I heard them saying things like, “Oh!! This is the same process in a new place!” I was sort of shocked by that…. they didn’t recognize it on their own. Once they grabbed onto that, the whole problem was much much easier for them…because we had already spent a fair amount of time at the beginning of the class on basic osmosis, forces, and potentials of different sorts.

Perceived Supports and Obstacles

Prof. E shared her perceptions of the supports and obstacles she encountered while implementing active learning (Appendix I). Nine supports and 23 obstacles (a majority at the instructor level) were mentioned during pre-project interviews. Although Prof. E perceived a campus and departmental climate that valued teaching and learning, she reported one obstacle at the college level—over enrollment—that had resulted in a doubling in size of most of her classes. At the departmental level, Prof. E had been disheartened when an expressed need by several of the younger faculty to hire someone with an education degree to teach lower division courses and support faculty teaching had been overturned. Several tenured faculty had rejected the proposal stating that any new departmental hires had to have a Ph.D. in science or they wouldn't be respected. At the course level, Prof. E reported large class size, variable availability of teaching assistants and lots of content to cover. Consistent with her attribution style, Prof. E reported her biggest obstacles at the instructor level: the fear associated with giving up control of the classroom ("It's the most frightening thing I've done professionally"), the unpredictable nature of classroom sessions, where "I don't have the experience yet to know where student minds will go…", and a lack of instructional knowledge related to formative and summative assessment.

Also significant, Prof. E had just completed her first semester of trying active learning and had struggled through most of the semester with resistant students (another obstacle) who "hated group work". Although her self-designed, end-of-semester evaluations had contained positive comments that indicated students had, "learned things from their group members that they couldn't learn on their own", understood the rationale behind her group-forming policy, and felt overall that they had learned a lot in her class, Prof. E's departmental evaluations had been "terrible". Whereas she had become accustomed to tightly-clustered, high-end scores (9's or 10's on a 10-pont scale), the past semester had resulted in a distribution spread between 2 and 10, and comments about "all the things they didn't like…the point structure, the groups….". Prof. E also had a nagging uncertainty over whether students would really learn when she was teaching with active learning.

During the project semester, one new obstacle appeared at the College level related to a new awareness of a lack of collegiality among faculty who valued discussions about teaching and learning. Prof. E commented that not only was there no campus support for faculty conducting research on teaching and learning, there wasn't any means for these faculty members (who were "sprinkled all over the campus"), to get together as a cohesive unit. Toward the end of the project, Prof E reported a parallel support to the obstacle: she had identified a member of the University Collaborative for K-12 teachers who invited her to attend book club discussions. Despite being the only college-level instructor in the group, she commented enthusiastically, "[Participation in the book club discussions] has changed my way of thinking. It's challenged me to think about what I really want my students to know and challenged my core beliefs about teaching and learning". She said the most important learning that came out of the discussions was how obvious it was that she was not setting up the kinds of "supports" that students needed to be able to participate as active learning. She elaborated:

> All along I thought I had been setting up really strong supports for them, but I came to the conclusion that I wasn't setting up the kind of supports that they needed. I think it's one of those things that as I'm learning more about this…I see that what I really thought I was doing…I was not doing at all [laughing]…so I'm going back and looking at the early parts of the course…and working on drawings that I can use throughout the semester…that I can start with and then as we move to other systems, pull it out. What I've been doing is explaining the same concept different in every system…and I was thinking I should do that to give students some variety…but I think it's also important to build a solid support through consistent use of drawings and language before we go on to talking about the unique aspects.

Quite surprisingly, toward the end of the project, none of the obstacles that Prof. E had expressed at the instructor-level were mentioned. Rather, two new supports were mentioned: a new awareness and acceptance of her current ability and knowledge, and increased confidence to facilitate active learning. Prof. E mentioned the event that may have been responsible for the change. She was involved in teaching a workshop on active learning with a community college colleague, when she suddenly became aware of workshop participants perceptions of her knowledge, and her own perception of her knowledge. She explained that, "It just struck me as odd [that they were hanging on every word I said] that I probably did know a lot more than they did…but I feel so strongly that I am really just at the beginning phase of my learning and realize how much I have to learn."

Also of interest, the obstacles related to large class sizes had been eliminated because "spring semester enrollment is always lower than fall" and student resistance and poor evaluations had been removed when she stopped assigning students to groups, let them choose their own group members, and altered the grading system for group problem solving activities. She commented in an email:

> I just (finally) read the anonymous evaluations that I give my students at the end of the semester (to get their feedback on the active learning things I do), and they were overwhelmingly positive. There were repeated comments of how they really felt like they retained the information better, how they liked being able to apply concepts immediately, how they felt like classroom time was consistently useful – I tell you, I couldn't have dreamed up better comments! I'm so amazed!! I believe I told you that my previous semesters' comments were all over the board, which made it difficult for me at times to "stick to my guns" with this stuff, but now it all seems worth it. Hooray!

Throughout project participation, Prof. E commented on the value of the support she received through the ITIP group. “[ITIP] has been a very large part of my ability to “tinker” with the course that led to its present state.” At the end of the project semester, Prof. E had reported 17 supports and 2 obstacles.

Impact of Project Participation: A Snapshot

Three separate categories of change beliefs are reported: Self-reports of change, data-based belief changes, and theory based conceptual change. The impact on student content learning and attitudes are also summarized as points of triangulation.

Self-Reports and Critical Incidents Promoting Change

Prof. E reported two perceptions of change and speculated on the critical incidents that may have facilitated the change:

<u>Changed expectations (Experience related to using active learning):</u>

> When I first started, I was so optimistic about active learning; I thought I was going to turn the world around. I seriously thought my students were going to be coming up to me thanking me for do this in the classroom… 0h my god did I get a rude awakening! Now I don’t expect students to embrace active learning in the beginning and I expect them to grumble.
>
> I also used to feel upset that I couldn’t control where students’ minds went. Now, I have a better feel for where they might go and what I can do get their wheels turning in the right direction…
>
> I also used to be so apprehensive going into the classroom thinking, “Will this work?” Now my expectations are more like, ‘Well the challenge level is in line with what I think they can do…they shouldn’t be befuddled…it’s situationally based and I know that is engaging for them…and it’s not too long…so let’s see what happens with this

Changed philosophy that takes multiple perspectives into account and leads to different instructor responsibilities and balanced decision making ("Classroom cues" such as, student resistance, low evaluations, student frustration):

> Now that I understand this more as… a system, I make decisions that are in line with my philosophy. So I know I want them to build a strong foundation in their understanding of concepts and at the same time I want them to be learning a thinking process. That I WILL NOT bend on. So when I make decisions about how to structure the class and they say, "We want more lecture"…whereas I used to appease them and do more lecture…now I see that wasn't the right decision.
>
> Now what I do is look at it from their point of view…they want more lecture… so two things have to happen…they need to hear again why we are learning this way…they need to hear why we are learning to play a SONG…not just learning the chords. Then I need to adopt a student perspective and say …more lecture might be more guidance or more structure… so how can I do that and not bend on what's important. So one thing I did was make up some self-study questions that are organized on Bloom's taxonomy. So now they have a better idea of the concepts that are important and they can start to get a feel for what questions look like when they are structured around different levels of knowledge.

Data-based Changes in Beliefs about Teaching and Learning

Learning: Prof. E transformed her adopted creative, freedom- and equity-dependent definition to an experientially grounded definition (learning is about making connections but that is not something that students do naturally, they need to have it modeled; "individuality makes learning slippery"; and a two-faceted process that requires stumbling and then knowing how to recover from the stumble).

Implementing active learning: Prof. E transitioned how she spoke of active learning from "designing cool activities", "winging it and giving students the freedom of deciding what they will discuss in their groups", and making instructional decisions based on student polling-- to being committed to a system that requires “sticking to your guns about what you know should be happening”.

Students**:** A revised description from “people who have control of where they go in the classroom” to a recognition of students as capable people who have been pulled out of their comfort zone and need assurance, clear expectations, and an environment that is conducive to building self-confidence as well as the ability to self-assess what they understand and don’t understand.

Student actions: From descriptors that suggested a generalized/random approach to learning (they: take off, write down, complain, feel too rushed, get confused, hate) to responsibility mixed with specific, engaged descriptors (they: struggle, conceptualize, apply, sort through, make predictions, explain). There was also a strong indication that Prof. E believed that students’ actions were warranted and representative of the way all people feel in given situations (When they are focused on grades they don’t learn; when the don’t know what’s expected of them they get frustrated).

Instructor: From an adopted metaphor of “guide” to a personalized metaphor (“engineer of content and thought process learning”).

Instructor actions: From descriptors that focused on leading, clarifying, and giving information in a variety of ways, to descriptors that focused on trying to envision how students might perceive the design elements of the classroom (fine-tuning, using the learning goals as a guide for what goes on in the class, gives problems that stimulate discussion, provides tools to help students develop an awareness of the structure of knowledge).

Instructor/student relationship: From guide and explorers to engineer and active learners.

Class meeting purpose: From an information transmission purpose “for students to get it”, to a clarifying and elaborating purpose that emphasizing scientific thinking.

Evaluation: From a belief that “students get points for everything they do in class”, to assessment that is aligned with objectives and contains a variety of different opportunities for students to demonstrate the extent to which they’ve met the learning goals.

Conceptual Change

Evidence of Dissatisfaction

Frequent evidence of dissatisfaction was found in transcript analysis. Prof E realized as a graduate student how little she had learned as an undergraduate physiology major from lectures that were packed full of facts. She commented that the lecture format hadn't provided the opportunity for her to, "put the puzzle pieces together", nor did she even realize that learning could be more than memorizing and spitting it back.

Evidence of Intelligibility

At the beginning of the project, statements of unintelligibility were much more frequent than statements of intelligibility. For example:

> How much can a teacher say when students are doing active learning? I'm thinking it should be a guided…but maybe that is only true when working with lower-division students and it's skills based…so I don't know about lecture where it's so content driven…. I need to make sure that certain things are covered…. but I also know students need ownership of their learning. I'm very fuzzy on this….

Later in the project semester, statements of intelligibility became more common. For example, Prof. E differentiated "beginning active learning" and "real active learning":

> When I started, I was doing "beginning active learning". The focus was totally on me…what was I doing…was I doing lecture? Was I leading active learning? Was I coordinating the group activities? Was I pleased with how it went?

> Then when I realized that, I stepped aside and just let students go…without realizing I was way out of balance with the freedom thing…I was mainly telling them, "Okay go for it…find the answer or an approach that will get you to the answer". So, the switch was that I was still there…but there to watch them struggle…and did they ever struggle…they had so much freedom, they had no idea where to go.
>
> Then, by getting involved with discussions and reading on my own, I started to see what needed to be happening…. and even though I thought I had been doing active learning right…I wasn't…what I was doing didn't match what I thought I was doing. Basically, the scaffolding I was setting up for students was so weak, when they tried to build on it, it just crumbled and they were so frustrated. Now, I think I'm starting to do "real active learning". I'm seeing how important it is for me to set up strong scaffolding and monitor the cues in the classroom to see if what I think I've set up…is what I actually set up.

<u>Evidence of Plausibility</u>

Plausibility statements became common toward the end of the project. Interestingly, most of Prof. E's statements related to the application of strategies to promote active learning contained a comparison to the old system of lecturing. For example:

> When we are doing active learning, I know it's not possible for me to have complete control. Part of the system is just accepting it's totally not possible when you think about how individual the process of learning is. Now maybe some people would say, "I can't handle that…I have to have control." But the reality is…in lecturing it never occurred to me to wonder or even care where their minds were going…it was me being in control of what? There's no comparison to make. This way is much better.

Evidence of Fruitfulness

Fruitfulness statements were also apparent towards the end of the semester. Prof E speculated on her next challenge:

> Now I'm thinking the next step is to start thinking about how I can help students develop an awareness of their learning as well as the ability to self-assess their learning…. because that's really hard for them…maybe writing assignments will be something to explore. Maybe ask them to give their thoughts about studying physiology at the beginning of the semester and then ask them to write about how their thinking is changing…. I'm thinking about that.

Student Changes

Changes in thematic content understanding and attitudes toward teaching and learning were determined from pre and posttests.

Thematic Content Learning

With the limitations (described in Chapter One) on this data in mind, the following data summarizes gains in students' understanding of gradients at four knowledge levels: remembering, understanding, applying, and analyzing: an 11% increase in remembering, a 29% increase in understanding, no change in applying, a 10% increase in analyzing, and an overall increase (all categories) of 15%.

Attitudes about Teaching and Learning

Statistically significant changes in one of the eight beliefs were suggested by student attitude surveys. At the end of the semester, students were more inclined to believe that they had lots of useful knowledge about topics in the class.

Summary of Beliefs

An overview of Prof. E's beliefs about teaching and learning, motivational profile, perceived supports and obstacles over time, and change profiles are summarized in Table 19.

Table 19 Prof. E: Summary of Data

Beliefs								
	Learning	**Students**	**Student Action**	**Instructor**	**Instructor Action**	**Class**	**Assessment**	
Pre	A creative process dependent upon ownership and freedom; includes building upon foundational knowledge; facilitated by group work and lecturing before an activity	People who have control of where they go in the classroom, and have a good feel for what needs to be happening	Take off in unexpected directions when working problems; write down questions to be answered by the instructor and complain if all questions aren't addressed; hate group work; Want lecture before activities	Leader/clarifier/interpreter; Knows that lots of facts translate into little retention; Somewhat unclear about whether the priority rests with teaching thinking processes or teaching facts and how teaching is accomplished--transmission or interpreter?	Focuses on a strong content foundation and homeostatic integrated systems; Makes classroom decisions based on what students say they want; Explains the benefits of active learning to students; Assigns student groups; Gives students ownership and freedom; Collects feedback; Gives individual and group tests	A time for students to "get it"	Students get points for what they do in class	
Post	A personal process of internalization, making connections, integrating and elaborating material and using it to solve unfamiliar problems; Tow facets- stumbling and getting back on track; facilitated by visuals and concrete components	Very capable individuals, but not always aware of what they understand; people in transition who need clear statements of expectations and assurance in the new learning situation; respond like anyone when expectations and grading criteria aren't clear	Learn basic concepts on their own. Like working in groups conceptualizing and applying information, making predictions, struggling with making connections	Engineers learning experiences; Provider of opportunities; Gaining confidence as a facilitator; Values reflection on teaching and learning; Focuses on depth of understanding and building student confidence	Defines learning expectations; Focuses activities on learning objectives; Places emphasis on individual tests rather than groups; Fine tunes classroom strategies; Challenges students with groups; Questions students ideas	For concept clarification; contextualizing and applying information; emphasizing thinking processes	Aligned with learning objectives so assessments determine if learning goals have been met; A range of opportunities for students to experience novel problems	
Motivation								
	Goals	**Intelligence**	**Mistakes**	**Success Attribution**	**Failure Attribution**	**Failure**	**Success**	
	I want students to learn the logically-oriented thought process of physiology	Instructor malleable	Useful learning opportunities	Internal, Unstable, Controllable (Instructor ability and effort)	External, Unstable, Controllable (Student Reaction)	Student Oriented	Student Oriented	
	I want students to always be asking questions about the content, "Does this make sense?"	Students malleable			Internal, Unstable, Controllable (Instructor ability and effort)			
	Teaching students how to think in this discipline is my goal. That's the best tool they can leave my class with.				Internal, Unstable, Controllable (Instructor ability and effort)			
					External, Unstable, Controllable (Student Preparation)			

Obstacles and Supports								
	Academic Community	**College**	**Department**	**Course**	**Instructor**	**Student**	**Professional Org**	**Total**
Obstacles Pre	0	1	3	3	14	2	0	23
Obstacles Post	0	1*	0	1*	0	0	0	2
Supports Pre	1	1	1	3	0	1	2	9
Supports Post	1	1	2*	3*	4*	3*	3*	17
	* Modified or changed							
Change								
	Self-Report	**Change Event**	**Data-Based**	**Conceptual**	**Tries to Adopt Student Perspective**	**Student Attitudes**	**Student Content**	
	Active learning expectations	Doing active learning and reassessing my beliefs	Learning: Yes	Dissatisfaction: Evidence	Yes	Useful Knowledge: More inclined to believe that they had lots of useful knowledge about topics in class at the end of the semester	Remembering: from 28 to 38% = 11%	
	Change in philosophy that takes students perspective into account and leads to different instructor responsibilities and balanced decision making	Doing active learning and monitoring the "cues"; Using a problem solving approach to improve the situation. Reading, reflecting, and discussion (critical)	Students: Yes	Intelligibility: Evidence			Understanding: from 31 to 59% = 29%: from	
			Student Action: Yes	Plausibility: Evidence			Applying: from 34 to 33 %= -0.1%	
			Instructor: Yes	Fruitfulness: Evidence			Analyzing: 32 to 42%= 10%	
			Instructor Action: Yes				Total: 32 to 47% = 15%	
			Class: Yes					
			Assessment: Yes					

PROFESSOR F: TWO-YEAR RESIDENTIAL COLLEGE A & P INSTRUCTOR

> I had been giving some thought to how to get students more involved in the learning process, when an opportunity came to redesign a classroom. Since I wanted to encourage collaborative learning and also wanted to be able to switch between different activities—lecture, labs, working with models, computer simulations—to keep students from being so passive, I designed the classroom with a projector mounted from the ceiling…hooked into a document camera and tables that accommodate four students and a computer.

Pre-Project Information: A Snapshot

College and Course

- The college is somewhat different than a typical community college. Although it is open admission, there are very few terminal two-year programs (a nursing program is one of two exceptions); rather, the college offers a wide range of programs designed for transfer to four-year institutions.
- The overall context is conducive for active learning. Although there is a teaching center, they have not gotten involved in active learning yet.
- During project participation, Prof. F was: Department Chair, teaching, serving on the presidential search committee for the college, and involved in accreditation.
- The course is a two-semester, Human A & P course that is taught as units organized around concepts and organ systems.
- The class is small, approximately 25 students.

- In the past, the class has been a traditional lecture with questioning. The format has recently been changed so that it's more of a combination class/lab. It meets for two-hour periods, three times a week.
- Students purchase the lecture notes outline so that they are free to listen during class rather than scrambling to write everything down.

The Students

About half of Prof. F's students are younger students who "are starting from scratch" with no biology or chemistry experience. Others are older, non-traditional students, who may have had either some high school or college chemistry or biology. About half the students in each class have plans for a career in allied health--primarily nursing.

The Instructor

Prof. F is both an A & P instructor and a Division Chair. He has been teaching at the college level for over 35 years. He has undergraduate and graduate degrees from large, Research Universities.

Three features distinguished Prof. F from the other instructors in this study. One was that he was originally "turned on to the potential of active learning" when he participated in a workshop on the studio learning approach to physics teaching and learning. He explained:

> The guy taught physics and he had designed his classroom so that all of the apparatus was right there in the classroom. He showed how he introduced the topic and then had students doing some calculations and experimentation and collecting and analyzing data…it's exciting to think of new ways to teach this material and it just seems like such a natural

> with anatomy and physiology with the models and technology modules…I just thought, 'Boy! Isn't that neat?'

Second, Prof. F said that when he has read about why people teach, he hasn't ever seen his view represented. "Most say they love to interact with students and to see them learn," he explained. "I enjoy working with students but that is not the reason I like teaching. To me teaching is enjoyable because of the creative aspect of the process." As he has reflected on his teaching he realized that his joy comes from figuring out a better way to get a topic across to students and "learning something…trying something new everyday". Prof. F expressed that "going into the classroom is like a vacation for me…it's the thing I love."

Third, Prof. F maintains a file of thousands of multiple-choice questions (and how students have scored on each question over the years) that are aligned with his lecture notes. This system allows him to alter the presentation format of the content material and determine if student performance improves or declines. He explained that tracking student performance as he varies the presentation format has convinced him of the value of active learning. He elaborated:

> I had been teaching chemical equilibrium in the same way for some time…just projecting the outline on the screen and plodding through the information…asking rhetorical questions. Whenever students came across test questions on chemical equilibrium, on the average about 30 percent would get the questions right. When I developed a little paper and pencil activity last semester that forced them to think and wrestle with [the concept]…practice on a few questions…. 75 percent of the students got the test questions right…so there was a pronounced difference.

Project Participation: A Snapshot

Project participation data was collected through four, 45-minute telephone interviews, four written surveys, one observation of workshop participation, course syllabi, class notes, and numerous email exchanges.

Beliefs Related to Teaching and Learning

Elements of an information transmission and an interactive system were present in Prof. F's pre-project beliefs about teaching (Appendix I). Although he clearly valued experiential learning where students had the opportunity to manipulate things to "get a sense of form and complexity" and emphasized that students should learn to use their own words to explain concepts rather than using technical definitions, he also believed that lecture knowledge, if structured in a logical fashion, could be transferred to students who "take it in". Juxtaposing Prof. F's stated beliefs to his description of teaching, it seemed clear that the information transmission system was enacted in the lecture.

Goals and other Motivational Beliefs Impacting Change

The goals and other beliefs related to motivation that were articulated by Prof. F are listed in Table 20. His primary starting goal was to develop and have students use some simple computer programs to get them more interactive. He also wanted to "sprinkle more questions" into the delivery of information. After the first activity, and subsequent use of a computer program developed some time ago (which did not contain questions and did not promote interaction), his goal was modified to, "rethinking activities as learning tools".

Table 20 Prof. F: Motivational Profile

Nature of Competence/Theory of Intelligence:

I'm getting "new wrinkles"…new ideas for learning all the time.

I have test exam evidence that shows when the mode of presentation changes from lecturing to student activity, students performance improves

Goal Statements

I want to introduce more technology by developing and implementing some simple computer programs to change the mode of presentation for lecture to student activity [pre]

I want to revise my lecture outline by sprinkling more questions throughout the presentation [pre]

I want to be prodded to follow through and collect student feedback after an activity [pre]

I want to rethink the activities as learning tools so that students have to put in more thought and come up with responses that will show me that they are learning [post]

Task Choice - Challenging Tasks that are fun for the instructor to develop and benefit student learning.

Modified an ITIP paper-membrane model activity (Membrane Potential) and wrote a simple, interactive computer program to accompany the activity.

Mistakes: Useful Learning Opportunities

My first computer program contained some nice animations but students didn't interact. It was a real flop. It wasn't until I had students using the second program (which had lots of questions built in) that I realized the importance of the questions in getting students interacting with each other.

What is Failure?

Students doing poorly on an exam

Students not engaging with an activity…no conversation…no interaction…a totally gloomy room

What is Success?

I have been extremely pleased with the way students are interacting with the computer program and with each other…they were asking questions and struggling with concepts and I thought it was great. It was simply a thrill to teach that way."

Attribution for Success:

The second computer program worked much better because I built in lots of questions and opportunities for students to interact. I figured out the process and got it to work the way I wanted it to. [Internal, Unstable, Controllable (Instructor Effort and Ability)]

Attribution for Failure:

If my students were to say, "We are not sure what we just learned" after doing an activity, then that is something I will need to look at again and modify. [Internal, Unstable, Controllable (Instructor Effort and Ability)]

The first computer program was a flop because I didn't build in any opportunities for interaction. [Internal, Unstable, Controllable (Instructor Effort and Ability)]

Although Prof. F did not outwardly indicate a disposition toward risk-taking in the classroom, he did express a concern that removal of the class notes/outline would make using active learning much more difficult, but his rationalization seemed more tied to the belief that students needed to take in more than one perspective (the textbook) in order to learn new material.

Statements and explanations of success and failure were all either learner-oriented or activity-oriented, but when talking about computer modules (versus paper and pencil activities) the ultimate explanation for success or failure seemed to be focused on the quality of the module ("Students are not engaging with the activity…"). Although excerpts from interview transcripts suggested that Prof. F applied a malleable theory of intelligence to both himself and students ("I am getting…new ideas…all the time", students' performance improves when the mode of presentation changes), there is some question as to why he consistently disregarded students' prior knowledge ("My students are starting from scratch"). Prof. F's interpretations of success and failure events were consistently internal, unstable, and controllable (The computer modules work better when I build in lots of questions…I figure out the process and got it to work the way I wanted; If student learning was questionable…I would need to figure out why.)

Project Activities

Prof. F developed a paper model membrane activity (a modified version of the ITIP Membrane potential activity), a computer program focused on membrane transport and osmolarity, and a worksheet to accompany the computer program (both are in the researcher's possession). Rather than focusing on the movement of ions as the ITIP module had done, Prof. F designed the activity to deal with the movement of uncharged particles across membranes, so that students could become familiar with membrane transport processes. He designed the activity with the hope that he could modify it later in the semester by replacing the uncharged particles with charged particles when students began the unit on the nervous system. His formative assessment included the following set of questions:

1. Did you use the program either in class or out of the class?
2. Was the use of questions and animations useful?
3. Do you think the program increased your understanding of osmosis?
4. Would you like similar programs on additional topics?
5. What are your comments?

Prof. F tabulated and emailed all responses: Students responses were:

1. 29 yes; 1 was absent
2. 29 yes
3. 29 yes
4. 28 yes; 1 maybe
5. Comments ranged from general: "I really enjoyed this", "I think I'm getting a god education"; to feedback on teaching, "I liked the way you helped us work through the ones we couldn't understand. Now I am getting a visual picture of what is going on. I still don't totally get this but when I can concentrate some more I probably will"; and

feedback on the program, "I'm having trouble with the net and the gradient."

Perceived Supports and Obstacles

Prof. F shared his perceptions of the supports and obstacles to implementing active learning (Appendix I). Six supports and seven obstacles were mentioned during the pre-project phase. The biggest obstacles Prof. F experienced were a limited knowledge about all the issues that come up with active learning (in particular, how to grade in-class activities so that grades remained discriminating), and how to go about including questions from activities on summative assessments. Although other obstacles were mentioned, they were of no particular significance.

The supports identified were related to personal classroom experiences, which had reinforced Prof. F's belief that "active learning was the way to go". Informative professional development opportunities were also mentioned as supports. Prof. F was somewhat uncertain about the impact of providing the lecture notes outline to students, stating that while it did free students from continuously scribbling notes, the resource may have contributed to a passive attitude toward learning. Similarly, he felt that while the outline provided him with some flexibility while teaching; the resource certainly made it easy for him to slip into paraphrasing and lecturing rather than interacting with students.

During his project participation, new supports, including a modified grading strategy that awarded points for summative assessment but not classroom activities, and an increased comfort level with active learning emerged. Prof. F also decided that the lecture notes outline was more beneficial than detrimental because it: provided the structure students needed to know what they were responsible for learning; and allowed a means of quick summary prior to doing some in-class exercises. Prof. F. said, "it just puts the basic content right there in front of the students and they can read that as well as I can read it to them…I think there is a definite advantage and I wouldn't want to change that". Only one obstacle emerged during project participation and it seemed more like a perplexing issue than an obstacle. After changing the grading strategy so that in-class exercises were not awarded points, Prof. F said that students seemed to have a lot of trouble with the new system. He elaborated:

> We'll be doing an exercise and they will ask, 'Does this count?' It seems that if it doesn't count then they think they don't really need to do it. And I keep telling them, 'Look! Get out of this mindset that anything you do counts for a grade. It's a learning exercise!' Some of them just look at me blankly as if to say, 'Well that just doesn't make sense'. I'm thinking I had better address this so they are clear that they are being graded on their knowledge and understanding of the subject…I have to try to get them out of this mindset but it's been pretty well engrained….

Impact of Project Participation: A Snapshot

Three separate categories of change beliefs are reported: Self-reports of change, data-based belief changes, and theory based conceptual change. Because of an unfortunate loss of posttest data during mailing, student content learning and attitudes are not included with this snapshot.

Self-Reports and Critical Incidents Promoting Change

Prof. F reported seven areas of change and factors that influenced the change:

Changed grading system (Incorporating computer modules into class):

> When I tried to introduce active learning exercises…some involving either computer work or modules of some sort…I began by simply giving some points for each activity and figured at the end of the semester I would figure students grades by just dividing their points by the total possible…a simple percentage…trouble is…. I had a whole lot of these modules and it became apparent very quickly that the grading system was not very discriminating…and as far as I could tell, it was not promoting learning. Students were just asking me how many points things were worth.

Changed thinking about what active learning is or can be (Reading and reflecting on a post to the ITIP Listserv):

> I have been…really quite taken with how a simple change…adding questioning…just asking students to wrestle with and respond to a very simple question prior to any instruction on the topic…stimulates students' thoughts and keys me in to what they are thinking. Just to give them a slip of paper and five minutes and have them respond to something simple like, 'What are carbohydrates, fats, and proteins?' Then I can read their responses to the class and they are more involved in this by having expressed their ideas.

Change in teaching philosophy ("It just dawned on me"):

> It dawned on me that I had this whole thing of teaching backwards! I was giving them the facts and expecting them to figure it out and that's not my job. They can get the facts on their own…and I can structure it so that they can better get the facts…but my real job is to help them figure it out…I am realizing that maybe it's better sometimes to pretend that I don't know some of the answers to questions…use the approach of seeing if we can figure it out together.

Change in understanding of the instructor's role (Interacting with students during implementation of a self-authored computer program):

> My dream had always been to get computer modules developed for the entire A & P class so that students could progress through them on their own. I had though it would be nice to assign the programs for them to do out of class but I have realized that it is essential for me to be there and assist…answer questions…circulate around the room. I think no matter how carefully something like this is put together …students get stumped and need a few elaborations or 'what if' kinds of questions, or need to come back to the big picture for the light bulb to come on, and then they'll say, 'OHHHH Yeah! I see!

Change in classroom dynamics toward more interaction (Interacting with students during implementation of a self-authored computer program):

> Since adding the active learning there is so much more interaction in the classroom…now when we have a class session that is not interactive it seems gloomy.

Change in the purpose of assessment as well as grading strategies (Comparing current survey responses to those of two years ago)

> For years I thought the purpose of assessment was to determine a grade…and maybe I knew that an exam was a great way to learn but I didn't use it that way. But since we have started all of this, I use a lot of formative assessments, quizzes, and exercises that don't count for points simply to see if student learning has been stimulated.
>
> I've also been forced to rethink the whole idea of how I assign grades. I've moved to a system where no short in-class assignments receive a grade. Students grade is based on their performance on six to eight hour exams.

Change in thinking about the content material (Listserv discussions and doing computer modules in classroom)

> I used to think that when dealing with science material there wasn't much room for debate…I mean there's the stomach and it does a certain thing and how do you debate that? Now I see so many questions…why does this happen and not this…?

Data-based Changes in Beliefs about Teaching and Learning

Learning: Revised definition of learning from "transmission of knowledge" to a personalized definition that included remembering. The definition was also extended to include understanding and the necessity for students to wrestle with information and ask questions.

Implementing active learning: From "changing the structure of the course" and "adding a lot of little things" to thinking more about the process issues that come up when active learning is implemented.

Students: A distinction between traditional and non-traditional students was made and references to students' thinking processes became evident. Of particular salience were processes that involved struggling, wrestling, and getting stumped.

The learning process: From a passive "taking in" process to one that requires working with new information.

Student actions: From passive descriptors (do, sit, answer, "plod through") to engaged descriptors (prepare for; get stumped; ask; provide feedback; interact).

Instructor: From lecturer and organizer of information to a creative, open-minded person who is trying to improve student learning and improve the odds that students will succeed at the next level.

Instructor actions: From a disseminator of information ("plodding through what is projected on the screen") to someone who helps students "figure things out".

Instructor/student relationship: From an unspecified relationship to one where the instructor informs and convinces students of the benefits of an integrated course structure that uses active learning instructional strategies.

Class meeting purpose: From "covering the content" to "helping students figure things out".

Evaluation: From "figuring a grade" to extending and gauging student understanding.

Conceptual Change

Evidence of Dissatisfaction

Evidence of dissatisfaction was found.

> I am not pleased with the way I have gone about this process [of adding active learning activities]. Maybe by jumping right in with the activities and modules, I put the cart before the horse. I now am at the point where I need to be thinking all the way through what this is all about…thinking about all the issues…particularly assessment…that has to be reconsidered in this approach…. a real weakness has been doing activities…just sort of throwing them out there and then rushing off to something else…that's just not how this should be and I'm thinking, 'Oh man…I really missed something here…."

Evidence of Intelligibility

No strong evidence of intelligibility was found but indicators were suggested toward the end of the project:

> I am working to develop the exercises so that they really are learning tools not just something I throw out there and move on….
>
> Had I just been lecturing, I might have noticed the confusion on their faces…but there wouldn't have been any interaction…there wouldn't have been the opportunity to interact and elaborate and explain with them.

Evidence of Plausibility

No strong evidence of plausibility was found, but indicators of plausibility were suggested near the end of the project:

> I want to develop more of the computer modules…working on making them more interactive…contain more questions…continuously incorporate them into the course…interact with students to see how they are working…. see if student learning improves

Evidence of Fruitfulness

No evidence of fruitfulness was found.

Summary of Beliefs

An overview of Prof. F's beliefs about teaching and learning, motivational profile, perceived supports and obstacles over time, and change profiles are summarized in Table 21.

Table 21 Prof. F: Summary of Data

Beliefs								
	Learning	**Students**	**Student Action**	**Instructor**	**Instructor Action**	**Class**	**Assessment**	
Pre	"Getting knowledge" and "Getting across ideas" "Get an impression of how information from different sources goes together"	Students who are starting from scratch (haven't had experience with material)	Listen to lecture; read textbook; do homework; pay attention; are passive; "plod through"	Information organizer/Enjoys lecturing and asking rhetorical questions	Encourages students to put things into their own words; teaches units via lecture; organizes information; integrates lab and lecture and encourages collaborative learning	Cover the content so that students have notes to study for the exams	"Have students learned what they have been instructed to learn?" A way of figuring a grade for students. All activities are graded and become part of the point percentage.	
Post	Starts with remembering; Is facilitated by asking questions and wrestling with ideas; May be accompanied by mild frustration	Two groups: Traditional and non-traditional. Both groups begin to think differently about the information over the semester	Get the facts on their own; work and wrestle with material; interact with classmates; ask questions; show when they "get it"	Enjoys creative aspects of teaching; interested in improving student learning	Helps students figure things out; asks questions prior to instruction; provides elaboration; is conscious to what content is presented	Where the instructor helps students "figure it out"	A way to gauge students' knowledge and subject understanding. Assessments are a learning tool and way to determine how understanding has changed. Activities are not graded; they are for learning	
Motivation								
	Goals	**Intelligence**	**Mistakes**	**Success Attribution**	**Failure Attribution**	**Failure**	**Success**	
	Change the structure of the course [pre]	Instructor Malleable	Useful learning opportunities	Internal, Unstable, Controllable (Instructor effort and ability)	Internal, Unstable, Controllable (Instructor Effort and Ability)]	Poor student performance on an exam [pre]	Improved student performance on exam	
	Change the mode of presentation from lecture to student activity via technology [pre]	Student Malleable; Some question as to why prior knowledge is disregarded				Students not engaging with an activity	Student interaction with computer modules	
	Revise lecture outline by "sprinkling" questions throughout presentation [pre]					Activity failure - doesn't promote conversation/interaction	Activity success- promotes questioning and struggling	
	Want "prodding" to collect student feedback after an activity [pre]							
	Be thinking of activities as "learning tools" [post]							
	Be thinking more about the process issues that come up when active learning is implemented [post]							

Obstacles and Supports								
	Academic Community	College	Division	Course	Instructor	Student	Professional Org	Total
Obstacles Pre	0	1	0	0	6	2	0	7
Obstacles Post	0	1	0	0	5*	2*	0	8
Supports Pre	0	0	0	1	3	1	2	7
Supports Post	0	0	0	1	4*	1*	1	7
	* Modified or changed							

Change								
	Self-Report	Change Event	Data-Based	Conceptual	Tries to adopt student perspective	Student Attitudes	Student Content	
	Instructional strategy: Changed grading system	Adding quizzes, activities, computer modules, and questions	Learning: Yes	Dissatisfaction: Evidence	No	Post tests lost	Post tests lost	
	Instructional philosophy/strategy: Changed purpose of grading	Doing active learning has made me realize that assessment is more than a way to give a grade; ITIP interviews and Listserv has made me reconsider what I once thought	Students: Yes	Intelligibility: ??				
	Instructional philosophy/strategy: Chang in thinking about content material and role of questioning	Doing active learning; Reflection on Listserv discussions	Student Action: Yes	Plausibility: ??				
	Definition of active learning: Changed definition	Doing active learning/ ITIP interviews/ Reflection on Listserv discussions has made me think differently	Instructor: Yes	Fruitfulness: ??				
	Teaching Philosophy: "I had teaching backwards"	It just dawned on me one day that I had it backwards	Instructor Action: Yes					
	Instructor's Role: Changed vision of how to implement technology	Doing active learning with the computer modules has made me realize the critical role of the instructor	Class: Yes					
			Assessment: Yes					

Professor G: Community College A & P Instructor

> We were told ten years ago that accreditation was moving toward data-driven outcomes assessment and that we needed to be moving towards this…but for a variety of reasons the college did nothing until a year ago…and now we are learning to assess at the same time we are supposedly writing up how we assess and what the results are…it's a horrible situation and I think a lot of colleges have done the same thing.

Pre-Project Information: A Snapshot

College and Course

- The college is in the throws of self-study for accreditation.
- Since full-time faculty make up only 30 percent of the teaching force (70 percent are adjuncts), they are required to participate in many administrative areas. During her project involvement, Prof. G was: teaching, in charge of the campus accreditation visit, getting training to be a site evaluator, on the steering committee for self study, the Teachers' Union President, on the master planning committee for new campus buildings, the graduation speaker, writing a level-one pilot proposal for a new radiology program, compiling course catalog changes, and, in charge of advising 60 students.
- Although Prof. G believes that the Community College context is conducive for active learning, there is little in the way of on-site support for instructors interested in improving student learning.
- The course is a two-semester, Human A & P course that is about half physiology and about half anatomy.
- The class size is approximately 30 students.

- In the past, the class has been traditional lecture with questioning.
- Class meets for 50- minute lectures three times per week.
- Since Prof. G was not a skilled note-taker as an undergraduate, lecture notes (an outline of the textbook organization) are purchased by students so that they can listen to lecture rather than write everything down.
- Labs meet for two hours, once per week. Students buy a lab manual and a supplemental lab note packet (the latter written by the instructor) that contains lab introductions, methodology, data analysis techniques, and specific instructions and questions to address in lab reports. To reduce the amount of time students spend doing "busy work" (therefore increasing time spent on thinking), Prof. G compiles and formats class data into tables and graphs.

The Students

Prof. G's students are local students, which means they are not "ethnically diverse". Most have plans for a career in allied health—primarily nursing or dental hygiene. They range in age from 19 to 55, with the majority falling between the ages of 25 and 35. The class is generally 75 percent female and most students work and are taking three to four other courses. Although Prof. G's students may complain behind her back to each other about the work load, she finds them to be highly motivated, compliant about doing the assigned work, and very enjoyable to teach. Semester after semester, Prof. G considers herself lucky that, "students consistently develop into a very tight knit and cooperative group". They "hang out" together in room just adjacent to the classroom, where there is a coffee pot and microwave, and they get to know each other quite well. If one student catches on quickly, there seems to be a natural tendency for the student to find someone else to help. "Students just pull each other through the semester"

The Instructor

Six features distinguished Prof. G from the other instructors in this study. One was that she had taken an active role in the accreditation process and had developed an acute awareness of educational programming and data-driven outcomes assessment at the division-, departmental-, and course-level. As a consequence of her involvement, reflective questions such as,"Am I doing what I think I am doing" and "Do my students know what I think and what I say they know?" had gained status in her reflections.

Second, Prof. G expressed that she is regarded as an "excellent lecturer". When asked to elaborate, she said,

> I am organized and energetic. I explain difficult concepts by introducing the most basic ideas and then building on those, constantly tying things back together and reviewing by asking students questions. I use transparencies efficiently and have great analogies.

A third feature was that she routinely teaches both lecture and lab to the same group of students each semester but creates very different atmospheres and holds very different beliefs about students when they are in lecture or lab, despite the fact that they are the same students. She explained: "The lecture is more formal, it's been a pretty traditional format with some questioning." When students are in lecture, Prof. G says she operates with the belief that, "If I don't tell them, they probably won't figure it out." The lab, on the other hand is very informal, very cooperative, and "there are so many things in lab that I won't tell students…I just let them figure stuff out…I have this great confidence that they will figure things out". Although she has been frustrated with the two distinct learning atmospheres and has considered "bridging" the lab atmosphere to the lecture, she hasn't been successful. "I don't know if it's the control I'm concerned about…like I might not be able to maintain their attention in lecture if I deviate from the formal atmosphere…. I really am not sure that I want to do this anymore…or for that matter, am not even sure how I do it."

A fourth feature was, that in cleaning out some old files, Prof. G came across some student reports from years ago and it struck her how her expectations had "gone way up". She elaborated:

> At first, when I found the old reports I was pleased because I thought, 'Wow! The quality of lab report that I am getting is so much better now…what earned an A in my class ten years ago wouldn't even get a C now!' Then I started to wonder if it was because students are better…or did I get more comfortable and knowledgeable and raise my level of expectation? I don't know. I just kept thinking, 'I can't believe these reports were okay with me. What has happened to me? Am I asking way too much of these people?' I don't know.

Fifth was that although Prof. G had "good indications" that pause time for processing information and formative assessment should be part of lecture —she didn't routinely use either technique. With regard to formative assessment, she stated in a matter-of-fact way, "I look at the clock and I think, 'We've only been going for five minutes…what would they have to process? So I keep going and before I know it, the class is over and I haven't paused." She also commented on her awareness of her avoidance of formative feedback:

> I tried some activities this past semester and it's funny because I thought I would get feedback on what students think they learned but then I didn't

> ask them about it and I don't know why. You know…it's like…well I think, 'It worked out alright'…and I just sort of say that I forgot or didn't have time…but it's more like I'm afraid that it's going to be negative…but if it's negative I need to know so that I can tweak it or throw it out…but it's something…that I've got to get past.

The final distinguishing feature was that during the project semester, Prof. G applied for, and was granted a semester sabbatical to follow her project participation. During this time she spent a month working with various ITIP developers as well as Prof. C.

Project Participation: A Snapshot

Six, 90-minute telephone interviews, three, 60-minute personal interviews, four written surveys, one classroom observation, one teaching journal, course syllabi, class notes, and numerous email exchanges served as data sources.

Instructor's Prior Experiences

Prof. G received her undergraduate degree from a small, Liberal Arts College and her Master's and Ph.D. from a Research University. She reported skilled and inspirational instructors at each stage of her secondary and post-secondary educational experience. Perhaps the teacher that had the biggest impact was her high school biology teacher (who also taught A & P). She recalls

> He was unrelenting in his expectations of us. He gave us frequent quizzes and they and his exams always included a lot of writing. Time on both was limited…so there wasn't time for long deliberations on how to organize thoughts…the students who did well the ones who were able to separate main points from all the minutia, because there wasn't time to write everything. Because he never compromised in what he expected from us, he brought out the best in me. I remember doing a blood lab and rat dissection…and remember thinking that I was learning a lot and it felt powerful. He believed in us enough to make it tough, but he taught well

> enough to give each of us a chance at success…I purposely set about to imitate him in as many ways as possible…

In contrast, she also recalled an eighth-grade science teacher who designed an entire semester class around how an airplane flies. She recalls, “Man…we didn’t do anything that was directly related to that topic…but boy did we learn how an airplane flew!”

Prof. G has taught at the college level for 14 years (the past five years at her current location) and currently teaches A & P and a number of other biological science courses. Although she enjoys teaching courses that focus on the human body, her passion is clearly teaching—not necessarily content.

Teaching Strategies

Prof. G characterized her teaching strategy as lecturing with “quick-fire” questioning. This technique was confirmed by classroom observation. She is very enthusiastic, friendly, and animated when she lectures. Although she often referred to a “discussion style classroom”, the style might be more accurately described as a lead in with some review type questions, and a logically connected lecture with brief pauses to ask factually-oriented, recall, or connection types of questions.

Beliefs Related to Teaching and Learning

Elements of two systems were expressed in Prof. G’s pre-project beliefs about teaching (Appendix I). She described strategies of information transmission as well as more interactive strategies. Salient features of her belief system included an intuitive definition of learning (“learning is learning”); a belief that knowledge pieces, if structured in a logical fashion, could be transferred to students, and that learning was a function of teaching. She explained a significant point of frustration related to her knowledge of how people learn,

> If somebody learns like I learn…I can help them…but I have really just begun…at least I am aware…and that is about the extent of it…that we are not all alike. So if they don't learn like I do…I have no idea how they learn. I'm just such a total outline person. I can't imagine anybody not thinking in outline form. It's such an obvious way to think! But I'm just now becoming aware that it's not the way some people think. I mean you would think that I have been doing this enough years that I would know more.

Juxtaposing Prof. G's stated beliefs to both her own description of her teaching, and to classroom observation data, it was clear that the information-transmission belief system was enacted in the lecture. It seems reasonable, that a more interactive system might have had slightly stronger status in laboratory instruction, although lab observation was not conducted.

Goals and other Motivational Beliefs Impacting Change

The goals and other beliefs related to motivation that were articulated by Prof. G are listed in Table 22. Of particular salience, her primary starting goal was to "tweak" her lecture curriculum and make it a "bit more problem-based". She elaborated that she needed to keep the modifications doable without completely throwing her whole curriculum into an upheaval. In addition to adding activities, Prof. G also expressed concern about students' ability to write. She explained, "This year more than any other year, students just don't have the

Table 22 Prof. G: Motivational Profile

Nature of Competence/Theory of Intelligence:	
	Students are creative and capable people. I can ask a lot of my students because I know they have the ability to do it.
	I am becoming more open-minded and am learning more about using active learning ("baby steps").
Goal Statements	
	To "tweak" the lecture curriculum and make it a bit more problem-based, making sure that techniques I add are compatible with my personality.[pre]
	To free up some time to plug in some activities.[pre]
	I want students to walk out of the class with a good understanding and be well-prepared for their next step in the education process.[pre]
	I want to be better at my craft and need a nudge to try some new things and pick up ideas from others.[pre]
	Be a part of a team working on a common goal.[pre]
	I don't want any D's or F's this semester.[pre]
	I want to see a shift in myself where I take my eye off the clock, introduce more activities, and am willing to give students permission to work through a situation.[post]
	I want to be willing to cut out some of the material.[post]
	I want to gain the confidence that letting go of the lecturing isn't so scary. [post]
	I want to get past thinking that if I design an activity that is a failure, students have no way of learning. They are capable of learning some of this on their own.[post]
	I want to transfer the strategies and confidence in student abilities that I have in the lab into the lecture.[post]
	I want to streamline lectures, narrow the amount of information that students are responsible for, and make some time for activities.[post]
Task Choice - Instructor risk is that activities may be less effective than lecturing	
Mistakes:	
	I regret cutting the mapping activity short so that we could push on with more content because students could have benefited from looking at each others' maps and comparing alternate organizations.
What is Failure?	
	If students get to the next step and find they aren't prepared.
	If an activity fails, students can't get the information.
What is Success?	
	My success comes from hearing that students have felt prepared (over even over-prepared) as they went on to the next step
Attribution for Success:	
	Students like my lectures because I've put a lot of effort into building a logical flow that includes both function and structure.[Internal, Unstable, Controllable (Instructor Ability and Effort)]
Attribution for Failure:	
	There are times that I am very clear but students just don't hear the directions.[pre] [External, Unstable, Uncontrollable (Student Attention)]
	Students were confused because I didn't make the instructions clear.[post] [Internal, Unstable, Controllable (Instructor Ability and Effort)]
	The reason some students don't learn is because they can't take good notes because the instructor has to go so fast so they don't get behind on the syllabus [pre] [External, Stable, Uncontrollable (Nursing Board Content Coverage Requirement)]
	I always run out of time before I've had a chance to get the active learning assignment passed out [Internal, Stable, Uncontrollable]

ability to write coherently, completely, or concisely…it's just abominable…bad spelling…bad grammar…punctuation…" As a result of her observations, Prof. G indicated that she was becoming more committed to "writing across the curriculum" and was considering a project where students might design their own lab and write about the process. After completing the first activity for the project and collecting formative assessment, her goal took on the tone of wanting to trim some content from the curriculum; but she reasoned that her ability to do this was dependent on developing confidence that she could implement classroom activities and that students could learn effectively from the activities.

Although Prof. G did not outwardly indicate a disposition toward risk-taking in the classroom, it was clear that she viewed deviating from lecture a risk because, in her mind it was very probable that activities were less effective than lecturing.

Statements and explanations of success and failure were all either learner-oriented or activity-oriented ("If students get to the next step and find they aren't prepared"; if an activity fails, students can't get the information"), and excerpts from interview transcripts suggested that Prof. G applied a malleable theory of intelligence to herself and students ("I am becoming more open-minded and am learning more about using active learning, taking baby steps"; " I can ask a lot of my students because I know they have the ability to do it.") . Interpretations of success events were consistently internal, unstable, and controllable ("Students like my lectures because I've put a lot of effort into building a logical flow…").

Interpretations of failure events were more variable in nature. The three most common variations were external/unstable/uncontrollable ("There are times that I am very clear but students just don't hear the directions"; student attention); Internal/unstable/controllable ("Students were confused because I didn't make the instructions clear; instructor ability and effort); and external/stable/uncontrollable ("The reason some students don't learn is because they can't take good notes because the instructor has to go so fast so they don't get behind on the syllabus; nursing board requirements).

Project Activities

Prof. G developed both of the activities she implemented in her classroom (in researcher's possession). The first was a concept map and formative assessment activity related to volume, velocity, pressure, and flow. The activity was similar in format to the ITIP curriculum module implemented by Prof. A; however, Prof. G was not aware the module existed. She explained that the class had been working on the cardiac cycle and cardiac output quite a bit prior to the activity but that she hadn't lectured extensively on the concepts addressed by the activity, other than to say just a little about pressure and flow and resistance and the relationships and the formulas of flow, and then talked about how flow and resistance affects pressure.

As she reflected on the activity, she said that it was clear to her from feedback she had gotten, was that her first error had been not telling students what the goal of the activity was. "My goal was to have them take some information that they knew a little bit about and see what they could come up with". Prof. G indicated that students had thought it was a review and were somewhat anxious about not knowing the relationships. She commented, "Honestly, I thought I mentioned it to them but it wasn't at all clear to them based on all the comments I got."

Prof. G described that she gave students 31 terms and index cards after sorting them into groups. Groups were formed alphabetically, "with a little fudge" to make sure that there was one student who was typically prepared in each group. She said she didn't let students use their notes or books as they worked on the maps because she was afraid that they would just try to imitate an outline of their notes.

She described an awkward point in the activity where students weren't proceeding the way she thought they should have been. "I had this picture" of what students needed to be doing, but either they didn't hear me or thought they knew a quicker way…but they just sort of took off on their own". When she circled around the room and asked students why they weren't laying out their cards, they explained that they didn't want to work with the cards until they had an idea of relationships on the list, or they said they would rather do it on paper and then match their cards to the paper. Much to Prof. G's dismay, another group had found some glue.

As the activity progressed, students were very interactive, some were dominant, and some made comments that they couldn't participate very much because they hadn't read the assignment before coming to class. Prof. G indicated that students seemed to need a lot of reassurance. “They just kept asking, ‘Are we doing okay so far?’” One group that was stuck on knowing how to get started had started to mumble, “Why are we doing this?” The comment seemed unnerving to Prof. G, but she said that once they had a breakthrough they were the first ones done.

Perhaps the most surprising part of the activity for Prof. G was toward the end when she realized that none of the seven groups had made the same maps, but none had made errors or linked inappropriate terms. “I had thought there was one way…the way I pictured…and they came up with seven ways!” Although she realized it would have been a great teaching moment to put up all the maps and have students critique other maps, she felt they needed to press on and cover capillary exchange and ultra filtration. “That’s my biggest regret now”, she commented. “I think…having to think about the principles of flow and pressure and resistance as represented by another group would have been a nice way to reinforce the principles.”

As Prof. G began to share her reflections on the comments she had received, she indicated that she wasn’t at all sure how to interpret some of the comments. In particular was a comment related to the issue of timing, which she was sensitive to because she felt that she “always ran out of time with active learning”:

> This one says, ‘the activity should have all happened in one day’. I don’t know how to interpret that…at first I thought, “Were you even there?’ because we did spend one and a half periods on it …and I thought that I couldn’t do it in one day…it took us a day and a half…so now I am thinking that this person thought we spent too much time on it …

Although Prof. G had expected students to ask if their feedback had been valuable, she said the only question she got was, “Have you decided how many points we get for doing the activity?”

The second activity was a mini-case of a man running in the desert on a very hot day, munching peanuts and drinking beer and coke, followed by a summary-style matrix for students to complete. Students were given stressors (exercise, ingested protein, fats, and salts, beer and coke) and had to describe how each stressor would disrupt homeostasis, and then describe how each of the systems would respond. The intent was to see what students could pull together from all five systems studied. Prof. G said that despite the fact she included an instructional page in an effort to be more clear with the directions, students still had a hard time getting started. She elaborated:

> They couldn’t understand what I wanted on the top row of the matrix so I had to really bounce around from group to group clarifying…. once they got on track they were doing well. But then unfortunately, like every activity that I ever give…they ran out of time. But I think they would have had fun with it if they had had more time.

Formative assessment did not follow the second activity. Prof. G said she had planned to get feedback but then thought it would be “too weird” because she was using the activity as an assessment and wondered, “why would I want to assess the assessment?” Once back to her office, she decided not to grade the matrix. “I just didn’t think my directions were clear. Even though I went to the extreme by typing out the directions they just locked in on an element I hadn’t intended.”

Perceived Supports and Obstacles

Prof. G shared her perceptions of the supports and obstacles to implementing active learning (Appendix I). Eleven supports and 17 obstacles were mentioned during the pre-project phase. The three biggest obstacles were a lack of time due to heavy administrative commitments, "lots of content to cover", and a lack of confidence in her ability to implement effective activities. She elaborated, "It really is scary for me…I have so little confidence in my ability to do this and bring it back…so that students get what the point of the activity was". She explained that the feeling of being scared was related to her belief that class time had to be used efficiently. She elaborated on what appeared to be a struggle related to a fundamental belief:

> [Students] have made sacrifices to be in my class and I do not want to waste a minute of their time…not that some of them might be tired and don't hear a word I say…but that is on their shoulders. On my shoulders…if I design an activity and it's a failure…and I do that A LOT…I mean I don't want to tube out the semester…I guess my worst fear is that students will look at each other and say,' Man…did she think we were supposed to be learning something here?'

In other words, Prof. G seemed to think that if she said it, they would learn it… unless they were tired. But, if she designed an activity that was a failure, students had no other way to learn it.

Although Prof. G identified two obstacles at the student level (busy work/school schedules and weak writing/self-assessment skills) she indicated that student ability was not a significant obstacle. The true obstacle, she said, was her belief about student ability in the lecture atmosphere.

Although new obstacles at the college level emerged during project participation (budget cuts and small teacher salary increases), these were minor compared to a developing self-awareness of a "limited paradigm", limited knowledge of active learning, and mounting administrative time commitments. Also, she indicated that if she was spending a day doing an activity, she needed to realize that being flexible was a challenge for her, so she needed to build a plan to "be flexible" because she "has a hard time being spontaneously flexible". Increasingly, Prof. G began to speak of dissatisfaction with her "tweaking the curriculum approach" and made plans to begin restructuring and rethinking her course during her upcoming sabbatical. With careful attention to her vocabulary, she explained, "I just foresee that sabbatical will make be a better teacher… no that isn't what I want to say…sabbatical and the opportunity to learn will allow me to create environments where learning is improved". She explained, "When you are treading water like crazy and just trying to keep your nose out of it…you just don't have the perspective you need [to sort through all of this]". She continued to be perplexed at her desire to dodge formative student assessment. She explained that she understood and valued feedback as a means of improving "at the craft" of teaching; but found that when she had gotten feedback in the past, and most recently on the first activity, her tendency was to become somewhat defensive and think, "Were you even there" or "Oh…. I kind of thought…. we DO…do that…. how could you say that? We DO Do that!"." At the end of the project semester, Prof. G had reported 22 obstacles (most at the instructor level) and 11 supports.

Conversations with Prof. G suggested a strong desire to persist with active learning. At least five different factors supported the desire: her new awareness that her expectations for a quality lab report had increased significantly over the years; an awareness that although her lectures were exemplary, students didn't always seem to get or hear what she said; a recalling of an experience with an assessment tool she gleaned at a teaching workshop that had revealed a significant difference between her perceptions and students' perception of learning; an acknowledgement of her own progress (albeit "baby steps") in learning about possibilities in the new paradigm; and a realization that her continued persistence with active learning would be assisted and supported by the ITIP development team.

Impact of Project Participation: A Snapshot

Three separate categories of change beliefs are presented: Self-reports of change, data-based belief changes, and theory based conceptual change. The impact on student content learning and attitudes are also summarized as points of triangulation.

Self-Reports and Critical Incidents Promoting Change

Prof. G reported five areas of change and factors that influenced the change:

Value of formative assessment (Using formative assessment):

The discrepancies between students' perceptions (that I collected through formative assessment) and my assumptions as I watch them work together are making me rethink my ability to gauge the level and quality of engagement during activities.

Doing this immediate feedback thing has made me realize that students don't…they just don't get everything I tell them…. despite my outstanding delivery! Even though they answer questions during lecture, I'm thinking it's something different …like somehow my words get stuck in their heads and they say them, you know?

Potential change in teaching philosophy (Colleague informal interaction at HAPs):

I had dinner at HAPs and [someone] said, "We spend so much class time going over the fairly simple stuff with students…like list the three characteristics…or the name of something and then we send them home with a problem to figure out where they have got no support system…and we really should be making them do the obvious easy stuff at home so that we could facilitate the more critical thinking things in class. That really struck me. I just thought of how much time I spend doing that and the students like it because it is clear…but I think maybe it should be different… maybe presenting facts isn't so important as I thought it was.

Potential change in understanding of the instructor's role (Finding old files containing student work):

I think because I've become a more sophisticate teacher that my students are leaving the class with a greater potential for success…because I know more now…my students know more…but maybe I'm making more of myself than I should. I don't know. It goes back to the idea of, 'If I don't tell them, they can't learn it.'…I've always thought it was important to present all the facts and connect the dots for students, but I'm changing on this.

Understanding the process of changing self (Through personal reflection and discussion opportunities)

> I've been able to outline the process of what it's been like to want to try something new and it all starts with first of all needing to be convinced…totally convinced that the results will allow me to meet or exceed what's happening currently in the classroom….

Data-based Changes in Beliefs about Teaching and Learning

Over the course of the project, Prof. G's belief changes were documented and are summarized below:

Learning: From an intuitive definition of learning toward an explicit and personalized definition that included: recognizing something on an exam that you didn't know before, building relationships out of what was known, and gaining the ability to be conversant.

Implementing active learning: From the add-in approach described as "tweaking" the existing curriculum in order to engage students, to an approach that included more manipulation of the course content by cutting content, adding running themes and practical examples for students to tie their knowledge into, and providing more time for activities.

Students: From a demographic sort of description (competent people with complex lives, paying local customers, compliant, people who enjoy each other) to a recognition of students as learners with preferred ways of approaching learning and clear perceptions about the effectiveness of the learning environment.

The learning process: Prof. G elaborated her description of how learning occurs from a passive mode of knowledge transmission based on what the instructor is doing ("learning as a result of classroom instruction") to an elaboration on what the instructor does—organizes material, records, and presents information—and a more action-oriented descriptor of the learning process ("make sense of it").

Student actions: From passive and generalized descriptors (listen, "roll with", answer, and have trouble) to a recognition that students don't hear directions, don't do things the way the instructor expects, become very animated and interactive during group work without having been told to do so, ask for feedback and clarification, and need to "work through" some things with their classmates.

Instructor: Prof. G transitioned from adopted and generalized metaphors (tour guide, gardener, coach) to experiential statements and an awareness of and frustration with personalizing and describing who the instructor was in the classroom. Clearly, Prof. G gave higher status to the comfortable belief system where efficiency of information transfer was valued and good teachers were born (" teaching is a natural talent"). Alternatively, there was frustration in the belief system where student interactions and time for depth of processing were valued.

Instructor actions: From a disseminator of difficult information (points out, explains, "mushing through" and "hammering") to a stated acknowledgement that class has been conducted in a very egocentrically- arranged manner. At the end of the project, Prof. G was in the process of restructuring the course and lab.

Instructor/student relationship: From a friendly, yet very traditional relationship between devoted professor and students to an uncertain relationship.

Class meeting purpose: From efficient information transmission to an intention to share less information in order to make more time for learning activities.

Evaluation: From a definition of evaluation as, something that is separate from teaching, and the way we find out if students have learned what they have been instructed to learn, toward a compilation of what has been implicit ("tests reflect the teaching") to what has been learned in workshops (there are different ways of talking about assessment and testing and evaluation), and her own experience with formative assessment (I'm not certain how to interpret some of what students are saying in their comments).

Conceptual Change

Evidence of Dissatisfaction

Although Prof. G was dissatisfied with the amount of information she delivered (evidence is found in interview transcripts), there were also strong statements of confidence in the lecture method. During the first interview Prof G said:

> To tell you the truth I have done so much soul searching the last semester and it's that age-old question, 'Do I really need to be doing what I am doing…the way I am doing it?'
>
> I'm sort of coming around to the idea that I am just way over the top in what I am having students do…I'm just asking them to do too much. I don't know why I'm teaching actions, origins, and insertion of muscles…that's probably never going to come back and be useful to them…. I think it's my comfort…not that it will help them be successful…

Later in the interview she commented:

> If I really wanted students to learn something really important I would talk to them about it because I would feel confident that they learned it. Some things like membrane potential and action potential, I don't think they could figure that out without me lecturing because they've told me the book makes o sense…it would seem ridiculous to tell students, 'you know…I'm not going to teach you about this…instead I came up with an activity that will teach you…I have no confidence in that…. maybe some stuff could be taught with an activity as long as I pre-explained it
>
> Doing activities is just not a good use of time.

However, following the second activity (the man running in the desert), Prof. G commented that she had realized that students really weren't getting an integrative understanding of the body because of the way the systems are all covered so distinctly from each other during the course, and when comparisons were made, "it's me doing the comparisons…not the students". During the final interview she commented further on her recent reflections about student learning:

> I'm switching…I'm just realizing more and more that just because I say it and I say it in a very clear way doesn't mean that they get it until they go home and study it anyway. So maybe my time can be better used by not telling them every word of what they are not going to get until they go

> home and study it. I think it's enough to make it clear what they are expected to do when they are at home.

Later in the interview she stated that she wasn't really switching…she was determined to find a better balance.

Evidence of Intelligibility

Evidence of intelligibility, as well as unintelligibility was expressed in a back and forth sort of pattern, during the project, as in the following comments:

> I can see how it would be beneficial to do more depth because one of the lab segments that students seem to respond the most positively to is the blood lab. They do six or seven activities on their own blood. Even though it's a lot of work students always tell me it's their favorite part of the course.
>
> How can I be helping students restructure their knowledge when I don't even really know what structure they start with? I mean maybe what I know is that there isn't much structure there to begin with…. because they don't seem to know anything about what we are doing…and I've never asked them to tell me what they know about anything before we start…I just go on my merry way.

Evidence of Plausibility

Although no evidence of plausibility was found, Prof. G began to talk about her plans for restructuring her class during her sabbatical. She indicated, "Although I've always wanted to do this…I've never seen how it could work before…now I do." She described with excitement, a course that only presented new information within a context that students could understand. "Instead of doing what I've done…have students learn 25 different glands and 60 hormones all for one exam…they'll just learn them as we go and as they apply to the system". She also described having two cases that students encounter at the beginning of the semester that served as a connecting thread throughout the course.

Also of interest, having experienced the value of teaching and learning discussions throughout the ITIP project, Prof. G compiled a Needs Assessment Survey to distribute to faculty on her campus to find out what kinds of topics they would like to get together and discuss. In an email that followed project completion she wrote:

> Results from the faculty survey are trickling in. So far the most popular topics are "How do you know your students have learned what you want them to know?" and "What does a good lecture look like?" There was also interest in learning communities, team teaching, and seven intelligences and …a couple of faculty even volunteered to facilitate [topics they nominated]. So…there are some faculty out there who are excited about this!

Evidence of Fruitfulness

No evidence of fruitfulness was found.

Student Changes

Changes in thematic content understanding and attitudes toward teaching and learning were determined from pre- and posttests.

Thematic Content Learning

With the limitations (described in Chapter One) on this data in mind, the following data summarizes gains in students' understanding of gradients at four knowledge levels: remembering, understanding, applying, and analyzing: no change in remembering, a 24% increase in understanding, no change in applying, a 9 increase in analyzing, and an overall increase (all categories) of 11%.

Attitudes about Teaching and Learning

Prof. G's students reported three statistically significant changes nested within the constructs of learning preferences and goals. At the end of the semester, students were more inclined to believe that hearing a lecture was the best way to learn information and less inclined to believe that in class problem solving activities were a good way to learn information. Also, at the end of the semester, students were less inclined to believe that "making mistakes" was a useful part of the learning process.

Summary of Beliefs

An overview of Prof. G's beliefs about teaching and learning, motivational profile, perceived supports and obstacles over time, and change profiles are summarized in Table 23.

Table 23 Prof. G: Summary of Data

Beliefs								
	Learning	**Students**	**Student Action**	**Instructor**	**Instructor Action**	**Class**	**Assessment**	
Pre	Taking in knowledge	Capable, compliant, and likable people	Learn as a result of instruction by "rolling with" the presentation of information	Tour guide, gardener, coach - likes "normalcy"	Teaches a reputable hard course; Needs to tell students in order for them to figure it out (lecture). Lecture and lab are rather independent	Giving and taking in of foundational knowledge	Summative; Did students learn what they were instructed to learn?	
Post	Building relationships out of what is known; includes being stumped/ breakthroughs	Individuals who will give learning impact feedback	Learn by making sense of making sense of material	Lecturer/ frustrated facilitator	Teaches a reputable course; Gaining awareness of egocentric nature of class; beginning to integrate lecture and lab content	Clarify information with lecture; some time for activities	Tests reflect teaching and an extension of learning; formative comments are difficult to interpret	
Motivation								
	Goals	**Intelligence**	**Mistakes**	**Success Attribution**	**Failure Attribution**	**Failure**	**Success**	
	Curriculum "Tweaking" [pre]	Instructor malleable	Useful learning opportunities	Internal, Unstable, Controllable (Instructor Ability/Effort)]	Internal, Unstable, Controllable (Instructor Ability and Effort)]	Student 0riented	Student Oriented	
	Free up time for activities [pre]	Students malleable			External , Unstable, Uncontrollable (Student Attention)]	Activity Oriented		
	Well-prepared students [pre]				External, Stable, Uncontrollable (Nursing Board Content Coverage Requirement)]			
	Instructional skills [pre]				Internal, Stable, Uncontrollable (Instructor Ability to allot time to active learning)			
	Inspiration and teamwork [pre]							
	No D's or F's [pre]							
	Goal statements aimed at confidence building and minimizing the feeling of risk [post]							
	Goal statements aimed at developing a more considered and integrated approach to including activities [post]							
Obstacles and Supports								
	Academic Community	**College**	**Division**	**Course**	**Instructor**	**Student**	**Professional Org**	**Total**
Obstacles Pre	0	2	0	3	9	2	1	17
Obstacles Post	0	3*	0	3	14*	2	0	22
Supports Pre	0	2	0	3	2	2	2	11
Supports Post	0	2*	0	3	5*	3*	2*	15
	* Modified or changed							

Change								
	Self-Report	Change Event	Data-Based	Conceptual	Tries to Adopt Student Perspective	Student Attitudes	Student Content	
	Valuing of formative assessment	Doing active learning	Learning: Yes	Dissatisfaction: Evidence	No	Learning Preferences: More inclined to believe that hearing a lecture is the best way to learn information; less inclined to believe that in class problem solving activities are a good way to learn information	Remembering: 63 to 63% = 0%	
	Teaching philosophy reconsideration? "Teaching backwards?"	HAPs informal interactions	Students: Yes	Intelligibility: ??		Goals: Less inclined to believe that "making mistakes" is a useful part of the learning process	Understanding: 38 to 62% = 24%	
	Instructor's role reconsideration: "If I don't tell them, can they learn it?"	Using active learning	Student Action: Yes	Plausibility: ??			Applying: 37 to 34% = -3%	
	Awareness of changing self	Reflection/ITIP interviews	Instructor: Yes	Fruitfulness: ??			Analyzing: 31 to 40% = 9%	
			Instructor Action: Yes				Total: 36 to 47% = 11%	
			Class: Yes					
			Assessment: Yes					

CHAPTER 5

Cross-Case Analysis and Interpretation

The participants in this study all expressed a strong value for teaching; and, as an expression of their value, committed themselves to a long-term research project that focused on exploring their experiences as they added active learning to their methods of instruction. Throughout the project, they described distinct yet overlapping experiences while implementing active learning and all reported different perceptions of how and what they had changed. While Prof. A was slowly replacing her "old mold" with questioning and beginning to think about structuring the elements of her teaching to transfer responsibility for learning to students, Prof. B was discovering that "being the product of a certain way" was the source of much conflict as she attempted to create conditions to foster active learning. As the neuroscience researcher (Prof. C) was discovering the "new faces of teaching", another neuroscientist (Prof D) was contending that he was not a teacher at all. As Prof. E was discovering that giving students freedom for their course of learning was problematic and that "sticking to her guns" was part of the solution, Prof. D was steadfastly continuing his practice of "giving students a voice" in course structure decision issues. While Prof. F was diligently integrating his labs and lectures, Prof. G was questioning why and how her lecture and lab courses had become so disparate, despite the fact that the same group of students were enrolled in both.

Despite some overlapping experiences and similar expressions of value, by the project's end, six of the participants indicated a continuing commitment to using active learning, while one was seriously contemplating returning to traditional lecture. Moreover, although all instructors provided self-reports of change, and changes in beliefs about teaching and learning (What is learning? How is active learning implemented? Who are students and what do they do to learn? Who is the instructor and what does the instructor do in the classroom? What is the relationship between students and the instructor? What is the purpose of class? What is the purpose of evaluation?) were documented, at least in part, for all instructors, only three instructors provided evidence of conceptual change (dissatisfaction, intelligibility, plausibility, and fruitfulness). The change experiences are summarized in the table below:

Table 24 Conceptual Change Profiles of Participants

Instructor	**Institution**	**Self-Perceived Change**	**Data-Based Change**	**Conceptual Change**
A	Vocational College	Yes	Yes	Yes
B	Community College	Yes	Partial	No
C	Research University	Yes	Yes	Yes
D	Professional College	Yes	No	No
E	Comprehensive Public University	Yes	Yes	Yes
F	Two-Year, Residential College	Yes	Yes	No (only partial)
G	Community College	Yes	Yes	No (only partial)

These data raise the questions: Why the differences in change experiences between the seven instructors? Why were the end of project self reports of change from Prof.'s A, C, and E supported by conceptual change analysis, while the self reports from Prof.'s F and G, and B and D only partially supported, or not supported at all? The questions are critical because understanding the differences in change experiences creates the opportunity to anticipate and encourage factors that may favorably influence the potential for conceptual change in faculty learning programs.

Since conceptual change was documented for participants in different types of institutions—a technical college, a research university, and a comprehensive public university—it does not appear that the likelihood of change was a function of institutional type (as hypothesized by several of the instructor participants), at least within this small purposive sample. While two instructor participants had speculated that ability to implement active learning was most likely to occur in a community college setting where there were smaller class sizes and a stronger commitment to serving student needs, two others proposed that an instructor's ability to implement active learning was least likely to occur in a community college setting where faculty schedules were burdened with administrative tasks and where there was little encouragement for peer observation and scarce opportunity for collegial interactions related to teaching improvement. Since neither of the predictions were confirmed, other factors that may have influenced the differences in the instructor change experiences were explored.

The data collected in this study allowed examination of three sets of factors that may have explained, at least in part, the differences in the change experiences: characteristics of students, characteristics of participants, and participants' experiences and beliefs.

CHARACTERISTICS OF STUDENTS

Several of the instructors in this study suggested that, aside from institution type, one of the factors most likely to complicate the use of active learning was student characteristics. Although the instructors did not specifically state that the compounding factor was diminished student ability, certainly it is implied in the following comment,

> Part of the reason that I've had such an uphill struggle is because of the types of students we are pulling in…they are so under prepared. Are instructors at schools with more restrictive admissions policies having the same kinds of problems I am? I just can't believe they are because their student populations are entirely different.

Beginning of semester, self-report student demographic and attitude data are summarized in Table 25 and 26, respectively. Instructor beliefs about students (supplemental to those reported in interviews), collected during the first phase of the project are shown in Table 27.

Table 25 Student Self-Report Demographic Data (Pre Test)

Class Data of Participant	**Average Age**	**Age Range**	**Grade Point Average**	**Full Time (%)**	**Female (%)**
A	31	18 to >35	3.2	90	78
B	27	18 to >35	3.0	52	86
C	23	18 to 34	3.1	87	92
D	23	18 to 34	2.6	94	58
E	23	18 to 34	3.0	92	68
F	25	18 to >35	2.9	84	81
G	27	18 to >35	3.6	74	77

Table 26 Student Self-Report Attitude Data (Pre Test)

Attitudes Reported by Students	A	B	C	D	E	F	G
Mastery Goals (For me, understanding is more important than getting a good grade)	3.7	4.0	3.7	3.6	3.9	3.2	4.8
Performance Goals (I work hard in this class primarily to get a good grade)	3.3	3.4	4.1	3.4	3.6	3.7	4.3
Learning (I use strategies of rewording, reorganizing, and applying when I am learning)	4.6	4.3	3.9	3.7	4.1	3.6	4.4
Preferred Teaching Method (Lecture is the best way for me to learn)	3.7	3.6	3.6	3.2	3.2	3.7	3.3
Preferred Teaching Method (Problem Solving is the best way for me to learn)	3.8	3.9	3.5	3.6	4.0	3.7	4.2
Confidence in Learning Ability (My confidence to learn the basics, capability of learning the basics, confidence to integrate the facts)	4.2 4.1 4.2	4.6 4.5 4.2	4.4 4.3 4.0	3.6 4.0 3.9	4.1 4.2 4.0	4.1 3.9 3.6	4.5 4.2 4.6
I have useful knowledge about the topics in this class	3.6	3.7	3.8	3.4	3.0	3.4	4.0
Instructor's Role (The most important role of the instructor is to paraphrase information in the textbook	2.8	3.2	3.3	2.2	2.6	3.0	2.5
Instructor's Role (The most important role of the instructor is to challenge student thinking)	3.9	4.1	3.7	3.8	4.2	3.5	4.7
Test Purpose (The purpose of tests is to confirm that students have memorized information)	2.6	2.3	2.5	2.2	2.2	2.9	3.0

Test Purpose (The purpose of tests is to challenge student thinking)	3.0	3.1	3.3	3.1	3.4	3.8	3.9
Struggling to Understand (If I struggle to understand information in the course, it's the teacher's fault)	2.0	2.0	2.7	2.3	2.2	2.3	2.4
Struggling to Understand (If I struggle to understand information in the course, it's my responsibility to work harder)	3.5	4.0	3.7	3.8	3.9	3.8	4.6

Table 27 Instructor Self-Report Data

Belief Reported by Instructor	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Is your student population diverse?	Very	Very	Very	Very	Very	Very	No
Are students academically talented?	Some	Some	Very	Some	Some	No	No

When asked to respond to the level of diversity in their classrooms (very, some, not very), none of the participants asked what was meant by diversity. All participants, except Prof. G, believed that the students in their classrooms were very diverse (Table 27). In interviews, Prof. G commented that most of her students were from the local area, which was not "ethnically diverse". Triangulating instructors' perceptions with those of their students allowed comparison of student reports of diversity (full-time/part-time student status, gender, age range, cumulative grade point average, and attitudes related to teaching and learning).

According to student data, Prof. B had the most diversity in student status. Only about half of her students were full-time. Prof. D had the most gender diversity—just slightly more than half his class was female. Prof.'s B and G had the widest age range (less than 18 to greater than 35), with 20% of the students older than 35, 20% between 25 and 34, and the remainder younger than 24 (data not shown). If only average age is considered, Prof.'s C, D, E had the youngest students, and Prof A had the oldest students. While Prof. C believed that her students were academically talented, Prof.'s F and G did not. Despite the fact that Prof. G did not believe that her students were academically talented, she indicated repeatedly that they were wonderful people with "very teachable attitudes". Student self reports of cumulative grade point averages (Table 25), indicated a hierarchy with Prof. G's (not academically talented) students on top (3.6), then Prof.'s A, C, B, E, F, and D.

Of further interest, during interviews, Prof.'s A, B, D reported that their students were more under-prepared than students at most colleges, and Prof. F indicated his students were "starting from scratch.". However, students in all classes believed they brought a moderate level of useful knowledge related to the topics of study to the classroom (Table 26). Also, despite the fact that Prof. C's students had taken more college-level science prerequisite courses (Biology, Chemistry, Physics) than the students at other institutions, her students rated themselves about the same in terms of useful knowledge as students in Prof.'s A (Technical College) and B's (Community College) students.

Prof.'s B and D stated during interviews that they believed their students wanted to be told what to memorize for tests so that they could simply regurgitate the information. Curiously, students in these and all classes, gave a higher rating to the belief that the instructor's role was to challenge student thinking rather than to paraphrase the textbook and also gave a higher rating to the belief that tests should challenge student thinking rather than check to see if students have memorized information. Moreover, data suggested that students in all classes valued understanding nearly as much, if not more than grades. From a practical perspective, valuing both understanding and grades is expected given that most of these students must receive a required grade in order to move on in their studies and ultimately attain their career goals. Further, students in all classes believed they used learning strategies of rewording, reorganizing, and applying information; were very confident in their ability to learn the basics in A & P and integrate facts; believed that problem solving was the preferred teaching method over lecture (the exception is Prof. C's students who began the semester with a preference for lecture); believed that the instructor's role was to challenge students to think (rather than to paraphrase information in the textbook); and believed that if students were having trouble understanding the information, it's the student's responsibility to work harder, not the teacher's fault. It is particularly interesting to note the discrepancy between Prof. B's perception of her students, and her students' beliefs on the last point. Throughout the project interval, Prof. B believed that her students blamed her when they were struggling with difficult information in the class; however, her students clearly did not begin the semester with the perception—they believed if they were struggling it was their responsibility to work harder (4.0), rather than to blame the instructor (2.0).

Overall, since there were no emergent patterns that suggested large differences in student ability or attitudes toward learning between institutions, it doesn't seem prudent, based on this data, to presume that student ability is diminished in institutions with open-door admissions policies, nor does it seem reasonable to assume that admissions policies complicate the use of active learning.

Data triangulation between student self reports and instructors' perceptions of their students suggests several important points. First, although diversity is an ambiguous term, and one often cited by the instructors in this study as the reason active learning strategies aren't effective in their classrooms, there don't appear to be differences in student learning attitudes (goal orientation, self efficacy for fact learning and integration in physiology, and failure attribution) across different institutions. Even within a given instructor's classroom, standard deviations around each classroom attitude mean ranged from 0.6 to 1.1 in all classes. Second, the data suggest that it is not uncommon for instructors' beliefs about their students' attitudes toward learning and past academic success, to be out of alignment with what students report. Despite the possibility that students may not have had a standard against which to compare themselves, the self-report student data across institutions are remarkably similar. Finally, it may be that the complicating factor in using active learning strategies in some classrooms is not student ability, but the assumptions faculty make about student ability.

CHARACTERISTICS OF PARTICIPANTS

Several of the instructors in this study suggested that prior experiences as science students and the impact of working exclusively within a scientific paradigm may complicate the use of active learning strategies. For example, Prof B commented, "When all you've known is one way…the lecture way…change is much more difficult". Prof. G commented:

> I'm finding out that my scientific training may have promoted a narrow perspective and a limited paradigm when it comes to thinking about teaching and learning. It seems like once scientists form conclusions [about lecture], facts to the contrary are dismissed until they are absolutely overwhelming.

Further, some instructors believed that the "instructional climate" might have been an obstacle to the use of active learning strategies.

Instructor self-report data on a variety of teaching experience variables, perspectives on institutional attitudes toward teaching, as well as on course and instructional strategy characteristics are summarized in Table 28, 29, and 30, respectively.

The only obvious common feature of professors demonstrating conceptual change, were that they are all female. However, due to an artifact of sample attrition, five of the seven participants were female. Although Prof.'s A, C, and E had all experienced courses taught using interactive teaching methods, their experiences were not all in science classrooms (Prof. A had experienced interactive teaching in a Lamaze class). However, all instructors except Prof. B,

Table 28 Instructor Characteristics: Self-Reports

	A	B	C	D	E	F	G
Years Teaching at the College Level	10	15	3	5	5	34	20 + years
Graduate Degree	M.S.	Ph.D.	Ph.D.	Ph.D.	Ph.D.	Ph.D.	Ph.D.
Are you tenured?	No	No	No	No	Received tenure during project	Yes	
Age	51-60	51-60	25-34	35-43	25-34	60+	51-60
Gender	Female	Female	Female	Male	Female	Male	Female
Rank	Instructor	Instructor	Lecturer	Assistant Professor	Assistant Professor	Division Chair/Professor	Lecturer
Primary Responsibility	Teaching	Teaching	Teaching/ Postdoctoral Research	Teaching	Teaching	Teaching and Administration	Teaching
Educational Experience in Science (others taught using alternate modes of instruction)?	Science Lecture/Cookbook Labs; Lamaze Instruction	Science Lecture	Science Lecture, Discussions, Inquiry Science	Science Lecture; English/Literature Discussion	Science Lecture and Discussion; Water Polo	Science Lecture; Science Group Fieldwork	Science Lecture, Science In-Depth (one subject) Course
Have you taken formal Education Courses?	Yes, as an undergraduate	No	No	No	No	Yes, as an undergraduate	Yes, as a graduate student
Experience Using Active Learning? (5 none; 1 extensive)	3	3	4	3; 3 (one month later)	2; 3 (one month later)	3	3; 3 (two months later)
Level of commitment to Using Active Learning? (5 not committed; 1 very committed)	1	1	2	1; 2 (one month later)	1: 1 (one month later)	1	1; 3 (2 months later)
Level of familiarity with Active Learning Research Literature? (5 not familiar; 1 very familiar)	3	3	3	3: 3 (one month later)	1; 2 (one month later)	4	2; 3 (2 months later0

Table 29 Institution: Mission Statement and Instructor Perceptions

	A	B	C	D	E	F	G
Institution Type	Technical College	Community College	Research University	Professional College	Comprehensive Public University	Two-Year Residential College - Public	Community College
Mission Statement	Provide exceptional technical instruction for adult learners in a dynamic learning community	Serve a community of lifelong learners committed to realizing their full potential through customized training and skill development	Transform lives for the benefit of society through core values (learning, discovery, freedom, leadership, individual opportunity and responsibility)	Primary commitment is to student learning (professional abilities, lifelong learning and personal understanding, community service); principal responsibility is professional education excellence	Preserve, communicate, and advance knowledge; cultivate wisdom; encourage creativity; promote value of people; and improve quality of life for graduates and regional people	Provide the best educational environment possible for student development (lifelong learning, responsible citizenship, leadership) and save the needs of the community	Promote excellence in lifelong learning by offering two-year programs, first two of a four-year degree, occupational training, and opportunities socio-cultural, and economic factors for students and communities
Department	None	Science	Biology	Professional Sciences	Biological Sciences	Natural Sciences and Mathematics	Biology
Program	Biology	Biology	Integrative Biology	Doctor of (Profession)	None	None	None
Do other courses use AL?	Very	Some	Some	Some	Some	Some	Some
Is good teaching rewarded?	Some	Some	No	Very	Very	Very	No
Are ideas for new courses encouraged?	No	Some	No	Very	Very	Very	Very
Are administrators and instructors at odds?	Very	Some	No	Some	Some	No	Some
Do instructors respect each other?	Very	Some	Very	Very	Very	Very	Some
Are you encouraged to maximize content coverage?	Very	No	No	Very	No	No	No
Are you encouraged to participate in teaching enhancement workshops?	Very	Some	Very	Very	Some	Very	Some
Are you encouraged to teach problem solving skills?	Very	Some	No	Very	Very	Very	Some
Are you encouraged to modify courses?	Very	Some	No	Very	Very	Very	Very
Is there on-site faculty teaching assistance?	No	No	Yes	Academic Technology Manager (assists in technology use)	Yes, but they are not useful	Yes, but they don't do active learning	No

Table 30 Participant Course Information

	A	B	C	D	E	F	G
Course Title	Human Anatomy and Physiology I (first of two semester sequence)	Human Anatomy and Physiology II (second of two semester sequence)	Physiology and Functional Anatomy II (second of two semester sequence)	Introduction to Human Physiology	Systemic Physiology	Human Anatomy and Physiology II (second of two semester course)	Human Anatomy and Physiology II (second of two semester course
Class Meets	Five days a week in 3-hour blocks	Lecture is 1.5 hours, twice /week; Lab is 4 hours, once/week	Lecture is 50 min three times/week; Discussion is 50 min once/week; Lab is 3 hours once/ week	Lecture is one-hour, three times/week; Lab is 2 hrs, once/week; Discussion is 1 hr, once/week	Lecture is 95 minutes, twice/week; Lab is 3 hrs, once/week	Three times a week in 2 hour sessions	Information not in syllabus
Course Objective	Basic knowledge of systems level structure and function	Clear understanding of systems level structure and function	Cover physiology system and basic theories of function	Physiology at sub-cellular, cellular, organ, organ system and whole organism levels	Control, functioning, and integrating animal organ systems and use of scientific thinking	Anatomy and physiology of major organ systems	Anatomy, systemic organization, structure function relationships
Student Performance Objectives Stated	Yes	No	Yes	Yes	No	No	No
Student Affective Objectives Stated	Yes (cooperative learning, communication, self learning)	Yes (independent learners)	No	Reference to College Objective	No	No	No
Content	Terminology, Tissues, Integumentary, Skeletal, Muscular, Nervous, Endocrine	Cardiovascular, Blood, Lymphatic/defense/immune, Respiratory, Urinary, Digestive, Reproductive	Cardiovascular, Respiratory, Renal, Digestive, Reproductive, and Endocrine	Terminology & Basics, Endocrine, Nervous, Renal, Cardiovascular, Digestion, Respiratory, Reproductive, Development, Cancer	All organ systems	Basics (Matter, Cell Structure, Function, Reproduction), Tissues, Skin, Skeletal, Muscular, Nervous, Sensory	Cardiovascular, Blood, Lymphatic, Immunity, Endocrine, Respiration, Digestion, Excretion, Reproduction
Class Prerequisites	Cell Biology	Chemistry, Biology	Physics, Chemistry, Biology	Completion of second-year courses	Biology, Chemistry	None	None
Class size	24	50	75	50	75	25	35
Lab Component	Integrated	Yes	Yes	yes	Yes	Flexible Format	Yes
Student Instructional Materials	Text, Instructor-Authored Workbook (not aligned with text) , Medical Dictionary, In Class CD programs, Videos, Web-Based Resources)	Text, Instructor-Prepared Class Notes and Lab Packet	Textbook, Workbook (aligned with textbook), Problem Sets, Active Objectives	On-line Instructor-Authored Text, Lab Handouts	Text, Instructor-Authored Workbook (aligned with text), Lab Manual	Instructor Class Outline/Notes; CD programs	Textbook, Instructor Class Notes, Lab Manual
Primary Method of Instruction	Interactive lectures; small group discussion	Lecture with questioning	Interactive Lectures; small group discussions	Interactive Lecture, Team Learning, Case study	Mini-Lectures, Group problem solving	Interactive Lecture/Lab (combined format) and small group work	Lecture with questioning

reported that they had experienced secondary, post-secondary, or graduate coursework outside of science that was taught using interactive teaching methods. Triangulation with interview data indicated that all instructors in the study (including Prof. B) had participated in professional development workshops (at one time or another) and had taken on the role of learner in a simulated active learning classroom. Prof. C, E, G were the only participants that spoke of taking science classes taught in a format other than lecture.

The dissimilar characteristics of professors demonstrating conceptual change (Prof.'s A, C, E) were years of teaching experience, age, graduate level degree, tenure status, and education coursework experience. Only Prof.'s A, F, and G reported that they had taken education courses at some time during their undergraduate or graduate careers, and all said they remembered little if anything from the coursework.

All instructors in the study had teaching as their primary responsibility, except Prof. F who split his time equally between teaching and administrative duties, and Prof. C who was finishing postdoctoral research during the pre-project interval. All instructors rated themselves moderately (3) in terms of the amount of experience they had using active learning in their classrooms; Prof. C rated herself somewhat lower (4) than the other participants. All instructors rated themselves as very committed to active learning (1); again, Prof C rated herself somewhat lower (2). All instructors rated themselves as somewhat familiar with the research literature supporting active learning (3); Prof. E rated herself somewhat higher (1 or 2; rating dates one month apart) and Prof F rated himself somewhat lower (4).

Table 29 summarizes the mission statement of each institution represented in the study as well as instructors' perspectives of the "institutional climate" toward teaching. Terminology that suggested an institutional commitment to quality teaching and learning (creating life-long learners, quality instruction, learning community) was present in the mission statements of colleges who employed Professors A, B, D, F, and G. Only Prof. A reported that many courses at her institution used active learning. While Prof.'s C and G did not believe good teaching was rewarded at their institutions, Prof.'s A and B felt somewhat rewarded, and Prof.'s D, E, and F felt very rewarded. Only Prof.'s C and D felt they had access to useful on site teaching support and Prof.'s B, E, and G felt somewhat less encouraged to participate in teaching enhancement workshops than the other instructors in the study.

Only Prof. A reported significant tension between administrators and instructors. All instructors felt there was a very good level of respect between instructors, while Prof.'s B and G felt there was somewhat less respect between instructors. Only Prof.'s A and D felt they were encouraged to maximize content coverage. All instructors except Prof. C felt that they were encouraged to some degree to teach problem solving skills.

Table 30 summarizes course and instructional strategy characteristics collected from course syllabi and interview data. All instructors organized and taught courses focused on human A & P. During the project semester, Prof. A taught the first semester of a two semester sequence, Prof.'s B, C, F, and G taught the second semester of a two-semester sequence, and Prof. D taught the first semester of a two semester course that covered all systems, at different levels during both semester. Prof. E taught a stand alone, one-semester (all systems) course. During the project, Prof.'s A, C, and E were addressing content in four, six, and ten systems; Prof.'s F and G were teaching content in three and seven systems; and Prof. B and D were teaching content in five and ten systems. All instructors emphasized structure function relationships in syllabi objectives. Only Prof. E indicated that the use of scientific thinking was of utmost importance. Prof.'s A, C, and D listed specific performance objectives in their syllabi or provided supplemental handouts. Both Prof.'s A and F taught integrated lecture/ lab courses, Prof.'s B, E and G taught separate lecture and lab courses, and Prof.'s C and D taught courses with lab, lecture, and discussion sections.

Although all instructors reported variation in class size between semesters (except Prof. A whose enrollment was fixed), during the project semester, Prof.'s A and F and G had the smallest classes (less than 35 students) and Prof.'s B and D had 50 students. Interestingly, two of the three site testers demonstrating conceptual change (Prof. C and E) taught the two largest classes in the study (75 to 125 students when extra sections were added), and both had reported that over-enrollment seemed to be the trend of the near future.

With regard to instructional material, although all courses used textbooks, Prof. D had written an on-line textbook, and Prof. F had his students buy a text to use primarily as a second perspective. Interestingly, three of the four non-conceptual change (Prof.'s B, F, and G) participants provided students with extensive class notes or outlines; but rationales for doing so were quite different. While, Prof. B said she believed it made the course more doable for students, both Prof. F and G felt it freed students up so they could listen.

Also of interest, all three instructors that expressed evidence of conceptual change, used workbooks that students completed prior to class in conjunction with reading assignments. However, there was some variability in that Prof.'s C and E used workbooks that were aligned with texts (Prof. A's was not), and Prof.'s A and E had both authored their own workbooks (The workbook Prof. C used was publisher produced). All of the professors indicated that students viewed the workbooks favorably, indicating that they were better able to focus on main points while doing pre-class reading assignments. Although Prof.'s B, D, F, G had out of class questions and reading assignments for students to complete, they were not described as systematically as those used by Prof.'s A, C, and E.

All participants began the study using "interactive lecture". More specifically, Prof.'s. B and G used lecture with questioning, Prof's A, C, E and F used interactive lecturing with small group work, and Prof. D reported using short lectures with case studies and a team learning approach. Triangulation data from interview transcripts, where instructors were asked to describe in detail what the flow of a particular class day had been like, and observations (where possible) indicated wide variation between instructors. Further, descriptions provided by a single instructor were highly variable, with some descriptions suggesting high levels of interaction and others much lower levels of interaction.

Overall, the only common characteristics shared by Prof.'s A, C, and E were gender (and this cannot be considered significant in this sample) and one instructional strategy—they all had incorporated workbooks into their courses that students completed prior to class in conjunction with reading assignments. Although data are far from conclusive, no obvious trends in course or instructional factors seemed to differentiate the instructors who experienced conceptual change from those who did not. Further, the implied institutional commitment to quality teaching and learning (mission statements), instructors' perceptions of reward for teaching, or a critical mass of instructors using active learning also did not appear to be factors that differentiated conceptual change in this purposive sample.

PARTICIPANTS' EXPERIENCES AND BELIEFS

Instructors' beliefs and experiences were initially categorized into first (the five month acclimation and baseline data collection period), and second phase experiences. Prior to cross-case analysis of the experiences, it is necessary to explain a significant change in the planned interpretation of quantitative survey data. Reports of first and second phase experiences follow.

Change in Use of Instructor Survey Data

As a point of interest, it was not possible to directly determine quantitative changes in instructors' self-reported beliefs over the course of the project using the Attitudes Toward Teaching Inventory as originally (albeit tentatively) planned. The rationale for changing from a quantitative to a qualitative analysis, unfolded during the last round of interviews when the inventory statements were read over the phone by the interviewer to each instructor. After each statement was read, instructors were asked to respond to the statement with a value (1 to 5) and asked to explain why they had rated the statement as they did. They were then provided with the response they had given the first time they had responded to the inventory statements in writing (15 months earlier).

Interestingly, despite having completed the survey in written form at least three times previously, most instructors asked for several readings of each of the sixteen statements and struggled with interpreting the statements, stating that it was more difficult to respond to a statement that was read to them than to respond to a written statement. Moreover, while some of the instructors clearly recognized some of the statements and responded in the manner, "Oh yeah…I remember that one….read it again please", others seemed to have no recollection of some of the statements. In one instance, the following exchange occurred:

> Interviewer: Okay, here is the second statement. I feel it is important that this subject should be completely described in terms of specific objectives relating to what students have to know for formal assessment items.
>
> Prof D: Huh? Who wrote that [laughing]?
>
> Interviewer: a very wise old researcher… who likely takes great joy in perplexing A & P professors….
>
> Prof. D: Oh…..well read it again…..it worked…I interpreted that about six different ways.
>
> Interviewer: Okay…here it is again….and remember there's no right or wrong here….just listen to it and tell me how you interpret it, okay? I feel it is important that this subject should be completely described in terms of specific objectives relating to what students have to know for formal assessment items.

> Prof. D: 2.
>
> Interviewer: 2?
>
> Prof D: Yeah.
>
> Interviewer: Why 2? What do you think the statement is getting at?
>
> Prof. D: Well it sounds to me that the question is stating that I have to tell them what it is that they need to know in order to pass the tests. So I only partially agree with that. It's my job to teach them and assess what I have been teaching. And it is also my job not to assess what I have not taught. But I don't think it is my job to tell them specific items that will be on the test and then to test them on it.
>
> Interviewer: Okay
>
> Prof D: Leading…that's what the students want though…they want to be lead.
>
> Interviewer: When you responded to that statement 15 months ago…you gave it a 5. Why do you think there's such a big difference?
>
> Prof. D: Because the term formal assessment is confusing. I don't think that it's a change in what I think…just a change in how I am interpreting assessment because I waffle back and forth on assessment…I mean what is formal assessment? Is that the tests in my class or the professional exams that students will take? Before I might have been thinking it was happening outside of my course….

Prof. G was also confused by her prior response to a statement and speculated that maybe "since all of this was so new" she had no point of reference for where her initial response should be placed on the Likert scale. During the last interview after responding "1" to a strategy statement and being told what her response had been 15 months ago, she asked, "Why in the world did I score this a 4 to begin with? I've never done that in the classroom!" Similarly, when Prof. E rated a strategy statement a "5" at the end of the study and elaborated that this was an area that had changed significantly for her, she commented on her beginning rating, which was also a "5": "That was too high…either that…or I thought I did it but now I see I didn't". Prof. F rated a strategy statement four points higher than he had rated it when initially completing the survey, but indicated there was no change. "I remember I was thinking about the question differently then…but there's no change…I've always used textbooks in an ancillary kind of fashion…so that's no change." Prof A also elaborated on what appeared to be negative movement on a survey belief statement ("assessment should reveal conceptual change"):

> I gave it a 2 today because I'm not very good at writing assessments that reveal change…I don't know why I gave it a 4 before….I mean I know why….I think I was rating my belief in the statement…but to some extent I think I thought that I was doing a better job of that than I actually was….and I agree with the statement to the same extent or more than when we began but now I just see that this is a difficult thing to do and I'm much more aware of my deficiency to make this happen, you know?"

Prof. E stopped the final interview to describe what had "just hit her" :

> Many of the questions I'm answering, I'm answering with the same number I answered over a year ago…that's what you are telling me…but I'll tell you I am interpreting the questions totally differently! I can't believe how differently! Back then when you asked me if I make opportunities available for students…to do one thing or another…I was totally answering by what I do…you know, am I available? In terms of MY time…in terms of MY attitude. NOW, I am thinking, 'Well, would students think they have access to the opportunity…or the confidence to speak up or come and find me or communicate something to me? My response isn't about ME anymore…I'm answering with a focus on them. So maybe you are reading the question to me…and they are the same questions I responded to before…and maybe I am responding with the same number…but when you ask me to explain…I'm giving a totally different interpretation of what I would back then!

These interview exchanges have important implications for future research focused on conceptual change professional development. First and most importantly from a research perspective, the value of triangulation of multiple data sources and methods becomes strikingly apparent. In fact, beyond Lincoln & Guba's calls for establishing the methodological rigor or *trustworthiness* of an inquiry by using multiple methods of data collection (1985, p. 290-294), Davidson & Tolich (1999) have defined viewing an inquiry focus from several vantage points as, "the heart of qualitative research's validity" (p. 34).

In this research, a reasonable conjecture drawn through triangulation is that, as instructors were gaining familiarity with the vocabulary of constructivist learning theory, activating prior knowledge, and building new knowledge based on their own classroom and professional development experiences—launching into their own conceptual change learning experience—they began to encounter and interpret the wording and emphasis of the survey statements in very different ways. Instructors' alternate interpretations of the survey statements supports the evidence from conceptual change analysis conducted using emergent interviews over the course of the study. Presumably as instructors moved back and forth through the conceptual change constructs of dissatisfaction and intelligibility (and unintelligibility), instructors were attempting to make sense of the survey statements in new ways. As such, the interview exchanges promoted by the survey tool contributed to what Pajares (1992) has referred to as the shaping of a "richer and more accurate inference" (p. 327).

Second, and important from a practical perspective, professional development staff should anticipate and plan for changing interpretations of tools used to collect data to document faculty change. This conclusion extends Richardson's caution (1996) that the use of surveys, questionnaires, or multiple-choice inventories to gather data about teacher conceptions can be confining and often "do not validly represent teachers' beliefs" (p. 107). This caution should be promoted to a serious concern in long-term conceptual change faculty development programs. However, the results from this study also suggest that changing the way that a survey is administered—from a written format, to a tool guiding a semi-structured interview—is one way of effectively altering the type of data collected. It is also foreseeable that the survey tool would likely provide rich ground for reflection if used in faculty development programs to begin to explore the differences between espoused theories of teaching and teaching practice or to explore the role of learning preference modality in the students of participating faculty.

First Phase Experiences

During the first phase of the project all instructors struggled to some degree with one or more of the following: a perceived lack of instructional knowledge, a perceived lack of pedagogical content and clinical knowledge, student resistance, a perception that they were engaging in personal and/or professional risk-taking, and shifting attitudes toward active learning. Representative excerpts coded in each category are provided.

Lack of instructional knowledge

Examples of a perceived lack of "know how" can be found in each of case studies (Chapter Four). The following excerpts indicate lack of knowledge related to planning, designing activities, and an overall sense of not knowing what should be taught.

> Planning a class session takes too much time! I'm planning from the minute class is out until the minute it starts. I need to develop a system to increase my efficiency. I'm starting to move toward organizing the material I want to present for the day, thinking about what the main two or three topics are, and putting them into an outline form. Then for each topic, I try to find or design a quick activity. Sometimes I alter a workbook question that students are supposed to have already done….it's impossible to be creative enough to come up with activities day after day. [Prof. C]

> I haven't been ready to incorporate an activity module from the website. It's still such a shift from lecture for me and when I do introduce an activity, I want it tailored to my class. The modules are too complicated for the level my students are at. I'd like to make my own activities but I'm not quite sure how to do that. [Prof. A]

> I wish I had access to the favorite test questions and problems of people who have been doing active learning in A & P for a while. Then as I was starting a new system, I'd have a better feel for what I really want my students to be doing and thinking about. [Prof E]

It was also common for instructors to question the efficacy of using active learning as an instructional technique. Despite the fact that all participants indicated a commitment to doing active learning and indicated that they understood the research findings related to the use of active learning, there remained a loyal commitment to the traditional lecture as the "tried and true" standard method, against which all alternatives had to measure up to. Six of the seven participants made the statement and asked the question, "I'm not sure if students will actually LEARN the material when I teach it this way. How will I be able to tell?" Several instructors continued to ask this question throughout the study. When challenged to consider whether students learned material when they were taught by lecture, most said that they knew students didn't learn "all that well from lecture", but questioned whether it was possible that active learning might be even less effective.

In addition to a lack of confidence in the general instructional method, there was discomfort in the use of class activities: "There's this awful feeling of, 'How will this go?' I feel like I'm stepping into the unknown."[Prof. E] The question of not knowing how it would go was in many instances followed by reports that it wasn't going all that well, in part because of student diversity:

> I've done three sessions of active learning and I'm not sure how it's going. I've had students break into groups, solve some problems, interpret graphs, and analyze data. But I don't know what else to do! I have some students who seem bored (they finish too quickly!) and some that seem confused that this is what the class is like. Everyone is wondering what we are doing…including me! [Prof. E]

> I'm swinging back and forth between meeting the individual needs of the slower students, trying to lead the class as a group and leaving some behind, and trying to provide challenge for the better students. [Prof C]

All instructors began to express quandaries around the general issue of classroom management and some struggled with these issues throughout the project. The general question instructors faced was related to *who* should be making classroom management decisions when active learning was used in the classroom. While some instructors seemed to assume that "transferring the responsibility of learning" to students, meant giving the responsibility for making classroom management decisions, others began to see this practice as problematic:

> I'm struggling with the issue of polling students to see what they need and what they think. When the responsibility for learning is transferred to the students, isn't polling part of it? Shouldn't they have a say in how we do things? To what degree should students make the decisions about what we do? [Prof E]
>
> I had the students vote on how they wanted the lecture and test for the day sequenced and then I went with what they said. [Prof. B]
>
> This course will be taught chiefly by interactive lecture, group activities, and assignments. The emphasis for learning will shift from teacher-centered (by lecture) to student-centered. [Prof. F syllabus statement]
>
> Students said they want less group work, less lecture, and more individual problem solving so that is what I am planning to do. [Prof D]
>
> I understand the importance of giving students ownership of their learning and know that is important from a motivational standpoint…so I want them to be in control. But at the same time, I have a responsibility to teach them the material so I'm stumped on how to make both things happen at once. [Prof. E]

Also, as instructors began to tap into student "cues" in the classroom, there was an eroding sense of confidence in skills they had previously considered themselves good at. For example, while questioning students one day in a large group discussion, one instructor overheard a student tell another student a strategy for answering questions in class, which had to do with "reading the instructor" rather than responding to the content question. The professor commented later:

> Apparently, my questioning procedure in the classroom is taking on a predictable nature. Since I didn't want to always be the one telling students they were wrong, I tried to defer to another student. For example, if somebody answered a question incorrectly, I'd ask another student, 'What do you think about that?' That works well but I've fallen into a pattern where I do that only when the answer is wrong. If somebody

> answers a question correctly, I say, 'Good'. So I am reducing the overall challenge level by the verbal cues I use and I don't ever challenge students to defend what they think is right. [Prof. C]

In instances where graduate or undergraduate teaching assistants, peer tutors, or part-time instructors were involved in teaching in some capacity, the issue of conflicting teaching philosophies also became a dilemma. One participant explained:

> The [teaching assistants] don't understand the philosophy behind active learning and are trying to compensate for my "not telling students everything" by telling students everything they need to know. Not only is this counterproductive to what I'm trying to accomplish, it's probably contributing to poor student attitudes…because there's this chatter about whose going to tell the students what they need to know. I need to provide some structure [activities, strategies, questions] for the assistants to use so they feel like they have something to hang on to. [Prof. C]

Issues relating to how to assign points for activities and how to align assessment with what was going on in the classroom also quickly became dilemmas for four of the seven instructors. Since most had not been presented with opportunities to question the purpose of assessment within the framework of their "interactive lectures", it came as quite a surprise that the purpose of assessment could be something other than "giving a grade". The grading issue was compounded by students' discomfort:

> I'm struggling because I feel a need to associate points with what they do in class but I don't think students are liking that. They get anxious. I took up their group assignments and graded them really easily and all group members got the score…but then the students who were working hard didn't like it that the ones that weren't working were getting the same scores. [Prof. E]

> My grading system doesn't work. Somehow students have figured out how to participate in the activities or quizzes with the highest point value

pay off. The students that are selecting the activities they will participate in are ending up with more points than the ones that are participating in all the activities. [Prof. C]

I gave an activity. I said, 'This is not for points. It's a learning activity'. One student said, 'Then we don't have to do it?' [Prof. F]

I'm not sure how to transfer what I do in class to an exam. Because the class is so large, I can't ask the kind of open-ended questions I do in class because of grading issues. [Prof. C]

Lack of pedagogical content and clinical knowledge

Another set of dilemmas was related to a lack of pedagogical content knowledge and/or a limited knowledge of the clinical aspects of Anatomy & Physiology. Comments on the discrepancy between what instructors had anticipated would happen when students engaged in problem solving, and what actually happened, were common. Three instructors commented that the most unnerving part of using active learning was the "chaos" or "unpredictability" associated with how students interpreted and approached a problem or activity, even when they had "gone all out and written the instructions down to minimize the confusion". One instructor said,

There is the unknown element of what the student mind is going to do with the content. Sometimes I have no idea what they are talking about or even what they are asking. I think it was so clear what they were supposed to do and where they should have ended up, but they are nowhere near…. I don't know which track they are on, let alone how to pull them back to the one I think they should be on. When I answer what I think their questions are they say I didn't answer the question. [Prof. E]

Another participant commented that she found it difficult to know what concepts students would comprehend easily and which ones they'd get stuck on: "Some things I take for granted that they must surely know…like how models are used in science…. but they don't know…and then other things I think might be challenging they get right through." [Prof. A]

Two instructors also commented on what they perceived to be a noticeably different level of engagement evoked by "real" physiological disorders rather than hypothetical situations, but commented that their own clinical knowledge limited their ability to come up with real life examples quickly. Prof. C commented that although she liked what she came up with because she could set the challenge level to students, the process was time consuming because she had to go through the literature first and then formulate a doable kind of problem.

Student Resistance

Numerous statements related to student resistance were expressed by five of the seven participants (Prof.'s F and G did not report student resistance). The most frequent examples shared were related to frustration over the absence of a structure that students were accustomed to, and a perception that students were blaming the instructor for not telling them what they needed to know:

> Students are frustrated. They say they don't know what they are supposed to learn. Should I lay out some kind of map for them each class session so that they know where we are going? [Prof. C]

> Student frustration is being manifested as blame toward me and my teaching strategies. The blaming feels likes it's playing out in a way that's creating bad attitudes and students are now telling me…just to tell them what they need to know…give them the bottom line. [Prof. B]

> Student resistance is a big problem. When I switched gears to active learning with less lecture/notes, students were extremely displeased. They want to be told the right answer and told when they are wrong. They also don't like being called by name. I don't know how to help students

> through this transition from lecture to one where they are expected to think.[Prof. D]
>
> My students told me that if I didn't paraphrase the text for them and go over the handouts that I wasn't doing my job. [Prof. B]

Personal and Professional Risks

The first level of risk that two instructors (Prof. A and C) seemed to experience while acclimating themselves to active learning, was the personal discomfort of doing something different and truly interactive in the classroom. Both explained variations on the same theme, of how they had set a goal of "getting students to speak out" in class, and how the goal had been achieved, albeit in a disappointing way. Because of a need to minimize personal risk, and knowing that students might "gander" unanticipated responses, both had scripted (written clues on cards) parts of the activity to encourage student participation. One instructor commented several weeks later:

> I'm letting my own comfort level interfere with implementing better learning exercises. I anticipate that activities that are less structured will be scary for me but I need to take the risk knowing that things will not always go the way I expect. [Prof. C]

There was also an indication by five instructors that active learning involved the personal risk of "revealing self" to students and this revealing was uncomfortable (Prof. A, B, C, E, and G). Prof B conveyed more discomfort than the other instructors:

> I am not comfortable in my own skin doing this…what am I trying to prove? At what point did I lose sight of where I'd been and where I'm going…and how did I end up here? I think I'd rather be back in my comfort zone even though I know it means putting my blinders back on. [Prof. B]

Two participants (Prof.'s C and E) elaborated on how, as scientists trying to practice new educational techniques and understand the theory underlying the techniques, they felt like imposters. One participant explained,

> I know this feeling…it's the feeling you get when you are doing something new and you know you know a little, but not enough…so you assume everybody around you sees the inadequacy that you feel…like an imposter…and somebody is going to say it! Even though I am trying to think about education and how students learn, I'm not someone who has an education background. I know some but maybe too little to be trying to inform my own techniques. [Prof C]

Personal risk was also manifested as instructors began to engage in "two-way" conversation with students. Prof. B wondered if students felt as uncomfortable as she did with the interaction and commented that as often as she was intrigued by students' comments, she was put off: "It's almost as if I have these beliefs that I'd rather leave alone …there's something I don't want to see about them and something they don't want to see about me." Prof. F commented, "There is something to be said for being the sage on the stage. It sure makes life easier, doesn't it?" Two participants spoke of the risk of collegial alienation, both commenting in a similar fashion that when a commitment to valuing student learning was made, they had felt looked down on by both older colleagues and tenure-bound peer researchers (Prof.'s A and C). One instructor elaborated that, "There is still a cultural aspect…if the research isn't done in a lab…by god…it's not research."

Another level of risk that coincided with the instructors' perception that students were frustrated with the instruction, was expressed at the professional level in relation to anticipated end of semester student evaluations:

> I'm feeling the risk involved in being an instructor who uses active learning. Unlike the authoritative image I've taken on when I've done presentations or lectures, this role requires that I step back and let students struggle with things a little. Despite the fact that this way of teaching requires that I know the material better than a standard lecturer would, students don't understand that. I overheard two students say, 'This instructor is clueless!' I'm afraid that teaching this way may be inducing students to be critical of me. I am thinking about talking with students more about why I give them problems with more than one answer and why I'm not positioning my own knowledge at center stage…. I want them to examine what they understand…but students could argue that, 'Yeah…but then you are going to test us and give us an exam and grade us…' so it doesn't hold. [Prof. C]

> Students are voicing their displeasure to the Dean and other faculty members. My evaluations will be the worst I've gotten…I'm sure. [Prof. D]

Shifting Attitude Toward Active Learning

Four participants expressed frustration over feeling, "so up to take this on—so tired", "so excited—so discouraged", and "so committed to student learning—so wanting to just lecture". While many of the attitudinal comments were brief generalized expressions without elaborations, Prof. C articulated at length on the emotional component associated with doing active learning:

> My attitude about active learning fluctuates so much. I have an experience in class where students engage in an activity and make connections and seem to be retaining the information because they reference the activity down the line and I'm so sold on active learning. But then I encounter students with negative attitudes and am not at all sold. My attitude is influenced by the amount of time it takes, the burnout, the self esteem factor, student understanding or confusion, sometimes student anger…. trying to be enthusiastic yet knowing they are not keeping up with the homework and reading, trying to help them build their confidence by making it through a tough problem but then watching it get stripped again when they have no idea how to proceed the next time around.

Second Phase Experiences

Second phase experiences, including activity choice (modules versus design), use of formative assessment, and reports of experiences were diverse. Only Prof. A chose to use the ITIP curriculum modules, all others designed their own problems, activities, and matrices. Prof.'s A, C, E, and F followed each activity with formative assessment, but asked a broad range of question types from very closed ended, temporal (Did this activity help you learn?) to very open ended questions (Explain how the case problems helped you learn and give examples of the points you better understand now) and content questions built into the following exams. Prof.'s D and G reported feedback from only one activity, and their analysis of the feedback was uncritical ("Most of them liked it", "Some said they would rather have a lecture" and "Some said they needed more time.") After Prof. G opted to omit the formative component of her second activity she reflected,

> It was funny…I guess I thought initially that I would do formative assessment after the students finished the matrix [of the man in the desert]…but then since I did it right at the end of the semester [and the whole intent of the activity was to see if students could pull together information from the whole semester]…I thought… well the activity itself is an assessment…so wait a minute…why would I want to do an assessment on the assessment? But then I wondered if I was wanting to assess their thinking ability or their ability to draw things together…but then I thought the activity was assessment and I didn't need to assess their assessment.

Similarly, following the heart dissection activity, Prof. B (who did not report formative assessment during the project) said that she noted that students learned more from the dissection and had a better, three-dimensional understanding of anatomical structures and relationships than they had in the previous semester. Although quiz results (a standard part of the class format) some weeks later didn't particularly reflect improved learning, she felt that "students understood much better" based on conversations she overheard. She did however categorize responses to her question at the beginning of a lab session to determine whether students had read through the lab material, as "…technical difficulties…they get disturbed by a few typos or mislabeled figures…the second group is having logistical problems [they couldn't pipet or do dilutions]…and the third group is just out in the ozone someplace!"

The tendency not to value formative assessment was common to varying degrees among all instructors at the beginning of the project. Many commented that they felt it was simply more of what they were already doing, and given the redundancy, were not keen on using class time to do more of the same. However, after two rounds of activities followed by formative assessment, Prof A. reflected that she noticed a change in her attitude toward formative assessment. She said that she had approached the first round of feedback with the belief that she "might find out something interesting here…" rather than what had become more obvious to her after the second activity and formative assessment. She reflected, "It just became so obvious that it's a way to find out what I can do to improve student learning". She elaborated:

> I got a window into what students were getting and what they weren't. It was just so obvious from the way they had made their map connections that there were five points—after-load, stroke volume, contractility, pre-load and the fact that both norepinephrine and acetylcholine could affect both the SA node and the muscle itself-- that they weren't clear on and I was able to focus the next days discussion on those points…This is the

> first time that I've done feedback in such a complete way and it was interesting because even though I had collected index cards before, and I had graded maps before…but this was the first time that I did everything together and this is the first time that the trends in student thinking just jumped out!

AN EMPIRICAL SCHEMATIC OF CHANGE DESCRIBING INSTRUCTORS' EXPERIENCES IN THIS STUDY

The pronounced difference between instructors' attitudes toward formative assessment suggested that issues surrounding feedback represented a critical element in the experiences of these instructors. The difference prompted the naturalistic question, "What's going on?" and forced a "teasing out" of critical questions. Two questions emerged:

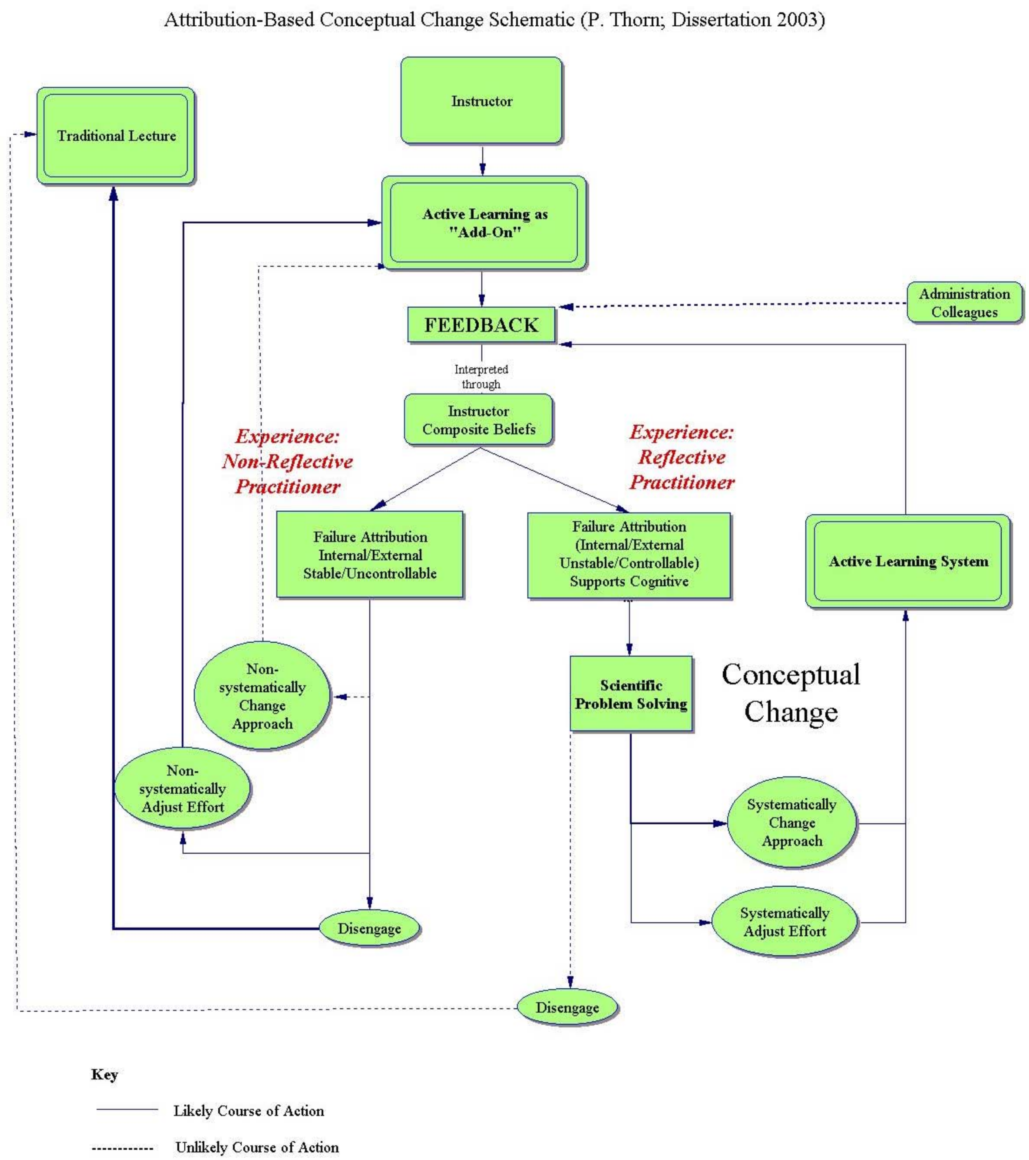
> Why were some instructors engaging in reflection and problem solving subsequent to getting student feedback with a goal of improving student learning, while others seem unaware that the potential for cognitive engagement and problem solving existed?
>
> Why was it that the instructors that had expressed evidence of conceptual change were the ones monitoring student cues in the classroom and using formative comments in conjunction with classroom problem solving, while the other professors remained exclusively focused on structuring activities and on discussing problems with resistant or low-ability students?

In some respects, the differences in faculty behavior were very similar to the differences Hall & Hord (1987, 2001) described between the self, task, and impact Stages of Concerns expressed by student teachers as they developed within the framework of a teacher education program. While the instructors that had not reported evidence of conceptual change could be described as teaching with an "egocentric frame of reference" (self concern) and focusing on the mechanics of the activities (task concern), the instructors who had reported evidence of conceptual change had developed to a point where they were focused on what was happening with students and what each could do to improve the potential for student learning (impact concern). But, why the differences in development? What were the factors impeding development, particularly in Prof.'s B and D? Although Hall & Hord confirm that change is not an inevitable consequence of teacher training, their advice on how to facilitate change is limited to a re-examination of contextual factors (appropriateness of the chosen innovation and leadership) and the "careful facilitation" of the change process.

Analysis of instructor experiences, motivational profiles, and beliefs about teaching and learning within and between the most distinct conceptual change groups revealed significantly different patterns of causal attribution beliefs. Although differences in goal statements and theories of intelligence were also apparent between Prof. A/C/E and B/D, these constructs often became disparate if an adopted belief system had gained temporary status (Prof.'s B and D). Therefore, failure attribution was identified as the primary explanatory variable impacting conceptual change. Over the course of experiential analysis, a classroom-situated schematic was developed to describe the change experiences of the instructors in the conceptual change and non-conceptual change groups in this study (Figure 3).

Not surprisingly, the "Attribution-Based Conceptual Change Schematic" combines Attribution and Conceptual Change Theories. Given the research base that documents the influence of attribution beliefs on cognitive engagement (Pressley, Borkowski, & Schneider, 1987; Dweck, 1978; Jonnassen &

Figure 3 Attribution-Based Conceptual Change Schematic



Grabowski, 1993; Weiner, Russell, & Lerman, 1979) as well as theory of intelligence, goal orientation, expectancy for success and self-efficacy beliefs (Pintrich & Schunk, 1996; Ormrod, 1995), the schematic differentiates change experiences by predicting that instructors with adaptive attribution styles (internal/external, unstable, controllable) will be motivated to cognitively engage in problem solving or "reflection" within their classroom contexts, and that problem solving will facilitate a process of conceptual change.

The common-sense link between reflection and learning (conceptual change) has been referred to by many researchers (e.g. Loughran, J. 1996; Boud, Keogh & Walker, 1985), with Dewey (1933) being among the first. In *How We Think,* both the link to Conceptual Change Theory and the importance of cognitive engagement in teaching becomes obvious:

> Reflective thinking, in distinction from other operations to which we apply the name of thought, involves (1) a state of doubt, hesitation, perplexity, mental difficulty, in which thinking originates, and (2) an act of searching, hunting, inquiring, to find material that will resolve the doubt, settle and dispose of the perplexity (p. 12).

In addition to cognitive engagement enacted as a problem-solving orientation to teaching, the adaptive attribution style is expressed as persistence and commitment to continued use of active learning, classroom risk-taking due to the valuing of student learning over personal comfort, an affective state of pride and satisfaction, and expectations for future success using active learning. In contrast, the maladaptive attribution style is expressed as little or no cognitive engagement, giving up on active learning when faced with student resistance which is perceived to be stable and uncontrollable, an affective state of anger or gratefulness (when the locus is external), and a low expectation for future success or high expectation for future failure.

A description of how the schematic represents the experiences of the instructor participants as they began using instructional strategies to facilitate student active learning follows. Recall from the case studies that all instructors approached the addition of active learning as an "add-on feature" (top of schematic, and first passage through) to try to get students engaged in learning.

The experiences of the three instructors (Prof. A, C, E) who demonstrated conceptual change are represented on the right side of the schematic. These instructors chose or designed activities to implement in their classrooms and followed activities with formative assessment and summative assessment, the latter of which was not specified as a project requirement. With consideration of data from Prof.'s C and E, an additional source of feedback—from an administrator and departmental colleagues (far right side of schematic)—was observed. Both instructors received unanticipated negative feedback from individuals who did not support the use of active learning as an instructional strategy or as an alternate form of scholarship.

Central to the schematic, once feedback information passed through the instructors' personalized prior knowledge framework and lens of causal attribution (right side of the model; internal/external, unstable, controllable) all three instructors were motivated to engage cognitively and engaged in a process of systematic, scientific problem solving by considering how the feedback could be used immediately and in the future to improve student learning. As seen in the schematic, the most likely courses of action were to consider a variety of options and perspectives and either adjust the level of effort in some way or systematically reconsider and change the teaching approach. As a point of interest, Prof. A, C, and E were the only instructors in the study who consistently used phrases such as, "if I were in students' shoes" or "what might students be picking up on?" A third but less likely course of action, disengagement, is also included in the schematic. Although it was less likely to occur, disengagement was observed several times during the study. For example, Prof.'s A, C, E each described instances that interfered with their ability to plan, implement, or integrate activities. Sources of interference included conference attendance, a sick family member, death of a pet, being exhausted, and "falling behind" as exam time approached. Despite the requirement for only two activities coupled with formative assessment, Prof.'s C and E reported during the post project interval that they had consistently used instructional strategies to facilitate active learning and monitored student feedback regularly throughout the course of the semester. Although Prof. A limited the activities and formative assessment to the two required by the project, she reported using more questioning, more "two-way" conversation, and more informal collection of student feedback over the course of the semester. Toward the end of the project, all three instructors began to express a changed conception of active learning; rather than an add-on, active learning had become something of a classroom system. All three instructors completed the project by engaging in a process of learning objectives/assessment alignment, syllabus reconstruction, and plans to incorporate further structures to facilitate the transfer of responsibility for learning to students. Comments from all three instructors were indicative of changed perceptions about active learning. For example, Prof C commented:

> …there's a balance…it's not just activities. Students have to have help setting a framework …to build their knowledge on…. especially when they are just starting…or for that matter every time they start something new. They have to be shown how to build this framework. It's not either or…it's not active learning or lecture…it's a balance of providing the supports they need to start integrating all the knowledge and skills we encounter. There's even a difference what works for my first semester students versus the second semester students…they need different kinds of structures and grading systems. There's also the need for the instructor to tie the knowledge gained through activities into the exams and to bring the knowledge from the lab into the lecture. Everything in the class needs to be structured with some activity-based learning objectives. You can't just tell students to be active learners, you have to get them on board with what their responsibilities are and then set up supports so you can transfer the responsibility over to them. You have to help them with motivation by giving them the assurance that there are concrete things they have to know…and can know…to do well in the class and that they can control what path they take in the course …

Coincidentally—or not—the balance described by Prof. C has also been previous described by Dewey (1933.). In fact, Dewey has much to say about "searching for a balance" between teaching that is exclusively transmissive as opposed to that which is solely student-centered, and how a problem-solving approach to teaching (Dewey refers to this as a "reasoned approach to teaching by reflecting") might impact student learning. This point seems particularly important in A & P courses where content coverage is an important and foundational feature that is critical to scientific thinking and problem solving.

The evolution of an active learning classroom system by the instructors, who expressed evidence of conceptual change, parallels what has been described as constructive alignment (Biggs, 1999). Biggs contends that since education is about meaningful learning, and since constructivism posits that learning is about conceptual change, a teaching system composed of compatible parts must be built upon the foundation of intended instructional outcomes. Because Biggs' elaboration of the alignment principle is grounded in constructivist learning theory, he refers to the concept of "constructive alignment".

Alternatively, if the instructors did not demonstrate conceptual change (Prof.'s B and D), again central to the schematic, feedback is accessed in some form—whether it be formative or observational in nature-- passed through the instructors' personalized prior knowledge framework and lens of causal attribution (left side of the model; internal/external, stable, uncontrollable). Because of the maladaptive attribution style, there was little or no motivation for cognitive engagement; therefore the most likely course of action was to either disengage or adjust the level of effort by doing more or less of the same action (Prof. B) or non-systematically, and non-scientifically change the approach (Prof D). A systematic, changed approach is unlikely because of the requirement for cognitive engagement, which is not an outcome of the stable/uncontrollable attribution construct. At the end of the project, both Prof.'s B and D, continued to speak of active learning as an add-on to what they were doing in class.

Representing the left side of the model, Prof.'s B and D each did at least one activity, collected formative feedback on one occasion, and interpreted feedback through a lens of internal/external, stable, uncontrollable attribution. A sense of amusement rather than cognitive engagement followed feedback review by Prof. B:

> This has just made my whole day…because I am not thinking like they are at all! They knew the lab was about blood and most could name the tests but the third question…. I can categorize the responses! The first group is having technical difficulties…they get disturbed by a few typos or mislabeled figures…and that's helpful because it's easy to fix…the second group is having logistical problems…they aren't sure how to make dilutions or use a pipet…and the third group is just out in the ozone someplace! Stunned is a strong word…but some of these questions are the kinds of questions that [elementary-age students] would ask…[describes how comments aren't relevant to the lab]…

After setting his feedback aside, Prof. D retrieved it, reviewed it quickly and commented:

> One-third of the students want more individual problems. Some students are frustrated with the lack of details. Some students don't like their group and don't like my policy of not letting them move out of a group after the first week of class. I have one truly dysfunctional group and one quasi-dysfunctional group out of nine…

Despite repeated suggestions, neither instructor responded to the feedback in any way, and did not anticipate incorporating any lessons learned into the next session of active learning. Again, Biggs' (1999) comments are relevant, as are reflections on the pilot portion of this project (Chapter One). Biggs contends that one way to interpret the mismatch between an instructor and active learning is to understand that despite a genuine desire to improve student learning by incorporating constructivist-based practice, if the tenets are not understood and instructional practices are guided by partial understanding, it is likely (and probable) that default practice (behaviorism) will guide assessment. Despite the fact that instructional alignment seems so commonsense, researchers including

Cohen (1987) have concluded that the lack of excellence in classrooms is not so much due to ineffective teaching but misalignment between what instructors intend to teach, what they teach, and what they test. The data from this research suggests that the lack of alignment may also be in part to a maladaptive attribution style, which may preclude reflection on practice.

Although speculative, an implication of the schematic is that an important point of faculty development intervention is attribution retraining. The research on attributional retraining assumes that individuals have stable attribution styles that are repeatedly invoked in a generalized fashion across different situations (e.g. Dweck, 1975; Forersterling, 1985). The focus of attributional retraining (or similarly, the learned helplessness change research) is to encourage individuals to change their attributions, particularly for failure, to effort. The intervention is generally described as a one-on-one, extended period of repeated effort attribution feedback in response to both success and failure attempts to accomplish a task. Although not anticipated to be a trivial task, since the ontological shifts may be very difficult to make, it seems probable that if an instructor with a maladaptive attribution style were to succeed in modifying his or her attribution style, cognitive engagement could represent a means of transfer to the "reflective practitioner" experience.

CONCEPTUAL CHANGE INSTRUCTOR PROFILE

Prof.'s A, C, E expressed evidence of dissatisfaction related to the inadequacy of lecture for promoting retention, understanding, and lifelong learning skills; and lack of alignment between learning goals and assessment.

Intelligibility statements were focused on the thematic nature of the content material, coming to understand dialog as a two-way process, and formulating a deeper understanding of what active learning was and how it could be used in the classroom. Plausibility statements were focused on formative assessment as a means of determining if student understanding was improving, and again developing realistic and personalized understandings of active learning. Fruitfulness was expressed as instructors' commitment to "doing a little at a time" while focusing on student learning, making students partners in the learning process, and exploring possibilities for helping students develop self-assessment skills.

Prior Experience

Prof. A., C, E received their college educations primarily through traditional lecture but all had experienced alternate instructional strategies (a Lamaze instructor, a Biology instructor, and water polo coach) and reported that the experiences had shaped their current teaching practice.

Beliefs About Teaching and Learning

The instructors initially viewed *learning* as a mechanistic process of integrating information from different sources. While Prof. A described a challenging process (clearing a hurdle), Prof. C described a practical process that allowed problem solving, and Prof. E described a creative process. Common classroom practice suggested that all believed learning was facilitated by small group work and that students needed to hear a lecture prior to doing an activity.

Prof. E was the only instructor that believed learning was dependent upon ownership and freedom.

Conceptions about *students* were somewhat different within the group. While Prof. A focused on demographic characteristics of her students and believed many were academically under prepared, Prof.'s C and E maintained that students were individuals with busy lives who were strategically operating from a position of comfort. When describing what *students did in order to learn*, all instructors emphasized low-effort behaviors (piecemeal learning without integration, cramming for exams, and unsophisticated learning strategies). All believed that students did not generally think to look outside of their textbooks for needed explanations, didn't generally recognize that learning activities provided a means of identifying gaps in knowledge, and didn't consider the need to check the credibility of information accessed through the Internet. Prof. E was the only instructor in the group to characterize students as "really hating group work."

All *instructors* in this group initially identified themselves as guides or facilitators. Despite believing that they had not learned in a meaningful way or retained information through lecture, as instructors they all questioned whether student learning would decline when activities replaced lecture. When the professors described what they did in the classroom to facilitate learning, they listed directive activities such as: summarizing information, comparing, and making connections. All held the belief that the role of facilitator was complicated by the fact that students worked at different rates during problem solving and activities. While both Prof. A and E held the belief that it was the instructors' responsibility to form student groups, Prof. C believed that students should be allowed to choose their own group members. Further adding to the contrasting perceptions of the instructor's role, while Prof. C believed it was her responsibility to continuously try to encounter the course material from a student perspective, Prof. E believed that in order to transfer responsibility for learning to students, she needed to turn over some of the classroom decision making to students.

While two instructors perceived the role of the *class sessions* as a time to "hit the highlights" and for students to "get it", Prof. C (who shaped her perception through the metaphor of piano teacher), believed that class time should be used to represent concepts in different ways and give students a chance to work with the material. Similarly, *assessment* was viewed by two of the instructors as an opportunity to find out if students got what they instructor wanted them to get, while the other instructor believed that assessments should be an opportunity for students and the instructor to determine problematic understanding.

Motivation Beliefs

Excerpts from interview transcripts suggested that the professors who experienced conceptual change applied a *malleable theory of intelligence to both themselves and students.* With regard to their ability to facilitate active learning, all commented on improving in their ability to conceptualize and implement activities that targeted what they wanted students to learn. With regard to students, all believed that their students' skill deficiencies (problem solving and making connections) were related to inexperience—students simply hadn't been taught the skills or hadn't had many opportunities for practice. All made statements that they believed that student skill ability would improve as a function of experience and effort.

All instructors articulated project goals focused on students; such as, to engage students and encourage conceptual learning and logical process thinking, help students acquire facts and integrate information with prior knowledge, improve confidence, and help students understand how the parts fit together and functioned as a whole. They also expressed a secondary interest in exchanging ideas and interacting with other instructors engaged in similar activities. Consistent with a mastery goal orientation, all students viewed mistakes as useful opportunities for learning.

Attributions

Interpretations of success events were consistently internal, unstable, and controllable for all three instructors. For example, Prof. C reported that in order for active learning to go well, "there has to be organization and spending a lot of time learning this stuff forward and backward and thinking of questions that will help students make connections" and concluded that the process was a lot like running a marathon. *Interpretations of failure events* were external or internal, unstable, and controllable. For example, at the midpoint of the project, Prof A indicated that although she was committed to learning as much as she could about improving her teaching, she hadn't been able to put the effort into rethinking her goals and objectives. In this example, she attributes failure to herself (internal), to a temporary and unstable condition (the semester is crazy right now but things will settle down as it draws to an end and I will have a sizable chunk of time to commit), that she can change through her own effort and ability (controllable). Likewise, Prof. E made a similar attribution when she commented that when students are confused by an activity, "there are lots of possibilities", such as unclear guidelines, being asked to make too big of a jump, not completing their workbook assignment, or simply not making the connections she thought they should be able to make.

Prof.'s A, C, and E demonstrated a *willingness to take risks* in the classroom and indicated that the personal or professional discomfort was secondary to student learning. Because of personal alignment with the institutional mission, Prof. A's approach did not seem outwardly risky (from the standpoint of having the potential to lose her job or be denied tenure, as did Prof.'s C and E), but there was initially a perceived risk that students might not learn as well from activities as they did from her lectures. She also demonstrated risk taking when she shared student misconceptions with the Cell Biology teacher, and later when she persuaded two colleagues to participate in an upcoming research study. Prof. C perceived the use of active learning as risky because the methods conflicted with students expectations of being told everything and could lead to accusations that the instructor "wasn't doing her job", and subsequently poor end of semester evaluations. Prof. E also suggested that the benefit of improved student learning outweighed both the personal discomfort and professional risks associated with using active learning.

Given the attribution-affect link, Prof. A's statement of pleasure ("This is awesome" and "Being involved and trying these things is motivating for me. I am really enjoying it.") reflect a feeling of satisfaction. This link was also apparent in Prof. C's pride statements in her students' learning when she commented at the end of the semester,

> I feel so much better than I ever have about teaching this way. The students struggled the first semester…and that was tough…. but now suddenly as second semester students…I'm seeing they are really able to do it…I think they are just going to hit the Nursing School and the faculty there are just going to be blown away with the percentage of well-prepared and just intelligent…. just physiology savvy students that come out of this class [laughing]!

Prof. E's made a similar statement of satisfaction in her students' learning: "I wish I had the ability to look into the future and see what these students accomplish! I think they are going to be so strong in a foundational sense." All statements reflect a feeling of being control of what goes on in the classroom environment.

Cognitive *engagement* is also suggested by Prof. A's interpretation of student feedback following active learning. Not only did she identify content areas that students "weren't getting" and formulated an instructional response that improved student learning, she also identified what she believed were two distinct preferences for instructional sequencing. Both Prof. A and Prof C's responses to student resistance also suggest cognitive engagement. Presumably, due in part to situational attribution styles (external, unstable, controllable), both responded to student frustration by providing more structure to support student learning. Prof. A made it a point to be explicit about which concepts were central and which were extraneous (and how they were connected), and Prof. C developed learning objectives that were used to structure classroom learning and aid students in exam preparation. Cognitive engagement was also suggested by Prof. E's responses to initial student resistance to group work. Again, due at least in part to her attribution style (external, unstable, controllable), Prof. E concluded that when she observed student frustration, she reasoned that students were dissatisfied with some aspect of the instructional system (the situation was temporal) and that she had some control. She reflected on her process of problem solving:

> They [students] had let me know under no uncertain terms that they hated group work…at first they tried to be polite I think and they said, 'you know we get enough of that in lab'…. but then we'd be at a point in class when I wanted them to do an activity and I'd tell them to get in their groups and they'd all just sit there and look at me…my gosh… this just made no sense because students usually like working together. But then after I listened to some of their comments. . They were saying that it wasn't fair that they all got the same group grade…and then I just started thinking that [based on an interview challenge and reflection]…well how would I feel if I were in their shoes? Not only did I have to work with people I didn't choose…I had to accept their crummy grade…. so it just turned 180 degrees when I started letting them form their own groups…

NO CONCEPTUAL CHANGE INSTRUCTOR PROFILE

Prof.'s B and D did not express evidence of the conditions necessary for conceptual change: dissatisfaction, intelligibility, plausibility, or fruitfulness.

Prior Experience

Prof.'s B and D received their college educations primarily through traditional lecture. In verbal accounts, Prof. B did not describe experiencing alternate instructional strategies; however on a written survey she reported attendance at several HAPS workshops that were structured using active learning strategies. Prof. D reported discussion courses in secondary school. Neither instructor suggested that experiences as students had shaped their teaching practice.

Beliefs About Teaching and Learning

Prof.'s B and D each began the project with two distinct sets of beliefs about what learning was, what students did in order to learn, and who the instructor was and what the instructor did in the classroom. One set of beliefs (personal) was consistently expressed when speaking of classroom experiences. The other set (adopted) were expressed in professional development settings or when discussions drifted toward an abstract or theoretical perspective.

Both instructors initially viewed *learning* uncritically (something anyone can do, requires thinking on your feet and a wiliness to buckle down, is like riding a bike—you don't read about it you do it). Prof. B often referred to learning as excruciating. The adopted definitions of each were somewhat different; Prof. B referred to making connections, Prof. D referred to neurocognitive theory. Descriptions of classroom practice by both suggested confusion about the role of group work in learning. Prof. B commented that she was not particularly fond of some of the techniques (like group work) that were felt to promote active learning. Although Prof. D spoke highly of the impact of group work on learning, he also made a decision to reduce group work at one point in the semester because "students said they wanted less group work and more individual problems to solve". Interestingly, toward the end of the project, Prof. B's dual belief system seemed to merge and descriptors of learning became more personalized ("hanging onto things" and "pulling knowledge together"). In conjunction with a developing metaphor, she began to define learning as something that could be survived if one was adequately prepared. Prof. D maintained both the personal and adopted belief systems throughout the project.

Conceptions about *students* were similar. Both instructors began with a belief that students were under-prepared and had poor skill sets. Consistent with his attribution style, Prof. D commented on how most students in his class had received A's in the secondary education system (external, stable, uncontrollable) but were now earning C's and D's because of fixed mindsets about learning that didn't work. Throughout the project both instructors continued to speak of students' poor skills and abilities, but Prof. B spoke some of the capabilities of the second semester students. This shift was likely due to her fixed theory of intelligence, which pegged the second semester students as having "more brain power". Prof. D's description of students began to shift toward an adopted description of "people who are responsible for their own learning" and he continued to use negative descriptors (students don't have a clue about physiology, they are really bad critical thinkers, and will not ask for better learning contexts because they are afraid of anything new). When describing what *students did in order to learn*, both instructors emphasized low-effort behaviors and generalized descriptors (they can't answer, they don't get it).

Both instructors described their relationships with students uncritically. Prof. D referred to the relationship as "people who relate to each other". Prof B referred to the relationship as one between an expert and under-prepared student (initially) and then in more personalized and metaphorical language, as a travel guide working with unprepared tourists, and then to "prepared travelers" (end of project; after an invitation during an interview to speculate on what students might become).

Both *instructors* began by describing themselves as facilitators; however, Prof. B elaborated her definition to a "frustrated and disconnected facilitator".

Excerpts from interview transcripts suggested that Prof. D was somewhat conflicted over his role in the classroom. He stated at one time that he was NOT a teacher, and then later commented that if he were to stop engaging students in the classroom, he "would no longer be happy as a teacher." When the professors described *what they did in the classroom to facilitate learning*, they listed information transmission activities such as: reaching students, running class at a fast pace, demanding, providing instructions, giving details). Both instructors believed that transferring responsibility for learning to students meant polling students regularly to find out how they wanted the course structured. While Prof. B was conflicted by the impact of student diversity on her role (her opinion shifted between viewing the diversity as unmanageable to a "wonderful opportunity"), Prof. D's mention of diversity issues was limited to women and Asian students. While Prof. B let students form their own groups (but insisted on groups of four), Prof. D used a grade-oriented system to form groups.

Both instructors perceived the role of the *class sessions* as a time to cover information and deliver content. While a*ssessment* was initially viewed by Prof. B as a way to give a grade, Prof. D's version of grading was somewhat more complicated (Chapter Four).

Motivation Beliefs

Excerpts from interview transcripts suggested that the professors who did not experience conceptual change applied a *fixed theory of intelligence to* *students, and either a fixed or malleable theory of intelligence to* themselves. With regard to students, both seemed to believe that their students' skill deficiencies (integrating knowledge, critical thinking) were stable--students simply didn't have the required background or the ability to concentrate on learning. When describing herself, Prof. B reflected, "I don't have the ability to change things efficiently" and "I can't write objectives because I don't think that way". Neither instructor commented on improved ability to facilitate active learning, but Prof. D said that he was improving in his ability to write problems and case studies.

Both instructors articulated project goals focused primarily on themselves, such as, to improve as a teacher, find better teaching methods, and learn what I find to be intriguing, and network or get together with people that share similar beliefs. Goal statements made in reference to students were limited (I want students to learn material well enough to do well on boards, learn 50% of the material in the course) and in Prof. D's case, depreciative (get students involved rather than sitting like vegetable waiting for nutrients). While Prof. B clearly did not value mistakes as opportunities for learning, Prof. D did not mention mistakes. Toward the end of the project, Prof. B expressed two new goals. Although still limited in nature, the goals were focused on students. She wanted students to construct their own knowledge base, and she wanted some of the course content to be more understandable to students when they finished the class.

Attributions

Interpretations of success events were internal/external, unstable, and uncontrollable. Both Prof. B and D's statements related to success were focused on self. For example, he explained that he was able to go into more detail in class because student were good at understanding a particular mechanism—however, he made it clear that they were not always able to understand.

Interpretations of failure events were consistently focused on self (rather than the students) and indicated maladaptive patterns of attribution. For example, both Prof.'s B and D indicated that because of the, "under preparedness of students" an approach other than lecture had to be used to reach them.

Statements throughout the project indicated that Prof. B prioritized comfort and control over risk taking (interaction with students). Although she had great difficulty articulating her thoughts, it seemed she had concluded that introducing an interactive component into her teaching required her engage personally with students and the communication was not worth the personal discomfort. Further, when asked about how she prioritized her roles in the classroom, without hesitation she said: "I want to be able to keep it more tightly scripted so that I can feel more in control. Sometimes that is more important to me than knowing what student know or don't know."

Given the research-based attribution-affect link, Prof. B's frequent expression of gratefulness following a marginal success (rather than pride in success accomplished by self) reflect a feeling of being out of control of what went on in her classroom environment. For example: "Nothing I've tried has been a phenomenal success this semester…but I am glad that it went as well as it did".

Prof. B's surface processing and interpretation of student feedback did not suggest cognitive engagement. For example, when meeting with student resistance or negativity, she labeled her efforts as "defective" and disengaged, rather than using the students' cues to consider a change in strategy or alternate interpretation of the situation. Presumably, due in part to her situational attribution style (external, stable, uncontrollable), a response was not considered since the situation was stable and she had no control. Similarly, when challenged to consider that a students' motive was not to challenge her authority, rather to seek help for a topic that wasn't addressed by the textbook, Prof. B firmly responded that the student had deliberately come to office hours to attack her authority.

CHAPTER 6

Conclusions and Recommendations for Future Research

SUMMARY

This study was designed to address the issues of reform of undergraduate science teaching that are called for by *The College Pathways to the Science Education Standards* (National Science Teachers Association, 2001) which envision that science will be taught according to four guiding principles, paraphrased as follows: science is for all students; students learn best by active participation in the learning process; education should reflect the way that science is done; and improving science education requires a systemic and coordinated effort of many stakeholders (e.g., teachers, supervisors, local communities, administrative personnel, policymakers, assessment specialists, curriculum developers, science educators) to change the complex educational system. These principles have at least two important implications for how college science instructors teach their courses. First, science instructors must ground their practice in constructivist learning theory, and second, they must design engaging learning experiences that encourage student thinking about and working with scientifically oriented questions.

Given that the call for reform of undergraduate science teaching issued by the *Standards* is now over a decade old, this study was the result of the felt need to respond to problematic issues thought to be impeding change at the college level. Specifically, these issues include a lack of consensus on how to define "active learning" in college classrooms; the unexplored impact that traditional scientific training and little or no formal teacher education has on science instructors' ability to interpret and implement constructivist-based instructional strategies; and, unexplored instructor conceptions about teaching and learning within the framework of a classroom-situated, conceptual change faculty development. program.

To address the principles explicated by the *Standards*, the study was designed to document the longitudinal experiences of seven volunteer Anatomy & Physiology instructors from diverse types of institutions as they implemented active learning in their classrooms. The research questions were: When college A & P instructors commit to using active learning in their classrooms, what kinds of experiences do they have? How, if at all, do their beliefs about teaching and learning change as they implement active learning? What, if any, supports or obstacles do instructors encounter as they implement strategies to facilitate active learning? If they encounter problematic classroom situations, how do they respond and how do their responses influence decisions regarding future use of active learning in their classroom?

Conceptual change and social cognitive motivation theory provided guidance for the 15-month project. The first phase was a five-month acclimation and baseline data collection period. Phase two, was a semester during which instructors were supported with a classroom-situated, professional development framework that included goal setting, planning and doing a minimum of two activities followed by formative assessment, and reflecting on classroom experiences (phase three). Data for the project included verbatim transcripts from emergent and semi-structured interviews, observation field notes, surveys, journals and written correspondence, instructional materials, and student attitude and content understanding surveys.

CONCLUSIONS

A number of findings emerged from the study. First, data indicated that instructors struggled with a lack of instructional, pedagogical and clinical content knowledge, student resistance, personal and professional risk-taking issues, and widely shifting attitudes toward active learning. These findings suggest important design elements for faculty learning opportunities. Understanding that six out of seven instructors in this study chose to design their own activities tailored to their own classrooms, there is a need for workshops that address creative and pedagogical elements of activity design. Creative elements might include using clinical cases, newspaper or magazine articles, experimental graphs, and classic experiments as the basis for classroom activities. Understanding that all seven instructors in this study continued to comment and question throughout the study, "I'm not sure if students will actually learn the material when I teach it this way… How will I be able to tell?" and five of the seven instructors struggled with issues related to grading, there is also a need for workshops that address the coupled use of classroom activities and formative assessment, and provide the rationale and skills training for the creation of teaching systems with aligned learning goals, instructional strategies, and assessment components. Further, workshops that promote the use of instructional strategies to facilitate student engagement in learning should represent active learning as a system that can be gradually introduced if attention is given to constructive alignment, rather than as an "add-on" to "get students active". Understanding that all but two instructors struggled with the issue of student resistance, there is also a need for workshops that redefine student resistance as negative motivation (Ames & Ames, 1990). Faculty need to be assisted in understanding the rationale for promoting learning contexts focused on mastery orientation goals and high task value and be provided with opportunities to explore strategies for promoting maintenance and building of student self efficacy and autonomy so that the responsibility for learning can be successfully transferred to students. Further, understanding that student resistance is in part due to a feeling by students that they may not be successful in an active learning course (because they have little experience with the instructional format and are therefore out of their comfort zone), there is a need for workshops that provide opportunities for instructors to explore the importance and methods for communicating and structuring courses on a foundational set of realistic learning objectives.

Data also suggested a developmental progression in beliefs about teaching and learning as instructors implemented active learning, and the progression shared similarities with reports of preservice teacher development documented in the learning-to-teach literature. Initially, instructors' beliefs shifted from knowledge transmission and intuitive theories to constructivist theories; however there was marked variation in the intelligibility, status, and endurance of the new beliefs in each of the seven instructors. Kane, Sandretto, & Heath (2002) recently commented that although it is reasonable to expect that findings from research on preservice teachers' beliefs may have relevance for post-secondary instructors, researchers have not taken advantage of the consensual findings, including:

- Preservice teachers enter their training programs with preexisting beliefs based on their own school experiences and through the "apprenticeship of observation";
- Preservice teachers' beliefs are robust and resistant to change;
- The belief systems of preservice teachers act as filters of new knowledge, making way for new knowledge which is compatible and blocking that which is deemed incompatible with current beliefs; and finally,
- Preservice teachers' beliefs are largely tacit, intuitive, and difficult to articulate.

In their critical literature review on the teaching beliefs and practices of university academics, Kane et al. (2002) found that less than half of the studies conducted at the post-secondary level referenced findings on primary or secondary teacher beliefs. The omission has also been noted by Entwistle & Walker (2000) and Entwistle, Skinner, Entwistle, & Orr (2000), the former commenting that while "teaching in higher education is bound to have distinctive characteristics, it also has elements in common with more general ways of describing teaching.

Consequently, we can draw on research on school teaching" (p. 343, as sited in Kane et al., 2002).

Documentation of the apparent developmental progression of college instructors' beliefs about teaching and learning suggests important design elements for faculty learning opportunities. Certainly, faculty development staff need to be aware that instructors may hold concurrent and conflicting beliefs and that newly adopted constructivist beliefs are likely to gain status when workshop discussions are theoretical rather than grounded in the context of actual classroom practice. As a result, faculty development staff need to encourage instructors to talk specifically about what they do in the classroom and what their students do in order to get a clear representation of the instructors' belief system. Further, in order to flush out the extent to which instructors find constructivist terminology intelligible, faculty development staff need to encourage instructors to elaborate beyond statements that are limited to generalized statements. Recall that when Prof. D stated, "I create a syllabus that is a contract with the student", he went on to explain, "It contains the course outcome…and the course outcome tells students, 'When I am done with you, if you have done what I told you to do, you will have this set of skills.'" Clearly, the elaborated rationale for the use of a syllabus is inconsistent with the seemingly constructivist nature of the initial response. Recall also that when Prof. D explained that he routinely had students pause or take a short break in the middle of class to reflect and compare notes, he elaborated that, "I tell them that this is a good time to identify their misconceptions….", as if misconceptions could be easily self-identified. As a final example of the misleading nature of generalized statements, Prof. D commented that his teaching method related teaching, learning, and grading, but then elaborated that his method, "increases students' likelihood of getting a better grade, thereby increasing their ability to retain the material."

Understanding the potential for a developmental progression in instructors' beliefs about teaching and learning provides a strong rationale for faculty development opportunities that challenge intuitive and often dualistic ways of thinking. Perry's developmental scheme (1968) may have important implications for ways in which faculty might be supported to move beyond a dualistic way of thinking about teaching and learning toward more complex phases of multiplicity and relativism. For example, workshops that present conflicting, alternative, or paradoxical points of view (e.g., How do people learn? What is student-centered learning? What must a lifelong learner be able to do? What does it mean for students to take responsibility for learning?) and encourage faculty to find truth in more than one view may challenge dualistic thinking. Alternatively, extended duration workshops that allow faculty to design, administer and interpret student attitude surveys may challenge instructors to reconsider long-held beliefs about students as well as beliefs about teaching and learning.

Data from the study also allowed identification of two distinct conceptual change experiences. Analysis of instructor beliefs within and between the change groups strongly suggested that causal attribution constructs either facilitated or precluded belief development, conceptual change, and a more encompassing and sophisticated definition of active learning, and supported the emergence of an Attribution-Based Conceptual Change Schematic. Although this finding is generally supported by the "hot" conceptual change theory (Pintrich et al., 1993), it stands in contrast to a more recent argument that conceptual change is most likely to be facilitated by three adaptive motivational beliefs including: adoption of mastery goals for learning and understanding; high levels of personal interest, utility and value of content learning focused on student cognition and motivation; and high personal self efficacy and control for learning and understanding cognition and motivation content learning (Patrick and Pintrich, 2001, p. 137). Somewhat curiously, these authors fail to describe the theoretical implications of adaptive attributional styles in facilitating conceptual change or maladaptive attributional styles in precluding conceptual change.

The findings related to conceptual change have important implications for the design of faculty development learning opportunities. First, as suggested by the Attribution-Based Conceptual Change Schematic, an important point of faculty development intervention may be attribution retraining (e.g. Dweck, 1975; Forersterling, 1985). Although not anticipated to be a trivial task given the tenacity of ontological beliefs, attribution retraining represents a potential means of developmental progression toward a reflective stance in classroom teaching.

Second, with an understanding that the process of conceptual change coincides with a reflective approach to classroom teaching, there is a need for extended duration workshops that support science faculty as they develop their own systematic, problem solving approach to classroom teaching. For example, workshops might provide opportunities for faculty to identify a problem in their classroom or generate a hypothesis about why student learning is constrained, design a method and tools for data collection, collect and interpret data, and modify their teaching practice in accordance with their findings.

The overall findings of this study have significant implications for both change-desiring instructors and faculty development staff. The findings allow faculty to familiarize themselves with the obstacles and response patterns that may shape their own change experiences and allow development staff to design empirically grounded learning opportunities that may facilitate the developmental progression of teaching and learning beliefs and promote faculty conceptual change.

RECOMMENDATIONS

As with most research, this study generates numerous opportunities for future research. Perhaps the most compelling are to evaluate the efficacy of the Attribution-Based Conceptual Change Schematic with larger numbers of A & P instructors and other science faculty to explore validity and identify change mechanisms not yet explored. There is also a specific need to explore the potential for attribution retraining for movement from the non-reflective teaching approach to the reflective approach and a need to develop and validate a context-specific survey containing hypothetical success/failure situations that can be used to assess instructors' causal attributions.

Using the change schematic to design curriculum to support topic-based (active learning in undergraduate classrooms) faculty learning communities is also intriguing. Cox (2002) defines a faculty learning community as a, "cross-disciplinary faculty group of five or more members engaging in an active, collaborative, yearlong program with a curriculum about enhancing teaching and learning and with frequent seminars and activities that provide learning, development, interdisciplinarity, the scholarship of teaching and learning, and community building". Based on the findings of this study, faculty learning communities that engage instructors and graduate teaching assistants, or instructors and departmental chairpersons might be especially beneficial.

On a final note, one needs only to glance over the *Teaching Standards* (College Pathways to the Science Education Standards; 2001, p. 2-24) to surmise that the need for continued and collaborative research is considerable. If science instructors are to design and provide experiences for student active learning in their college-level courses the *Teaching Standards* posit that instructors will be required to:

- Plan an inquiry-based science program supported by long and short-term content and inquiry learning goals and pro-actively consider the logistics of inquiry teaching (Standard A);
- Guide inquiry learning as an interactive facilitator while, "recognizing the worth of all students and by communicating with

them on a level that challenges their thinking and piques their curiosity"… "weaving content and inquiry skills"…" "modeling the kinds of thinking students are expected to exhibit" and "encouraging students to accept and share responsibility for their own learning" (Standard B, p. 5-6);

- Link assessing, learning, and teaching by identifying and building on students' prior knowledge and experiences, evaluating their conceptual understanding, and measuring the extent to which students meet course content and inquiry learning goals (Standard C);
- Design and manage the learning environment by managing start-up logistical difficulties (group work, time, space, and resource management issues) and creating a flexible and safe working environment that supports science inquiry (Standard D);
- Build learning communities that emphasize diversity and build respect among individuals by helping all students identify and develop their unique strengths as well as by helping them to identify weaknesses and work to overcome them (Standard E); and
- Participate in science program development by striving to understand and apply the conceptual basis of national, state, and local science reform initiatives by connecting science concepts to relevant and real world issues, assessing the needs of changing student populations, collaborating and networking with other

> colleges, departments, school systems, informal science centers and businesses, and fostering a vision of science that stresses habits of mind consistent with positive scientific perspectives and attitudes (Standard F).

Weimer (1990) suggests a metaphor to characterize the approach that many faculty take as they go about making instructional improvements. An extension of this metaphor to faculty development staff seems appropriate if the *Standards* vision for reform of undergraduate science education is to be realized. Weimer contends that,

> faculty do instructional improvement a bit like children play Pin the Tail on the Donkey. They get a new idea and become convinced that it is worth trying right away. They take this instructional tail and blindly attach it to whatever is happening in class tomorrow. Although the results may not be quite as humorous as the game, the chances of getting the new instructional tail positioned where it fits and functions effectively are not very good.

Just as faculty who are learning about pedagogy and the content of educational psychology may assume a non-reflective stance toward improvement of their teaching, so may faculty development staff working with science instructors assume a non-reflective stance toward development of faculty learning opportunities for promoting conceptual change. Weimer cautions that the "piecemeal addition of new techniques does not transform teaching" (2002, p. 185). It is reasonable to similarly conclude that, the piecemeal addition of new techniques will not transform faculty development. The challenge must be to create faculty development systems. data indicated that instructors struggled with a lack of instructional, pedagogical and clinical content knowledge, student resistance, personal and professional risk-taking issues, and shifting attitudes as they began to introduce active learning into their classrooms. Analysis of second and third-phase data differentiated two distinct conceptual change groups, with three of the seven instructors providing strong evidence of conceptual change. Instructor experiences, motivational profiles, and beliefs about teaching and learning within and between the conceptual change groups revealed that the conceptual change profiles were differentiated by failure attribution constructs and supported the development of a classroom-situated schematic (Attribution-Based Conceptual Change Schematic). The research findings and structure of the empirically grounded change model have significant implications for both change-desiring instructors and professional development staff. The findings allow interested faculty to learn how colleagues have gone about introducing active learning into their classrooms and to become familiar with the nature of the critical issues and response patterns that may shape their own change experiences. The findings also allow professional development staff to anticipate the range of baseline conceptions and teaching language of science faculty and thereby design learning opportunities that are structured on the epistemological foundation of constructivist learning theory, highlight particular elements that might usefully form the components of an effective faculty learning program, and influence the route of change toward conceptions that are compatible with a problem solving approach to classroom teaching and development of an active learning instructional system.

APPENDIX A

Human Subject and Participants Consent

CONSENT FORM

The Nature of College Anatomy & Physiology Instructors' Experience as they Introduce Instructional Strategies to Promote Active Learning into their Undergraduate Classrooms

By recommendation from a member of the Integrative Themes in Physiology (ITIP) Development Committee, you are invited to participate in an extension study of the nature of college instructors' experiences as they introduce active learning into their classrooms. ITIP is a NSF-sponsored cooperative project of the Human Anatomy and Physiology Society (HAPS) and the American Physiology Society (APS).

My name is Patti Thorn and I am a doctoral student working under the direction of Dr. James P. Barufaldi (Science Education Committee Chair) and Dr. Dee U. Silverthorn (ITIP Principle Investigator: Department of Zoology, The Univ. Texas at Austin). Through this study, which involves approximately 10 instructors at colleges across the nation, we hope to gather data about the processes that faculty go through when changing from a traditional instructor-centered classroom to one which focuses on student learning.
This particular study, is an extension of the project that you consented to participate in roughly a year and a half ago. The study, to be conducted as a doctoral dissertation study, will begin in January of 2002 and terminate in June 2002. The project will differ from the original study by including a set of focused professional development activities designed to extend instructors' understanding of student learning and improve effectiveness of active learning strategies in the classrooms. The professional development activities are based on data collected during the initial ITIP study.

If you choose to participate, you will be asked to design, implement, and collect student feedback on two active learning exercises that focus on the theme of gradients and conductance in your classroom, maintain an electronic journal of your classroom experiences, participate in a series of telephone interviews, and participate in a Web-based discussion forum. Telephone interviews will be audiotaped and transcribed; tapes will be destroyed following submission of the dissertation report. I would also like your consent to review your journal notes, student feedback, and teaching demonstration materials at the end of the term. Following journal review and interviewing, I will provide you with summaries by e-mail and request that you check and correct them. Since this is a dissertation project, timeliness is extremely important--I am planning a December defense and graduation date.

I will also ask that you administer two, short surveys to your students—as pre-and post-surveys at the beginning and end of the term. One survey requires students to respond to 25 statements, in a likert-scale format, regarding study strategies, instructional preferences and, beliefs about learning. The other survey requires students to respond to 25 content questions related to the theme of gradients and conductance. We have found that students are able to complete both surveys in less than 30 minutes. The goal of survey use is to learn about the study strategies, instructional preferences, and beliefs that anatomy and physiology students hold as well as whether or not students conceptual understanding of a common anatomy and physiology theme changes after a semester of instruction.

Due to the nature of the research topic, there are no known risks or discomforts that I can reasonably expect. On the positive side, I anticipate that it may be interesting for you to reflect upon your own beliefs about learning and teaching practices as well as to become familiar with those of other faculty through review of the research findings.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. Your attitudes will be reported under a pseudonym of your choosing, and will be reported only to Dr. Silverthorn.

Please decide if you would like to participate in this study. You are under no obligation to participate and your decision will not affect your future relations with HAPS, APS, or The University of Texas at Austin. Your signing of this form will be taken as evidence of your willingness to participate and your consent to having the information used for the purposes indicated. Should you choose to discontinue participation in this study, you may withdraw at any time after signing this form by contacting me by telephone or e-mail. Please retain one copy of the signed consent form.

If you have any questions, I would be happy to address them! Please contact me at (512) 347-1187/ PThorn@mail.utexas.edu or Dee Silverthorn at (512) 471-6560.

______________________________ ______________

Signature of Participant Date

______________________________ ______________

Signature of Investigator Date

APPENDIX B

Data Examples: Interview/Observation Transcripts, Correspondence

Class Session followed by Interview
Prof. C

Key

……	Normal pause in speaking
[ ]	Indicates action or observation
[**?]	Speakers voice is a statement, but rising tone suggests it's a question
[<<V]	Speakers voice level is too low to hear; no classroom noise
[^^^^ooooo]	Chairs squeaking and coughing, tape is not audible
[SQ]	Student question
[GW]	Group work
[SR]	Student Response

CLASS SESSION

C: So….by today you should have completed Chapter 5… and completed the workbook activities for Chapter 5. That includes quantitative problems, practice makes perfect problems…all of it. So by next week, by Tues….we'll be working on chapter 6, so do the workbook before you come to class.

Now also after the class today, I'm going to do a test of the class e-mail list…so if you don't get an e-mail…from that list by the weekend then you know you aren't on the class mail list and you need to get on it…so I didn't want to freak you out when I sent an email that said "test". So use that e-mail list to contact people in the class….that's what it's there for…if you've go a quick question or a problem you can just send off an e-mail to the whole class….and the TA's and I are on that list and we will answer the questions for you as well. You can use that list to get together with your study group…

I'm going to start with what we did last time….and then we are going to go on and talk about osmolarity and tonicity.

So we're going to talk about osmolarity and tonicity …an understanding of osmolarity and tonicity is essential to be able to properly use an intravenous fluid therapy in medicine. A solution that is approximately equal in concentration to body fluids in a normal human body is .9 percent sodium chloride [**?] that is normal saline….that is in your text…it's in the table….chapter 5. 0 .9 percent sodium chloride….normal saline….

So today the objectives for understanding are for you to understand osmosis….the movement of water…molarity….which is something that you should have learned in other classes….[^^^^^ooooo]….osmolarity….and tonicity….understand what those terms mean and how to use them in a quantitative way. Okay…

First we are going to have a demonstration. I made a calculation based on the chart in the book that talks about how much water is in a normal person's body…and…you know…people have been using students….actually for years….that's why the average, 70Kg, 21-year-old person ….is what is used.

So I need a volunteer and we are going to calculate body water. So I did it for myself based on the chart in the book and I figured I have about 29 point something something liters of water in me [goes and picks up to large plastic water storage containers and holds them in front of her body]. So this is about 30 L here…so this is about how much water content I have in my body. That's a lot. Right?

Okay, let's calculate our volunteer…she I chose a male because some females might lie about their weight….[laughing] . Goes through the calculation on the board in a "what do I do first?" kind of format with students responding.

You might want to figure out how much water content you have in your body…in fact, I thought about assigning that as homework exercises…but it will be optional. But if you can't do the problem we just did here….if you can't figure out for yourself….then there's something about the math that you aren't understanding…please let me help you….math is not something you're born with…math skills are not something you're born with…most of you are probably good at math because you've practiced it….if you can't do these conversions from Kg to Lbs and Lbs to Kg….all that…you just need practice…I'm glad to help you….I'll be your piano teacher…alright

Let's start with….oh…the point about knowing about the amount of water in your body….knowing the difference for different people….is that that dilutions of drugs…they act differently in people with different amounts of water in their body. I know this from my own research….when I anesthetize animals for surgery…the anesthesia acts very differently in animals that are obese [<<V] and figure out how much anesthesia you use…that's probably why in a hospital setting….they have people who are trained in anesthesia so you don't have to figure it out….they are the ones who are figuring out the calculations…and these days with so many obese people in the world…in the US I should say…not all over the world…[<<V]

Let's talk about molarity first then we'll move on to osmolarity. If you….let's see…on page 27…in your textbook it talks about molarity. [^^^^^^^oooooooo] [^^^^^^^^^oooooooo] [^^^^^^^^oooooo] [talking with TA's; trying to get them to find someone to get the computer system working] [^^^^^^^oooooooo] [class talking at moderate level]

Okay….so…I sent my Tas off….[^^^^^oooooo]…we gotta get a computer person to figure out why this thing is flashing….[<<V]…..okay….molarity….so…you should understand molarity. One mole of anything is 6.02 x 10^{23} ….molecules, right ? So if you have a one molar solution of anything…molarity refers to the number of moles per liter of water….so a one molar solution of anything ….has the same number of molecules….in that solution. So one mole has 6.02 molecules so 2 moles….a 2 molar solution has twice that number….sodium chloride….glucose….one molar are the same number of molecules. Um…so the weight of a mole though….is different depending on what the molecules is. The weight of the one mole is its' molecular weight…so let's say for example….glucose….[goes to the board and writes while talking] …$C_6H_{12}O_2$… There's a periodic table of the element in your book….I forget what page….it show's molecular weight….so one molar solution is the weight of this molecule…so it would be the molecular weight of carbon is twelve….so there are six of those….so that would be twelve times six….molecular weight of hydrogen is one….one times twelve…..the molecular weight of oxygen….anybody? ….[SR=16]….oh great everybody….16…..so you add these up so…..it's….comes out being….180….that's the molecular weight of glucose….so you would put 180 grams of glucose in a solution of water and bring it up to one liter and that would be a one molar solution.

So, osmolarity…when you put a molecule into water….into a fluid….some molecules break apart into pieces….like sodium chloride….sodium chloride breaks into two ions…a sodium ion and a chloride ion. So…there are two parts….osmolarity refers to the number of particles in the solution….not just the molarity…..but it's the molarity….[writing on the board] say you have a one molar solution times the number of particles….per unit volume….so then molarity is moles per liter….and that's the osmolarity…[<<V] um…this is important because the number of particles in a solution on one side of the membrane determines whether water will move in to that mem…move into that compartment or not….so this is a concentration….so this is the concentration of particles….and for molarity you add up the number of moles of everything in there…and for osmolarity you add up the number of osmoles….of everything in there. So if you have….in your….in your body you have potassium ions, urea, glucose, proteins….all of that…and you add up how many molecules of all

different types you have….then that's your molarity…if you add up all the different types you have of particles….that's osmolarity….so osmolarity is really more important…for ….[<<V] [SR<<V] [walks to board] Um….let's see…so you've got….you've got something that was one but it's broken up into two….this is the disassociation constant we'll say for sodium chloride….it went from…a one molar solution….is a two osmolar solution….because you have two particles of ….[SR<<V] per molecule….you're right. That would be the disassociation constant. I'm sorry….yeah…so…so how many particles for every molecule that it breaks up into? [<<V] okay so….so if you've got two solutions of different osmolarities….say you've got a membrane and you've got an 11 M solution on one side and an 11 M solution on the other side….then…isoosmotic…they're the same…there's isoosmotic….hyperosmotic….hypoosmotic….there are three precursors you need to know for osmolarity ….hypo…hyper….and iso….so iso is the same [^^^^^^oooooo] the solutions are equal. Hyper refers to a solution that has more particles….like hyperactive…like more….hypo….less….

[^^^^^^^^^^] hyper…to this….so any solutions you get you should be able to tell if they are hyper or isoosmotic….and if you are given the molarity….be sure you convert to osmolarity before you start. [SR<<V]

Okay let's talk about tonicity. Tonicity does not have units. It describes the way a cell behaves when put in a solution…[^^^^^^^^^^] So it depends not just on the relative osmolarities across a membrane but also on the properties of the molecules or the particles on each side of the membrane….and the property of importance is whether or not that molecule can penetrate the membrane or not. A penetrating molecule is one that can pass the membrane for example in biological systems urea, calcium ions, glucose…glucose is slow when it penetrates…[<<V] a non-penetrating particle cannot pass the membrane and some examples of that are sucrose, the sodium ion…the sodium ion can pass the membrane freely but it is kicked out so fast…as soon as it goes in…the sodium ion is functionally non-penetrating.

Okay…[<<V]…I have a demonstration that I'll show in a while….but let's pull out these handouts that you've got and [^^^^^^ooooo]. If you have a cell in a solution….and when that cell…you want to look at the osmolarity before the cell is in solution…[^^^^^]compare osmolarities….do it before in solution because the cell in solution will always go to equal concentrations [ooooooooo] so the osmolarity after equilibrium is always equal. And the way….that…um….this happens is either that ….the non-penetrating solutes move….cause they always move….I'm sorry penetrating….penetrating move across the membrane….going to equilibrium…they always do that. Water goes across the membrane and goes to equilibrium and creates equal concentrations...equal osmolarities.…on both

sides of the membrane. So, if you put a cell into a solution where to make the concentrations equal….water has to move in…then the cell will swell up…and that's what kind of….is it iso, hypo….? [SR <<V]….hypotonic…right….so that's hyponic….if the cell shrinks…if water has to move out then it's hypertonic…and if nothing happens [<<V]. So this is really important….especially in [this region].

Why is it important? So why do you think the fire department has a policy that firemen have to take water breaks at frequent intervals…..why? I know , they have a rule that they made for the fire department and the EMT…whenever the fire department people are going into a building….and they've got their full gear on…and they are fighting a fire….they are sweating like crazy….they are losing body fluids really fast…and they are going into a serious dehydration state. So turn to the person next to you and tell them what's happening when a fireman dehydrates…what's happening to the cells….and what's happening when he drinks water? [walking around through aisles talking to student pairs]

Okay….that should be pretty straightforward….so who is brave enough to take a gander? [SR] okay…perfect. Everybody got that? All right…I'll say it again….if you couldn't walk through the logic of this….please contact a classmate or me….

All right…so what's different when you drink Gatorade? Same thing happen? Talk to the person next to you.

Remember the formulation on Gatorade….it's got a lot of glucose……is glucose penetrating or nonpentrating? What's gonna happen?

Whose got an explanation? [SR] All right so it's penetrating…..goes into the stomach….[<<V]…. [SR] Okay…what about potassium? The concentration of it is very high of Gatorade….even though there are things penetrating….it's slow….so water moves fast…and this is an example where….the tonicity was correct but they didn't account for what happens immediately. The water floods into the stomach, robs the cells of water, and then the solutes move across…the glucose and the potassium ions move across into the cell….and then the water follows back out…and then you get hydrated….[oooooooo]

[SR<<V] ….yes, yes…so the rule is always water. Water is the safest thing [<<V]. There are people who drink 16 glasses of water a day…and they make themselves [computer system goes on with it's three-second orchestra type blaring sound] [Repair person says, sorry] [class laughter].

[^^^^ooooo]Okay….let's work on some problems here. So tonicity is [^^^^^^]. In your text book you have some rules...these are the same rules basically that I just gave you. Rule one- you're always going to compare osmolarity of a cell in solution before they are put together since at equilibrium the osmolarity will be the same.

So let's try example number one and I'll show you how we're doing this…..what we have is a red blood cell…the cell….just your standard cell is 300 mOsM….and in each of these examples we are always going to use the same cell…we're going to assume that everything inside the cell is nonpenetrating and then the solution is 200mOsM so….what is this solution?
What is the osmolarity compared to the cell? [SR] Hypo….right? Okay….Now you put the cell into the solution.
Will solute move into or out of the cell? This is sodium chloride…it's what? [SR] nonpenetrating…we're assuming everything inside the cell is nonpenetrating…so will these solutes move? [SR} No why?. Because the sodium chloride can't move into the cells….so it doesn't go anywhere…but…the osmolarities are different so what moves?….water…..which way does the water move? [SR<<,V]

Oh good…good…we have a debate….into the cell or out of the cell? So the concentration is higher inside the cell than outside the cell….of particles…[^^^^^] so which…so the water has to move to dilute to create equal osmolarities so the volume of water here needs to increase…water moves in…and this will then become [ooooooo] you go to equal osmolarity, 250 inside, 250 outside and to accomplish that….because none of the particles can move….to change the concentration….then water moves…water moves inside the cell….into the cell…and the cells swell.

So…the red blood cell is pretty standard for looking at tonicity…this is just a little demo that shows a red blood cell, put it into distilled water, and the water has to flood into the cell…and in fact…it can't reach….it doesn't reach equilibrium…before that cell gets so swollen that it breaks apart.

[computer simulation of cell taking on water and bursting, runs the simulation 4 times]

That's not happening in your gut…because you've got stuff in your gut…so when you drink pure water….your digestive cells are not exploding all the time. [<<V]

This does happen, you get little particles of red blood cells in plasma and they are called ghosts [^^^^^] You can give an IV solution of pure water….you ever do that [question is addressed to the TA who is an RN] [TA No….] I can't think of a reason why you would ever give pure water….cause you'd always want to put something in it…..[SR<<V] ….yeah….d5 which is [<<V] [ooooo] ….there are solutions given in the textbook….you have normal saline….0.9% sodium chloride…..[<<V] glucose….

Alright, that was example number 1….so the tonicity of the solution is determined by the [^^^^^oooooooo] equilibrium so it swells….hypotonic…if you work this out you'll find that there is not…there's not hypoosmotic solution that you could prepare for a cell and have it be anything other than hypertonic…it just always works out that way because water will always move in even if these were penetrating….then they went to equilibrium then you would still get water moving in…[oooooooo] then the glucose would go along its own concentration gradient and you would end up with 100 of glucose outside…………and 300….and these are all nonpenetrating……plus 100 inside……………..but then the water the water would have to go in even more to dilute this back to getting….the amount of fluid in this would drop enough to get this back down to….and get this back….350 [<<V] [oooooooooo]. So hypoosmotic is hypotonic….but when you talk about…….yes? [SQ But if you have penetrating inside the cell….<<V]]

Well…you can set that up….um….[goes to write and draw on the blackboard] there's…………………………say that………………let's try this and see what happens………………let's say this has …………..[oooooooooo] so it has…………………………100 osmolar nonpenetrating, 200 osmolar penetrating…total osmolarity is 300 ….but most of everything in there is penetrating….and then….let's go again….200…we'll start with this being non penetrating…..[^^^^^^^]….okay…..so…..this is still hypoosmotic….200 penetrating that goes so that you have….100 inside….100 outside….right?….and then….okay so this has gone to 200….it went from 300 ….it's now 200…it's now [ooooooo] and this one went from 200 to 300 total. Is that right? And then….right….so this is a greater concentration so…..water is moving out….to make that 250…..so look at the rules [^^^^^^^^]textbook. Because in this case we are always referring to a cell that has 300 omoles….look at your textbook….what does that say about….hypoosmotic and hypotonic? [^^^^^^^^^^^] …………….[ooooooooooo]Anybody? There is a table….that has rules….on page 139……tonicity….[ooooooooooooo^^^^^^^^^^^^]…..[oooooooooo]…………… ………………………………………………okay so number four, a solution that is hypotonic….to a cell will always be hypotonic no matter what the nature of the solutes in a solution….yeah….that must be the exception….[<<V]   They're talking about a human cell that will always be….that's what all these examples

have…..[^^^^^^^^^^^] yeah, I'm trying to think of any example….somebody….yeah….water will move out but the cell….[<<V}….yeah….that's not happening….so you can keep those rules….so the isoosmotic and hyperosmotic solutions….luckily that's why all my examples here have….are dealing with a cell that has set nonpentrating….[<<V] …set at 300….not really set….people come in and have 340….[<<V]

Okay, let's go onto example 2. You guys go ahead and get into groups and went on examples 2, 3, and 4….and then we'll go through them as a class.

About 10 minutes working time given. [GW]

Then groups volunteered to go to the board, one person writing, one explaining how they responded to each problem.

Interview Transcript

C: The role playing exercise…. I'm going to have to write all this down but…. That was an example of afterwards…I felt good about how it happened but I thought I missed on content…that was just a fun thing for students to do…and they didn't get as much out of it as they could of…. I mean it just wasn't as hard…. It was something that middle school students could have done…. And I realized I could have made the activity better by having…. By just modifying it just a little bit….so next time I do it….I would actually do the same exercise….but I have less scripting….believe it or not of the students and the audience…to have them asking the questions…what I did was I passed out questions…one of my objectives was to get the students to start opening their mouths….and asking questions…so I'm basically forcing them to but what I did was I had certain students asking questions and then the rest of them didn't….and I could have done things to get them asking questions….or I could have made it so that everybody in the class was participating….not just asking questions but forming their own membranes….and then have the questions go around the room to different membranes…and that would have been even less structure. Which would have been scary for me…walking in the classroom…a little bit….having less structure but now I realize….oh yeah that would have been actually a more learning exercise and then all the students would have had to figure out how do we do this….but they enjoyed it…they've been saying to me already…."Oh, we love your class" and that makes you feel so good….that was of course before they got their pop quiz [laughing]….it may have changed a little bit…but I had to make them get a little more serious…but I think they are enjoying it…my profound statement is going to be that this is somewhat like a marriage…like when something goes wrong or doesn't go the way you expected it to, you have to just say, "Well now….this is what I am going to do…we're together." And I expect for things occasionally to happen that are not exactly what I thought would be ideal….and that's okay….that's just the way things happen…..instead of going, "Oh my gosh! I can't believe my students didn't like this!"

Me: Okay…then if you were to make a statement, you would say that teaching undergraduate science is like a marriage?

C: [Laughing] Well no….I would say that trying to incorporate active learning in the classroom…that kind of a commitment is like commitment in a marriage where you have to be committed to it….you have to have faith that it will work or else….every time something happens…you get to nick pick it because you look for either the failures or looking for the successes….and you have faith that it is going to work…okay…this is profound [laughing] this is coming from someone who has never been married….and doesn't actually know….but from what I have read in theory….hypothetically….but really…people approach things in different ways….it's just whether you are an optimist or a pessimist about it. So far I've been an optimist and I've had moments of pessimism and I just keep shoving them aside….and so far I've been very pleasantly surprised with how well this works in two ways….one, to get the students enjoying the class…and really using the material in class and two, in uncovering the difficulties they are having. This is better than any teaching technique I've found so far…this is new for me….in the classroom before they leave…for me to find the problems that they are having….and address those….or address those the next day….somebody says…."Oh, I tried to do this in the classroom and I didn't….and….why did this go this way….?" And I think, "Ahhh, I forgot to tell them….why this goes this way…."

Me: So let's think about….

C: I know I am reading all of this too….that this is how it works but I'm experiencing this stuff now and going, "Ahhh, this is great! It really does work"

Me: So based on our talk last time when we had the tape recorder on….you may have had one conception about what a teacher should do….now you're a teacher and you are doing…do you think you've changed your conception of who you would be in the classroom? What did you go in thinking you would do? I remember you said that you wanted them to become facile with content material and you wanted them to learn problem solving.…but you didn't really talk about who you were in the classroom…you also said that you thought you had a dog trainer mentality.

C: Yeah [laughing]

Me: So, now that you have been in the classroom…what's your job in the classroom?

C: Oh...let's see….maybe it is a little more like a piano teacher….I mentioned that today….

Me: I heard that.

C: Because I want them to recognize that they can do this…but still like the dog trainer ….the dog trainer that just sounds terrible but….with dogs….you have to be positive and they have to enjoy the activities and they have to want to do it….and then you can't punish them when they do it the wrong way or they lose motivation to do it. You have to maintain a very positive attitude for just the motivation….and hmmm….how has it changed for me? I mean I still feel like practice makes perfect….for these guys…the same as the dog trainer….you work on an activity and you do it over and over again…and they get to see it in different contexts so that ummm…you know…so that they become comfortable with the different possibilities…and that's still what I am trying to do….is teaching them the rules…like this is what the notes, ABCDEFG on a sheet of music look like….these are rules…try to play this in a different way…and then eventually you will become competent enough that you can take any sheet of music and play it….because you are not just memorizing one piece of music….you're memorizing the rules that allow you to play it…so that's what I'm trying….that's what I see as my role given that practice….

Me: When I've taken piano lessons, the piano teacher waits for me to make an error…she has to before she can correct me….

C: Hmmm…

Me: Does that apply?

C: That's part of my role to basically watch them play the music and step in when I see that they are going on the wrong track or ask them what they thought.…or ask another student to make the judgment….using that technique….I like it….when a student responds….ask another student what they think….rather than just having it be me but I realize that now the students are seeing that when they say something incorrect then I'll turn to another student…"What do you think"…so I need to break that pattern of only calling on another student when the first student was incorrect….[laughing]…I have broken that….I did that today….I asked the whole class…."what do you think of that?" when it was a correct answer….but what was your question….oh yeah….it was….yeah…I can't be at every place in the classroom so some of the feedback has to come from their groups….I go to a handful of groups…so that's why I go from me walking around to them working in groups….to doing it in front of the classroom….so that when they are having trouble letting the groups talk about it…that worked real well today…

Me: There are some qualitative researchers that say we don't really understand concepts until we are able to put words with them….and having to talk about them…it's really interesting what emerges….I was working with a young man today who started off trying to apply the simple rule, "water follows"….but he ended up confusing himself as he thought about cells and the solvents they were in….he shared how he'd always thought about the exterior fluid sloshing into the cell….and kept using the "water follows"…but then decided that the way of thinking was not helping him think about the reality of the cell environment and he was modifying what he thought….very interesting to listen to him merge information and sort through it again.

C: I've heard that theory before that you can't have a thought or concept until you have a language or words for it….I've always thought well, what about babies…is it really true that you can't think about something until you have words for it…..you fantasize about something even if you have no descriptors for it….if you sit and try…and I think you can….

Me: With images?

C: Just with images…but you naturally put words with it. I don't know….probably that's a constraint of adulthood…or of language formation. Once language….once you have language then you use that…but before that you probably can do that ….I don't know….

Me: So like innate behavior may be something that happens without language…

C: I think dogs form concepts….dogs can be taught how to play hide and seek….and then they can go off and play hide and seek on their own…people have said that animals don't form concepts but I think they do….my random musings….

Me: So….then overall, what's the experience been like? You say it's been…..

C: It's been positive but it hasn't always been successful…but even when it's been unsuccessful or I didn't feel like I accomplished what I wanted it to….I've realized later that it did…because it pointed out to me…the areas that I missed…or where I didn't get information across for the students to understand. And I wouldn't have gotten that just by lecturing….so

Me: And what will you do in response to not feeling like you got information across to students?

C: Uh….I've been modifying the exer….w3ell what have I done?

Me: Is it internal or have the reflections prompted you to do something different?

C: Oh yeah! It changes what I do in the classroom cuz like if I set up one kind of exercise and it doesn't quite do what….you know it may accomplish some goals….but if it misses a goal that I thought it might meet….then I think about how would I change that….what would I do….and then….yeah….I change another activity….for example, having other….having students go up to the front of the classroom and having students in the class ask them questions. Open-ended questions where I am not telling them what to do…or how to do it….I'm more comfortable with that…I just….I wouldn't have thought about it without having tried to script it and then realizing that what I did was made everybody else stop thinking about possible questions and now I'm less likely to try to script questions from the audience for the students. I mean I did meet one goal….I got students asking questions….even if I had to hand the questions to them and say here…ask this question….which is what I did to start with….that was really my goal…but then I though…."Ah I see what happens"….what other thing? [talking to herself and thinking]…..Yeah I've given them some activities like in discussion…which I think were maybe too open….the problem has been when I have given them something to do and I didn't have an idea of what specific objectives I wanted out of it…and then I wasn't sure if it accomplished anything…because I didn't know what to really check…I mean I went in to it thinking I had an objective….but ………or with one of em you know….like in discussion….it worked okay….I asked them to design an experiment to test an idea and you know one objective I had was for them to design an experiment and then see what conflicts they hit when designing an experiment…also dealing with molecular weight and diffusion….do they understand molecular weight do they understand diffusion…um….but I probably could have come up with a better example.

Me: But I heard you telling Valerie that everybody came up with something different….

C: Right….right…so …it was….it worked really well to get the students actively thinking about how to design an experiment…the only thing lacking was….and it revealed somewhat where they were missing in background in chemistry….because I had a student come up later who said…"you know I didn't know how to do this at all because I didn't even know what molecular weight meant…." And so it revealed to the students more than me where they were lacking in thought. Um….so I did want to look at their chemistry background and what they understood about diffusion….but I think I could have come up with a better example for them that more fit the content of what I wanted them to learn at the moment…because that was a little behind where we were. We were already past diffusion…and I had already done it…that nice exercise where I had them derive the equation from Fick's law…how the equation would change if you were talking about facilitated diffusion….across the membrane. I thought that went really well.

Me: I did too.

C: Yeah….I did….that went really well. That was a nice example….but then when I went and did the other….I could have had the problem be more relevant to the current kind of material that we were covering at the moment that drew out something…drew out more about…I felt that I was taking them backwards to stuff that they should already know….I could have taken them a little forward. Give information….I don't mean information that we haven't covered yet…but I mean….concepts that were new to them that they hadn't yet worked with….I felt like….yeah they needed to learn about diffusion but during that exercise I could have given them more practice with things that they were poor at….it revealed where they didn't have the knowledge should have had before the class…but it could have given them more practice with things that they had not yet done. That was all.

Me: What do you predict…..when you are asking them to do things….like go to the board in a large lecture….or share their opinions…or when maybe you share that you'd like to reevaluate something you said in a previous lecture because it wasn't accurate…what do you think is going on with them?

C: In all those different circumstances?

Me: Yeah…Is there like….can you describe what their experience might be?

C: Well, I think when there is an opportunity for them to talk to each other or to talk in front of the class…they're thinking about how they would say it….but when I have students going up to the front of the classroom…even the students that are out in the classroom that were not the people that got brought up….if they don't know that they aren't next….they are sitting there thinking about how they would answer that….questions…or what they would do if they were the one in front of the classroom…I think that they would naturally do that….and get more prepared in the future to do what they see their classmates doing. I am going to try to get everybody up talking tot he class sometime. But when they are talking to each other….it depends on their personalities….I mean most of them are…some of them are….most of them are talking but some are listening and they are substituting their peers….they are not thinking how they would describe it….they are just listening to what their peers say the answer is….and that's okay….as long as we give them enough opportunity so that at some point maybe they are the ones that know the answer or at least maybe….if they sat there and just listened…I think with most students….that would bother them over time….if they were always the passive listener…unless that's their personality anyway….I think eventually they are going to be the one who has the voice….I've experienced that because when I was in groups….I was typically too quiet and I knew the answer but I didn't say anything….and it would always bug me later…you know, I'd think,"Gosh, I wish I would have said …" so I think that one thing is that I think students….the ones that are thinking about….after they hear the answer they go…."Oh yeah….I could have done that…I knew that….I knew the answer." They do want to be…a lot of them are going to want to display that….at some time. If they didn't know the answer then they are going to be glad that they weren't the one talking….but if they did know the answer then so….but ….um….they are trying to work problems….when they are listening to me….I think….they are mostly….I see them taking notes…they may or may not go back to it later and try to understand what I said….but when I'm correcting mistakes that I made…conceptual misrepresentations that I gave them…then….then they will go back and re-evaluate what they heard….they'll go "Oh why was that wrong?" I'm not going to use that as a teaching technique [laughing]…giving them erroneous information.

Me: I wonder if maybe part of what happens for the students is they are starting to think….."okay she's not going to stand up there and be the authority". And then you identify a spot in the lecture that caused confusion and you go back and go over it and they are going…"Hmmmm." And then today I observed when you had the girl go to the board and she wrote solute instead of solvent….and you know the class….when you wrote moles and it should have been particles…and they are very critical….but when their classmate made the same kind of error….they start to understand what it's like to be in the role of the teacher….it's like they have this belief system…and it is starting to get mushy on them….

C: Um hmmm

Me: One of the girls behind me that asked about if you had penetrating solutes inside the cell…what would happen…and

C: That was great..

Me: But no matter how you responded I doubt that she was hearing what you were saying because she was getting angry with everything….this class isn't going the way she wants it to….I wonder if students are starting to get to the point where they are starting to have to reexamine who they are….who you are….and it is a really funny transition period.

C: Yeah….I'm risking a lot because they may end of hating me…because I am a small female…because I am traditionally what students end up disrespecting…and thinking, "Oh…she doesn't know what she is doing." And there are already some that are going to take these few examples and where I have said something that didn't make sense or said something incorrectly….or put something on the board and it was wrong…and they're saying…"this class sucks because our teacher sucks". And they're going to….but right now I am just going to have to live with that….I gotta admit, it bothered me just a little bit…because I don't want to lose them…because they lose motivation because they think that they are getting this information and I'm not going to give them what they need for this class and they need this information and they need it to be correct….and ummm…but it's inducing them to be critical of me and they speak up about it….and they correct me…I'm fine with that…I'm not super happy about making mistakes…but …I'm the teacher….I don't know all this stuff….and I also….I've been in research for a long time….so I tend to think through things and I don't always have it memorized what the sequence is…..like in a particular cell….I think it through and hypothesize as I'm going so if I get a questions….like with that glucose question I was thinking it through….and that's fine….but I gave them this information because I didn't think of all the parts correctly….and you know…yeah…they caught me on it and I caught myself on it…and that's okay….I don't know…I don't know what is going to happen to the students that end of thinking…."Ahhh, she can't do anything…." I don't know….If they think that….you know I mean…hopefully they are getting comfortable with working on their own…and working with their peers and getting the information that way…. So they are not dependent on me and they don't feel dependent on me….and….you're prompting me…..

Me:[I was shaking my head yes….] No but I mean that is really an important change that you are asking them to make….and I wonder if it might be good to be explicit about it. You're taking them from…science is a set of facts that we memorize and use to predict situations….blah…blah….to science is a process of understanding and working it through….and working it out and considering alternatives….you know it's a different epistemology…that you are asking from them…..

C: I don't see that as exclusive…I can see it both ways…but I guess I see what you are saying. That's the thing with physiology….it's so active….I'm giving them a couple of examples….they are giving themselves a couple of examples and then you can go from there and there are so many different possibilities….

Me: Yeah…

C: Hmmm…so what kind of thing….what would I say to them….I mean I don't want to stand up there and say….I mean I did say…."Thank you for catching that…" I reward them verbally for catching my mistakes…and oh yeah….I also work it through in front of them….because I just didn't go…."No. No." When the….well the thing with the particles per unit volume…which I knew was wrong when I put it up there [on the board, the denominator was incorrect] but….it's okay…yeah….I talked it through….I said, "this is this way….yeah right….that's particles." And then, the one with the penetrating solvents and the cell…I hadn't even….I had completely forgotten about that assumption….about everything in the cell is nonpenetraing…and so that was great….but for me to remember that I had to work it through and I did that….and I'm fine with that….but if it makes students angry that I am working through it in class….

Me: But being angry might be a way not to take responsibility for your own learning….if you can blame it on someone else…

C: I meant to go over and specifically thank her ….and say that was good….I think I did say, "Oh yeah….that's good"

Me: I was meeting with Marilla….do you know her….?

C: Yes…

Me: And she said that she's wondering that teaching active learning is like medicine. You know when we have a patient that broke their leg….the doctor tells you….well since you broke your leg it is going to be really uncomfortable but in two weeks time….you'll be able to put a little more weight on it….but we walk them through…what's happening….I wonder if….Marilla's idea was….what if we were to tell students ….just briefly…."So by now you may be feeling a little uncomfortable….I'm doing what a traditional instructor does….I'm not giving you closure….I'm suggesting that there are alternative ways to think about situations….you may be starting to feel like I don't have all the answers….that's natural…."but to tell them this is part of the switch from traditional learning to active learning.

C: Yeah….maybe that's a good idea….I could go back to my piano teacher analogy…with them…say that…."you're getting some of the rules….you're getting practice with a few examples….but there are many many examples and it's up to you to walk through all the possibilities…because I can't work through them all for you….I mean its' up to you to think about the different possibilities…simply in this kind of science I can't work through all the possibilities for you. There are too many….but that doesn't really address the problem…."if you are uncomfortable…with me not being the center…"

Me: Or maybe even something like…."the purpose of doing these problems in class is not to frustrate you…the purpose is for you to identify for yourself what you don't know….and to go home and to figure it out and ask the questions that need to be asked."

C: Um hmmm.

Me: A lot of times we get closure in our science classes…they….the lecturer tells us what the answer is ….Fick's law….if we consider active transport, then what does the equation look like? You said, there are many different answers to this.

C: Yeah

Me: So the purpose of that is not to get closure….to know the right answer…the purpose of that is to generate the question internally, "What didn't I understand?" "How could I have thought differently about this?" Sometimes I think that students need to be told the purpose is not closure…the purpose is to force them to examine their own understanding.

C: Yeah…I think it's a good idea….but I don't know….because the students could argue that…."Yeah….but you test us….you're going to give us an exam…." And one thing I've been saying about some subject…is that you need to know this this and this….and I've thought…wow…I'm drawing them a bone…they are waiting to hear those things…they jump on those…they love those…."oh we need to know how to do this and that…" So I try to make it a broader objective today….and actually state the objective….rather than picking one thing and saying you need to be able to make a graph of time versus diffusion….is to say…."an objective is you know for you to understand diffusion and how it works and how we use it….in different circumstances…."

Me: Yeah

C: In specific circumstances….

Me: Yeah, and there has to be a consistency between what you are doing in class and what you do on the assessment.

C; Yeah….I've told them that what they do in class is practice for what they will do on an exam….that was one of the problems with the question that I gave them in discussion to design an experiment….blahblahblah….uh…it's the kind of thing….I would have maybe something like that on an exam….but it itself…was a question that I would never have on an exam….too…way too open ended and way too parts of it were too far field to what we were trying to accomplish in the class….and so yeah…and I am trying to give them practice with the kinds of problems….I haven't made an exam yet thought….I am a little worried about that…because I am not sure how to transfer this to an exam…except…that I am using these questions that are from old exams in the workbook….and in the text…and using those to base my in class activities so…

Me: Last time we talked you said that part of their motivation….you said the first test will be hard….and part of their motivation would be to prepare for that test….to make sure they are ready for the test…

C: I mean they naturally want to do that….so I don't want to be too easy in class. I'm trying different things….with the quiz….it was built like an exam…I gave them that pop quiz….the multiple choice questions were probably easier than those I would have on an exam….but there they were…but then I had that one question that had two possible explanations…

Me: The Z and X problem?

C: Yeah it had molecules moving and here are the parameters….and what could be happening…..I thought that was a great question….that was a good way to give them an introduction to that kind of question…other than just the workbook….I mean they are getting introductions in different ways but to actually test them on that…they'll get another quiz or two before the exam but it will be built the same way….so that they get pretty much exactly the situation they would have on an exam…because they are getting practice talking to peers….they are getting practice….working problems in class…they are getting practice…and all that stuff….but they also need time when they are answering questions in a test-like environment before we get to the test. I mean….so nothing comes as a surprise to them…I hope on an exam…but still….but the questions sometimes are…what we are doing in class…that was one thing I was worried about is that things were too easy and they weren't up to the level….I was afraid that what I was doing in class was so easy that once they got to an exam….they would be surprised by how difficult the questions were in that I would ask them to go beyond what we have done in class. So with that in mind….I think that I am addressing that better….now….that I recognized that and worried about that….like today….exercises….they built…some were easy but they built on each other and that was the kind of question they would get on an exam….they got to that level of difficulty I think.

Me: One of the other things I've seen over in the math department when they give a multiple choice quiz like that …each student has color-coded cards….you know like, red, green, yellow, blue….so if you want to vote for A on the quiz….you just hold up the card…wherever….you can hold it high if you are confident or in next to your chest or whatever….but the instructor….told me that's an immediate way for me to check their understanding….so if I've gone over something in class and then ask a question and they all hold up yellow cards….when the answer was red….I know immediately that nobody was following what I said….but that's a cool system.

C: That's cool…like my who wants to be a millionaire punch pad idea…that I think that all classroom should have where you instantly get the histogram of everybody's response. That's nice…then they couldn't look at their neighbors…or what about colorblind….I had a friend who was colorblind but he didn't know it until after he failed microbiology….because he had to do the gram staining….where you have to see what kind of cell you have by whether it turns this color or another….he said it was so frustrating to try to tell the difference between dark gray…and he mean he didn't know…because to him it was all shades of gray…but

Me: Man….I guess I have one last question….

C: Sure.

Me: Have you modified the way that you are preparing for each class meeting?

C: Well, I didn't give you a real clean answer the first time anyway….but umm….but yeah….but I've modified from the way I would have in the past….probably…because I am reading the text and looking through the workbook….as I'm reading it, I'm asking….I'm looking for central activities….as I go through…so I am looking for two different things….two or three new different activities….but as I read what I do is….so I'll read through the section…quickly to review….so I am reading through and just looking for what are the concepts in each part of what we are doing….and then as I see an important concept….I'll design a quick activity….like the Fick's law of diffusion….like when I saw that, I designed that right then…I didn't pull that out of a book or anything….so I did that….and I just make a list…I've got an outline that I made of the topics and then I …then I….highlight the….I mean in my outline I highlight it….I put it for myself the terms and concepts that I want to make sure that are addressed….and I don't mean by just me saying them….my outline is not for what I am going to say in class…some of it is…um….but then I put in these different activities and then I go back and then make a time estimate…think about what activities would encompass other concepts…like tonicity….if they can do tonicity…then they understand osmolarity and molarity….somewhat so….um….so then I could eliminate those activities…based on….that I would only have time to do one and these two…I think I only had two today…and then I read the teachers' workbook and the student workbook…

Me: Oh, there's a teacher's workbook too?

C: There's teachers guide….

Me: Oh, I didn't know that.

C: But I found this handy because it suggests activities so I go through and check off activities from here and so sometimes I get my ideas out of this…sometimes I think up ideas on my own….so I read the text, I get my own ideas….I read this…I get ideas from this…and read the workbook….and look through the student work book for activities that they already were responsible to do and maybe modify….one or two of those…I haven't' done any of that…well I did one of those….in a discussion the other day….I took one of the questions to make sure they knew how to do it. But not all of the students have the workbook yet….coop is way behind…so I haven't hammered on the workbook yet…but later we'll probably do more questions in class….but yeah…

Me: Okay, so you really have changed from what you described to me last time…changed

C: Well I have more of a system now….yeah…yeah…I have….my system in the past was just cause I wasn't looking for active learning exercises….cause what I have done in the past was where they had a lab…and they are doing…I haven't taught the lectures…except as a guest lecturer…I've never done it…for labs you don't really have to look for an active learning exercise….

Me: So that's something we'll want to keep talking about….just how the system develops for you…

C; This is really helpful to have this…this kind of thing[points to the teachers' guide]….I wouldn't just use this but to have suggested ideas….if I didn't then I would be under a lot of pressure….I don't think I could be creative enough day after day after day to think of all the activities….I feel comfortable that at least these are good ideas that someone else has thought about to….so the thing about holding jugs up in front of you…

Me: Yeah….I thought that was really a good idea

C: Body water content…I saw the students smiling on that one….that was straight out of this book….so that effective demonstration….I mean it described soft drink bottles and using a student to do it.…but I figured why? I don't want to be asking students what their weight is….

Me: And when you start to think about putting salty popcorn in your body and you see how much water there is in the body….you can start to imagine a real scenario….it forces you to define the mental image you have.

C: Yeah, I think that is a great example right there….just me saying that I sat down and figured out my own body water….and suggested that they do it….some of them are never going to go to that….but I like the idea…that for those that are motivated and excited about this…then giving the suggestions, I like that. Not everything has to be an assigned graded exercise….some of it is just demonstrating the fun of how to use this material….if I do it on my own….they can do it on their own.

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Turned off tape and then talked about Cindy's perceptions of RQ at the teaching seminar. Richard couldn't think of how to make physiology relevant for his students and posed the questions. Cindy's impression was that RQ thought his students were really stupid. She was in disbelief over the question he had asked.

Also talked about the TA situation. Valerie who has been a nurse for over 10 years has been really uncomfortable going into class, cold. She wants to have things worked out to do and not leave so much to uncertainty. Apparently Valerie attended the TA teaching seminar and connected with some of Dee's past TA who were badmouthing how they were just sort of left on their own to come up with a design for the discussion. Cindy has decided that it's worth it for her to try to structure how the discussions will be spent and give them ideas for activities. Apparently Mark is more easy going that Valerie….I suggested that AL may not fit with Valerie's current belief system….mistakes and uncertainty may not be compatible with her paradigm….such concepts are dangerous in life and death situations….Cindy is considering talking casually about belief systems that work with AL…..

I picked up the content scantrons and took those to the measurement office for scoring.

Hi Patti - It has been a while since I pestered you so I thought I had better resolve that situation. How was your Christmas? Mine was quiet -delivered presents to some friends during the day then went to a turkey dinner potluck that evening with the friends I usually do outdoors stuff with. It was a nice time. We did not have more than a skiff of snow so that was a bummer but that has definitely changed. We are in the middle of our third storm system in a week so there is lots of the white stuff out there now. It is beautiful. I am going snowshoeing on Thursday in the park so that should be fun - although we are supposed to get hit with another storm on Thursday. I should take my skis to the golf course this afternoon. It has some nice hills so it is not all flat terrain.

Before the school closed for the holidays I worked really hard to get as much done as I could so everything could be printed off. All my notes and lab handouts are done, the first set of review questions for lecture, course syllabi, pre-test, attitude survey, and criteria for lab reports. I have been reading Walvrood and Anderson's book on grading and assessment and the other day took one of their suggestions. I listed all the days of the semester and then to the right of that inserted the lecture topics and then to the right of those listed all assignments on their due dates. It helped me to see trouble areas with lecture exams and lab assignments coming too close together. The next step (which I have not done - only thought about) is to take each assignment or exam and determine what you want your students to learn for that particular item. This particular semester (more than the first) I am very concerned about the lab assignments serving to prepare the students for the lecture exams. In other words, I want both areas to emphasize the same principles. So when they write up a lab report, they should be writing for the exam. What I have to determine is whether or not my exams test in such a way that even though the material is the same, they are not asked to think in the same way, so doing the lab reports really does not facilitate better scores on the exams. Partly I want to work on this and partly, I want to not think about school for 2 more weeks!

Correspondence

I finally printed off that article you sent about learning. I am not sure yet how I will use it. I have had a book for years that says the same basic thing. I must have it at school as I can't find it, but I think the name is "The Second Most Important Book You Will Ever Read" by Steve Douglas. It goes through efficient approaches to get the most out of a class. Sometimes I think there are no more new ideas in education. Just resurfacing of ideas with new vocabulary. Anyway....the paper you sent is interesting and has some very valid points. Obviously I still disagree with his assessment of handing out notes for the students. I still believe it frees them up to write down insights and analogies without worrying about getting the basic facts written down. I have never had attendance problems because the students think there is no reason to come to class. Besides that minor issue, I think it is worth the students reading, but I have their first two days already so packed there will be no time. However, their first assignment (so far) does not come in until Feb. 7 so maybe I can work it in the second week....... I will say this for the author - he is in love with quotation marks and contractions. I know because quote marks and apostrophes came through as some other marks and I had to go through all 11 pages and change each by hand.

Well, as I said, I just thought I would pop in for a quick hello. I am due at the hospital in 30 minutes for a meeting about the radiology program.

APPENDIX C

Instructor and Students Surveys

Instructor Experience Profile

Name:

Mailing Address:

Phone:

E-mail:

In what classes will you use active learning during the 2000-01 year?

Which of the following will you teach in these classes?
______Osmolarity/Diffusion
______Neuro
______Cardiovascular
______ Renal
______ Respiration

Which of the following:
do you currently use (indicate with **X**)
have you tried and abandoned (indicate with **O**)
techniques are you not familiar with (indicate so with a **?**)

______Lecture with Pause (Share and Compare Notes)
______Questioning
______Short (5 minute) Informal Group Exercises
______One-minute Papers
______Concept Mapping
______Case Studies
______Inquiry or Discovery Activities
______Problem-Based Learning
______Informal Formative Quizzes/Feedback Opportunities
______Role-Playing or Plays (Teacher Written)
______Plays or Demonstrations (Student Written)
______Debates
______Demonstrations or Physical Models
______Posters
______Library or Term Papers

_____Student Presentations
_____Simulations or Experiments
_____Conference Period for Clarification/Homework Discussion
_____Out of Class Group Projects

_____Please Explain Others You Use:

_____Please Explain Others That You Have Tried and Abandoned:
Please check the workshops you attended at HAPS 2000.

_____The Elvis Experiment
_____ Using Concept Maps as Co-operative Learning Activities to Explore Physiological Relations
_____Designing a Physiology Course Around Problem Solving
_____Assessment Materials that Test for Conceptual Understanding Rather than Memorization
_____Misconceptions About Pressure and Flow Relationships: Uncovering and Remedying Them
_____Quantitative Investigation of Blood Pressure
_____Beyond Virtual Reality: Physical Models for Teaching Cardiovascular Physiology
_____Active Learning in Lectures
_____Computer-Based Methods for Learning the Basics of Membrane Potentials

Have you used supplemental curriculum modules or ancillary materials in this or another course before?

If yes, please describe.

Have you participated in Web-based collaboration with other instructors in the past?

If no, describe your reaction to this element of the project.

If yes, please describe the nature of the collaboration and your reaction.

APPROACHES TO TEACHING INVENTORY

This inventory is designed to explore the way that academics go about teaching in a specific context or subject. This may mean that your responses to these items may be different to the responses you might make on your teaching in other contexts or subjects.

Please describe the context here: . . . .

For each item please circle one of the numbers (1-5). The numbers stand for the following responses:

1 - this item was **only rarely** true for me in this subject.
2 - this item was **sometimes** true for me in this subject.
3 - this item was true for me **about half the time** in this subject.
4 - this item was **frequently** true for me in this subject.
5 - this item was almost **always** true for me in this subject.

Please answer each item. Do not spend a long time on each: your first reaction is probably the best one.

		nly rarely				almost always
1	I design my teaching in this subject with the assumption that most of the students have very little useful knowledge of the topics to be covered.	1	2	3	4	5
2	I feel it is important that this subject should be completely described in terms of specific objectives relating to what students have to know for formal assessment items.	1	2	3	4	5
3	In my interactions with students in this subject I try to develop a conversation with them about the topics we are studying.	1	2	3	4	5
4	I feel it is important to present a lot of facts to students so that they know what they have to learn for this subject.	1	2	3	4	5
5	I feel that the assessment in this subject should be an opportunity for students to reveal their changed conceptual understanding of the subject.	1	2	3	4	5
6	I set aside some teaching time so that the students can discuss, among themselves, the difficulties that they encounter studying this subject.	1	2	3	4	5
7	In this subject I concentrate on covering the information that might be available from a good textbook.	1	2	3	4	5
8	I encourage students to restructure their existing knowledge in terms of the new way of thinking about the subject that they will develop.	1	2	3	4	5
9	In teaching sessions for this subject, I use difficult or undefined examples to provoke debate.	1	2	3	4	5
10	I structure this subject to help students to pass the formal assessment items.	1	2	3	4	5
11	I think an important reason for running teaching sessions in this subject is to give students a good set of notes.	1	2	3	4	5

12	In this subject, I only provide the students with the information they will need to pass the formal assessments.	1	2	3	4	5
13	I feel that I should know the answers to any questions that students may put to me during this subject.	1	2	3	4	5
14	I make available opportunities for students in this subject to discuss their changing understanding of the subject.	1	2	3	4	5
15	I feel that it is better for students in this subject to generate their own notes rather than always copy mine.	1	2	3	4	5
16	I feel a lot of teaching time in this subject should be used to question students' ideas.	1	2	3	4	5

Thank you

REFERENCE: Trigwell, K. and Prosser, M. 1996. Congruence between intention and strategy in science teachers' approach to teaching. Higher education, 32, 77-87

Notes on the Approach to Teaching Inventory

The Approach to Teaching Inventory is composed of 16 items. Eight items are part of a sub-scale describing an approach, which is intended to change students' conceptions or ways of seeing things through a focus on the student. Four items refer to the motive of the approach and four to the strategy. The other eight items form a sub-scale labelled Information Transmission/Teacher-focused Approach with four items referring to the intentions to transmit information and four to the use of a teacher-focused strategy to achieve that intention.

The items are grouped as follows

Sub-scale: Conceptual Change/Student-focused (CCSF) Approach **Intention Items**	**Item no.**	
I feel that the assessment in this subject should be an opportunity for students to reveal their changed conceptual understanding of the subject	5	
I encourage students to restructure their existing knowledge in terms of the new way of thinking about the subject that they will develop	8	
I feel that it is better for students in this subject to generate their own notes rather than always copy mine	15	
I feel a lot of teaching time in this subject should be used to question students' ideas	16	
Strategy Items	**Item no.**	
In my interactions with students in this subject I try to develop a conversation with them about the topics we are studying	3	
I set aside some teaching time so that the students can discuss, among themselves, the difficulties that they encounter studying this subject	6	
In teaching sessions for this subject, I use difficult or undefined examples to provoke debate	9	
I make available opportunities for students in this subject to discuss their changing understanding of the subject	14	
Sub-scale: Information Transmission/Teacher-focused (ITTF) **Intention Items**	**Item no.**	

I feel it is important that this subject should be completely described in terms of specific objectives relating to what students have to know for formal assessment items	2	
I feel it is important to present a lost of facts to students so that they know what they have to learn for this subject	4	
I think an important reason for running teaching sessions in this subject is to give students a good set of notes	11	
I feel that I should know the answers to any questions that students may put to me during this subject	13	
Strategy Items	**Item no.**	
I design my teaching in this subject with the assumption that most of the students have very little useful knowledge of the topics to be covered	1	
In this subject I concentrate on covering the information that might be available from a good textbook	7	
I structure this subject to help students to pass the formal assessment items	10	
In this subject, I only provide the students with the information they will need to pass the formal assessments	12	

All items are scored positively

We have not published norms, nor will we, as we have gone to some lengths in writing on the research behind this inventory, that responses to it are relational and are specific to the context in which they are collected. Teachers who adopt one approach in one context may not adopt the same one in a different context. Our main use of the Inventory has been as a source of data for analysis of associations within a specific context. For example the associations between approach to teaching and perceptions of leadership in departments, or relations between approach to teaching and student approaches to learning.

Permission to use this Inventory is given, provided:
- a) that its source is acknowledged in all publications*
- b) that users notify Keith Trigwell of their intention to use the inventory, and
- c) that once data have been collected and used as intended that the raw results on the inventory items are available for the use of Michael Prosser and/or Keith Trigwell.

[Michael Prosser and Keith Trigwell, 1996]

References on the ATI

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Note that this version of the ATI have been modified to accommodate more flexible learning environments than those from which the ATI was developed. The original version is available in Prosser and Trigwell (1999).

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Student Attitudes Survey

Your instructor is participating in a study to find out how active learning techniques influence students' attitudes and beliefs as they study anatomy and physiology. We would like to get some information from you that will tell us what you think as you are learning in the course. Your assistance with this will be greatly appreciated, but your participation is strictly voluntary.

Please put your DATE OF BIRTH on the computer answer form so that we can keep data organized as we look for trends across the semester.

The results of this survey will NOT be available to your instructor. All information is confidential. Your responses to these survey questions will NOT have any effect on your class standing, grades, present or future association with your college, or status on an athletic team.

Thank you for your help.

---

1. Gender
   A. Female
   B. Male

2. Enrollment status
   A. Part-time
   B. Full-time

3. Age
   A. < 18
   B. 18-24
   C. 25-29
   D. 30-34
   E. >35

4. Grade point average

A. < 2.0
B. 2.0 - 2.8
C. 2.9 - 3.2
D. 3.3 - 3.8
E. > 3.8

Directions: There are no right or wrong answers for the following questions. We want to know what *you* really believe. For each statement indicate the degree to which you agree or disagree.

STRONGLY DISAGREE			**STRONGLY AGREE**	
1	**2**	**3**	**4**	**5**

5. I am confident that I will be successful in this course.

6. I learn the most when I listen to a lecture.

7. It is the instructor's responsibility in this class to stick to the facts so that students know what they have to learn for tests.

8. The best way for me to evaluate my learning in this class is to compare my performance to other students in the class.

9. The instructor's role in this class is to encourage and help students think about the subject in new ways.

10. Some class time should be set-aside for students to discuss and help each other understand difficult concepts in this class.

11. I am confident that I can integrate the facts of physiology to understand bigger ideas about how the body works.

12. I learn the most when I have the chance to work in small groups during class

13. The role of the instructor in this class is to question students' ideas.

14. When I am learning new information for this class, I try to use word-for-word memorization and repetition strategies so that I can state the information exactly as it is stated in my text or by my instructor.

15. The instructor of this class is responsible for giving students feedback that describes students' abilities and helps them improve.

16. I worry about being able to calculate an answer to a physiology problem.

17. Whether or not I learn this subject depends on the time and effort I devote to learning.

18. I work hard in this class primarily to get a good grade rather than to learn new information.

19. When I make a mistake I see it as a normal and useful part of the learning process because it helps me make improvements

20. The learning strategies I use the most for this class are ones that force me to understand information deeply. I may draw diagrams or maps, rephrase information or apply it to a new problem
Situation.

21. If I am going to learn this subject, the information will make sense to me the first time I hear it

22. If I am having trouble understanding information in class, I ask the instructor for clarification or read explanations in different resources.

23. Understanding this subject area is a slow process that develops through practice and effort

24. When I make a mistake I see it as a sign of failure and incompetence

25. Mastery of new knowledge and skills is a more important goal for me in this class than getting a good grade.

26. The best way for me to evaluate my learning in this class is to look at the progress I make.

27. I feel comfortable volunteering information out-loud in class.

28. The purpose of tests in this class should be for students to demonstrate that they have memorized important facts.

29. Students in this class should not be expected to learn on their own or from other students

30. I have very little useful knowledge of the topics covered in this class

31. The instructor in this class should know the answers to any questions that students ask about the topic.

32. Class time should be used to cover information and facts.

33. The purpose of tests in this class should be to challenge students to think about the information and concepts in new ways.

34. Whether or not I learn this subject depends on the instructor's ability to teach it to me.

Student Concept Understanding Survey

Your instructor is participating in a study to help determine if the use of active learning teaching techniques influence students' understanding of anatomy and physiology. We would like to get some information from you that will tell us what you know as you are learning in the course. Your assistance with this will be greatly appreciated, but your participation is strictly voluntary

Please put your DATE OF BIRTH on the computer answer form so that we can keep data organized as we look for trends across the semester. As you respond to the questions, please do your best. You may choose to stop responding to the survey all together at any time.

The results of this survey will NOT be available to your instructor. All information is confidential. Your answers to these questions will NOT have an effect on your class standing, grades, present or future association with your college, or status on an athletic team.

Thank you for your help.

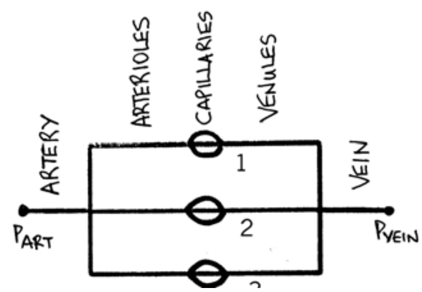
---

1. A large vein in the leg of an accident victim is cut, and the individual loses 2 liters of blood. The PRESSURE in her veins will:
a. increase
b. decrease
c. remain unchanged

2. Arterial blood flows through an organ of the body at a constant rate. If the metabolic activity of that organ is DECREASED, the amount of oxygen in each milliliter of blood leaving the organ in the vein will:
a. increase
b. decrease

c. remain unchanged

3. If cardiac output (the volume/min ejected from the heart) increases significantly, then the resistance of the arterioles will:
a. immediately and directly increase significantly
b. immediately and directly decrease significantly
c. not change directly to any significant extent



4. Consider the small piece of circulation shown below. The PRESSURE gradient across the circulation (P_{artery} - P_{vein}) is constant. If the arterioles in path 1 VASOCONSTRICT (get smaller), then pressure in the venules of path 1 will:

a. increase
b. decrease
c. not change

5. The ventricle fills:
a. ONLY when the atrium contracts
b. ONLY when the pressure in the ventricle is less than the pressure in the atrium
c. ONLY when the papillary muscles contract and open the A-V valve

6. When the heart beats:
a. the right and left ventricles pump the same volume of blood each beat
b. the right ventricle pumps less blood each beat than does the left ventricle
c. the right ventricle pumps more blood each beat than does the left ventricle

7. The blood pressure in the capillaries is ______ than the blood pressure in the arterioles.
a. greater than
b. less than
c. the same as

8. The regulatory mechanisms involved in maintaining normal cardiovascular system function essentially set to hold__________within a relatively narrow range.
a. mean arterial pressure

b. mean arterial pressure and cardiac output
c. mean arterial pressure, cardiac output and heart rate

9. The rate at which blood is pumped out of the veins by the heart is increased. If the rate at which blood enters the veins is maintained constant, the volume of blood in the veins will:
a. increase
b. decrease
c. remain the same

10. The flow (ml/min) through the pulmonary circulation is ________ the flow through the systemic circulation (the rest of the body):
a. the same as
b. greater than
c. less than

11. The blood pressure in the capillaries is _______________ the blood pressure in the arterioles.
a. greater than
b. less than
c. the same as

12. If all of the nerves innervating the heart are cut, the heart will:
a. stop beating
b. continue beating at the same rate
c. continue beating, but at a different rate

13. The left ventricle contracts NOW. The right ventricle contracts_______the left ventricle did:
a. before
b. after
c. at the same time

14. You measure a patient's cardiac output and determine that it is increased above its normal value. This MUST mean that stroke volume has:
a. increased
b. decreased
c. not changed
d. cannot be determined from the data given

15. You measure the blood pressure in the artery of the upper arm of a patient. You then measure the blood pressure in the artery of the patient's leg. What do you expect to find?

a. similar values in the arm and leg measurements because blood pressure is similar throughout the body

b. a lower blood pressure value in the leg than the arm because blood pressure decreases as the blood moves further away from the heart

c. a higher blood pressure value in the leg because the blood pressure will increase due to the effects of gravity

16. Compared to the outside surface, the inside of a resting cell membrane is _______.

a. positively charged

b. negatively charged

c. electrically neutral

d. continuously reversing its electrical charge

e. positively charged whenever the sodium-potassium pump is active

17. Membranes are said to be selectively permeable. This results in a body state of:

a. Osmotic equilibrium but Chemical and Electrical disequilibria

b. Osmotic, Chemical and Electrical equilibrium

c. Osmotic, Chemical and Electrical disequilibria

d. Osmotic and Chemical equilibrium, and Electrical disequilibrium

18. A patient is being given an intravenous (IV) treatment for blood loss. The IV solution is .9% NaCl in water (normal saline). The IV solution is ______. When administered, body osmolarity ________. Since NaCl is a ________solute, the replacement fluid _________.

a. Issoosmotic; doesn't change; non-penetrating; remains in the ECF (extracellular fluid)

b. Isoosmotic; doesn't change; penetrating; slowly enters the cells

c. Hypoosmotic; increases; penetrating; slowly enters the cells

d. Hyperosmotic; decreases; non-penetrating; remains in the ECF (extracellular fluid)

19. A patient is being given intravenous (IV) treatment for dehydration. The IV solution is D5W (5% glucose in water). The IV solution is isoosmotic and _______. Since glucose is a penetrating solute, the replacement fluid ________

a. isotonic; enters the cells

b. hypotonic; remains in the ECF (extracellular fluid)

c. isotonic; remains in the ECF (extracellular fluid)
d. hypotonic; enters the cells

20. When the diaphragm and external intercostals muscle contract:

a. intrapleural pressure increases
b. the volume of the lungs decreases
c. the volume of the thoracic cavity increases
d. the lungs collapse
e. expiration occurs

21. During inspiration the:
a. Intrapulmonary (alveolar) pressure is greater than atmospheric pressure
b. Intrapleural pressure is greater than intrapulmonary (alveolar) pressure
c. Intrapleural pressure is greater than atmospheric pressure
d. Intrapulmonary (alveolar) pressure is less than atmospheric pressure
e. Intrapleural pressure is greater than atmospheric pressure but less than intrapulmonary (alveolar) pressure

22-24 A patient is anemic and also has less-than-normal hemoglobin content in her red blood cells.

22. What will her ARTERIAL PO2 be, compared to normal?
 a. increased
 b. decreased
 c. not changed

23. What will the amount of O2 dissolved in her arterial PLASMA be, compared to normal?
 a. increased
 b. decreased
 c. not changed

24. What will the % saturation of her hemoglobin be, compared to normal?
 a. increased
 b. decreased
 c. not changed

25. As the PO2 of a person's plasma increases, the amount of oxygen that dissolves in plasma:
a. increases

b. decreases
c. does not change

26. As the PO2 of a person's plasma increases, the amount of oxygen that binds to hemoglobin:
a. increases
b. decreases
c. does not change

27. Which person will carry more oxygen in his blood:
a. a person with hemoglobin of 15g/dL and an arterial PO2 of 80 torr (normal = 100 torr)
b. a person with reduced hemoglobin of 12 g/dL and a normal arterial PO2 of 100 torr?

28. If the smooth muscle layer lining the afferent arteriole supplying a given glomerulus were to contract (thereby constricting the afferent arteriole),
a. blood flow into the efferent arteriole increases
b. the glomerular filtration rate decreases
c. hydrostatic pressure in the glomerulus increases
d. the protein concentration of the filtrate increases
e. hydrostatic pressure in the glomerular capsule increases

APPENDIX D

Emergent Themes

Codes 9-04-02

Categories		Subcategories	
Beliefs	(about)	Self	
			Culture
		Student	Gender
			Intell
		Science	
		Peers	
		Admin	
Goals		Assessment	
		t/l process	
		roles/resp	
		open	
Strategy (I did)		planning	
		In class instruct	
		Assessment	
Metaphor/Anal.		Struggle/grapple	
		Change	
Reflection		Motivation	
Event (This happened)		institution,	
Context		department personal	

1-25-02 Codes:

05000 Catalog description of course

10000 Strategies (Used by Instructor)

- In Class Teaching 10100
  - Modeling 10101
  - Mini-lecture 10102
  - Specific Activity for ITIP 10103
  - Problem Solving 10104
  - General Approach 10105
  - Visual Aids: Chalkboard/Media/PowerPoint 10106
  - Comments to Class about Self 10107
  - Comments to Class about Teaching Philosophy 10108
  - Reflection on Strategies that didn't work 10109
  - Reflection on Strategies that work 10110
- Forming Groups 10200
- Assessment 10300
  - Individual 10301
  - Group 10302
  - Peer 10303
- Out of Class Teaching 10400
  - Problems 10401
  - Web Reading/Textbook 10402
- Grading Policy 10500
- Selling Active Learning 10600

2000 Beliefs (Held by Instructor)

- About Students 20100
  - Culture 20101
  - Resistance 20102
  - Culture 20103 oops duplicate category
  - Ability 20104
  - Study Strategies 20105
  - Responsibility 20106
  - Impact of Instructional Change 20107
  - When they work in groups 20108
  - Preferences for Instructional format 20109
  - Impact of Summative Assessment 20110
  - Impact of Heavy Classload 20111

Student preparedness 20112
What they need to be successful 20113
About Grading 20200
Instructor Grading 20201
Peer Grading 20202
About Groupwork 20300
Goal/What it should accomplish 20301
Forming groups 20302
About Self 20400
About Other Faculty 20500
About In-Class Activities 20600
ITIP Activities 20601
About Science 20700
About Active Learning 20800
About Class Size 20900
About Class Format 21000
About Content 21100

3000 Interaction With Colleagues/Peers

Interactions with colleagues 30100
About colleague teaching strategies 30200
About colleague teaching beliefs (This is what colleagues tell me about their own Strategies) 30300
About colleagues experiences with active learning 30400
What other faculty say about my teaching strategies 30500
Accepting help or collaboration with other faculty 30600
Colleagues beliefs about students 30700

40000 Student Feedback

Study Strategies 40100
Formative 40100
Summative 40200
About ITIP Activity 40400

50000 Struggle (Instructor doesn't know…)

60000 Event (external to instructor)

Administrative Action 60100
University Policy 60200
Standardized grading 60300

70000 Learning Analogy (Learning is like….")

80000 Teaching Metaphor (I'm like a ……")

APPENDIX E

Researcher as Instrument

My purpose in generating this statement is to convey self-knowledge-- as experiences, beliefs, and values-- that may impact the data generation and interpretation as well as the conclusions that I draw from this study. My hope is that the reader will gain some insight from this statement about "where I am coming from" and understand, to some extent, the grounding of my interpretations in this research. Toward this goal, I must (and you the reader, must) attempt to recognize the parts of me that may cloud perceptions of others' experience. By raising a representative portion of myself to the level of awareness, perhaps we can become aware of, and differentiate to some extent, my thoughts, feelings, and judgments from those of my research participants. As the primary instrument of this study, my goal will be to try to see through the eyes of the research participants in order to understand and accurately describe their conceptions and experiences as they introduce teaching strategies and contextual factors to promote student active learning in their classrooms.

"*All we can work for is that our vision is not too skewed by our own subjectivities. And that means work for most of us. But this work is of a different class from that of striving to reach the impossible goal of pure objectivity. The trouble is that, as participant-observers, it looks as if we are trying to do just that. That is, as qualitative researchers, we must educate and re-educate ourselves to practice detailed observation without reading in our own answers, our own biases. That process entails becoming increasingly more aware of our own 'eyeglasses', our own blinders, so these do not color unfairly both what we* *observe and what we detail in writing. With all the striving to observe fairly and with all the self-awareness and introspection this demands, we are still subjective people doing a subjective job*."

(Ely et al. 1991, p. 53-54)

Throughout my childhood I maintained an incredible sense of wonder and an attitude of curiosity while observing and interacting with my surroundings. I can remember watching in amazement as calves and kittens were born, building forts out of pine needles and tree branches beside a pond, catching insects and tadpoles in jars, breaking rocks in half to see their insides, finding new uses for a "pea-sheller" that my grandmother had fashioned out of an old crank-and-wring clothes washer, putting my carnival goldfish in the cows watering trough to see how big they might grow, and collecting flowers and leaves to look at under a microscope.

Unfortunately my public school education did not facilitate active exploration and learning. Rather than being encouraged to explore, I was seated with textbooks, math worksheets, books to write reports on, and spelling and vocabulary tests. My teachers seemed old and worn out and focused on classroom management. Perhaps the most important thing I learned in elementary school was that getting along meant being agreeable--and that school learning was nothing more than memorizing what other people thought was important.

The school experience that seems to have been important in the shaping of my core philosophy of teaching and learning was a brief encounter with Mr. Barker in the sixth grade. Mr. Barker wasn't officially a teacher—I don't think. He might have been an administrator that liked to do science with kids-- I really don't know. Mr. Barker was like no one I had ever met. He was a small blond-haired man with a booming, baritone voice and a laugh that matched. He always wore a tan-colored suit with a bow tie. He had a cluttered office—away from my classroom-- with posters on the walls that had words about drummers who marched to a different beat and differences among students. I loved being around Mr. Barker because I could ask questions, sort through boxes of supplies and tools, and read through his books about designing experiments. Over what seemed like a period of six months, Mr. Barker and I built a machine that smoked cigarettes, set up a plant growth experiment to watch how plants responded to different variables, made a solar cooker, dissected a frog, and studied electrical circuits. Through Mr. Barker and his resources, I learned that ideas could be tested and questions could be answered. I learned there was no such thing as an experiment that didn't work—there was always something to be learned. I learned flexibility, how to change my course, and tenaciousness. I learned to trust my intuition. I learned what it meant to be an active learner, responsible for determining my own depth of learning.

I share my short experience with this "teacher" because it provided a point of comparison and became a critical element shaping my beliefs about the transformative nature of "effective" teaching. I came to know first-hand the power of teachers' attitudes, the power of relevant learning materials that made connections to real life, and the complex relationship between self-efficacy, motivation, and learning.

My college learning has taken place at a variety of institutions. I attended a community college and a land grant/major Research University (B.S. in Microbiology), a private, Catholic-affiliated college (M.S. in Biology), and am currently working towards my Ph.D. (Science Education) at a Research I University. Although opportunities for active learning were largely absent in my undergraduate experience (even laboratories were of a cookbook nature and the challenge was to reproduce the procedure outlined in a lab manual), I consider myself fortunate to have connected with a variety of personable lecturers and knowledgeable researchers. Although my graduate education has allowed ample opportunity for practical active learning, through participating in scientific and educational research, my formal science learning has taken place in traditional lectures—with one exception.

A significant shaping experience for my dissertation research was my participation as an “active learner” in Dr. Silverthorn’s vertebrate physiology course at The University of Texas at Austin. When beginning the course, I outlined three goals: 1. To participate as a student by attending lectures and discussion sections, participate in cooperative learning groups (in-class as well as study groups), take quizzes and exams, and to receive a final, performance-based grade; 2. To keep a journal documenting my experiences; and, 3. To administer surveys and interviews to other students enrolled in the course in order to begin to understand how other students experience a science course that is taught using classroom strategies to promote student active learning. Having completed coursework in constructivist learning theory and worked as a curriculum developer for the Biological Sciences Curriculum Study (Colorado Springs, CO) group, I entered the class with what I believed to be a solid understanding of active learning. However, once in the classroom, in the shoes of an active learner, the tenuous nature of my science learning strategies became apparent. The instructional format I was experiencing, placed the responsibility of learning general concepts on students, with class meetings and discussion sections dedicated to elaboration of difficult concepts and small group problem solving. Keeping up with readings and problem assignments was the students' responsibility, and essential to class participation. An entry from my journal three weeks into the class summarizes the extent of my discomfort:

Horrible class. Didn't understand a thing. Sat there full of self-doubt. Thought I understood the information when I did the reading…apparently only a surface understanding and not the kind that translates into transfer. The whole self-doubt feeling is ballooning into a generalized feeling that I probably don't know anything and I feel like some kind of imposter with a graduate research degree. I'm scared. I talked to Dr. Silverthorn after class and she said she is being really careful to go slowly in class. The awful thing is that I can't keep up! She's flying through and I don't know what she is saying. If this is slow….is she planning on speeding up? It's apparent how passively I've approached learning up to this point. Even though I've always come to class with the goal of "paying attention"… what about learning? There was never time when the professor was *rattling off all that content…. all I had time to do was write, scribble…. try to get it all down! There was no time to reflect and ask myself what it meant. I always counted on the fact that I'd make sense of it later. With reflection…."making sense of it later" is a very low level of cognition. I know in theory-- active learning is a good thing, but I'm scared to death I won't be able to do it. I know part of what is driving my fear is the importance of the grade…I have been focused on grades rather than meaningful learning for…how many years? This is painful. I wish I could drop. This is a time and energy drain!*

The opportunity to be an active science learner, and more recently to serve as the Assistant Instructor for the course, provided much-needed opportunities for critical reevaluation of my adopted theoretical understanding with practical experience. For me, active science learning is incredibly difficult and elicits a strong affective response. Ironically, active science teaching is not the "delightful challenge" that I had anticipated it to be—certainly there are incredible moments where everything comes together but there are also times of discomfort and disorientation, feeling "out of control" and, misunderstanding between instructor and students.

These are some of the experiences that have influenced my current beliefs and values about teaching and learning. As I position myself as the primary research instrument of this study --it feels like an awesome responsibility. And, with that responsibility in mind--I summarize the beliefs that will undoubtedly shape this research project:

1. The tenets underlying constructivist learning theory and conceptual change theory will form the supporting foundation of this research. Briefly stated, within the context of learning new teaching strategies, college instructors are "inquirers" into teaching and learning. Consequently, the process of new knowledge construction is strongly influenced by an extensive network of beliefs and knowledge about what it means to teach in their area of expertise.
2. College instructors' starting network of beliefs about teaching and learning are likely to have been shaped through their own experiences as learners in the traditional lecture classrooms. These beliefs are likely to be incompatible with instructional strategies that are grounded in constructivist practice.
3. Although short-duration workshops and symposia may provide some incentive for change in instructional practice and ideas to try, they are insufficient for long-term change. In order for meaningful change in instructional practices to occur, a safe and long-term learning context must be available. An instructor's classroom is the most feasible context for meaningful change to occur.
4. To sustain intrinsic motivation for change, faculty must "own" their learning experiences. Therefore, they must be engaged in day-to day activities that originate in their own development goals and their own ideas and reflections derived from classroom experiences and/or interactions with students.
5. Trust building, receiving acceptance, as a content-knowledgeable "insider", and balancing empathy and challenge are essential components of a naturalistic inquirer in all interactions with college science faculty.

6. The most important consequence of faculty change and learning is improved student learning. Students should be provided with multiple opportunities for students to learn how they learn and explore new learning strategies, and to challenge students to achieve more meaningful learning than they may think possible by creating a classroom context in which they are motivated to engage and learn science, apply their learning to problem solving situations, and ultimately transfer their learning beyond the walls of the classroom to life situations. In our age of rapidly changing information, knowing how to interpret relationships and recognize discrepant data is a critical skill that learners must acquire. Instructors and learners must recognize the importance of going beyond memorization of content material to application of facts to problem solving.

"*The naturalistic researcher must come to rely on his/her own talents, insights, and trustworthiness and, in the end, go public with the reasoning that engendered the results, while accepting with equanimity that other people may make different meaning from the same data*." (Ely, et al. 1991; p. 86)

I am willing to explore and let this study unfold in a way that is meaningful to the participants and myself. I am willing to describe in rich detail the data that emerges. I am willing to watch the data continuously, and bring to light patterns and relationships that emerge. In terms of the qualitative research process, I am willing to discover what it is like to rely on my own talents and insights to create ongoing meaning out of evolving data. I imagine the process to be something like slowly writing a story without a preconceived idea of how it will end. I am willing to publicly share the reasoning engendering the results while accepting with equanimity that other people may make different meaning from the same data. I am willing to trust the interpretive research paradigm, and most importantly, trust myself as a flexible instrument capable of aligning myself with the needs of the study and reflecting upon possible next steps as I proceed. I don't think that there is anything that I am not willing to discover, but I will let my feelings be the gauge. If I begin to feel anxious, wanting to withdraw, wanting to dismiss or manipulate what a respondent is saying, I will honor those feelings by considering that I may be coming up against something outside of my current belief system that feels threatening to discover.

It is my hope that this research project will be useful within the context of undergraduate science education reform and that the themes and patterns that emerge from the study will be helpful in understanding the possible range of experiences that faculty encounter as they introduce strategies for facilitating active learning in their classrooms.

APPENDIX F

Peer Debriefing: Selected Examples

Peer Debriefing: Selected Examples

7-30-2002 Peer Debriefing Meeting

Schlotsky's
X.L. present
BK present
PT present

PT

Discussion of observation of participants outside of study but issue is similar

The big question is how can professors who are teaching in a way that is clearly not facilitating learning….be entirely satisfied with what they are doing? Why is there no reflection on teaching situation? Why aren't they attending to facts in front of them? Why is perception blocked?

There is such a disconnect! It's as if another reality is playing out for the professor and for me..

Professor had said he was doing active learning but it was disappointing from my perspective. Follow up interview questions:

- Which component of your class did you feel was most successful for getting students involved in thinking conceptually?
- Which component demonstrated active learning?
- What evidence do you have that students were involved in conceptual learning.

Professor had indicated that teaching is a common sense activity. Why does he think this way? Does he have conversations with colleagues about teaching? Does he have conversations with colleagues about chemistry research? If yes or no? Why? What's the difference? Amazing that scientists who are problem solvers within the realm of their labs don't problem solve in their classrooms…what's even more frustrating is that they don't see any problems to solve?

My questions are that when you have a class of 250 students—is there some kind of mindset about teaching excellence being limited by the number of students? Because I have a large class…this is the best I can do?   Can it be more than lecture? Is excellence demonstrated merely by conveying excitement of the topic? Why is that excellence?

Becoming obvious that science faculty won't listen to non-scientists. There is no credibility from an expert outside the field. Another situation where there is a transfer going on…you can't help me because you don't know what I do…well other than that…I don't have any real problems to solve.

Seems like a critical issue that scientists and mathematicians are involved in organizing professional development issues. CTE staffers aren't getting the points across in terms that are concrete enough to be understood.

BK thinks that the approach being used to try to facilitate conceptual change is simply giving faculty info to read, digest and apply. But honestly you have to be working with them on a continuous basis in a classroom situation and waiting for them to raise an issue. Then once the issue is raised a dialogue can begin.

The frustration of faculty is perhaps that they feel they are being bombarded with information rather than guided through the real problems that are coming up in their classrooms.

My approach with A & P participants has been to help them be active learners themselves…I have to wait for critical issues to emerge and then begin a series of questions and challenges to help them discover the underlying theory on their own,

Approach of giving information to faculty is no more effective than lecturing students…sitting faculty down outside of their working context is proving to be quite frustrating…there is no connection

The approach has to be to help teachers discover pedagogy. The first step has to be getting them to reflect on what is going on in their classroom but the big question I have is, "How can it be that some simply WON'T engage?" They act as if the challenge I've presented to them is comical or ridiculous ….it's not…it's a problem they need to be dealing with.

Goal has to be to be in context with them through active dialog, asking them to raise issues that are occurring in the classroom and get them to realize that there should be dissatisfaction…geeze….they are not dissatisfied!!

XL story of using his collection of student questions to model what a good questions looks like…without the process, they don't have an idea of what a good question is…they have no reason to be dissatisfied until they have a new referent. Is this possible?

What does Fullan have to say on the topic?

What does Pintrich or Strike have to say on theoretical grounds?

BK

Big question is how does instructional design theory inform the current status of the calculus course?

XL

Big question is it possible to get at the issue of pedagogical content knowledge with participants who are unwilling to think out loud? What other tools aside from interview might allow the information to be accessed?

APPENDIX G

Reflexive Journal

Reflexive Journal

6-30-02

Maybe the reason some aren't reflecting is because there is the Issue of the danger of critical reflection…the risk involved. Is it my responsibility to prepare them tactically for political struggles that may ensue as they change systems?

Research the cultural barriers to change

Is it true that if we are going to encourage and promote reflection then we must "educate for critical reflection"? What does this require?

Careful study of the forces that oppose or support those who raise awkward and professionally inconvenient questions about the correct forms or purposes of teaching.

Research adult learning process for consideration of how college teachers go about identifying questioning and reframing their long-held assumptions about teaching and learning

Set up tables for Behaviorist and Constructivist paradigms to think about issues of being a life long learner…keeping the consumer happy…. what is the thinking that keeps people from making changes? How is it that reality can't be seen?

What does Perry's developmental scheme have to do with this? Why is there this dualism that hits me on the head when I hear some of the attempts at reflection. Yes, development and learning must include space for ambiguity

If instructors are letting student opinions and desires shape classroom practice they are ignoring the dynamics of the system and inhibiting their own development and learning…then when things go poorly of course it is the students' fault

Check Mezirow and Horton. They've described the critically reflective process and how it can be encourage. Look into adult education and think about faculty development from this perspective

As I think about writing think about describing seven peoples' journey…they find value in different contextual zed depictions….Their descriptions often to seem to be all over the place and this is so frustrating.

Where did I see the term “teaching innocently”…this is teaching from an uncritical stance…? The presumption is that we think we understand exactly what we are doing and the impact we are having on students…. the trap here is that when we experience resistances…. do we automatically define ourselves as incompetent.

Issue of consumerisms in which higher education is viewed as a market place in which colleges compete for a limited number of customers. Those who survive because they have enough customers must by definition be doing a good job….So is D blaming this societal view?

APPENDIX H

Activities Implemented by Instructor Participants

Introduction to Membrane Potentials

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I. Introduction

In living things, most cell membranes have **membrane potentials.** This difference in electrical charge between the inside and outside of the membrane is the basis for many types of physiological processes, including transport of particles across the membrane and signaling among cells. It is estimated that in some cells up to 40% of energy is used to power active transport, a process that maintains or restores membrane potentials. The goal of this module is to enable you to understand the mechanisms through which potentials are developed and changed over time.

II. Student Background

To complete this module successfully, you should have or be provided with the following background:

A. Basic operating skills for computers: open programs, navigate using a mouse, type in responses, etc.

B. Definitions of chemical and electrical gradients.

C. Graphing basics: reading axes, plotting points, stating in words the trends shown by a graph.

D. Skills to read and follow simple written directions.

III. Benchmarks for the Module

Having completed this module, you will be able to:

A. To represent a cell membrane by drawing a labeled diagram.

B. To identifying the hydrophobic and hydrophilic elements, gated and passive channels, molecular pumps and the distribution of ions and molecules on the in- and outside of the membrane.

C. To determine from a diagram the net charge in and outside the cell membrane using simple counting methods, and calculate the membrane potential in a static system using algebraic methods or the line method introduced in the module.

D. To predict how ions will move through passive ion channels, given a starting ion distribution across the membrane.

E. To represent a membrane potential on a graph and plot changes in potential over time from a data set that is provided.

F. To state in words, using the terms **resting membrane potential, depolarize,** and **hyperpolarize,** the changes in membrane potential over time illustrated in a graph.

G. To predict what will happen to membrane potential with the opening & closing of gated channels.

H. To illustrate the opening of channels, flow of ions, and change in potential using a paper model.

I. To graph changes in membrane potential for local potentials (PSPs) that depolarize and hyperpolarize the membrane and relate the segments of the curve to events in the membrane.

J. To predict what happens to Na^+ ions that flow into a neuron in producing local currents.

IV. Prelab Activities

A. The Intracellular and Extracellular Environments

__1. Use class notes and text readings, as assigned by your instructor, to complete the following steps. We encourage you to work with a classmate. When you complete a step, check it off in the space beside the number.

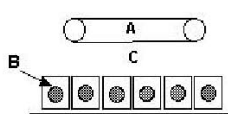
__2. The chemical makeup of **cytoplasm** inside a cell is quite different from that of the **interstitial fluid** (ISF) that bathes it (Table 1.1). It is with the ISF that cells directly exchange molecules and ions on a continuing basis. What are some molecules that are exchanged? ____ .

Table 1.1. Chemical makeup of the body fluids

Substance	**Interstitial Fluid Concentration**	**Intracellular Fluid Concentration**
Na+	142 mEq/liter	10 mEq/liter
K+	4	140
Ca2+	2.4	0.0001
Mg2+	1.2	58.0
Cl-	103	4
HCO3-	28	10
Phosphate ion	28	10
Glucose	90-100 mg%	0-20 mg%
Amino acids	4	75
Proteins	20k	160k
pH	7.4	7.0

__3. Figure 1.1 is a simple diagram of 3 **fluid compartments** in the body. A capillary (A) is drawn to represent the blood or plasma compartment, which exchanges water and solutes directly with the interstitial fluid compartment (C). The intracellular "compartment" (B) is actually the millions of individual cytoplasmic spaces inside each cell of the body. Label the compartments in Fig. 1.1.

Figure 1.1.



__4. Walls of most capillaries are quite leaky, and the gaps allow free exchange of water, small molecules and ions between the plasma and interstitial fluid. In Figure 1.1, draw a small circle to represent an oxygen molecule (O_2) in the blood, then use an arrow to indicate the direction of movement between the blood and the cell. Do the same for CO_2. Some large particles like protein molecules in the blood cannot normally cross the capillary wall, nor can most of the blood cells.

__5. Regulation of molecular exchange between the ISF and the intracellular compartments is accomplished by the cell membrane. You may have learned that the cell membrane is **semi-permeable**. What does that term mean to you? ___________________________________
____ .

__ 6. Figure 1.2 represents a piece of the cell membrane with the interstitial fluid above and the cytoplasm below. Label the compartments.

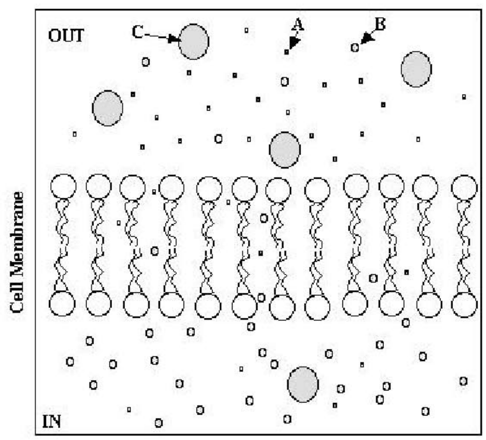


Fig. 1.2 Cell membrane, solutes and gradients.

__ 7. You may remember that an important part of the cell membrane is the **phospholipid bilayer** that is represented in this figure. Each phospholipid molecule in the bilayer has a phosphate head that is **hydrophilic** (attracted to water), and a pair of **fatty acid tails** that are **hydrophobic** (water repelling). The arrangement of the bilayer occurs automatically as a consequence of how each end of the molecule interacts with water. Looking at the diagram, can you briefly explain how this happens? ____
____ .

__ 8. Missing in Fig 1.2 are cholesterol molecules and the large proteins that are usually shown embedded in the cell membranes. We will study more about these important elements later.

B. Concentrations, Gradients, and Permeability.

__1. You may remember that in all fluid compartments of the body, **solute** molecules or ions (for example sodium ions or glucose) are dissolved in the **solvent** water. At physiological temperatures, the solute particles move rapidly (Brownian motion), colliding with one another and with the membranes of the cell.

__ 2. Also, each solute is present in a particular **concentration**. To review: Concentration refers to *the number of solute particles per unit volume of solution.* There are several measures, two of which are given in Table 1.1. What are they? ______________________________________ .

__ 3. Look at Figure 1.2 again. Assume for our work that the volume of solution both inside and outside the membrane is 0.1 ml. What would be the concentration of small molecules outside in the interstitial fluid? Use the measure "particles/ml" as the unit of measure. Enter the results into the data box.

Concentration

__ 4. What are the concentrations of medium sized molecules both in- and outside the cell?

Inside	**Outside**

__ 5. **Concentration gradients** exist in situations where the number of molecules per unit volume (concentration) at one location differs from that at another. In the prior item, you discovered that a concentration gradient exists across the cell membrane. The "high" end of the gradient is the location where the concentration is greatest. The other is the "low" end. In diffusion, the **net movement** of molecules by random motion is down the concentration gradient, from the high to the low end. Do molecules in a gradient ever diffuse up the gradient? Explain.

Movement up a concentration gradient? Explain.
____
____
____
____
____

__6. The movement of molecules is driven by the concentration gradient that exists between the two sides. A good definition of concentration gradient is "the change in concentration of a solute molecule over a distance between two points." One point is at the high end of the gradient, the other point is at the low end. In this module, we will be dealing primarily with very short distances, from one side of the cell membrane to the other, so the main focus will be upon concentration differences.

__ 7. The direction and rate of net movement due to **diffusion** depends largely on the differences in concentration for a molecule on the two sides of the membrane. The larger the difference in concentration, the faster the rate of movement can be across the membrane.

__ 8. In Figure 1.2, how many concentration gradients can you identify? ___________ .

__ 9. If a cell membrane is permeable to solute particles, some will move across to the adjacent compartment. In the Figure 1.2, you can see some tiny solute molecules between the larger phospholipid molecules of the membrane, possibly on their ways from one side to the other. Add arrows to a few of the small and medium sized molecules to indicate in what direction you think they are heading. Explain your prediction.

Explain your predictions in Fig 1.3

____
____
____
____
____

__ 10. **Electrical gradients** are especially important in moving charged particles into or out of a cell. You may remember from basic principles of magnetism that like charges repel one another, while opposite charges attract. In an electrical gradient, like that across the cell membrane, there are more negative charges inside and positive charges outside. If the membrane is permeable, positively charged ions (Na^+, K^+, and Ca^{++}) will be attracted inward, attracted to the negative charges in the cytoplasm.

__ 11. Now consider the electrical and concentration gradients together (Table 1.1). Do the two gradients for Na^+ work in the same or opposite directions? __________ What about K^+ ? __________________ . Predict how you think Na^+ and K^+ will move across the cell membrane. Which will have the strongest flow? ____
____ .

__12. Recognizing that an ion may be a part of 2 gradients at the same time, we can talk about its combined **electrochemical** gradient. In the case of K^+, the chemical concentration gradient tends to move potassium ions ______ the cell, but the electrical gradient moves them ___________.

__ 13. Diffusion of solutes across the membrane (Fig 1.2) depends on concentration gradients, but also on **membrane permeability** to the solutes. Two factors that influence the permeability of a membrane to a particular kind of solute particle are:

a. The size of the particle. Smaller particles pass across more easily than larger ones. Very large ones may not pass at all. The membrane is impermeable to them.

b. The electrical charge of the particle and/or it solubility in lipids. Electrically charged particles, called ions (example, Na^+), do not dissolve well in lipids, and the phospholipid bilayer is rather impermeable to them. The lipid connection to permeability is due to the fact that the center of the cell membrane is made of lipids (fatty acids). Many solutes must dissolve in the lipids in order to pass across.

__ 14. No electrically charged particles are shown in Fig 1.2. Based on size alone predict the permeability of the membrane to the three types of solute particles.________________________
____ .

__ 15. If we allow diffusion to occur, starting from the arrangement of solutes shown in Fig. 1.2, predict what changes will occur in the distribution of particles in and outside the cell membrane. Explain your predictions.

Predictions of particle distributions resulting from diffusion.
____
____
____
____
____

__ 16. The movement of particles in Fig 1.2 will result in a stable distribution on either side of the membrane for some of the particles. In this **dynamic equilibrium**, exchange across the membrane still occurs. However, the number of particles crossing in one direction is, over time, equal to the number crossing in the other direction, so the net movement is zero.

__ 17. In the case of large particles like C that don't cross the membrane in Fig 1.2, there is no dynamic equilibrium and a concentration gradient is maintained by the impermeability of the membrane.

V. Collaborative Learning

Collaborative learning is a strategy for improving students' efficiency and success on learning tasks that can be done in groups. It includes a **division of labor** on the task and **specific roles** for each student. Designed for tasks in which students are active learners (learning by doing, rather than by listening passively), collaborative learning encourages sharing and mutual help, rather than competition. Students must initially learn how to set up a group that works well, and how a task is organized to be done most effectively by a group. It is the purpose of this section to introduce collaborative learning methods which can then be used in the rest of this lab.

A. General Guidelines:

- The work for each task is divided up among the members, and each person has a role to play that is important for the success of the group's work.
- All members must participate and contribute, but no one may dominate or take over the work. Each member's input should be respected.
- If one member has a task that is long, difficult or troublesome, other members should help out.
- All information gathered by the group is shared among the members. It is expected that all members will understand what has been done and studied.
- Roles initially are assigned by birthday. The person with the nearest birthday becomes the principal investigator (PI) and so on.
- When the group does a new task, the roles are rotated.

B. Roles for Collaborative Learning

- ***Principal Investigator (PI)*:**
  a. makes sure each step of the task is completed in sequence.
  b. keeps the group on task, and within the time budget.
  c. communicates with the instructor about questions or problems the group has.
  d. leads the discussion in planning the task and in wrapping up the work.
  e. checks that everyone understands what was done or studied.

- ***Materials Manager (MM)*:**
  a. gathers all equipment and materials for the group.
  b. sets up the materials or directs the setup.
  c. operates the equipment (with the help of other if needed).
  d. organizes the clean up.

- ***Tracker-Researcher (TR)*:**
  a. locates the directions for the task.
  b. reads directions aloud to the group as the work proceeds.
  c. looks up additional information, diagrams, or readings to help the group.

- ***Recorder-reporter (RR)*:**
  a. records data, notes, answers to questions, etc. as the task proceeds.
  b. makes sure that each group member gets the information that is collected.
  c. reports to the class when groups share their results.

C. Group Organization

Set up your own group, assigning roles by birthdays. Fill in the table below.

Table 1.2. Assignment of roles for collaborative learning.

Task/Assignment	Group Member
Principal Investigator	
Materials Manager	
Tracker-Researcher	
Recorder-Reporter	

VI. Exploration

Based on your prior understanding, work with your group to answer two questions.

1. In the body, molecules move in and out of cells, across the cell membrane. What are some factors that cause molecules and ions to move back and forth across the cell membrane?
2. How do different molecules and ions like water, glucose, sodium ions and others get across the cell membrane?

Exploration Notes

VII. Membrane Potentials: Learning Activities

A. Introduction to Membrane Potentials (CD ROM)

__1. Work with your group on these computer-based activities. If you have not done so already, mount the CD-ROM onto the drive of your Mac or PC computer. Click the icon for the CD ROM drive or the APCD icon. Double click the file called Apmain to run the program.

__ 2. After the opening screen with music and credits, a menu will appear. Click on the globe at the lower left of the screen to bring up the **Sections** menu.

__ 3. Click on the "Membrane Characteristics" triangle to start with this section.

__ 4. In the first screen there is a review quiz for the cell membrane (which you have been studying in the prelab activities). Start the quiz by clicking on the yellow start button, and then dragging the labels onto the diagram. You will get feedback on your responses.

__ 5. When you finish, click on the single navigation arrow that points to the right located at the bottom of the screen. That will take you to the next frame. When you complete each frame or section, use navigation arrows to continue or go back.

__6. Complete the "Membrane Characteristics" and "Membrane Potential" sections to the end of the CD. Be sure to answer all the questions as you go along.

__7. If you have time, you can explore other sections.

B. Membrane Potentials

__ 1. All cells in our bodies have **membrane potentials**. The remainder of this module is devoted to understanding how they are established and maintained, and how they change over time. The concepts introduced here build upon your foundation of knowledge about cell membranes and gradients. Therefore, it is essential that you have a strong grasp of material in the prior sections. Review if you lack confidence in understanding the earlier material.

__ 2. Based upon what you learned from the computer program, define or describe what you think a membrane potential is. ____
____ .

__ 3. Does a membrane potential involve a gradient? Explain. _______________________
____ .

__ 4. How does the gradient involved here differ from the concentration gradients you studied earlier? ____ .

__ 5. It is important to distinguish between **charge** and membrane potential. An ion carries a positive or negative electrical charge that contributes to the **net charge** in one location such as in the cytoplasm of a cell. The net charge is the algebraic sum of all positive and negative charges in that area. For example if there were 5 + charges and 3 - charges, the net charge is +2. When the net charges in two separated areas are compared there may be a difference (gradient). The <u>difference in charge</u> on the two sides of the membrane is the membrane potential.

__ 6. When you are done, share your answers with another group or the rest of the class .

C. Working with the Membrane Model

__1. Membrane potentials are vital to the life of every cell. They are used to produce and conduct signals (especially in neurons and muscle cells), transport molecules across the cell membrane (for example, in moving glucose across the wall of the gut), and many other functions. Cells spend great amounts of energy maintaining membrane potentials by "pumping" ions in and out across the cell membrane. Understanding the cellular basis of many physiological processes ultimately involves a knowledge of membrane potentials.

__ 2. Find the cell membrane template at the end of this module and place it on the table with the various items that are used with it. You will notice that the membrane on the template has two gaps. In these locations you can place a number of different elements to represent the structure of the membrane. Membrane "patches" simply complete the phospholipid bilayer, while channels of various types add functional proteins that are involved in solute transport. Finally, the molecular pumps provide active transport of substances across the membrane using metabolic energy (ATP). Also the template has large, negatively charged proteins shown in the cytoplasm. What is the total negative charge of these molecules? ___________ .

__ 3. Paper circles with plus (+) or minus (-) signs on them represent **ions**. For our purposes, we will define each ion as contributing one unit of positive or negative charge to the in- or outside of the cell. When we measure the difference in net charge on the two sides of the membrane, we will express the resulting membrane potential in **millivolts (mV)**. For this simulation each difference of one unit of charge will be recorded as a millivolt of potential. So if the outside has a net charge of +2 and the inside -2, the membrane potential will be -4 mV. In actual life, each ion carries a very tiny amount of charge. Differences in the millions of ions are needed to produce each millivolt of membrane potential.

__ 4. To prepare for the simulations, cut out the elements as needed and punch out the ions using a single-hole punch. One set will be sufficient for your group.

__ 5. An "instrument" for measuring potential difference between the inside and outside of the cell is the voltmeter. In the model you have, the scale on the face of the meter measures between -25mV and +25 mV, with zero at the midpoint. Assemble the voltmeter as directed by your instructor. Align it so that the <u>reference electrode</u> is on the outside of the membrane and the <u>recording electrode</u> is inside. Electrodes are made of materials that conduct tiny currents to the voltmeter. So arranged this meter should display the difference between the inside charge and

__ 4. How does the gradient involved here differ from the concentration gradients you studied earlier? ____ .

__ 5. It is important to distinguish between **charge** and membrane potential. An ion carries a positive or negative electrical charge that contributes to the **net charge** in one location such as in the cytoplasm of a cell. The net charge is the algebraic sum of all positive and negative charges in that area. For example if there were 5 + charges and 3 - charges, the net charge is +2. When the net charges in two separated areas are compared there may be a difference (gradient). The difference in charge on the two sides of the membrane is the membrane potential.

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__ 6. Set up the voltmeter by cutting out the 2 pieces and connecting them with a paper fastener at the center of the meter. The arrow should be set to rotate over the range of values on the meter.

__ 7. For the first exercise place membrane patches into the gaps on the template. Next, add paper ions to the template so that the total charge outside the membrane is +8 units. Then add ions inside the cell so that the membrane potential is -11 mV. Record your information in the data box below. Align the arrow on the voltmeter to show the correct reading.

Membrane potential problem.	
Cytoplasm	**Interstitial Fluid**
Large protein (number/ total charge) _______	**Large protein (number/ total charge)** _______
1+ cations (number/ total charge) _________	**1+ cations (number/ total charge)** _________
1- anions (number/ total charge) _________	**1- anions (number/ total charge)** _________
Net charge inside the cell _________	**Net charge outside the cell** _________
Membrane Potential _______________	

D. Resting Membrane Potentials

__1. Although the phospholipid bilayer of the cell membrane is largely impermeable to ions like sodium (Na^+), potassium (K^+) and chloride (Cl^-), these ion may pass through the membrane from time to time through passages in large protein molecules called **channels.** With your model template you have three channels, two for Na^+ and one for K^+. Channels have several important properties you should know in order understand transport of ions across the cell membrane:

a. Channels are selective in what ions they allow to pass through them. For example, the structure and internal electrical charges in a K^+ channel enable rapid facilitated diffusion of K^+ ions to occur down the concentration gradient, but permit little or no flow of Na^+ and Cl^- ions.

b. Channels may be **passive** or **gated**. Some channels, like the ones represented in this simulation are open all the time, allowing ions to trickle constantly through them at some rate (for example 100 ions/sec). Later you will be constructing **gated channels** that can open or close in response to changes in the cellular environment.

c. Channels can vary the **conductance** of the cell membrane for different ions. Membrane conductance for a particular ion is a measure of the ease with which it can flow across the membrane through all its channels. To understand this, set your template up with membrane patches in both gaps. In this situation what is the Na^+ conductance? ____________ . If now you substitute one Na^+ channel for a membrane patch, what happens to the conductance? _________. If you add 2 Na^+ channels? ____________ .

__ 2. Set your template up as follows: fill the gaps with one K^+ channel and one membrane patch. Remove all ions from the ISF (outside the membrane). Add 10 K^+ ions to the cytoplasm. Record the net charge inside and outside the membrane, and the membrane potential. Set your voltmeter to the correct reading.

Inside	**Outside**	**Membr Pot.**

__ 3. Now move one K^+ ion through the membrane to the outside. What happens to the net charges inside and outside the cell? ____________________. What happens to the membrane potential? _____________. What is causing the K^+ ions to move outward? _____________ . Move two more K^+ ions out. What happens? __________________________________ .

__4. You probably discovered that each time a K^+ ion left the cell, the inside of the cell got more negative and the outside (ISF) go more positive. Also, the membrane potential got larger. The result is that a larger and larger electrical gradient is being produced with a positive end that tends to repel cations like K^+. Does the electrical gradient work with or against the outward diffusion of K^+ ions across the membrane? _______________________________________ .

__ 5. If the molecules and ions inside the cell were allowed to move naturally now, what would you predict that the distribution would be after a few seconds or minutes? Explain your answer.

Distribution of protein molecules and K^+ ions across the membrane

__6. In this situation where the concentration and electrical gradients oppose one another, eventually a dynamic equilibrium would be reached. Then the number of K^+ ions moving out of the cell down the concentration gradient would exactly equal the number moving down the electrical gradient (moving from the outside which is more positive to the inside which is more negative). For the model, let us assume that dynamic equilibrium is reached when 3 K^+s have left the cell. Determine the membrane potential at that point using the model. ________mV. This is called the equilibrium potential for K^+.

__7. In actual cells, the **resting membrane potential** is determined largely by the dynamic equilibrium potential of the ion (K^+) with the highest conductance across the cell membrane. Both Na^+ and Cl^- have very low conductances across the membrane and influence the membrane potential in a smaller way.

__ 8. If Na^+ and Cl^- ions had high conductance, in what direction would they move across the cell membrane? What would be the consequence on membrane potential for each one. Explain.

What would happen with high Na^+ conductance? High Cl^- conductance?

E. How Membrane Potentials Change

__ 1. Set up your template with a K^+ channel in one gap, and a sodium channel in the other. To each of these channels lay a gate across the opening on the outside of the membrane. The small notch in the gate should face up.

__ 2. Add the following ions to the ISF: 10 Na^+, 1 K^+, and 3 Cl^-. Add the following ions to the cytoplasm: 1 Na^+, 10 K^+, and 1 Cl^-. Note that these do not represent physiological proportions, but will be useful for helping you do the simulations.

__ 3. Determine by counting and techniques you learned in the computer activity what the membrane potential is for this model cell. Record it here.

Membr Pot.

__4. Observe the channels that you set up on your template. These are what types of channels? Specify both the ion and means of opening/closing. ________________________________ .

__ 5. One type of gated channel that is vital for communication between cells in the body is controlled chemically. These are found, for example, in the connections between nerve cells (motor neurons) and the skeletal muscle cells they activate. So when you decide to flex your arm at the elbow, the signal is sent out to the skeletal muscle cells of the biceps brachii muscle by means of motor neurons that signal the muscle to contract. In this example, the motor neurons release a chemical signal (acetylcholine) that attaches to the channel protein at a special **receptor site**. The arrival of the chemical signal causes the gate to open briefly.

__ 6. To be sure you understand this concept, choose the square signal molecule for your model, attach it to the receptor site on the gate of the Na^+ channel, and rotate the channel to an open position. Demonstrate what happens to the ions.

__ 7. The attachment between the signal molecule and the receptor site is weak. Soon it detaches and the gate closes. The signal molecule is split apart by enzyme (not shown here) in the cell membrane. You can simulate this by simply removing the square signal molecule.

__ 8. Based upon what you have learned so far, predict what will happen to membrane potential when Na^+ gate is opened. ____ .

__ 9. Test your prediction by running the following simulation: Attach the signal molecule to the channel, open the gate, move 3 Na^+ into the cell, and close the gate. Determine the new membrane potential and record it here. What forces tend to move Na+ into the cell? ________ ____ .

Membr Pot.

__ 10. If you did it correctly, there is a change called **depolarization** of the membrane. Confirm that the potential difference across the membrane was reduced (went closer to zero). This depolarization takes the membrane from its resting potential closer to zero.

__ 11. The influx of Na^+ ions creates a new gradient inside the cell. To understand this, consider the concentration of sodium ions in the cytoplasm directly beneath the channel compared to the concentration in the surrounding area. What is the gradient? _________________________ .

What do you expect will happen to the extra Na^+ ions that just came in? ________________ . The resulting diffusion of ions creates a tiny current in the cell. It also will restore the local membrane potential back toward the resting value.

F. Graphical Representation of Membrane Potentials

__ 1. Membrane potentials change rapidly over time. In a matter of a few milliseconds (one-thousandth of a second) major shifts can occur in membrane potentials with the production and transmission of signals among cells of the body. These changes are often represented graphically as shown in Fig 1.3. This graph represents a recording, over time, of the membrane potential from a single cell. You may remember that the recording electrode is inside the cell (cytoplasm) while the reference electrode is outside in the ISF.

__ 2. Examine the axes on this figure closely. The Y-axis represents the membrane potential with the convention we used consistently in this module. The values represent the electrical charge inside the cell as compared to the outside. Notice especially the location of zero on the Y-axis. At zero there is no potential difference between inside and outside the cell. Going down the scale from zero, is the inside of the cell is more or less negative compared to the outside. ___ Is the potential difference across the membrane larger or smaller? ___________ .

__ 3. The X-axis represents time in **milliseconds (msec)**. How many marks on the axis per msec? ________ .

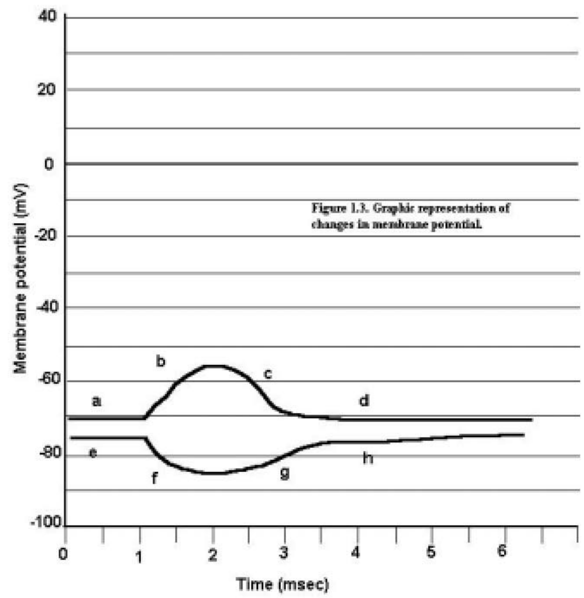


Figure 1.3. Graphic representation of changes in membrane potential.

__4. Look at the top curve **abcd** and answer the following questions:

a. In the curve, what is the name of the event when the curve goes up at **b**? _______

b. Referring to you work in the prior section, what change in the membrane is likely to have caused the shift in membrane potential at **b**? ______________________________

c. What is the resting membrane potential of cell? ____________

d. What event inside the cell is responsible for the change in potential labeled **c**? ______ ____.

__ 5. The lower curve in Fig 1.3 comes from recording in a different cell. What is its resting membrane potential? ________________________ .

__ 6. Using your template can you determine what event might have caused the change in potential labeled **f**? ______________________ . What is the most negative reading on the curve? ________________ .

__ 7. The opening of a Cl^- channel triggered a chemical signal results in an inflow of Cl^- ions from the ISF, causing the cell to become even more negative inside compared to the ISF. The result is that the membrane is **hyperpolarized** briefly, and then returns to resting potential.

__ 8. The events represented in Fig 1.3 are frequent occurrences in neuron and muscle cells. The brief depolarization of the membrane in response to a chemical signal (neurotransmitter) is called an **excitatory post-synaptic potential (EPSP)**. It is so named because it increases the likelihood that the cell will produce an **action potential**, a another type of communication signal.

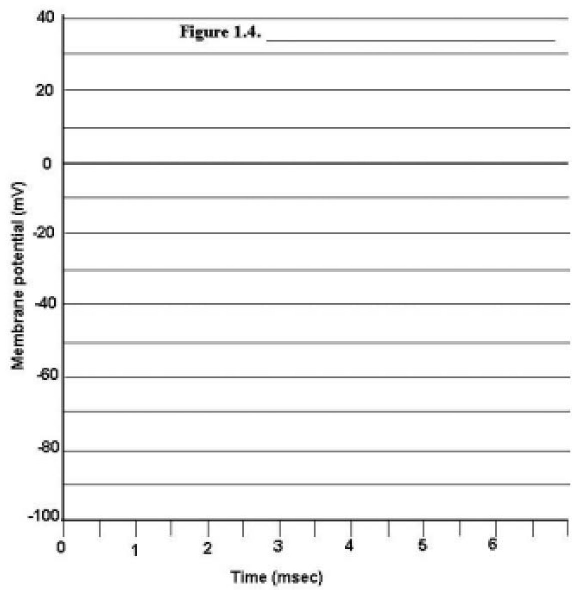
__9. The hyperpolarization in Fig 1.3 is called an **inhibitory post-synaptic potential (IPSP)**. These signals have the opposite action of EPSPs. They decrease the likelihood that the cell will produce an action potential.

__ 10. Use the blank graph in Fig 1.4 to graph the data from Table 1.3. The recordings in the table are from two different cells. Plot the points in Fig 1.4 and connect them to make the curve.

__ 11. When you have completed the graphing, label the segments of each curve referring to Fig 1.3. (A new segment begins with a change in direction of the curve). You may need to use more letters on the top curve than the bottom.

	Membrane potential (mV)	
Time (msec)	**Cell 1**	**Cell 2**
0	-60	-75
0.5	-60	-75
1.0	-60	-75
1.5	-50	-75
2.0	+20	-84
2.5	-50	-88
3.0	-60	-84
3.5	-65	-75
4.0	-63	-75
4.5	-60	-75
5.0	-60	-75

Table 1.3. Membrane potential recordings for two cells



__12. Next, interpret, in words, what is happening in each segment of the curve. Suggest what is happening in the membrane to bring about the changes from one segment to the next.

Explain the changes in membrane potential & what is causing them.
____
____
____
____
____

__13. The sudden large changes in potential represent an **action potential.** Action potentials are rapidly conducted signals. In neurons they trigger neurotransmitter release; in muscle cell they cause contraction. Action potentials occur in certain parts of the cell membrane where there are **voltage-activated gated channels**. The sequence of events is the following. When a section of membrane is depolarized by EPSPs to a level called **threshold** (by the opening of chemically activated Na^+ channels), action potentials are triggered. Refer to Fig 1.4 to see the segment of the curve between 1.0 and 1.5 msec. This initial depolarization (EPSP) brings the cell to threshold. What is the threshold value? __________ mV.

__ 14. In interpreting the segments of the curve which make up the action potential, note that for a brief period of time, the membrane potential is actually reversed. Locate this portion of the action potential and label it "reversal of membrane potential".

__15. The upward section of the curve between 1.5-2.0 msec is due to the opening of voltage-activated Na^+ channels that allow Na^+ to flow briefly into the cell. The downward segment from 2.0-2.5 msec is due to outward movement of K^+ ions through voltage-activated channels. The period of hyperpolarization between 3.0-4.5 msec results from the fact that more K^+ leave the cell than required to bring it back to resting potential.

G. Maintaining Gradients and Potentials across the Cell Membrane

__ 1. Thus far, we have talked mostly about the movements of ions and down their concentration or electrical gradients. Unless there were movements in the other direction, against the gradients, what do you predict would eventually happen? ____________________
____ .

__ 2. Ions and molecules do regularly move against their concentration gradients across cell membranes, but at a cost of energy to the cell. This is the process of **active transport**. Turning to your template again, place a "pump" protein in each of the gaps in the membrane. One of the best known of these pumps is the **Na^+/K^+ -ATPase** molecule (Fig 1.5). Embedded in the cell membrane, this protein uses the energy of ATP to pump Na^+ out of the cell and K^+ in, both <u>against their gradients</u> .

__ 3. Frame 1 of Fig 1.5 shows a diagram of a Na+/K+ ATPase protein embedded in the lipid bilayer. You will notice the protein has several parts. Part **B** anchors it in the bilayer because it is hydrophobic. The other sections (**A** & **C/D**) are hydrophilic facing into the ISF or the cytoplasm. Segment **C/D** has multiple binding sites for ions. The sites with lighter outlines bind Na^+, while those with heavier outlines are specific for K^+. The binding sites change shape during the transport process indicating their availability to bind with the ions. In Frame 1, for example the Na^+ sites are open (available), while the K^+sites are closed (unavailable) to binding.

__ 4. View the frames in Fig 1.5 to follow: a) the binding of ions (frame 2), b) the change in protein shape which exposes the binding sites to the opposite side of the membrane (frame 3), c) the release of Na^+ ions and binding of K^+ in the ISF (frames 3 & 4), and d) the completion of the cycle (back to frame 1).

__ 5. To check the effects of this action on membrane potential, set up your model with the protein pumps in the gaps. Then add the following ions. Inside: 4 Na^+, 10 K^+, 1 Cl^-; outside: 7 Na^+, 3 K^+, and 3 Cl^-. Determine and record the membrane potential.

M.P. before

__ 6. Now run a simulation, going through the steps you studied in Fig 1.5 for one cycle, moving Na^+ and K^+ ions across the membrane. Try to do each step. Record the new membrane potential.

M.P. after

__7. In comparing your result, answer the following:

a. What did the pump cycle do to the size of the gradient for each ion? _____________ .

b. What did the pump cycle do for the membrane potential? ______________________ .

__ 8. Because of the effect the pump has on the membrane potential, it is called an **electrogenic pump**. It not only restores the gradients, but also actually alters the membrane potential, making the inside more negative compared to the outside.

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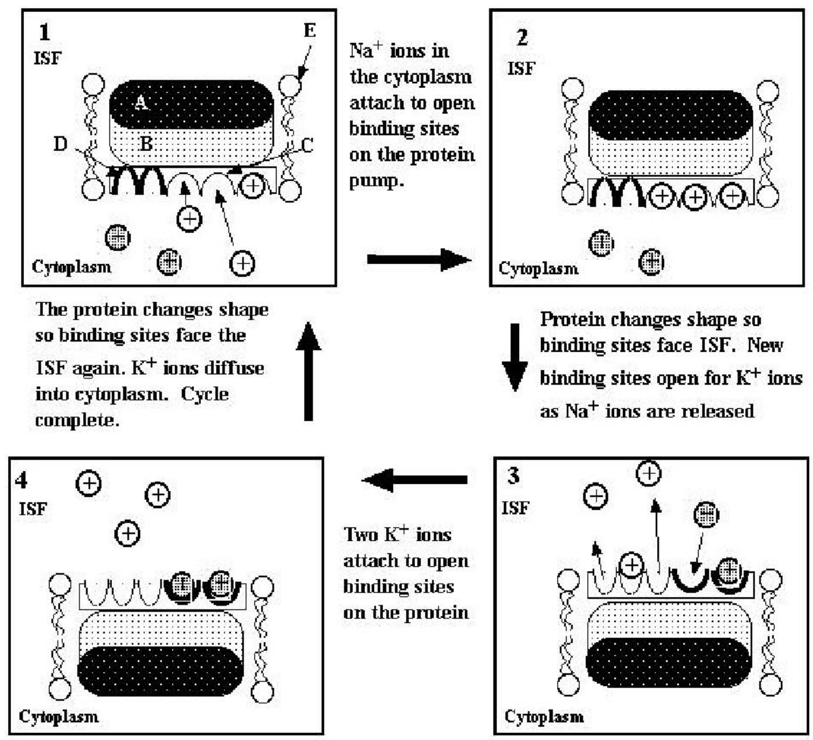
__ 8. Because of the effect the pump has on the membrane potential, it is called an **electrogenic pump**. It not only restores the gradients, but also actually alters the membrane potential, making the inside more negative compared to the outside.

__ 9. The ongoing work of **Na^+/K^+ -ATPase** pumps in the cell membrane restores and maintains the critical gradients needed to carry out other vital cell activities, especially transport and signaling.

Figure 1.5. Active Transport across the Cell Membrane by the Na^+/K^+ ATPase Protein "Pump" *(See key below)



K^+ ions **Na^+ ions**

A = a hydrophilic segment of the protein pump B = a hydrophobic segment of the protein pump

C = binding sites for Na+ ions on a hydrophilic segment of the protein pump

D = binding sites for K+ ions on a hydrophilic segment of the protein pump

E = phospholipid molecule in the membrane bilayer

* The energy molecule ATP and its by-products are not shown in the diagram

VIII. Problems to Solve (Assessment)

Use the problems provided by the instructor to check your understanding of gradients and membrane potentials. We encourage you to work with or check answers with a classmate or study group.

IX. Vocabulary

Review the following terms from this module and be sure that for each you can give: a) a definition in your own words, b) an example, c) at least one relationship with another of the terms.

action potential
active transport
body fluid compartments
channels
chemically activated gates
concentration
concentration gradients
conductance
cytoplasm
depolarization
diffusion
dynamic equilibrium
electrical gradients
electrode
electrochemical gradient
electrogenic pump
excitatory post-synaptic potential (EPSP)
fatty acid (tails)
gated channels
hydrophilic
interstitial fluid (ISF)
hydrophobic
hyperpolarized
inhibitory post-synaptic potential (IPSP)
ion binding sites
membrane permeability
membrane potentials
milliseconds (msec).
Na^+/K^+-ATPase
net charge
net movement
passive channels
phospholipid bilayer
receptor site
resting membrane potential
semi-permeable

solute
solvent
threshold
voltage activated gates
voltmeter

Prof. A. Using concept maps as cooperative learning

Using concept maps as cooperative learning activities to explore hemodynamic principles
(Student version)

Steven N. Trautwein, Ph.D.
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I. **Introduction.** In lecture, you have heard about the relationships between pressure, flow and resistance, along with the various factors that control these entities. This activity will show you how to build and use concept maps, which allow you to manipulate in a concrete manner the causal relationships between and among the various factors that determine blood pressure. It will also allow you to see how more than one factor can have an influence on blood pressure at the same time. Working in groups, you will be asked to explain why you have made certain decisions about the relationships you suggest. This will help you to identify areas where your understanding of the material is sound and where it needs some work.

II. **Objectives/benchmarks**. As preparation for this exercise, you should review the following objectives from your lecture notes and textbook:

a. Define end-systolic volume and end-diastolic volume.
b. Define stroke volume.
c. Define heart rate.
d. Define cardiac output and explain what determines cardiac output.
e. Describe the effects of *preload* on stroke volume. This would include a description of the Frank-Starling Principle.
f. Describe the relationship between end-diastolic volume and preload.
g. Describe the effect of myocardial *contractility* on stroke volume.
h. Describe those factors that will affect contractility.
i. Describe the effect of *afterload* on stroke volume. Tell one factor that can affect afterload.
j. Describe the autonomic control of heart rate, including listing the neurotransmitters and their effects.
k. Describe the effects of selected hormones on heart rate.
l. Describe what is meant by "resistance" in the circulatory system and point out where the greatest variation in resistance occurs in the circulatory system.
m. Describe how Poiseuille's Law can illustrate the factors that determine resistance.
n. Describe the control of resistance.
o. Describe the effects of cardiac output and resistance on mean arterial pressure (MAP).
p. List the effectors for cardiac output and for resistance and describe their effects on MAP.

After this exercise, you will be able to do the following:

q. Demonstrate an understanding of the causal relationships between flow, resistance and pressure.
r. Demonstrate an understanding of the factors that control flow and resistance, and their subsequent effect on blood pressure.

III. **Underlying Concepts.** Mean arterial pressure (MAP) is the product of cardiac output times resistance in the arteries and arterioles. Cardiac output is the product of heart rate times stroke volume. Any control mechanism that changes HR, SV or resistance, will thus have an effect on MAP. HR is controlled by nerves and hormones. Sympathetic release of norepinephrine onto the SA node increases HR (positive chronotropic effect) while parasympathetic release of acetylcholine decreases HR (negative chronotropic effect). Hormones from the adrenal medulla (epinephrine and norepinephrine) and thyroid (T_3, T_4) increase the HR

Stroke volume is the difference between EDV and ESV, so increasing the former or decreasing the latter will increase the SV. The converse is also true. The Frank-Starling Principle describes the relationship between venous return and EDV, via the concept of preload. An increase in myocardial contractility (positive inotropic effect) is accomplished by the sympathetic release of norepinephrine onto the myocardial cells. Release of epinephrine/norepinephrine from the adrenal medulla likewise has a positive inotropic effect.

The factors in Poiseuille's equation that affect resistance are length of the vessel, viscosity of the blood, and the fourth power of the radius. The latter is the only one under physiological control in the time scale operative for adjusting blood pressure. Arteriolar smooth muscle is responsible for changing the radius of these resistance vessels. It, in turn, is under the control of epinephrine/norepinephrine from the adrenal medulla and the sympathetic nerves.

IV. Learning Activities. You will be organized into groups of 4-6. Each group will be given a stack of index cards containing terms used in describing the relationships between pressure, flow and resistance. You will be given instructions on how to use these cards.

First activity: Arrange the cards into meaningful groups. Be prepared to explain to other student groups why you placed the cards into these groups.

Second activity: Draw arrows between the cards. Make sure that all the cards have been included. Be prepared to explain why you placed the arrows where you did.

Third activity: For each arrow, write a short label that tells what it means. Be prepared to explain why you chose each label. This arrangement of terms, arrows, and labels, is the concept map.

Fourth activity: You will be given some blank cards. On each card write a word or phrase that can be added to the concept map you have created. Place each of these new terms in their appropriate location, complete with arrows and labels.

Note: during each of these activities, you will be able to show your understanding of the material by explaining the reasons for the decisions you made. You will also be able to identify areas that you have difficulty in understanding. Finally, by seeing how other students have constructed their concept maps, it's possible that you will learn more about these relationships than you knew at the beginning of the activity.

V. Assessment.

To demonstrate your mastery of the above objectives on an examination, you will be asked to construct a concept map similar to that which was constructed during this exercise. You will be given a list of terms to use in the concept map. This list will not be identical to the list used in this exercise. You will also be expected to supply additional terms that will make the concept map more complete.

BLOOD VESSELS AND BLOOD PRESSURE

1. Describe what would happen to blood flow through arterioles as a result of each of the following:

    A. Application of heat

    B. Sympathetic Nervous System stimulation of α_1 receptors

    C. Histamine release

    D. Sympathetic Nervous System stimulation of β_2 receptors

    E. Application of cold

2. A subject rides an exercise bike for 30 minutes. Describe the blood flow changes to each of the following vascular beds, and give qualitative descriptions to changes (i.e. "increases slightly" or "decreases a lot", etc.). Secondly, explain *why* these changes occur.

    Kidneys

    Muscles in legs

    Heart

Brain

Muscles in arms

Small intestine

3. Normal values for the following pressures found in the capillary are given below.

Pressure	at beginning of cap.	at end of capillary
Capillary blood pressure (CBP)	37 mm Hg	17 mm Hg
Interstitial fluid hydrostatic pressure (IFHP): due to presence of fluid in interstitial space)	1 mm Hg	1 mm Hg

A. On the capillary shown above, use arrows to draw the <u>direction</u> and <u>relative magnitude</u> of these fluid forces on each end.

B. In addition to the fluid in blood, there are also a large number of *plasma proteins*, which are osmotically active. Because these proteins are large, they remain "trapped" within the capillary (cannot pass out into interstitium). The osmotic pressure they exert has a magnitude of 25 mm Hg. On the capillary shown below, draw the <u>direction</u> of the osmotic force due to plasma proteins (also called the plasma oncotic pressure, POP) on each end. Draw your force arrows to indicate the relative magnitude of this force compared to the fluid forces you drew above.

C. Add the fluid forces drawn on the first capillary to the one above. You should now have separate arrows for CBP, IFHP, and POP at both ends of the capillary. Mark the numerical values for the forces on each arrow.
D. Using simple addition, figure out the following values for each end of the capillary:

Beginning of capillary:

Value for net *ultrafiltration* pressure (outward force): ____________ mm Hg

Value for net *reabsorption* pressure (inward force): _____________ mm Hg

Direction and magnitude of overall force:
____

End of capillary:

Value for net *ultrafiltration* pressure (outward force): ____________ mm Hg

Value for net *reabsorption* pressure (inward force): _____________ mm Hg

Direction and magnitude of overall force:
____

E. **<u>Summary of fluid movement</u>:**

At the beginning of the capillary, fluid moves ______________________ with a magnitude of ______________ mm Hg of pressure. At the end of the capillary, fluid moves ___________________ with a magnitude of _____________ mm Hg. of pressure.

F. Does the net ultrafiltration pressure (moving fluid "out") equal the net reabsorption pressure (moving fluid "in")? What happens to the "extra" fluid?

G. Come up with three <u>different</u> ways in which these "normal" pressure values (CBP, IFHP, POP) could be changed to cause edema.

APPENDIX I

Belief Data and Supports/Obstacles used to construct condensed Case Studies

Prof. C: Beliefs Related to Teaching and Learning

	Pre-Project	Post-Project
What is learning?	Gathering and integrating facts from different sources followed by understanding sequences, logical patterns, points of comparison, problem solving, and making conjectures.	There are different levels--a factual level, more complex level where knowledge is linked and can be applied, the level where an integrated knowledge structure can be used to solve novel kinds of problems. Effective learning is engaged in by someone who wants to learn and has some foundational set of learning skills, and some factual foundation, the resources, and the opportunity to engage in problem solving
	Requires that behavior patterns are learned and repeated	

Who is the instructor?	Someone who guides and challenges student learning	Someone who sets up the right circumstances for learning in the classroom, provides opportunities: to interact with peers, apply information, get feedback
	Someone who tries to balance the classroom so that it's a place where students can take risks and want to participate, yet they know they need to keep up with the reading and homework	Someone who wants students to be successful and see that they can take base knowledge that they have and use it to solve complex problems
	Someone who gets frustrated with some of the things students do but tries to keep focused on finding the source of the problem and improving the situation	Someone who wants to help students develop confidence and take on challenges
	Someone who trains some basic behaviors and gives lots of opportunity for practice	

What does the instructor do?	Stresses the importance of using activities to become aware of what students don't understand	Applies the concept of "Coached Practice" to skills students need to learn recognizing that if you want them to do it, you gotta show them how to do it (meaningful reading, build content framework, data interpretation, graph reading)
	Tries to look at the course form a student perspective	Solicits ideas from students
	Makes sure that students know what the central ideas and rules are	Lets students know they are trustworthy
	Talks to students about why activities are being done	Uses problem sets in class to equalize working rates of more and less advanced students
	Models logical thinking and making connections for student so they can learn to do it for themselves	Facilitates group work
	Does NOT leave students behind.	Uses "cue-based" problems to contextualize information
	Writes classroom activities and problems that will engage students	Helps students bridge information that they might have from other courses
	Tries to help students target what they are doing that isn't working and suggests new strategies for improvement. Example: Writes a two-part test (I fact recall and simple application; II problem solving) aligned with learning objectives. Reviews tests with students to determine which learning objectives questions are tied to and if students are missing getting basic information or missing the practice of working with material.	Uses reading quizzes at the beginning of the class to hold students accountable for class preparation
	Creates a feeling of expectancy in the classroom so students anticipate that they will be active in class each day	Gets students on board with their class responsibilities and then transfers responsibility over to them. If they choose not to take the responsibility, THEY fall behind.
	Helps students create a habit of good studying.	Defines a grading system that encourages student engagement in all activities and supports student understanding.
	Keeps students on track.	References learning objectives frequently
	Uses a variety of strategies to informally assess student understanding during class.	Gives students feedback on their understanding
	Tries to focus students' attention on the value (application) of the content to their future career goals.	Uses formative assessment to find out the impact on student learning and things that can be changed
	Tries to structure activities with some variety so that students learn different skills like formulating an opinion, generating alternate hypotheses, and answering concrete problems.	Looks for "contradictory kinds of material" to use as teaching opportunities
	Acts strict and keeps a positive attitude	

Who are the students?	Individuals that have a lot going on and want to operate from their position of comfort.	Individuals working towards their goals by developing their intelligence and preparedness
	Individuals who don't realize what they miss understanding in their own study item and don't realize how much they can learn from an activity.	
	Very likeable and interesting people to be around	Individuals who improve at asking questions, speaking out, and making connections.
	People who don't have much experience with problem solving so are intimidated by being asked to problem solve	
What do students do?	Choose what they will participate in based on the grade it is worth.	Value application problems that help them learn how to use knowledge
	Ideally: learn the material at a factual level before coming to class; demonstrate their ability to deal with problems to understand the factual material, work with their classmates to get comfortable talking about ideas; when their classmates are answering a question they are thinking how they would answer or trying to understand what the classmate is saying; in class they listen, talk, write notes so they can go back and think it through again.	
	In reality: They get frustrated and angry if they feel like they are left hanging or if a response to a question is logical rather than "text-book right". They ask, "Do we need to know this?" Overall, they have a hard time sorting through what they are supposed to be doing or what they should know when they have finished. They read and memorize facts and diagrams but they don't ever just sit and think...and ask, "Does this make sense?"	Demonstrate maturity when asked for feedback
	Get frustrated when they are told that they will be taking responsibility for their own learning	Are becoming self-motivated and don't look to points as a reason to do something
	Most don't have the reading strategies to be able to identify themes	Keep up with assignments and developing some time management skills
	Send mixed messages. One minute they are rolling their eyes and saying, "Yeah we know", but the next minute they can't answer an application question on what they said they knew.	Pick up a lot on their own and from each other
		Develop maps and the ability to work through multi-step process
	Love to talk about ailments/disorders of friends and family members	Practice different methods of approaching material
		Approach problem solving with more confidence
	Make value decisions quickly-- if one activity doesn't go well, then all activities are just busywork	
	They are more apt to engage with activities based on real-life situations than hypothetical ones	
	Most won't read the syllabus	
	Most don't think to consult references outside of their textbook and don't think about resource credibility	
What is the purpose of class?	To pull out two or three topics and represent them in several different ways and challenge students to work with the material	A time to provide a structure and framework on which to build; give examples and elaborate; a time for students to interact with each other and learn how base knowledge can be used to solve problems
What is the purpose of assessment?	Honestly sometimes I feel like it's the motivator for learning An opportunity for students to see where they are at in their understanding ; a means for instructors and students to figure out problematic areas.	To determine if students can accomplish the specified learning objectives
What is the structure of class?	Objectives	Frequent reading quizzes
	Introduce a main topic -lecture for 15 minutes PowerPoint	Lecture/activity/Lecture/Activity
	Active learning	
What is the instructor student relationship?	Challenges students to see information from different perspectives and apply it in different ways	Provide opportunities

Prof. C: Perceived Supports Over Time

	Pre-Project	Post-Project
Academic Community		
College		
Department	Several colleagues do active learning & offer support	**Several colleagues and a few new lecturers are meeting to share ideas & activities**
Course	Flexible teaching system organized around Power Point slides	Flexible teaching system organized around Power Point slides
	Two-part exam format allows instructor to help students how to improve	Two-part exam format allows instructor to help students how to improve
		Restructured grading system reduces students tendency to choose participation based on point value
		Improved coordination between lab and lecture
		Reading Quizzes
Instructor	Textbook Teachers' Guide/Workbook reduces pressure to come up with activities	Textbook Teachers' Guide/Workbook reduces pressure to come up with activities
		Learning which activities are keepers and which are duds
		Improved effectiveness of teaching and confidence
		Learning to ignore second-hand feedback and focus on direct feedback from students
	APS Medical Objectives on Web site	**Learning Objectives for each system**
		"Cue based" activities during lecture
		"Bridging" of lab and lecture
		Confidence that teaching is more effective
		Improved understanding of misconceptions and how students' minds encounter concepts
		Writes problem sets to equalize working rates
	Familiar with some active learning techniques & activities	
	ITIP classroom observations and discussion	
		Improved ability to explain concepts in many ways
		Nominated for "High Impact Instructor" (Student Award)
Students	They have good basic knowledge to build on	They have good basic knowledge to build on
		Students thinking and group skills are improving
	Second semester A & P students have already had one semester of active learning	Second semester A & P students have already had one semester of active learning
		Students are becoming self-motivated
		Student are becoming more confident
Professional Organizations	Center for Teaching Effectiveness has excellent workshops	Center for Teaching Effectiveness has excellent workshops
		ITIP Resources
	ITIP Listserve	ITIP Listserve (especially after a crummy day)
	Lunch seminars	Lunch seminars

Prof. C: Perceived Obstacles Over Time

	Pre-Project	Post-Project
Academic Community	Emphasis placed on grades and testing by the educational system has created a situation where students are taught to expend effort for grade not for learning	
College	Little concern for the quality of student learning	Little concern for the quality of student learning
	Little communication between departments or with the Nursing School	**Difficulty getting feedback from Nursing School on topics they want students to encounter in depth**
	Researcher lab space required; ultimately impacted physiology teaching labs and office space	**Nursing school running it's own review sessions for A & P so students have "all the information" they need.**
	Lecturers are not valued	Lecturers are not valued
Department	Little concern for the quality of student learning	**Little concern for the quality of student learning; large concern for butts in seats**
	Heavy reliance on end-of-semester evaluations for judging effectiveness of lecturers	Heavy reliance on end-of-semester evaluations for judging effectiveness of lecturers
	The perception of teaching and learning held by many faculty is outdated	The perception of teaching and learning held by many faculty is outdated
	New instructors are given the past syllabi and the tacit knowledge that , "This is what the University thinks you should teach." There is little opportunity for questioning or guidance for modifying what's been done in the past.	**Advice from departmental colleagues about "how to" improve student evaluations**
		Department-Nursing School agreement to add two more sections to course (60 additional students)
	Scheduling issues require that lecture and lab topics are staggered; students don't encounter the same material all at once	**Harsh reprimand from Chairman of Biology (acting on complaint from student that she wasn't "getting what she was supposed to")**
Course	Graduate Teaching Assistants aren't familiar with active learning and try to compensate for students not "getting all the information" by telling students what they need to know.	**Some graduate Teaching Assistants are not effective**
	Too much content material to cover	
	Too much planning time required	
	Large size classes makes it harder to learn all the names of the students and it's easier for students to be anonymous	
Instructor	Lack of knowledge related to which concepts students find difficult and what misconceptions they have	**Instructors ability to balance challenge and support**
	Limited knowledge of how to effectively use feedback from formative assessment	**Limited knowledge of asking formative questions to get useful information from students**
	Non-authoritative instructor role may induce students to be critical of instructor knowledge and ability	
	Lacks knowledge of research supporting active learning	
	Limited teaching experience in large lecture	
	Lack of clinical knowledge of "cool exceptions to the rules of physiology" to develop activities around	
	Lack of knowledge for how to assign points to activities to discourage students from choosing activities based on the grade	
	Skepticism from research colleagues	
	Lack of knowledge for how to stay with the higher ability students without losing less prepared students	
	Lack of skill in writing Active Learning Objectives	
Students	They don't keep up with reading and have a hard time integrating everything that has to be done for the lecture/lab/discussion	**The "vocal holdouts" who blame the instructor for not "getting what they need" and "not going over everything in the textbook"**
	They get frustrated and say they don't know what to focus on or what to learn	
	The strongest motivator for most students is the grade	
	Students work at different rates. High ability/prepared students get done quickly & act bored. Other students work more slowly	
Professional Organizations	Teaching Resource Center excludes lecturers from workshop participation.	Teaching Resource Center extended workshop invitation, but I teach during scheduled time

Prof. D: Beliefs Related to Teaching and Learning

	Pre-Project	Post-Project
What is learning?	Learning is like riding a bicycle or having sex	Critical thinking is learning.
	Skills are improved by practice	It is the ability to come up with an educated opinion
	Learning can be forced by providing quizzes and assignments, is facilitated by giving students take home cases	Teachers should give guidance answer student questions but then get out of the way
	Learning is the ability to retain information	
	You can learn more from teaching others than from listening reading writing or all of them combined	
	Focusing attention and actively processing whatever is happening at that specific minute. Retention or commission to long-term memory.	
	Neurocognitive theories of learning and memory suggest that personalizing material makes it easier to shift from short term to long term memory	Neurocognitive theory which deals with learning and memory tells us that humans learn a heck of a lot quicker when they are actually doing something (because they are engaging multiple sensory modalities to accomplish a task) than when they are just listening or reading.
	Learning is improved by focusing on key points and omitting some factual material	

	Pre-Project	Post-Project
Who are the students?	Underclassmen, third-year students, relatives of either graduates or upperclassmen in the school	People who are responsible for their own learning
		People whose VARK scores indicate they cannot learn from audio materials or text (because VARK indicates that 75% are V or VK)
		People who have had anatomy and biology and they don't have a clue about human physiology. They know nothing
	People who had A's in high school but now are getting C's and D's and say it is the instructor's fault.	Really bad critical thinkers
	People with poor analytical skills and are not prepared to come into a class that requires problem solving	People who are tasked with learning
	People: frustrated with the lack of details given out during class; stuck in a mindset that "something has worked before and should still work"; who feel that all they need to know is what is on the test and if it's not on the test they don't need to learn it; think instructor should tell them what is on the test so that they can learn it; who come into the course with expectation and don't respond to change well because they can't use the frat files to improve their grades and they have to buy a new textbook; who are shooting for a C instead of trying to do their best to learn how the human body works; who don't like being called by name; who believe that class time is for lecture only; who must be force to keep up	People that want to be lead
		People who are not old enough to reflect
	People who believe that if information is not on the test they don't have to learn it	People who are accustomed to a certain format, afraid of anything new and therefore will not ask for a classroom context in which they can better learn.

	Pre-Project	Post-Project
What do students do?	Resist instruction that includes problem solving because they are poor at analysis	The are not very capable of self reflection and not inwardly directed
	Want homework to help their grade	
	Get familiar with the kinds of questions I ask and how I want an answer structured	
	Read the book ahead of time	
	Perform in the 50 to 75% range on problem solving even if the problem is assigned in advance	
	Won't engage in discussion (95%)	
	If they do poorly on a test they believe it is because the instructor tested on what they did not study	
	Prepare appeals for questions they got wrong on a test if they think they are right	
	Send the instructor body language to let him know if they are engaged	
	If given the option, organize themselves into groups by social cliques	
	Cram for exams then do a data dump after the exam (75%)	
	Use frat files (of tests from over the years) to improve grade	
	They try to cheat on take home essays	
	Respond to mechanistic questions with teleological reasons	
	Say the instructor's are out to get them	
	Put a glassy film over their eyes when the instructor is talking	

	Get their factual material from the text and handouts prior to coming to class	
	Use practice exercises to gauge what is going to be on the exam	
	People who have a hard time connecting the problem solving sessions to material that they should study for the exam	
	Solve assigned clinical problems	
	Engage in learning	
	Participate in group problem solving	
	Draw neural pathways and label each synapse correctly with receptors and neurotransmitters	
	Apply information	
	If they work a problem in class they want to know they are on track and want to know if they got the right answer	

Who is the instructor?	Does what he does because he believes in the methods he uses. If he were to stop teaching the way he believes is right than he would no longer be happy as a teacher.	Someone who ensures that students learn the material because teaches a gatekeeper courses
	The facilitator who helps people learn a difficult subject, helps them change their study habits, and changes the way students think about science and the human body	Someone who chose teaching to make a difference among the CDF students
		The instructor's job is to provide them with every opportunity and to clear up their misconceptions
		Someone whose job is to change the way that they think, not just about this subject but the way that they think overall pretty much about everything.
		A guide mentor coach motivator
		Someone whose biggest job is motivator
		Someone who believes it is students job to learn the material

What does the instructor do?	Provides instruction to improve the probability that students grades will improve	Show students how to maximize the potential to get better grades
	Motivates students by getting handouts from the 5th year teachers and tells them they have to get started now	Spends a lot of time designing exercises and writing case studies and problems that grab the students attention and make them want to learn
	Gives students the information they need to be successful on exams in texts and handouts	All of what the instructor does is geared toward helping them learn but I don't teach them anything. I can show them how I do it or critique what they do but in the end it's all up to them
	Sometimes gives students more details than he had anticipated	Pats them on the butt when they screw up and points out their mistakes so that they may learn from them
	Does not give out details during class	Evaluates the process of student logic
	Writes a text for the class that goes online	Gives his opinion
	Teaches students what is important for them to be successful in later courses (at the expense of some of the really cool stuff)	Spends most of his time writing my problems and exercises to get the key points across
	Talks to other instructors about what the class dynamic is	Has students do writing assignments from science magazine articles, students take a position and defend it by citing evidence. You would be surprised at the number of students who don't have clue how to formulate an argument let alone cite evidence for and against it.
	Holds seminars outside of class (primarily for the D and F students but anyone can come) to talk about how to study physiology and how to take tests. He differentiates between memorizing and understanding)	
	Doesn't use Power Point because it is too constraining and I go so fast students can't take notes	
	Writes on the chalkboard or overhead	
	Gives reading quizzes and assignments to force students to keep up	
	Designs take home essay questions so that students can't cheat and gives every group a different set of questions	
	Hands out review sheets with definitions and questions	
	Makes the manual for the course	
	Posts movies to the web site	
	Forms student groups by talking to other instructors to determine expected grade--uses to break students into equitable groups. Groups must remain intact all semester to teach conflict resolution skills. Counts on A grade student fro leadership	
	Asks students questions during lectures	
	Does active learning because I care how much students learn and retain	Points out issues of controversy and allows students to make up their own minds based on the evidence at hand
	Uses student comments in an ongoing fashion to modify the course structure	Focuses teaching on central concepts and models, rather than facts

	Gives students a voice in the class and gives them a lot of room to do what they want to do. Is not very strict. Tries to make an environment where they know their job is to learn.	Provide a pause period during class for students to reflect
	Spends time with students and groups through the problem solving process	Teaches students to think critically and teach them how to solve problems and succeed at the next step
	Does not curve grades	Teaches students to be critical thinkers
	Stops halfway through the lecture so that students can compare notes	Sets up groups based on GPA's and balances gender. If there is friction in a group the friction is almost always between a male and a female
	Sells students on active learning	Uses mini-lectures (never more than 15 min) to emphasize important points and clear up misconceptions
	Sometimes uses a demonstration at the midpoint of the class	Creates a syllabus that is a contract with the student and contains course outcomes. The course outcomes tell students, "When I am done with you , if I have done what I told you to do you will have this set of skills
	Attempts to guide students through the learning process without giving the answers because the answers are graded	
	Walks around the room and answers questions. Determines if answers or wrong or right and makes sure all members are engaging	
	Prepares take home cases to reinforce concepts	
Instructor Student Relationship	People who relate	People who relate
What is the Purpose of the Class Meeting	Delivery of content material. To go over what the instructor thinks the hardest parts of the chapter are	Delivery of content material application concepts critical thinking
What does instruction look like?	Lecture with questioning and problems ets, mini-lectures and student interaction	
	Hybrid instructional approach that includes elements of Team Learning and PBL	Hybrid instructional approach that includes elements of Team Learning and PBL
	When students come to class they do not know whether they will be quizzed using the team learning format or given a problem under the PBL formal	When students come to class they do not know whether they will be quizzed using the team learning format or given a problem under the PBL formal
	everything students go in class is graded and counts toward their final grade	
What is Evaluation /Assessment	There is a relationship between teaching grading and retention. The teaching method increases students likelihood of getting a better grade thereby increasing their ability to retain the material	
	I give 2 A's in a group of 105	I teach students and then assess what I have been teaching but not what I have not taught
	A way for the instructor to learn what students don't know	A way for me to gauge how well students understand the material
	In class assessment take the form of directed case studies so there's a little teaching and a little assessment	In class assessment take the form of directed case studies so there's a little teaching and a little assessment
	To determine how much physiology students have learned	
Implementing active learning	A process of finding out what works and what doesn't work	A process of finding out what works and what doesn't work

Prof. D: Perceived Supports Over Time

	Pre-Project	Post-Project
Academic Community		
College	Started offering Freshman seminar to help with note-taking and reading comprehension	Started offering Freshman seminar to help with note-taking and reading comprehension
	If the class leader is good - the dynamic the class creates is good	If the class leader is good - the dynamic the class creates is good
	College has determined what content is essential in A & P for students to be successful in later parts of program	College has determined what content is essential in A & P for students to be successful in later parts of program
	Small college atmosphere	Small college atmosphere
	Administration supports active learning	Administration supports active learning
	Curriculum revision precludes students from taking courses over and over until they get a C	Curriculum revision precludes students from taking courses over and over until they get a C
Division	Faculty are committed to active learning	
	Department little contact with administration	Department little contact with administration
	Good opportunities for talking amongst faculty	Good opportunities for talking amongst faculty
Course	The course content is amazing	The course content is amazing
Instructor	Gets to spend more time thinking about the physiology which is enjoyable	Gets to spend more time thinking about the physiology which is enjoyable
		Not an expert in education but know enough to get by
Student	Nontraditional students like active learning	
Professional Development	Books: Courage to Teach and Teaching Tips	
	HAPS	HAPS
	Michael's Problem Solving Book	
	Case studies in science	

Prof. D: Perceived Obstacles Over Time

	Pre-Project	Post-Project
Academic Community	High schools are not preparing students--students entering colleges have low reading comprehension, note taking skills, analytical thinking and basic math skills, and a short attention span	High schools are not preparing students--students entering colleges have low reading comprehension, note taking skills, analytical thinking and basic math skills, and a short attention span
	High Schools do not require students to engage in discussion or work on problem sets	High Schools do not require students to engage in discussion or work on problem sets
College	A culture with an "institutional memory" (because incoming students are the younger siblings or relatives of upperclassmen) promotes students to talk to each other about how things used to be or should be, and should continue to be	A culture with an "institutional memory" (because incoming students are the younger siblings or relatives of upperclassmen) promotes students to talk to each other about how things used to be or should be, and should continue to be
	If the class leader is bad- the dynamic of the class is bad	If the class leader is bad- the dynamic of the class is bad
	Lottery system is used for registration into course sections. Parents call the Dean if their kids don't get the section they wanted	
	Dean is trying to increase enrollment numbers and there is some pressure to satisfy the student consumer	Dean is trying to increase enrollment numbers and there is some pressure to satisfy the student consumer
	Dean is waving requirements for transfer students	Dean is waving requirements for transfer students
	Dean would like to see more A's. More A's require curving. Curving requires compromising ethics	Dean would like to see more A's. More A's require curving. Curving requires compromising ethics
	Administrators are invertebrates and only interested in pleasing the parent and politicians	Administrators are invertebrates and only interested in pleasing the parent and politicians
	Faculty here are still operating under the model where you inundate students with massive amounts of information and require that they memorize the information to pass boards	Faculty here are still operating under the model where you inundate students with massive amounts of information and require that they memorize the information to pass boards
	The college does not think students need to learn problem solving until later in the program	The college does not think students need to learn problem solving until later in the program
	No foundational course in study methods is available to students	No foundational course in study methods is available to students
Division	Some faculty are critical of my grading scale which they believe is grade inflation	Some faculty are critical of my grading scale which they believe is grade inflation
Course	Large classes make grading too much to keep up with	Large classes make grading too much to keep up with
Instructor	Potential influence on end of semester evaluations	
	Takes a lot of time preparing quizzes, activities, exercises, and grading	Takes a lot of time preparing quizzes, activities, exercises, cases and grading
Student	Voice their displeasure over active learning to the Dean and other faculty	
	Won't engage in discussion	Won't engage in discussion
	Poor analytical skills	Poor analytical skills
	Grade-oriented; not interest in learning how the human body works	Grade-oriented; not interest in learning how the human body works
	Traditional students don't like active learning	Traditional students don't like active learning
	Unwilling to modify their expectations (want to be lectured to)	Unwilling to modify their expectations (want to be lectured to)
	Not motivated to keep up with reading and assignments	Not motivated to keep up with reading and assignments
	Resist because of poor analytical skills	Resist because of poor analytical skills
	Have attitude for blaming the instructor for failure	Have attitude for blaming the instructor for failure
	Don't like group work	They can't formulate an argument and support it with evidence. They aren't old enough to reflect or have an inward eye
Professional Development	Don't make connections between class and tests	Don't make connections between class and tests
	Don't try new ways of studying-they are stuck in a mindset	Don't try new ways of studying-they are stuck in a mindset
	Under prepared to do problem solving	Under prepared to do problem solving

Prof. E: Beliefs Related to Teaching and Learning

	Pre-Post	Post-Project
What is learning?	A creative process driven by choices	Making connections between concepts and elaborations or examples of concepts
	Includes a foundational level of knowledge and an understanding of how principles function	Can be facilitated by starting with a concrete example and a visual component, so that students can really get a picture in their heads of what's happening
	Takes on more depth in group settings when there are opportunities for listening to and questioning each other	"Individuality makes learning slippery". Everybody internalizes events and information in a way that makes sense to them. If two students have been through the same learning session, it's hard to know what they have in common.
	Requires a feeling of ownership and freedom. (Learning is dependent upon freedom)	A process of integrating material to make a body of knowledge that can be used to solve problems that are unfamiliar.
	It is facilitated when student groups are formed "equitably"; so that group members represent different genders, cultures, and academic backgrounds	It has two facets: stumbling, and then knowing what to do when you stumble…to get yourself back going in the direction you need to be going
	It is facilitated by giving a lecture before giving problems	
	There are different levels of learning. In order to participate in active learning, students need to come to class already knowing some of the main ideas	
Who are the students?	People that have control of where they go in the classroom	People who have been pulled out of their comfort zone and need assurance and clear statements of what the expectations are in this new situation
	People who have a pretty good feel for what needs to be happening in class	People that have to learn each semester what's expected from different instructors, and get used to the instructional mode and cadence of each new instructor
		They are very capable individuals but not always aware of what they understand
What do students do?	When given a group problem to work on in class, they take off in unexpected directions	They learn the basic concepts on their own (prior to class) but still have to struggle contextualizing and applying the information in class
	Come to class on time to take (and get full credit for) the beginning of class "bluebook quiz"	Are motivated by open-ended clinical examples that require them to sort through the logical and make predictions
	As they do homework and reading assignments, they write down questions they have on index cards and give those to the instructor at the beginning of the class session so that instructor can spend some time clarifying information. They complain if all questions are not addressed in class.	Struggle with reading and interpreting drawings, charts, and graphs
	Say they are too rushed during group problem solving activities	They don't naturally make connections between themes previously learned and new content material
	Write on evaluations that they hate group work. Say they get enough in the lab and don't want more during class	They work in groups doing things like drawing and coming up with reasons why something might happen
	Most do the reading and a good portion of the homework before coming to class	They explain physiological processes in language that a non-scientist would understand
	Say they get confused if they are asked to do an activity without having a lecture first	They learn principles and demonstrate that they can apply the principle
	Report to the instructor that group members cheat	If they are freaked out over how many points they are getting they don't learn what they need to be learning
		Respond like anybody would when they don't know what is expected of them…they get frustrated
Who is the instructor?	Someone who knows, based on her own personal experience as a science learner, that if a course is crammed full of facts, little will be retained	Someone who understands the importance of reading, reflecting, and discussing teaching and learning
	Someone who leads students into new content areas and clarifies, interprets, and shows the way.	Someone who opens doors/provides opportunities
	Someone who believes it's more important to teach thinking processes than it is to teach facts	Understands that focusing on depth of understanding and student confidence building are important responsibilities
	Someone who knows which content is important for students to know	Someone who is gaining confidence in her ability to facilitate active learning
	Someone who is responsible for giving students the facts	
What does the instructor do?	Focuses on basic principles and content that will allow students to lay a strong foundation	Puts specific boundaries on what student need to learn
	Focuses teaching on the nervous and cardiovascular system because these systems contain so many examples of integrated homeostatic systems	Put herself in students' shoes and asks, "How would I like this learning environment?"

	Gives more mini-lectures because that is what students say they want	Tries to create a classroom feel that is not point (grade)-driven
	Tries to explain the theory behind the teaching methods to students and helps them see the long term benefits of doing things actively rather than passively	Accepts her responsibility of preparing students for the next step which may include taking a standardized test
	Assigns students to groups using a complex and time-consuming process of administering surveys and distributing students having different academic backgrounds, cultures, and gender to groups	Writes two-part tests : the first part is multiple choice, the second part is problem solving
	Lets students control where they go in the classroom learning so that they have ownership so that they are more involved with the learning process	Collects feedback and uses student responses to inform subsequent teaching
	Tries to design activities that show students the points that are important to know	Keeps activities short and focused on the learning objectives
	Designs and administers a student feedback survey at the end of the semester	Expects students will be able to figure some things out on their own
	Gets feedback from students on a daily basis to see if they are learning what she thought she was teaching	Is constantly fine tuning what she does in the classroom
	Addresses misconceptions	Structures content learning in a way that focuses on helping students "get their wheels turning in the right direction"
	Designs and administers two-part tests; the first part is individual and the second part is group	Organizes group learning activities so that students' knowledge is challenged and elaborated
	Posts group problem answers when students run out of time in class and there isn't time to do a problem session summary	Gives students problems that don't have clear cut answers
	Pulls student back on track	Questions students ideas with the intent of cornering them into making their conceptions explicit so that they can start to see that their conceptions don't align with the accepted mechanisms
	Polls students to find out what they need and want to do	Provides self-study questions that are organized on Bloom's taxonomy so students start to get a feel for different levels of knowledge
	Gives points to students for what they do in class	
Instructor Student Relationship	Guide and explorers	Engineer of content/thought process learning and active learners
What is the Purpose of the Class Meeting	Students come prepared to class by having done reading and a homework assignment but still really don't understand or "get it". Class sessions are a time for them to start to "get it"	To clarify concepts that are unclear from reading and homework. For emphasizing the use of scientific thinking as students deal with material that is not covered in homework
What does instruction look like?	Class Format:	Class Format:
	"Bluebook quiz" over information from the previous class session (Five minutes). Collects quizzes and asks students how they answered (end of quiz summary)	"Bluebook quiz" over information from the previous class session (Five minutes). Collects quizzes and asks students how they answered (end of quiz summary)
	Go over student questions from homework and reading assignments (20 minutes)	Go over student questions from homework and reading assignments (10 minutes)
	Mini lectures	Fewer and shorter Mini-lectures
	Problem solving. First five minutes by themselves then join up with their groups to finish.	Problem solving. First five minutes by themselves then join up with their groups to finish.
	Summary of group problem solving	Summary of group problem solving
	Reminders to do reading assignments	Reminders to do reading assignments
	Lab:	Lab:
	Consists of human demonstrations, vertebrate animal experiments, and computer simulations	Consists of human demonstrations, vertebrate animal experiments, and computer simulations
What is Evaluation/ Assessment	Students get points for what they do in class	Assessment is aligned with learning objectives so assessments determine if learning goals have been met
		Assessments contain a range of activities from multiple choice to novel kinds of problems

Prof. E: Perceived Supports Over Time

	Pre-Project	Post-Project
Academic Community	A few community college faculty in the area are interested in active learning and are interested in networking	
College	Institutional mission values teaching over research	
Department	The Dean is supportive of active learning and uses an active learning approach in his own classes	**Good end of semester evaluations**
Course	A conceptually-organized textbook	**Got an undergraduate teaching assistant**
	Physiology content is so amazing and beautiful	**Letting students choose their own groups has improved the class attitude immensely**
	Informative comments from self-designed end of semester evaluations	**Enthusiastic and wonderful comments from self-designed end of semester evaluations**
Instructor		**Letting students choose their own group saves time**
		Reading interview transcripts from this study has helped me see that I don't always connect my thoughts and creates an awareness that I might do that in a teaching context as well
		Realizing that although I've been using active learning for almost three years, I'm really just at the beginning phase of learning and have so much to learn.
		Increased motivation from end of semester evaluations (self-designed)
Students	Students use and value the workbook because it guides their reading and is a helpful study aide for exams	**Students like choosing their own groups**
		Student say they are learning & retaining information & making connections
Professional Organizations	Grant from the National Science Foundation to study student learning	Grant from the National Science Foundation to study student learning
	HAPS and ITIP group	HAPS and ITIP
		University Collaborative (for K-12) Book Club has provided a forum for challenge of core beliefs

Prof. E: Perceived Obstacles Over Time

	Pre-Project	Post-Project
Academic Community		
College	University has allowed over-enrollment	**No organized way for the sprinkling of faculty interested in learning to be cohesive**
Department	An interest in hiring a PhD in Science Education to support faculty teaching (and teach lower division courses) was over-turned by faculty in the department who said they wouldn't respect someone without a Ph.D. in science	
	A few colleagues believe that efforts should be expended on research and not teaching and are critical of active learning	
	Poor end of semester evaluations	
Course	The ability to get undergraduate teaching assistants to help in lecture varies between semesters	
	All systems are covered in a one-semester course That is a lot of content!	**Trying to do all systems in one semester is simply unrealistic**
	Due to over-enrollment, there are more students in the class	
Instructor	Difficulty prioritizing teaching thinking vs. teaching content material	
	Uncertainty about what information is really important for students to understand	
	Feeling uncertain that students will learn the material when taught this way	
	Discomfort when observing group problem solving; and seeing that some students finish quickly and act bored, while others seem confused	
	Discomfort over with not knowing how an activity will go	
	Difficulty finding the balance between letting students control their learning and keeping them on track to learn what they need to learn	
	Overwhelming feeling of "unpredictability" of class. Can't predict how students will think about and interpret problems	
	Time investment to create a course workbook to help students focus their study	
	"Frightening" feeling to give up control of the classroom	
	End of semester evaluations (previous semester) were significantly lower than when lecturing was the primary mode of instruction	
	No access to activities and test questions from people who have been doing active learning for a while	
	Lack of understanding of how students from different cultures respond to active learning	
	Lack of knowledge about formative kinds of questions	
	Lack of knowledge for how to adjust grading system with a change to active learning	
Students	Students dislike the group work and are very vocal about it	
	Students don't like the grading system that gives the same group score to all group members; hard workers don't like slackers getting the same grade.	
Professional Organizations		

Prof. F: Beliefs Related to Teaching and Learning

	Pre-Project	Post-Project
What is Learning?	It involves "getting knowledge" and "getting across ideas"	Starts with remembering but is facilitated as students begin to ask questions, wrestle with different ideas. The goal of learning is understanding. Maybe accompanied by feelings of mid frustration
How will Active Learning be Implemented?	By changing the structure of the course so that it's an integrated lecture/lab and trying a lot of little things (adding paper and pencil activities and computer modules)	
		By thinking about the process issues that come up as active learning is implemented
Who are Students?	Students haven't had a lot of experience with this material and are starting from scratch	"Kids" who find many of the ideas we work on in class "totally brand new"
		The older, non-traditional students want to learn everything. The younger, traditional students really would prefer that things be spelled out precisely. They want the facts
		People who begin to think differently about the course information over the semester.
How do Students Learn?	They "take in" information from different sources to get an impression of how this all goes together.	They struggle and wrestle with material and ask questions as they work with new information.
	They manipulate things.	They work independently on their homework before class and in collaborative groups during class.
	Can listen to lecture or read a textbook.	
	Do homework assignments	
What do Students Do?	They buy a lecture notes outline so they can pay more attention and are not busy scribbling notes	Do homework questions on their own before coming to class to get the facts on their own
	Often sit looking at the instructor with a glazed expression on their faces	Get stumped and ask, "What does this mean?"
	Answer questions posed by the instructor	Let the instructor know when they "get it".
	Answer questions with vague and generalized responses	Establish different kinds of interactions in different groups
	Are passive	Hear instructor tell them that the responsibility for learning is on their shoulders
	"Plod through" the screen of computer programs that aren't interactive	
Who is the Instructor?	Gets a kick out of organizing information in a logical way	A creative, open-minded person who has been working a long time to get the hang of how to improve student learning.
	Has always enjoyed lecturing	
	Wants students to not just memorize wants them to "get it"	
	Enjoys drawing on the board and asking questions	Believes students should read ahead, bring knowledge to class and be prepared to think
		Believes that using active learning approaches improves the odds that students will succeed at the next level because they will know how to think and communicate and figure things out
		Believes that educators that allow students to just learn and regurgitate the facts are doing a disservice to students
		Believes that end-of-semester evaluations address instructor popularity not learning

What does the Instructor do?	Encourages students to use their own words rather than memorizing and giving back technical definitions	Helps students figure things out after they've gotten the facts on their own
	Projects the lecture outline on the screen. Lectures and plods through the information.	Asks questions prior to instruction to give students a chance to wrestle with the material and write down their ideas
	Teaches the class as units organized around concepts and organ systems	Provides elaborations and 'what if' questions
	Is starting to integrate lecture and lab and encourage collaborative learning	Tries to get things across a little more efficiently
	Organizes information for students	Tries to listen as students talk through their confusion to find out what is going on in their minds
		Tells students that the responsibility for learning is on their shoulders
		Consciously selects terms and facts that will be presented to the class and organizes and presents material so that students can develop a better organization within their own minds

Instructor/ Student Relationship	Giver and receiver of information	Students are informed and convinced of the benefits of the instructional strategies the instructor is using

What is the Purpose of the Class Meeting?	To cover the content so that students have notes to study for the exams	Class sessions are where the instructor helps the students figure it out

What does Instruction look like?		Under construction
	Lecture	Somewhat "disjointed"
	Rhetorical questioning	
	Textbook is a resource, not a guide	A few units are "much better", a little lecture with interactive questioning; a little collaborative activity--looking at models, microscope slides, paper and pencil activities, or a computer simulations.
	Lecture note outlines are a guide	
	Logically sequenced information	
	Graded exercises structured as group learning tasks	Non-graded exercises structured as group learning tasks

What is Evaluation/ Assessment?	It's a way of figuring a grade for students	Assessments should be a way of determining how students understanding has changed
	Have a great potential to be learning tools but don't' use them this way	Assessments are a great learning tool
	Evaluate whether students are able to demonstrate that they have learned what they have been instructed to learn	Evaluation should be used to gauge students knowledge and understanding of the subject

Prof. F: Perceived Supports Over Time

	Pre-Project	Post-Project
Academic Community		
College		
Department		
Course	New classroom set up for integrated lecture lab and collaboration	New classroom set up for integrated lecture lab and collaboration
Instructor	Enjoyment of teaching interactively makes me want to do more of it	Enjoyment of teaching interactively makes me want to do more of it
	Inspired by personal "experimentation" that showed improved student performance following active learning	**Gained comfort with active learning makes me willing to ask more questions…do more**
		New grading strategy (exams are graded but no points are given for in class activities) is more discriminating
	Lecture notes outline allows easy revision	**Lecture outline notes allow me the opportunity to do things I couldn't do otherwise. Students get the facts from the outline so that class can be used to figure things out**
Students	Lecture notes outline frees up students from scribbling notes so they can pay attention	**Lecture outline provides the overall structure and makes it clear to students what they are responsible for**
Professional Organizations	Informative HAPS meetings and ITIP workshops	**HAPS and ITIP network support**
	Workshop on Studio Learning in Physics Education	

Prof. F: Perceived Obstacles Over Time

	Pre-Project	Post-Project
Academic Community		
College	Little on-site support for active learning	Little on-site support for active learning
Department		
Course		
Instructor	Many administrative duties	Many administrative duties
	Limited knowledge about all the issues that come up with active learning, in particular, grading class activities without diminishing the discriminating power of grades	**Feeling caught "off guard" and needing time to formulate a thoughtful response to student thinking that everything should count for a grade**
	Limited experience doing formative assessment	Limited experience doing formative assessment
	Limited experience incorporating activity questions on summative assessments	
		Need for examples and short case studies that stimulate debate
	Lecture notes outline allows slipping back into lecturing	Lecture notes outline allows slipping back into lecturing
	I talk too much	
Students	Lecture notes outline may promote students to be passive and bored	Lecture notes outline may promote students to be passive and bored
		Student mindset that anything they do counts for a grade and if it doesn't count then they don't need to do it
	Students work at different rates	
Professional Organizations		

Prof. G: Beliefs Related to Teaching and Learning

	Pre-Project	Post-Project
What is Learning?	Learning is learning whether it happens in the lab or the lecture	Learning is recognizing something on an exam not known before; putting it together and using it in an application; gaining the ability to be conversant; building relationships out of what is known; capturing the essence of related terms and ideas.
	Taking in knowledge; Knowledge is either retained and brought forward or relearned with less difficulty later on	Learning can be accompanied by periods of being stumped and then having breakthroughs

How will Active Learning be Implemented?	By "tweaking" the existing curriculum to make it more engaging, interactive and activity-based.	By: cutting some of the expendables to provide more time for activities; and restructuring the course so that students can tie information back to running themes and practical examples throughout the course

Who are Students?	People who have made allied health career choices and are in the process of attaining goals; people who work and take three other classes; creative and capable people with very "teachable attitudes"; paying customers; older people with complex lives; not ethnically diverse, generally from the local area; motivated and compliant about doing the required work; people who help each other and enjoy working together.	They are also people with individualized ways of doing things and clear /honest perceptions about the effectiveness of learning activities
		People who need to have material organized, recorded, and presented to be able to make sense of it

How do Students Learn?	They:	
	need to have material organized and recorded on class notes so that they are free to listen, follow along, highlight foundational information, fill in the gaps, and embellish the notes.	
	Learn as a result of classroom instruction	Need to have access to class notes because some are not good note takers
		Need to work through some things with classmates

What do Students Do?	Listen to the instructor's presentation and answer questions posed by the instructor	Do reading prior to class to prepare for an activity
		Don't hear instructions or think they know a better way
	"Roll with" the presentation of information	Are very active and interactive during group work
	Relearn and review material before showing that they know it on evaluations	Ask, "Are we doing okay?"
	Do different lab activities - some foolproof; write lab reports using data instructor has summarized	Assume that the purpose of activities is review or assessment
	Have trouble writing concisely and self-assessing	
		Have trouble on concepts and want clarification
		Assume that everything they do is for points
		"Lock in" on their own thoughts and put in good effort during an activity but don't think along the lines the instructor planned

Who is the Instructor?	Tour guide, gardener, coach	Someone who is:
		Trying to be a facilitator in lecture and transfer some of the atmosphere of lab into lecture
	Someone who is:	
	passionate about teaching and considers it a privilege to help students understand	Values the efficiency of information delivery by lecture
	uses "normalcy" as a safety net	Frustrated with how "picky" she is that students don't do things the way she anticipates
	gets "frazzled" when off-schedule on syllabus	Frustrated at how she imposes her way of learning, doing and knowing on students
	trying to be the best that natural talent allows (best = open and flexible to new ideas and techniques that will improve effectiveness and are personality-compatible)	Frustrated that she doesn't dispel anxiety by making her goal of "learning and figuring something out" explicit to students

What does the Instructor do?	Teaches a hard course that has a reputation	Teaches a reputable course
		Is gaining an awareness that her class is very ego-centrically arranged
	"Needs to tell them in order for them to figure it out"	Tries to be very explicit in giving activity instructions to students
	Structures material from big picture down to small pieces and back to big picture	Runs out of time every time an activity is given to students

	Arranges, points out, explains, and reinforces information so that students can appreciate and understand	Has a tendency to omit formative assessment
	"Mushes through" what needs to be covered, "hammers" the foundational principles, and throws out "quick fire" questions	
	Relies on student body language to know if they are "getting it"	Assigns student groups alphabetically, fudging occasionally to make sure that one prepared student is in each group
	Summarizes lab data for students to reduce busy work and increase time available for thinking	Reinforces students "in process" learning and offers suggestions.
	Prepares students to be successful at the next level ("teaches everything they need to know")	Applies a "flow" to material that makes more sense than textbook chapters. Covers function first, structure second and keeps the coverage more narrow than the text
	Keeps lecture and lab separate	Summarizes lab data for students to reduce busy work and increase time available for thinking
	Has a game plan for each course and class session	Revises several labs to make them more inquiry-based
	Nurtures, provides encouragement and an environment in which students can grow	
	Works at not being intimidating	
	Stimulates students to own the material	Is beginning to think about restructuring the class by balancing the efficiency of lecture delivery of material with allowing students to work some things out with their classmates
	Stretches students circle of confidence	Is rethinking how she's "done things in the past" in the classroom.
	Keeps competitiveness between students low by not curving grades	Is thinking about narrowing the field of knowledge students are responsible for
		Someone who regrets her decision to cut an activity short in the interest of moving on to cover more content
		Someone who realizes that despite her clear presentations, "student ears don't always hear"

What is the relationship between Instructor and Student?	In lecture there are formal interactions; In lab the interactions are more casual	Uncertain

What is the Purpose of the Class Meeting?	To give, share, clarify important content knowledge as efficiently as possible known to be foundational by the instructor	To: clarify the information in the notes; give students more detail that is connected (but knowing that they will not have to feed all of this back on a test), do
		Some lecture and some time for activities
	Instruction is an opportunity for students to take in information	

What does Instruction look like?		Under construction. It will include:
	Lectures (kind of rigid) with "quick fire" questions	Streamlined lectures aligned with textbook but with improved flow
	Textbook, lab manual, extra lab notes	Textbook, lab manual, extra lab notes
	Lecture note outlines aligned with the textbook	Progressive information
	Sequenced and progressive information	Integrated activities with explicit instructions so that students understand the purpose
	Prioritizing information, review and practice	More small group work focused on application of knowledge
	Independent learning or group work	Graded or un-graded activities
	Graded or un-graded exercises structured as group learning tasks	

What is Evaluation/ Assessment?		A way of knowing what students gained from class; "tests reflect the teaching"
	Separate from teaching	
		Tests should also be an extension of learning—so when students walk out of a test, they've connected some dots that they didn't when they were studying.
	Summative or product-oriented (lab reports)	
		There's a difference in assessment and evaluation and the purposes are quite different
	Used to determine whether students are able to demonstrate that they have learned what they have been instructed to learn	Is uncertain how to interpret some of the comments students make during formative assessment

Prof. G: Perceived Supports Over Time

	Pre-Project	Post-Project
College	Supportive President	**Faculty survey indicates interest in discussions on teaching and learning. Volunteers to lead two sessions.**
	Faculty have lots of autonomy	Faculty have lots of autonomy
Course	Successful image; Well-regarded by community health care providers	Successful image; Well-regarded by community health care providers
	5% student failure rate	5% student failure rate
	Classroom is next to a prep room that has become a student "hang-out"	Classroom is next to a prep room that has become a student "hang-out"
Instructor	Excellent models of teaching from inspirational teachers with high expectations	Excellent models of teaching from inspirational teachers with high expectations
	Excellent ability to facilitate student learning	Excellent ability to facilitate student learning
		Knowledge that I am becoming more open-minded and am learning more about using active learning
		Sabbatical approved for next semester
		Experience of using formative assessment was informative
Students	Wonderful and highly motivated students with teachable attitudes	Wonderful and highly motivated students with teachable attitudes
	Sense of community among students	Sense of community among students
		Students provide valuable feedback
Professional Organizations	Informative HAPS meetings and ITIP workshops	Informative HAPS meetings and ITIP workshops
		HAPS and ITIP network support
	In-service training on "assessment"	**National Assessment Conference**

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Vita

Patti Marie Thorn was born in Tillamook, Oregon on July 17, 1960. She is the daughter of George and Dorthea Kurtz. After completing high school at North Valley High School, Grants Pass, Oregon, in 1978, she entered Oregon State University where she received the Degree of Bachelor of Science of Microbiology in May of 1982. She entered the University of Dayton in 1986 where she received the Degree of Master of Science in Biology in 1988. In 1998, she entered the Graduate School of Science Education at the University of Texas at Austin. During her period of enrollment, she was nominated to the education honor society, Kappa Delta Pi. She was also nominated for the Addison E. Lee Fellowship in Science Education by the faulty of the Science Education Center. She received the Proctor & Gamble Professional Opportunity Award from the Educational Section of the Council of the American Physiology Society. Patti is a member of the American Association for Microbiology, American Educational Research Association, American Physiology Society, Human Anatomy and Physiology Society, National Association for Research in Science Teaching, and Profession and Organization Development Network in Higher Education.

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