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Engaging Middle School Students as Multimedia Designers: Exploring Students' Project Design Skills and Psychological Sense of Community

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Engaging Middle School Students as Multimedia Designers: Exploring Students' Project Design Skills and Psychological Sense of Community

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Dedication

To Alex, Ryan and Lauren Anselm

You are my constant inspiration

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Engaging Middle School Students as Multimedia Designers: Exploring Students' Project Design Skills and Psychological Sense of Community

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This study, based on the participation framework, investigated students' learning of project design skills, psychological sense of community, the relationship between project design skills and psychological sense of community, and design implications in a learners-as-multimedia-designers learning environment. One hundred and twenty-seven students from a middle school in the southwestern United States participated in this study. The treatment group consisted of students in the multimedia classes while the comparison groups consisted of students from the Talented and Gifted (TAG) classes and regular classes. Both quantitative and qualitative data was collected through Project Design Questionnaire, Concept Mapping survey, Design Task Ranking survey, Psychological Sense of Community in the Classroom Scale (PSCC), open-ended questions, interviews and classroom observations. The results from the pretest and posttest data indicated that students in the learners-as-multimedia-designers classes have developed project design skills such as awareness of audience, research, and presentation, and maintained high levels of interest and mental involvement. However, they did not regard evaluation and revision as a critical task and showed variations in their planning and collaboration tasks. The findings also showed that students in the treatment group demonstrated significantly higher sense of psychological sense of community than students in the TAG classes and regular classes whereas students in the TAG classes and regular classes did not differ significantly from each other in their psychological sense of community. Quantitative data also showed that there were significant correlations between some design tasks (audience, presentation, and collaboration) and psychological sense of community. The findings also indicated factors like selecting authentic group projects, providing facility access, and training interpersonal skills for group projects could help promote the learners-as-multimedia-designers environment during its implementation. This research implicated that teachers should create a classroom environment that engages students in collaborative constructive investigation as in the learners-as-multimedia-designers environment.

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SIGNIFICANCE OF THE STUDY

American society has shown immense enthusiasm and faith toward computer technology in education since the leap of information technology in the early 1990s. In his report to the nation on technology and education, former Department of Education Secretary Richard Riley stated that “computers are the ‘new basic’ of American education, and the Internet is the blackboard of the future” (Getting America's Students Ready for the 21st Century: Meeting the Technology Literacy Challenge, U. S. Department of Education, 1996). In the often-quoted United States Department of Labor Secretary's Commission on Achieving Necessary Skills (SCANS) report (U. S. Department of Labor, 1991), technological literacy was listed as an indispensable skill for the future workforce. The report, based on a comprehensive study of how well schools prepare students for future job markets, recorded business and industry leaders’ view of the skills required for the future economy. Enabling students to become computer literate has since become an imperative goal for educators across the country. Being computer literate is considered essential in the knowledge and information-driven economy of the 21st century.

Such enthusiasm has been backed up with heavy investment. A series of grants and funds have been allocated to programs with the hope of bringing computers into classrooms and of narrowing the gap between the “information-haves” and the “information-havenots”. As a result, there have been significant advances in the availability of Internet-enabled, multimedia-based technology in schools across the country (National Education Technology Plan, U. S. Department of Education, Washington, D.C., 2004).

However, progress in equity of access to technology in schools does not necessarily guarantee effective educational use of technology. As the most recent National Education Technology Plan concludes,

> We have not realized the promise of technology in education. Essentially, providing the hardware without adequate training in its use – and in its endless possibilities for enriching the learning experience – meant that the great promise of Internet technology was frequently unrealized. Computers, instead of transforming education, were often shunted to a "computer room," where they were little used and poorly maintained. Students mastered the wonders of the Internet at home, not in school. Today's students, of almost any age, are far ahead of their teachers in computer literacy. (National Education Technology Plan, U. S. Department of Education, Washington, D. C., 2004, p.10).

The potential of technology is not fully realized nor proven. As a result, policymakers are increasingly demanding accountability and return on investment of technology in education. Recently, educators and researchers (Pollard & Pollard, 2004; Roblyer & Knezek, 2003; Schrum, 2005; Strudler, 2003; Thompson, 2005) have called for identifying new research priorities. Among the various research agenda discussed and of interest to this study, researchers have identified (1) studying "the benefits of technology-based methods as integral components of solutions to instructional problems" (Roblyer & Knezek, 2003, p.62), (2) understanding "the impact of technology on the various domains of learning (cognitive, affective, and psychomotor)" (Pollard & Pollard, 2004, p.148), and (3) examining how to design technology-enhanced learning environments (Pollard & Pollard, 2004) and improve technology implementation methods (Roblyer & Knezek, 2003).

Researchers have long indicated that technology, in and of itself, is not a panacea to educational problems (Ayersman, 1996; Cognition and Technology Group at Vanderbilt, 1996; Jonassen, Campbell, & Davidson, 1994; Tergen, 1997). They recognized that, only when combined with sound instructional methods and strategies, could technology contribute to changes in students' learning. Technology innovations should operate hand-in-hand with sound instructional methods. Technology alone does not necessarily bring out the change in students. Rather, student changes are more likely due to sound technology-based/technology-supported instructional methods, in which technology affords students possibilities they otherwise would not have. This recognition has led to the conclusion that research should focus on examining technology-based instructional methods and their benefits on student learning, rather than examining the benefits of technology on student learning alone.

Next, researchers also recognize that technology-based methods may have impact on students in multiple ways. The emphasis should not only be on students' content acquisition, but should also be on examining how technology helps students become better problem solvers and accomplish learning tasks. Researchers have come to recognize the need to understand how people learn using technology and how the impact can be reflected in multiple domains (such as cognitive, affective and psychomotor).

Finally, researchers agree that research is urgently needed to understand how technologies are being implemented in schools and classrooms (Roblyer & Knezek, 2003). Findings from such studies can have important implications for future practices. For example, lessons from how technologies are implemented in classrooms in everyday life can help provide input on how to design and develop technology-based learning environments. Better design and development of these technology-based learning environments can help promote the effective educational use of technology and enrich students' learning experience, which can subsequently help realize technology's rich potential.

This current study attempted to research a technology-based method, the learners-as-multimedia-designers approach, and examine its impact in relation to students' cognitive and affective domains. Combining project-based learning with the use of computer technologies, the learners-as-multimedia-designers approach engages students in learning multimedia software and working on multimedia projects. The learners-as-multimedia-designers approach especially focuses on the project design and multimedia design aspects during the process and seeks to engage students in the roles of multimedia designers as in the real-world multimedia industry. The past research has mostly focused on examining students' subject matter learning and motivational effect. This researcher chose to undertake a few of the research priorities identified by researchers in the field, and focused on examining students' development of cognitive skills, specifically, project design skills (such as project management, organization, research skills, etc.) incurred from working on multimedia projects, and students' psychological sense of community as well as exploring issues arising during implementation of this type of environment.

PURPOSE OF THE STUDY

This study aimed to investigate the impact of the learners-as-multimedia-designers approach on students' project design skills development and psychological sense of community. This study also examined the relationship between project design skills and psychological sense of community. Considerations from the classroom implementation were also examined to help shed light for future design and implementation of the learners-as-multimedia-designers environment. In the following, each item was discussed.

First, this research focused on examining students' development of project design skills. The past research on the learners-as-multimedia-designers approach has focused mostly on examining its effect on subject matter learning and students' motivation. The learners-as-multimedia-designers approach has been proven to help students develop deep understanding of subject matter and motivate students greatly (Lehrer, Erickson, & Connell, 1994; Liu & Rutledge, 1997). However, when students work on collaborative projects using multimedia tools, they also have great opportunities to develop higher-order cognitive skills such as project management, research, organization, representation, presentation, and evaluation skills (referred as project design skills.) Perhaps due to difficulty in assessment, only a few studies (Lehrer, 1993; Lehrer, Erickson, & Connell, 1994; Liu, 1998, 2003; Liu & Hsiao, 2002) have examined students' development of project design skills in the learners-as-multimedia-designers environment. Because it's an important aspect and skill, this study built on previous research to further investigate this issue. Further, this study also examined project design skills in relation to psychological sense of community that has not been examined before.

Secondly, this research attempted to examine the impact of the learners-as-multimedia-designers environment on students' psychological sense of community. There have been frequent talks of "learning community" and "a community of learners" in the field of educational technology, but many researchers seem to "accept the term at face value without attempting to rigorously define the characteristics that differentiate a true learning community from any other class" and others "describe characteristics of community but do not offer a way to evaluate presence or level of community" (Misanchuck, 2001, p.477). This study chose to empirically examine students' sense of community using the psychological sense of community construct in the learners-as-multimedia-designers environment. Psychological sense of community is a concept widely researched in various contexts in the field of community psychology. Only recently did some researchers (Bateman, 1998, 2002; Chao, 1999; Misanchuck, 2001, 2003; Rovai, 2001, 2002a, 2002b; Rovai, Wighting, & Lucking, 2004) in the field of education begin to apply this construct in their research. This study examined students' psychological sense of community in the learners-as-multimedia-designers environment versus in the more traditional classrooms.

Thirdly, this researcher also chose to examine the relationship between students' project design skills and psychological sense of community in the learners-as-multimedia-designers environment. Previous research (Bateman, 1998) has found that psychological sense of community was positively correlated with students' academic achievement and other social skills. This researcher chose to investigate the association between project design skills and psychological sense of community through quantitative measures. Specifically, this researcher focused on examining the correlation and prediction relations between these two aspects.

Finally, this research also attempted to learn more from the implementation process in the classroom. By examining the learners-as-multimedia-designers approach in practice, this researcher sought insights about the design and development of such type of environment. The information learned from this study could help provide design implications for future research and classroom practices.

RESEARCH QUESTIONS

This research intended to examine five research questions:

1. What is the impact of the learners-as-multimedia-designers environment on the learning and development of middle school students' project design skills?
2. What is the impact of the learners-as-multimedia-designers environment on middle school students' psychological sense of community?
3. Is there any relationship between students' project design skills and psychological sense of community as they engage in the learners-as-multimedia-designers environment?

4. Can students' project design skills development be predicted by students' psychological sense of community?
5. What needs to be taken into consideration in designing the learners-as-multimedia-designers environment?

Figure 1 demonstrated the relationship between the research questions and the learners-as-multimedia-designers environment.

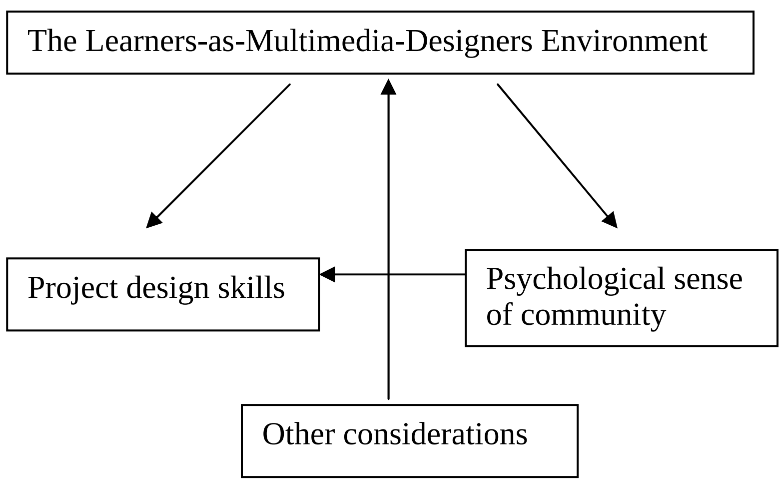


Figure 1: Illustration of Research Questions

Chapter 2: Literature Review

INTRODUCTION

The learners-as-multimedia-designers approach is an instructional strategy that engages students in the process of multimedia design and production. It is not simply the addition of multimedia software learning and production activities to regular classroom instruction. Rather, this approach engages students in projects with the goal of producing multimedia products and helping students develop knowledge and skills in multimedia design.

The learners-as-multimedia-designers approach derives its project format from the project-based learning approach and integrates the use of multimedia technology in the process. Aligned with the practice of the multimedia industry, the learners-as-multimedia-designers environment pays special attention to project design and management. In the following sections, we focused on the project-based learning process and the learners-as-multimedia-designers environment first. Then, an examination of the theoretical framework behind these instructional approaches was presented. Finally, the focus of this study---project design skills and psychological sense of community in a learners-as-multimedia-designers environment were examined in the end of this chapter.

PROJECT-BASED LEARNING

Characteristics of Project-Based Learning Environments

Project-based learning (PBL) is an approach that structures learning around projects. The notion of project is definitely nothing new. Kilpatrick (1918) has proposed the "Project Method" and Dewey (e.g., 1900) has advocated learning by doing. Over the years, projects have often been used as peripheral activities such as exercises and practices in traditional classrooms. However, since the publication of the SCANS report (U. S. Department of Labor, 1991) in the 1990s, educators have striven to find approaches that engage students in active learning. There has been a renewed interest in project-based learning.

There are diverse defining features and practices of PBL. To capture the uniqueness of PBL and to screen out non-examples, Thomas (2000) has identified five criteria of PBL: a driving question, authenticity, centrality, constructive investigation and student autonomy. In the following, each criterion was discussed.

A Driving Question

The practice in PBL usually starts with a driving question, compelling students to learn about the central concepts of a topic. The activities and products in the project also follow the direction of this driving question. The driving question can be an ill-structured or a clearly-defined problem/question. In either case, the scope of the problem or question needs to involve cognitively complex activities and cannot have a predetermined outcome, leaving students no room to develop new approaches to answer this question. Projects which students can finish easily and promptly are not considered an example of project-based learning.

Authenticity

This driving question usually corresponds closely with what happens in real life and requires students to play authentic roles and perform meaningful tasks as in real life. Authentic driving questions make the project more relevant, challenging, and interesting to the learners, which, in turn are believed to help keep learners motivated and sustain their persistence during a long-term project (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991).

Centrality

In PBL, a project usually serves as the central teaching strategy to drive students to learn and encounter what they need to learn. A project is at the center of the learning process rather than in the peripheral as an illustration, an example or additional practice. The traditional science fair projects, therefore, are not considered examples of PBL (Thomas, 2000).

Constructive Investigation

To answer the driving question, students are engaged in a range of cognitive processes such as asking and defining questions, debating ideas, making predictions, planning, gathering information, analyzing and solving problems, making decisions, designing, drawing conclusions, thinking reflectively and communicating ideas and findings to others (Blumenfeld et al., 1991). These processes help students transform information and construct their own knowledge and interpretation. If the investigation does not involve students' construction of new knowledge and can be carried out easily, then it is considered an exercise rather than a PBL process (Thomas, 2000).

Student Autonomy

Student autonomy is an important feature in project-based learning environments.

Throughout the process, students are encouraged to take charge of their own learning and make their own decisions. Students take on more responsibilities during the process and are encouraged to develop a sense of ownership towards their product. During the learning process, classroom activities become more student-centered than teacher-centered. Students learn to make their own decisions and work independently.

In addition to the five criteria identified above by Thomas (2000), several other practices can also be identified from the discussion of project-based learning activities. For example, project-based learning usually involves the production of artifacts or products. The project-based learning process also requires students to work in collaborative groups to accomplish the complex tasks at hand. Also, the time requirement is often for an extended period of time rather than a short-term engagement. To sum up, project-based learning also has the characteristics of product creation, collaboration and long-term engagement. In the following, this researcher elaborated more on these characteristics.

Creating Products/Artifacts

Project-based learning engages students in creating an end product or “artifact”, which represents students’ understanding of the problem investigated in the project. The production of the end product often requires specific content knowledge or skills, thus driving students to learn and acquire new knowledge and skills along the process. The final product is believed to represent students’ “emergent states of knowledge” (Blumenfeld et al., 1991, p. 372) and the process of production and creation is viewed as critical to students’ learning.

Collaboration

When students work on a project, the nature of the cognitively complex tasks often requires collaborative efforts from participants in order to accomplish their goal. Collaboration not only allows students to work together and share responsibility but also enables students to specialize in certain areas and to maximize their talents. Project work can therefore be accomplished more efficiently and effectively. Moreover, collaboration does not only exist among participants in the same classroom. Projects can also involve teachers and members of a society in collaboration with students. Experts in different subject matters can be brought in to share information, data, ideas and resources. A community of inquiry can be built to help advance students' investigation and enhance students' understanding of the driving question.

Long-Term Engagement

Due to the complex nature of project work, project-based learning can be very time-consuming. On the one hand, project processes such as gathering information, research, planning, design and production activities often require a fair amount of time. On the other hand, the learning of content knowledge and maturation of cognitive skills also take time to develop. Thus, project-based learning often requires students to work on projects for an extended period of time.

Project-Based Science

To illustrate the process of project-based learning, it is useful to examine project-based learning in practice. One typical practice of project-based learning can be shown in the project-based science activities (Krajcik, Blumenfled, Phyllis, Marx, Bass, Fredricks, & Soloway, 1998).

Typical of project-based learning, project-based science activities require students to define a driving question or problem for their projects. The driving question or problem serves to bridge between science concepts/principles and real-life experiences. With teacher help and some initial background probing, students begin their inquiry by asking a driving question. Students then organize their planning procedures and investigation activities around the driving question/problem. During the investigation, students may construct apparatus, design experiments, and make measurements to carry out their investigations. After they collect enough data, students learn to analyze and draw conclusion from the data they have collected. In the end, they present their findings by creating artifacts or presentations, which relate their conclusions to scientific interpretations.

For example, students may raise a driving question like “what is the pH value of rainwater in our city?” This driving question allows students to explore concepts such as acids and bases, pH, and concentration. Students can carry out investigations to measure the acidity of rainwater, the effects of acid rain on the environment and even examine the local industry and the legislation. During the process of investigation, students may need to research and determine how to test the acidity of rainwater and design experiments to examine the effects of acidity on living and nonliving things. When enough data is collected, students can show their findings through creating concrete products such as a written report, a video, a model, or a computer program to illustrate their conclusions. The project questions serve as a driving force to prompt students to learn, investigate and create products, which distinguishes project-based science activities from science fair projects.

During the investigation process, students have opportunities to discern from multiple sources of information and apply their own judgment. Students are not necessarily alone in this endeavor: they often work in groups and collaborate with each other in their investigation activities; teachers can provide support and scaffolding to ensure that students are on the right track; members of the greater community outside of school can also be involved or brought in to provide insights and expertise. In other words, a community of learners provides the social context for project-based science activities. Furthermore, the use of technological tools such as science apparatus, Internet, and other computer applications (*PowerPoint*, *Excel*, etc.) can also be used to aid students in their investigation, collaboration and artifact development. To sum up, project-based science activities engage students in active construction of scientific knowledge and in applying information in their design and conclusion with the help of community and technological tools.

Other Similar Approaches

There are other learning and instructional practices that derive from the same philosophies and share one or more similar characteristics with project-based learning. For example, problem-based learning (Barrows, 1986; Savery & Duffy, 1996), cased-based reasoning (CBR) (Kolodner, 1993, 1997; Riesbeck & Schank, 1989), design-based activities (Lehrer, 1993; Kafai, 1996) and anchored instruction (Cognition and Technology Group at Vanderbilt, 1993) are all variations with the same underlying instructional principle.

A problem-based learning session begins by presenting students with a complex and real-life problem. In order to solve the problem, students embark on a process of learning and acquiring new knowledge and information. Students need to identify the problem for themselves first and then collect data and generate solutions for the problem. Since the problem is cognitively complex, the whole process requires collaboration with a group to divide up tasks and share information. Students are actively engaged and have opportunities to learn and apply knowledge in a just-in-time manner.

Case-based reasoning (CBR), on the other hand, focuses on the use of cases as resources and examples as students are engaged in solving real-world problems. Cases, including “an old situation and its problem, the way the situation was dealt with, and the results of dealing with it in that way” (Kolodner, 1997, p. 58), illustrate the experiences of experts or fellow students. Since cases provide explanations and reasoning rationales, they allow students to make inferences and extract knowledge from them. Nowadays, CBR often utilizes computer technology, such as the World Wide Web and multimedia software programs to help establish case libraries to allow students easy access to various cases when they are solving problems. Through observing and applying other people’s experiences from the case libraries when solving problems, researchers believe that students can develop a deep understanding of curriculum content and can apply their knowledge flexibly.

Design-based activities also focus on the process of design to help students construct knowledge and develop deep understanding of subject matter. Students are engaged in a complex problem-solving activity in which they are required to construct artifacts. Through the iteration process of design, construction, testing and refinement of artifacts, it is believed that students can make connections between what they do and the real world around them.

Anchored instruction also tries to overcome the problem of inert knowledge found in traditional didactic instruction and aim to enhance active construction of knowledge and transfer. Their solution is to embed video anchors in an instructional unit. A rich, realistic and meaningful context and resources are provided while students are engaged in problem-solving activities as well.

All these approaches share one or more characteristics with project-based learning and it can get sketchy to try to distinguish them from one another. Overall, they all try to achieve the goal of breaking away from the problem of inert knowledge and try to create a solution to help students learn through construction of knowledge, apply knowledge as needed, and develop a deep and more systematic understanding of curriculum content. These approaches all provide students with a problem or a project to work on and allow students to actively seek out necessary information and resources to accomplish the project. The problem and project are usually not so straightforward but quite complex and rich in meaning, reflecting what occurs in real world. Students may need to spend a fair amount of time trying to solve problems in all these approaches and there is no one easy, absolute answer to the problem. Collaborative groups and support from teachers may be needed to help tackle the problem/project together. Technological tools such as computers are often employed to facilitate the working process. In short, all these approaches, despite the differences in names, are consistent with the project-based learning approach. After differentiating the various approaches, the next section examined the approach of engaging learners as multimedia designers, the focus of this study and a form of implementation of project-based learning.

ENGAGING LEARNERS AS MULTIMEDIA DESIGNERS

Historical Perspectives

Similar to project-based science activities, the learners-as-multimedia-designers environment is an implementation of project-based learning. In this approach, instead of doing science projects, learners focus on learning multimedia software and designing multimedia programs. The project topics are broadly based, ranging from subject matter content to issues in the community. The end products are presented on computer screens only, with multimedia elements including text, graphics, sounds, animations, videos or 3-D effects. Like other project-based learning activities, the learners-as-multimedia-designers environment often involves students in an extended period of time learning about and pursuing a driving question or topic. The driving question or topic has connection to the real world and is meaningful to students. During the project process, students also need to be actively involved to investigate and research about their topic/question, collaborate with each other, and work with the outside community. As in project-based science activities, students have the opportunities to actively construct their own knowledge and develop ownership about their own learning.

The learners-as-multimedia-designers environment has its precursors in many strands of thinking, including the concepts of knowledge-as-design, constructionism, learning *with* computers and using computers as cognitive tools. To gain a historical perspective about this approach, each strand of thinking was discussed in the following.

Knowledge-as-Design

Perkins (1986) proposed treating knowledge as design. When using the theme of design to understand knowledge, he argued, learners become designers and learning becomes a design process. In a design process, students focus on the purpose of the knowledge, seek its underlying structure, generate model cases, and use explanatory or evaluative arguments to justify the design (Perkins, 1986). This view presents an effort to break away from the traditional didactic view of knowledge as information and teaching as information transmission, and brings new way of looking at learning.

Constructionism

A similar view on learning as a design and construction process is echoed in the concept of "constructionism", proposed by Papert (1980, 1991). Papert (1991), observing young students enthusiastically using the Logo programming language to create programs, coined the term “constructionism” to elaborate upon his idea of learning as building knowledge structures. He wanted the term to transmit “a sense … much richer and more multifaceted, and very much deeper in its implications” (Papert, 1991, p.1). Constructionism has its base on the constructivist assumption that knowledge cannot be simply transmitted from teacher to student, but is actively constructed by the mind of the learner. It postulates that learners are more likely to construct knowledge when they are actively engaged in making some type of external artifact, whether it be a sand castle, a robot or a computer program. Therefore, it places great emphasis on engaging learners in activities of creating and making artifacts.

Constructionism focuses our attention on the knowledge construction process and stands in sharp contrast to “instructionism”, which treats learning as the transmission of knowledge from teachers to students. Papert’s (1991) view shares similar perspectives with Perkin’s (1986) in that they both emphasize learning as a process of design and construction rather than as a process of knowledge transmission.

Learning from vs. with Computers

Another perspective focuses on the use of computers in projects. Computers are the primary technology tools used by students throughout a project. There are two ways to conceptualize the use of computers in education: learning *from* computers or learning *with* them (Jonassen, Myers, & McKillop, 1996). Learning *from* computers implies that computers are an able source of information and that computers can impart knowledge to students. For example, programmed instruction, which takes the forms of intelligent tutoring systems, as well as many multimedia programs, reflects this view. Overall, computers are regarded as “conveyors of information, communicators of knowledge, or tutors of students” from this view (Jonassen et al., 1996, p.96). This view still reflects the traditional didactic view that information is to be transmitted from experts to novices. The only distinction lies in that computers, now replacing teachers, carry the role of information transmitters.

In contrast, the view of learning *with* computers focuses on how computers can be used to facilitate learners' knowledge-construction and meaning-making process. This view suggests that computers join or assist human efforts to accomplish tasks. Learners are placed in a more crucial role to actively construct their own meaning instead of passively receiving knowledge. Computers can either provide access or support to enable learners' maximum learning.

Computers as Cognitive Tools

Finally, another strand of thinking stresses on computers as cognitive tools, which is consistent with the view of learning *with* computers. According to Lajoie (1993, p.261), computers can serve four functions: (1) supporting cognitive processes. For example, computers can support memory process. Instead of committing information to memory, humans can keep records in database applications for quick browsing and retrieval. (2) sharing cognitive load for lower cognitive tasks. Given that higher order thinking can only be achieved when lower level cognitive tasks have become automated processes, computers can help carry out some lower-level cognitive tasks. For example, computers can do calculation much faster and more accurately, thus allowing learners more time to work on higher-level tasks such as analysis and synthesis. (3) allowing the learners to engage in cognitive activities that would be out of reach otherwise. For example, computers can provide flying simulations to pilot trainees, thus allowing the pilot trainees to learn how to fly without risking their lives. (4) allowing learners to generate and test hypotheses in the context of problem solving. For example, computers can link to scenarios, which engage students in guided, discovery learning. Students are provided opportunities to solve problems embedded in these scenarios. To sum up, when computers are used in these contexts mentioned above, they are regarded as cognitive tools and they are believed to have the potential of helping learners accomplish cognitive tasks. In other words, they have entered an intellectual partnership with humans, as proposed by Salomon and his colleagues (Salomon, Perkins, & Globerson, 1991).

These past strands of thinking have helped paved the road for engaging students in the learners-as-multimedia-designers environment. With the notion of treating knowledge as design, doing projects is considered to provide students a chance to actively construct knowledge rather than passively receiving information from teachers. The idea of constructionism strengthens the validity of engaging students in creating products. The ideas of learning *with* computers and using computers as cognitive tools further emphasize the importance of technology use in the learners-as-multimedia-designers environment and provide rationales for using computers as cognitive tools to promote human cognitive gains.

After examining the background of the learners-as-multimedia-designers approach, it was useful to highlight some examples of the learners-as-multimedia-designers approach for a closer inspection. In the following, two examples of the learners-as-multimedia-designers environment were presented.

Examples of the Learners-as-Multimedia-Designers Approach

Lehrer and his colleagues (Lehrer, 1993; Lehrer et al., 1994) have conducted studies about the learners-as-designers environment. An authoring tool called HyperAuthor was developed to facilitate the design and development of hypermedia documents. Ten eighth-grade students participated in the History by Design project. Their project was to develop presentations about the Civil War using HyperAuthor.

Students initially spent time collecting pictures, video clips and text for their project. Then they worked on creating their product on HyperAuthor.

HyperAuthor allowed students opportunities to construct and reflect. Students could use the "Linkmaker" to create links between related concepts. Students could also link resources such as text, drawing, graphic and sound to construct a meaningful document. Students also had opportunities to reflect on their learning process. For example, students were asked to construct a user's guide map, which helped students reflect on their organization and also served as a practical navigation tool for users. These features of HyperAuthor provided students opportunities to review and organize their thinking as well as constructing knowledge.

Other examples of the learners-as-multimedia-designers environment could be found in Liu and her colleagues' research (Liu, 1998a; Liu, 1998b; Liu & Rutledge, 1997; Liu & Pedersen, 1998; Liu & Hsiao, 2001; Liu & Hsiao, 2002; Liu, 2003). For example, in Liu and Rutledge's (1997) study, they engaged at-risk high school students in developing multimedia programs for a target audience. Using multimedia programs such as Director and Photoshop and multimedia equipment, these high school students created a CD-Yearbook for their school and a virtual museum for the local Children's Museum. Students learned to pay special attention to their audience, defined their topics and refined their strategies for presenting information.

In Lehrer and his colleagues' study (1993), HyperAuthor, as a computer program, was used to prompt student construction and reflection whereas in Liu and Rutledge's study (1997), students had to take initiatives to learn various multimedia-authoring programs and, under various constraints, create their products. In Lehrer and his colleagues' study (1993), students worked within their school environment whereas in Liu and Rutledge's study (1997), more attention has been directed to the outside community, namely the Children's Museum and the local multimedia industry. Despite these differences, students in both studies used computers as cognitive tools to construct their knowledge. Computers, in both cases, became an "intellectual" partner to students and helped extend students' cognitive capabilities.

The Process of the Learners-as-Multimedia-Designers Approach

Despite variations in terms and some implementation details, the same key cognitive activities can be found in both studies mentioned above. Students followed a four-phase design model: planning, design, production and evaluation and revision, which was based on Lehrer's (1993) instructional design model (planning, transforming, evaluation and revision) and design procedures used in the multimedia design industry (Liu, Jones, & Hemstreet, 1998). In the following, each phase was discussed.

Planning

The planning phase consists of efforts and activities to define the ill-structured problem or question in a multimedia project. Students specify the major goals of the project and decide what subtopics to include. Students are engaged in brainstorming sessions to come up with initial ideas on what to create (the content), for whom to create (the audience), and how to develop the program (the process). After discussion and negotiation considering their own interest and time factor, students then divide into teams to work on different topics. At the same time, students evaluate commercially available multimedia programs to develop a critical sense about good and bad features in the commercial multimedia products. Information search and research also starts at this phase.

Design

After going through the planning phase, students are engaged in refining their topic, subtopics and in finalizing the design, content, structure and strategies to be used for presentation while the information search and research goes on. In the design phase, each person in the team chooses or is assigned roles and responsibilities to work on. For example, there are various roles such as project manager, researcher/writer, graphic designer, programmer, video specialist, and audio specialist, and animator. Students can either assume multiple roles or take different roles at different times. Students also need to set a timeline for their project to ensure the product can be delivered on time. Visual maps such as flowchart and storyboards are also required as their project plan. Students also start learning about various multimedia software tools to use for their project.

Production

In the production stage, students begin to develop representation of their ideas in different media and they transfer the design into a presentation medium. In order to develop representations in different media, they are engaged in tasks such as scanning photographs, drawing pictures, creating animation, digitizing audio, and programming. In this phase, they may encounter the constraints of the project such as time and equipment problems. They need to make sure the project is going smoothly and the product is delivered as planned.

Evaluation and Revision

Evaluation and revision are on an ongoing basis, following the practice in the multimedia industry. Evaluation includes self-reflection as well as soliciting peer feedback. Feedback can also be obtained from teachers and the target audience for whom the multimedia product is designed. The areas for review may include the organization of topics, the content, the interface and interactivity design aspects. Revision, on the other hand, occurs as a response to the evaluation on an as-needed basis. The evaluation and revision phase is intended to be a dynamic and interactive process in which interactions between team members are encouraged and responses from the target audience are valued.

These four phases of the learners-as-multimedia-designers approach are actually flexible and recursive in nature in that different situations may entail different activities. Whenever there is a need, students can repeat some steps or skip the others. In essence, the purpose of the four-phase process model is to maximize student learning and to ensure the project is carried out in a timely and efficient fashion so that the final product can be delivered as planned.

In sum, the learners-as-multimedia-designers approach derives the project format from project-based learning. With a focus on design and the use of computers as cognitive tools, its process involves four phases, planning, design, production and evaluation and revision. With this overview of the background and the process of the learners-as-multimedia-designers approach, the next section examined current theories of learning that provided a theoretical framework for the project-based learning and the learners-as-multimedia-designers approach.

A THEORETICAL FRAMEWORK FOR THE LEARNERS-AS-MULTIMEDIA-DESIGNERS ENVIRONMENT

Instructional approaches usually carry some underlying assumptions about learning and teaching. The relationships between the assumptions and the instructional approach usually are not closely examined, but a close-up look at the relationship between the instructional approach and the theoretical framework may help provide clarifications and justifications for the instructional approach. In this section, we took a close-up look at the theoretical framework for the learners-as-multimedia-designers environment.

Research on project-based learning and the learners-as-multimedia-designers environment has mostly been conducted within a cognitive theoretical framework. The cognitive framework focuses on examining individuals' internal cognitive processes from an information processing perspective. Theories of working memory and long-term memory are invoked under the cognitive framework. With the focus within educational psychology shifting toward a more situated and more socially-constructed paradigm (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; Sfard, 1998), there was a need to examine the learners-as-multimedia-designers approach from this new framework.

This new framework has been characterized with a participation metaphor of learning (Sfard, 1998; Cobb & Bowers, 1999) in contrast to an acquisition metaphor. Sfard (1998) has explained the reasons for using metaphors in discussion and in distinguishing different theoretical frameworks. She said,

> Metaphors are the most primitive, most elusive, and yet amazingly informative objects of analysis. Their special power stems from the fact that they often cross the borders between the spontaneous and the scientific, between the intuitive and the formal. Conveyed through language from one domain to another, they enable conceptual osmosis between everyday and scientific discourses, letting our primary intuition shape scientific ideas and the formal conceptions feed back into the intuition. Thus, by concentrating on the basic metaphors rather than on particular theories of learning, I hope to get into a position to elicit some of the fundamental assumptions underlying both our theorizing on learning and our practice as students and as teachers. (Sfard, 1998, p. 4)

Indeed, the acquisition metaphor assumes that individuals go about acquiring skills and knowledge, with knowledge and skill becoming the possession of individuals. In comparison, the participation metaphor brings to mind an image of taking part in some process, which signals that there is a greater whole than the sum of its part. Underlying the participation metaphor is the assumption that individuals participate in social activities and that the focus of learning shifts to social interactions and knowledge construction within a social context.

There are significant perspective shifts from the acquisition metaphor to the participation metaphor. It is useful to compare the participation metaphor with the acquisition metaphor to understand their differences and their implications for learning and instruction. The comparison of the two was provided in Table 1.

Table 1: Comparison of Two Metaphors for Learning (Adapted from the table of Sfard, 1998, p. 7)

	Acquisition Metaphor	**Participation Metaphor**
Goal of Learning	Individual enrichment	Community building
Learning	Acquisition of something	Becoming a participant
Student	Recipient (consumer) (reconstructor)	Peripheral participant, apprentice
Teacher	Provider, facilitator, mediator	Expert participant, preserver of practice/ discourse
Knowledge, Concept	Property, possession, commodity (individual, public)	Aspect of practice/ discourse/activity
Knowing	Having, possessing	Belonging, participating, communicating
Theory Base	Behaviorism, information processing theory	Constructivism, situated learning, distributed intelligence
Unit of Analysis	Individuals	Individuals in the community

From the perspective of the acquisition metaphor, knowledge is considered an entity that can be acquired and transferred between people. Learning occurs when an individual integrates new knowledge with his or her prior knowledge structures or schemata. The goals of learning are for personal enrichment and learning is a process of acquisition. It is also implied in the acquisition metaphor that when a teacher gives a lecture and provides a good organization of content, students can receive information and learn the subject more easily. Context is not taken into consideration in the framework of the acquisition metaphor.

The participation metaphor, however, treats knowledge as an aspect of practice or activity. Instead of focusing on acquiring knowledge, the participation metaphor posits that learning occurs as a result of the activities and practices in which the learner participates. To put it briefly, learning a subject is regarded as a process of becoming a member of a certain community of practice. The ultimate goal of learning is to contribute to that community (Sfard, 1998). Students, as "legitimate peripheral participants" (Lave & Wenger, 1991, p.27), have chances to gradually gain experience and expertise in their community. Teachers, as expert participants, help facilitate students' entry into the center stage of the community along the way.

In addition, the acquisition metaphor bases its theoretical framework on behaviorism and information processing theory whereas the participation metaphor bases its theoretical framework on constructivism, situated learning, and distributed intelligence (Cobb & Bowers, 1999; Greeno, 1997; Sfard, 1998). In the following, we examined each theory in more detail.

Theories of Learning from a Participation Perspective

Constructivism

Constructivism, as one of the most current theories of learning, has greatly influenced our theoretical reasoning and instructional practices. Two perspectives, however, need to be distinguished in the discussion of constructivism: cognitive constructivism and social constructivism. Piaget's later work on cognitive structuring processes serves as the foundation of cognitive constructivism while Vygotsky's work about socialcultural effects on learning lends much to social constructivism (Fosnot, 1996).

Constructivist beliefs represent a paradigm shift from objectivist beliefs that stress the existence of an absolute reality. In objectivism, knowledge is regarded as existing independently of learners, and learning is believed to be a process of transferring knowledge from outside to within the learner. In contrast, constructivists claim that there is no such thing as absolute reality. Knowledge cannot be transferred from the teacher to the students. Learners are believed to actively construct their knowledge as they try to make sense of their experience. When interacting within the physical and social environments, learners constantly reorganize and adjust their mental structures to account for their new experience.

Cognitive constructivists and social constructivists hold different views about the process leading to the construction of knowledge or learning. Cognitive constructivists, following Piaget's (1977) work, adhere to the view that learning is a result of cognitive equilibration, a balancing process between assimilation and accommodation. Assimilation is the organization of new experience to fit with one's original logical structure or understanding. In other words, assimilation occurs when a learner tries to understand new experience through his or her prior experience and knowledge. Learners assimilate new experience into their prior experience. Accommodation, on the other hand, is the act to change one's original cognitive structure or understanding to fit with the new experience. When there is a contradiction between one's original understanding and the new experience, the learner accommodates to the new experience and changes their original idea. In short, cognitive constructivists assume that learning occurs as a result of the interchanging acts of assimilation and accommodation in one's mind. The cognitive constructivist view has much to do with an individual's ability to adapt to new experiences and environments.

Social constructivists, on the other hand, follow Vygostky's (1978) social developmental theory and emphasize the effects of social interaction, language and culture on learning. Vygotsky argued that when learners interact with slightly more knowledgeable others or adults in the "zone of proximal development"(ZPD) (Vygostky, 1978, p. 130), learners have the best chance of success. Similar in cognitive level, the slightly more knowledgeable peers can explain things in ways a learner understand, thus playing an effective role in helping the learner construct understanding. Adults can also adapt their instruction to fit learners' levels of understanding; that is, to fit into learners' "zone of proximal development". As a result of this view, some psychologists (Bruner & Ratner, 1978) have extended this concept into "scaffolding" in which adults or more able peers can provide language cues or other forms of support to learners.

Both cognitive and social constructivists share the same belief that learners construct their own understanding from their experience. Both recognize the crucial role activity plays in one's learning. However, cognitive constructivists focus on individual students' sensory-motor and conceptual activity whereas social constructivists regard activity as participation in culturally organized practices (Cobb, 1996). Cognitive constructivists use the individual's cognitive process as the unit of analysis whereas social constructivists examine the individual-within-the-social group. In other words, cognitive constructivists focus on individual skill and knowledge acquisition while social constructivists are more interested in an individual's participation in the social and cultural group and how the group influences the individual's psychological development.

Situated Cognition

The situated cognition perspective shares many similarities with social constructivism. However, there is no consensus regarding the use of terms (i.e.: situated cognition, situated learning, situated action or situativity). All terms have been used interchangeably by researchers. For the convenience of this paper, the term "situated cognition" was used to avoid confusion.

The situated cognition perspective developed as a response to the assumption that knowledge exists as a self-sufficient substance, independent of the situations in which it is acquired, and as a response to the practices of schools that teach abstract, decontextualized concepts to students. The situated cognition perspective argues that the situation in which knowledge is developed and used is an integral part of what is learned. Learning and cognition are believed to be situated in activities and situations (Brown, Collins, & Duguid, 1989).

Brown, Collins and Duguid (Brown, Collins, & Duguid, 1989) have used the metaphor of tools to illustrate the situated nature of knowledge. They explained that knowledge shares many significant features with tools. Like tools, knowledge needs to be used and understood in the contexts in which it is used. When schools impart knowledge away from its situations or contexts, it becomes inert to the learners, similar to tools that become unusable to the users.

Further, Brown, Collins and Duguid (Brown et al., 1989) argued, through the use of knowledge, a learner's view of the field of knowledge will be transformed and the learner can be enculturated into communities or cultures of the field. In other words, through the use of knowledge, learners are able to acquire and understand many of the intricate vocabulary, beliefs and behaviors embedded in communities or cultures. This will not be possible when knowledge is learned separate from its use. Only learning knowledge through its use, can learners become fully involved in the culture of the community.

The instructional implications of situated cognition point to providing authentic activities to learners. According to Brown, Collins and Duguid (1989), authentic activities are coherent, meaningful and purposeful to the learners. These activities reflect practices in the community and can provide learners access to real-world experiences. Additionally, these activities index learners' experience and knowledge. When dealing with problems, similarities between situations may help learners tackle problems more easily. In short, through participation in authentic activities, learners may have a better chance of applying what they learn successfully later on.

Both constructivism and situated cognition theories have provided important implications for the practice of the learners-as-multimedia-designers approach. Another approach that contributes to the learners-as-multimedia-designers approach is the theory of distributed intelligence.

Distributed Intelligence

Distributed intelligence, like the situated cognition perspective, has several names and researchers have not come to an agreement on what to call it and what it implies. For the purpose of this study, distributed learning, distributed intelligence and distributed cognition were collectively called distributed intelligence.

Proponents of the distributed intelligence theory argue that intelligence is a property that is distributed among the people who work together to achieve a common goal and the tools they use to accomplish the goal. For example, Pea (1993) argued that intelligence can have a social and material dimension of distribution. He believed that other than being simply distributed among the group members, intelligence could also be distributed in the tools people use. He explained that in order for individuals in the group to share information easily, ideas must be represented in forms that are external to the individuals. The tools that people use in the collaborative process are one of these forms. He believed that tools could scaffold individuals' development of new capabilities and allow people to offload their cognitive load to the tools and to focus on other tasks. Additionally, Resnick (1987) has offered an example of a manager who uses simulation tools to develop business forecasts and strategies. The simulation tools help present the charts and graphs so that the manager does not need to bother to remember what he or she is doing at the moment and can spare more time concentrating on the interpretations and meanings of these business strategies and forecasts. In this case, intelligence is distributed between the person and the tool, with the tool supporting and augmenting human capabilities.

Furthermore, intelligence can also be distributed in a community. When individuals have expertise in special areas, the community they are in can capitalize on the diverse talents of individuals. Collectively, the community can perform tasks and create products, which would not be possible without distributed intelligence in the community. For example, in a commercial multimedia production house, each employee has special talents and roles in different areas. There are graphic designers, programmers, instructional designers, video specialists, audio specialists, and project managers. Each member works collaboratively to create multimedia products. Each member's combined expertise adds to the combined efforts, namely, the distributed intelligence in the community. With the contribution of each member in the community, the community can produce something better than an individual can achieve.

As Bell and Winn (2000) observed, ultimately, the instructional implication of distributed intelligence may lie in shifting the unit of analysis away from the individual engaged in cognitive activities to focusing on individuals engaged in cognitive activities within social and material contexts. With this in mind, the theory of distributed intelligence shares similarities with social constructivism and situated cognition and have significant implications for the learners-as-multimedia-designers approach.

To sum up, the theories within the participation framework--- constructivism, situated cognition and distributed intelligence---share similar assumptions about knowledge, teaching and learning. Each of these theories has unique contributions to our conceptualization of the learners-as-multimedia-designers approach. Following that, the next section focused on the design implications of these theories on the learners-as-multimedia-designers environment.

DESIGN IMPLICATIONS FOR ENGAGING LEARNERS AS MULTIMEDIA DESIGNERS

The theories within the participation framework mentioned above could be used in examining how learning takes place in the learners-as-multimedia-designers approach as well as in offering insights on how to examine the characteristics applied in the learners-as-multimedia-designers environment. In this section, these theories (constructivism, situated cognition, distributed intelligence) were used to examine the characteristics (authenticity, collaboration, constructive investigation, student autonomy) of the learners-as-multimedia-designers learning environment as well as the practice of cognitive apprenticeship teaching.

Authenticity

Authenticity is an important characteristic of learning environments from the perspective of the participation framework. For example, the situated cognition theory places great emphasis on authentic activities. Authentic activities are believed to provide learners access to real-world experiences and to help learners enter the "community of practice". Authenticity also becomes one of the important characteristics of the learners-as-multimedia-designers environment.

According to Brown, Collins and Duguid (1989), authentic activities can be defined as coherent, meaningful, and purposeful activities. Honebein, Duffy and Fishman (1993) went a step further to identify three characteristics of authentic activities. First, they argued, authentic activities should be project-based. The activities should have both a global aspect that offers a purpose for learning and a local aspect that enables students to learn about the domain of the problem. Second, authentic activities should help promote students' ability to generate and evaluate alternative perspectives. By placing students in simulated or real situations, learners have greater opportunities to make judgments and refine their own viewpoints. Third, authentic activities should allow learners to develop ownership of the learning task. When students develop a sense of ownership toward what they do, they are more motivated and focused and have better chances of succeeding.

These definitions of authentic activities help anchor the practice in the learners-as-multimedia-designers approach. In the learners-as-multimedia-designers environment, students are engaged in project work. The driving question and the project that students work on emerges from real-world needs in either their school or local community. The process of project work allows students to work together to brainstorm ideas, share responsibilities and present final products. As a result, students are exposed to multiple perspectives and gain opportunities to refine their own thinking. With real audience and deadline, the project presents real constraints and possibilities, which makes the project more challenging and meaningful to students. Students may need to expend more efforts to accomplish the project, which may lead students to develop a sense of ownership about their own learning.

To sum up, authentic activities in the learners-as-multimedia-designers environment can infuse a sense of meaning and significance in students and help keep them motivated and persistent in their project efforts. Authentic activities can also help learners discern from multiple perspectives and develop more in-depth understanding. Finally, seeing meaning and significance in the authentic activities, students may also develop a sense of ownership about their own learning.

Collaboration

Collaboration refers to the process in which students work together to accomplish a project. Collaboration is supported by the theories in the participation framework. For example, social constructivism emphasizes engaging individuals in social interactions to promote knowledge construction. Collaboration can provide project participants plenty of opportunities to interact with each other in discussions and in joint activities, which allows individuals to encounter multiple perspectives of the group and to modify and adjust their own thinking. A more refined and well-rounded viewpoint is more likely to take shape.

The situated cognition perspective also supports collaboration. Collaboration is an authentic activity in a community of practice. In real-world situations, cognitively complex and demanding project work usually requires the efforts of many people. For example, collaboration is regularly practiced in the workplace. Engaging students in collaborative activities exposes students to the norm of the workplace and may help prepare them for working with and getting along with different people.

Collaboration also contributes to the distribution and augmentation of intelligence. According to the distributed intelligence theory, the combined intelligence among a group of participants is greater than individual intelligence; that is, joint efforts of the group members exceed individual contribution. Collaboration enables the groups to generate more ideas than what is possible when people work alone. Further, the joint intelligence is also distributed in the product that the group has created. Through the feedback that group members give to each other during the process, their product represents the collective expertise of the group members and can serve as a tool for further improvement.

Collaboration is an integral part of the learners-as-multimedia-designers approach and is pivotal for finishing the project work. From the very beginning of the project process, students work with others to brainstorm ideas, search for information, make plans, and make decisions about the content and strategies of the product. During the design and production stage, students take on different responsibilities and roles to share the workload together. Even in the evaluation and revision phase, collaboration proves essential. Students have better chances to listen to alternative perspective and receive help to overcome technical and design problems.

Constructive Investigation

Constructive investigation is a characteristic rooted in the concept of constructivism. The fundamental idea of constructivism posits that students learn by constructing their own meaning and knowledge rather than passively receiving knowledge from teachers. Whether it is from the perspective of cognitive constructivism or social constructivism, the idea remains essential. From the cognitive constructivism perspective, students need to be exposed to multiple sources of information and perspectives in their physical environment to establish their own construction. From the social constructivism perspective, students construct their meaning within their social environment.

The learners-as-multimedia-designers environment also places great emphasis on constructive investigation. When students are engaged in a project, students need to research the topic in depth. For example, they may apply various strategies such as interviewing people, and searching on the Internet and from the library to get a better understanding of the topic. After some initial research, they need to make judgments on the information they have gathered to determine which is valid and useful for their purpose. During the process of making decisions, students can develop a refined sense of matter and construct their own understanding of the project topic.

Student Autonomy

Student autonomy is another important consideration from the perspective of the participation framework. The constructivism theory recognizes students' roles in constructing their own meanings and knowledge when interacting with the physical and social environments. It is during the process of constructing their unique knowledge and meanings that students can develop autonomy over their own learning. In other words, students' active knowledge construction process may help promote student autonomy.

Student autonomy is also an emphasis in learners-as-multimedia-designers environment. When students work on their projects, they are actively engaged in constructing their own knowledge, rather than passively receiving knowledge from teachers. The project process allows students to explore and investigate a topic in depth with a lot of freedom. Students can express their imagination and creativity in their multimedia products. Teachers are more in a facilitative role to support student development and students are in charge of their own learning.

The above discussion examined how the theories of the participation framework provide foundation to the practices and features in the learners-as-multimedia-designers environment. The theories also point to students' need for support and scaffolding. Therefore, the next section examined the instructional practice of cognitive apprenticeship.

Cognitive Apprenticeship

Collins, Brown and Newman (1989) defined cognitive apprenticeship as a means of teaching the process experts use to handle complex tasks and a way of learning through guided experience. Cognitive apprenticeship differs from the traditional apprenticeship in that the emphasis is on invoking the learning of cognitive and metacognitive skills rather than physical skills. The purpose of cognitive apprenticeship is to make teachers/experts' internal processes overt to students so that students could better observe, enact, and practice knowledge.

Several teaching methods are used in the cognitive apprenticeship process to make experts' or teachers' thinking overt to students (Collins, Brown, & Newman, 1989). First, *modeling* involves an expert's demonstrating the process to carry out a task so that students can observe the process and build a conceptual model of the process. Because learners can learn by observation, providing demonstration and explanation helps make the procedures and cognitive processes overt to students. Second, *coaching* consists of an expert's offering of hints, feedback, modeling, reminders, and new tasks to students with the purpose of bringing students' performance closer to expert performance. The coaching interactions are believed to be directly related to students' performance since teachers or experts can make necessary adjustments in the coaching process to orient students' performance in the right direction. Third, *scaffolding* refers to the support teachers provide to help students carry out a task. Scaffolds can be in the form of suggestions or help, or in the form of physical supports such as cue cards. When students reach the target performance, scaffolds can be gradually reduced. Fourth, *articulation* involves getting students to articulate their thinking processes, including their thoughts, knowledge, reasoning or problem-solving steps. Articulation enables students to focus their efforts and allows teachers to find areas of inconsistencies or misconceptions and to help correct them. Fifth, *reflection* enables students to compare and contrast their own thinking process with those of experts and identify the incongruence. Reflection has the effect of “replaying” one’s thinking process and may entail self-awareness and attainment of a higher level of understanding of the subject matter. Finally, *exploration* involves allowing students autonomy to act on their own to explore and experience. Exploration allows students to practice the skills they learned and discover what they lack.

Cognitive apprenticeship is another important design implication of the participation framework. Social constructivism advocates engaging students in a “zone of proximal development” (Vygotsky, 1978) to support students’ learning process. Cognitive apprenticeship places teachers in students’ “zone of proximal development” and allows them to provide students with scaffolding and support. Teachers, as experts, can evaluate the needs of students and make decisions on how to organize and optimize students’ learning experience. In addition, the cognitive apprenticeship process may also help distribute the expertise among teachers and students. Initially, teachers offer scaffolding for students by giving examples, suggestions or help. As students learn and grow more competent, teachers can gradually reduce the scaffolding and overt support and allow students to become more independent in their learning.

Researchers of the learners-as-multimedia-designers environment have already paid attention to this issue and included cognitive apprenticeship in their discussion and practice. In Lehrer and his colleagues’ studies (1993, 1994), scaffolding was provided to students in multiple ways. First, the researchers provided explicit instruction in many occasions. Both direct instruction and modeling of design skills were presented. Skills were decomposed into distinct steps for students to follow and examples were provided. Second, the researchers also scaffolded students' efforts with the computer tool they designed. HyperAuthor, for example, embedded many features which scaffolded students' thinking process. Student reflection and organization of ideas were facilitated with the LinkMaker feature inside the HyperAuthor program. Third, the researchers supported students' project through questioning. By asking students leading questions and asking them to justify their choices, the researchers enabled students to follow the right direction and articulate their thinking. Fourth, the researchers also supported students' efforts with alternative assessment. Instead of using the traditional multiple-choice achievement tests, assessments of students' projects took many forms including examining their knowledge organization, time-on-task and retention a year later. For example, group cooperation was assessed in the project and announced in the beginning, thus prompting students to focus on their group efforts.

In Liu's (1998) study, the cognitive apprenticeship practices were also incorporated in the environment. Throughout the process, student learning was supported in different ways: (1) explicit design instruction was provided to students. (2) use of professional multimedia tools, (3) coaching by the teacher, the museum representatives (their client), and the graduate student, and (4) interaction with various multimedia experts from local industry (p. 148). Students in this study not only were supported by their teachers, but were also supported by experts (researchers and multimedia professionals). Since students had close contact with their target audience and understood the expectations, their efforts reflected real purposes and needs.

To sum up, the theories from the participation framework provides theoretical foundations and justifications for many of the practices and characteristics in the learners-as-multimedia-designers environment. Next, it was helpful to look at the research. In the next section, the discussion turned to the current research on the learners-as-multimedia-designers environment.

RESEARCH ON THE LEARNERS-AS-MULTIMEDIA-DESIGNERS ENVIRONMENT

Overview of Research

The learners-as-multimedia-designers environment incorporates the features of project-based learning and the use of technology, namely, computers, for student learning. Grounded on the theories of the participation framework, the learners-as-multimedia-designers environment has shown great potential and promises.

A number of studies have documented the promising results of engaging students in the designer role (Harel, & Papert, 1991; Kafai, 1996; Lehrer, 1993; Lehrer, Erickson, & Connel, 1994; Liu & Rutledge, 1997; Liu & Pedersen, 1998; Liu & Hsiao, 2002; Spoehr, 1993). Some earlier studies focused on the subject matter and content knowledge students gain from learning and designing multimedia programs. For example, Harel and Papert (1991) engaged seventeen fourth-grade students as software designers in their Instructional Software Design Project (ISDP). Students in an experimental classroom used a program called LogoWriter to build instructional documents on the mathematical topic of fractions for other students. Two other classes which studied math and programming in the traditional way served as control groups. In the end of the project, students in the experimental class improved in their ability to work on fractions and learned much more about Logo programming than the control groups. Following Harel’s study (Harel, 1991), Kafai (1996) engaged sixteen fourth-grade students in designing computer games using Logo. The control groups were three other groups who were engaged in instructional design, programming and traditional math lessons. She discovered that students in both the instructional design and game design groups improved their Logo knowledge more than the other two control groups.

With the evolution of multimedia technology, some researchers began to conduct studies on the effect of engaging students as multimedia designers. Spoehr's study (1993) had high school students design multimedia documents on American history. One experimental class learned history through developing hypermedia projects while one control class learned history through direct lecture format. Comparisons between the experimental class and the control class on 14 measures, including the verbal and mathematics scores on the SAT, semester grades, and classroom assignments, showed that students as multimedia authors developed more complex knowledge representations through the design of hypermedia programs. Students in the experimental class were better at articulating and defending essay topics and included more information in their writing.

Similar promising results were found in the studies of Lehrer and his colleagues (Lehrer, 1993; Lehrer, Erickson, & Connell, 1994). For example, in Lehrer (1993)'s study, eighth-grade students used a program called HyperAuthor to develop hypermedia presentations about the Civil War history for their peers as an educational tool. The ten participants in this study were selected by the teacher from a large pool of volunteers, with half considered successful and motivated, and the other half considered less successful and uninvolved in school. Students were divided into two groups where all of the successful students worked together in one group, and the less successful students worked in the other group. Teachers provided modeling and instructional support while the HyperAuthor software facilitated student reflection through embedded reflection tool.

The researcher went back to visit these students after a year to test their knowledge on the history topic and the result showed that the students in both groups have shown striking long-term recall of the topic and developed deeper, connected and more applicable understanding of the topic than their classroom counterparts who did not participate in the design project.

While a great amount of early research studies focused on the benefit of learning subject matter through multimedia projects, some research also paid attention to the motivating effect of working on design tasks. For example, in the study conducted by Lehrer (Lehrer, 1993), the findings showed that students in both groups had a high degree of involvement with the project and the students in the less successful and less motivated group also increased their time on task significantly. Liu and Rutledge (Liu & Rutledge, 1997) worked with at-risk high school students as they designed multimedia projects for a children's museum. Two classes of students from an inner city high school with a large minority student population participated in the study. The experimental class worked on developing multimedia documents while the control group class learned computing tools. The result showed that students in the experimental class significantly increased their interest and involvement throughout the project. These students steadily increased their time spent on the project and the on-task behavior, and became more motivated than the control group. Moreover, they had higher self-efficacy and obtained a positive image about themselves. Many have reset their goals for the future—to work in a multimedia design profession rather than working in fast food restaurants.

In another study by Liu and Pedersen (1998), elementary school students were engaged in hypermedia design using HyperStudio. Two fourth-grade classes participated in this study as part of their science class. Both classes of students were engaged in hypermedia project using HyperStudio. Students in the experimental class were engaged in the learners-as-designers environment while the other class worked in a more traditional, teacher-centered environment creating hypermedia programs. Students in the experimental group also worked collaboratively while students in the non-designer group worked independently. Quantitative and qualitative data were both collected for triangulation. Although the results showed that students in the experimental group increased significantly in their knowledge on the subject matter, both groups were as interested and motivated in the hypermedia project.

Despite difficulty in assessment (Carver, Lehrer, Connell, & Erickson, 1992), some researchers (e.g. Lehrer, 1993; Lehrer et al., 1994; Liu, 2003; Liu & Hsiao, 2001; Liu & Hsiao, 2002) have also examined the effect of the learners-as-multimedia-designers environment on students' learning of higher-order cognitive skills, specifically, project design skills during group projects. For example, Liu and Hsiao's study (2002) examined middle school students' development of project design skills while learning and designing multimedia projects. Working with sixteen middle school students taking a multimedia elective class, they found that engaging students as designers have increased students' awareness and understanding of the importance of the project design skills including planning, presentation, collaboration, and testing. The researchers also learned that students understood the importance of such design tasks as storyboarding, designing and evaluating in the end of the study. The researchers concluded that more detailed understanding on students' project design skill development in the learners-as-multimedia-designers environment was needed.

Another example of such research was by Carlin-Menter and Shuell (2003), who sought to investigate the possibility that multimedia authorship may help students become more proficient writers and learn various cognitive skills. Under the assumption that the thinking processes involved in writing and multimedia composition were similar, they had four classes of 8th graders given a 7-paragraph article and developing a nonlinear multimedia presentation using *HyperStudio*. Students were also asked to write an essay on an assigned topic both before and after they completed the multimedia project. The result indicated that students who experienced the multimedia composition showed significant increase in their organization quality of traditional text essays. They found that students were highly motivated throughout the process. They also noted that students may need multimedia instruction at an earlier stage of the class and that students would benefit from introduction to the concepts of organization and categorization before project work.

To sum up, the research on learners-as-hypermedia/multimedia designers so far has provided encouraging evidence on the following: (1) such learning environment may help students deep process subject matter content and enable them to have a better understanding of the subject matter they are learning (Harel & Papert, 1991; Kafai, 1996; Lehrer, 1993; Lehrer, Erickson, & Connell, 1994); (2) such learning environment may have a positive impact on students' motivation and self-efficacy toward learning (Liu & Rutledge, 1997; Liu & Pedersen, 1998); and (3) students may acquire higher-order cognitive skills such as project design skills from such environment (Liu, 2003; Liu & Hsiao, 2001; Liu & Hsiao, 2002; Liu & Pedersen, 1998; Liu & Rutledge, 1997).

Of all these aspects, the line of research on students' development of project design skills is particularly noteworthy, given that learning project design skills can "help students become better problem solvers" (Liu, 2003, p. 15) and "encourage students to be better learners as they become aware of their own thinking and monitor their own learning process" (Liu, 2003, p.15). It was one of the objectives of this research to further examine students' development of project design skills in the learners-as-multimedia-designers environment. This researcher chose to build on previous research and further investigate this topic.

In addition, there are still other aspects of the learners-as-multimedia-designers that research has not examined. Notably, research has not examined the affective and social aspects associated with the learners-as-multimedia-designers environment fully. The majority of research in this area, action research by practicing teachers, is anecdotal and mostly focuses on student motivation (Carlin-Menter & Shuell, 2003). It was the intention of this researcher to explore the construct of psychology sense of community in this environment.

In the following sections, we discussed the two focus of this study---project design skills and psychological sense of community--- in more detail.

Project Design Skills Development in the Learners-as-Multimedia-Designers Environment

The learners-as-multimedia-designers environment involves students in a variety of activities from brainstorming ideas, gathering and researching information, writing, creating art works, to programming and evaluating. These activities resemble what exists in a real world setting as shown in the practice of multimedia industry (Liu, Jones, & Hemstreet, 1998**.)** and require students to tap into their diverse talents and intelligences (e.g., artistic, logical, linguistic and musical) to accomplish the task (Gardner, 1999). Carver, Lehrer, Connell and Erickson (1992) have pointed out that engaging students in the multimedia design and production activities may potentially contribute to the development of many higher-level cognitive skills including project management skills, research skills, organization and representation skills, presentation skills, and reflection skills (see Table 2).

Table 2: Project Design Skills Involved in Designing Multimedia Programs (Carver, Lehrer, Connell, & Erickson, 1992, p.388-389)

Project management skills	• Creating a timeline for the completion of the project. • Allocating resources and time to various segments of the project. • Assigning roles and responsibilities to team members
Research skills	• Determining the nature of the problem and how the inquiry should be organized. • Posing thoughtful questions about the structure, model cases, values, roles, etc. • Searching for information using textual, electronic, and pictorial sources of information. • Developing new information with surveys, interviews, questionnaires, interviews, and other sources. • Analyzing and interpreting all of the information collected to find and interpret patterns.
Organization and representation skills	• Deciding how to segment and sequence information to make it understandable. • Deciding how information will be represented (text, pictures, video) • Deciding how the information will be organized (hierarchy, sequence) and connected. • Juggling constraints of the information and organization.
Presentation skills	• Mapping the design onto the presentation, implementing the ideas in multimedia. • Attracting and maintaining the interest of the audience
Reflection skills	• Evaluating the program and the process • Revising the design of the program using feedback

The breadth of these project design skills may appear to be daunting at first sight. However, these project design skills are required for creating and designing multimedia programs, and they are useful life skills. Carver, Lehrer, Connell and Erickson (1992) believed that these skills could be fostered through the activities of working on multimedia projects. One caveat they have pointed out was that working on multimedia projects alone does not necessarily engender the development of these skills. They pointed out that one way to foster these skills might result from teachers and peers' support. Teachers need to provide cognitive apprenticeship teaching---i.e. modeling, coaching, etc to facilitate students' higher-order thinking learning. In addition, peer collaboration can also play a role in assisting students to develop these skills because many project design skills in the learners-as-multimedia-designers environment can be internalized by learners during peer interaction (Vygotsky, 1978) or distributed across members of the group (Roschelle, 1992).

As mentioned earlier, this research built on previous research to further investigate this topic. This study examined students' development of project design skills in the learners-as-multimedia-designers environment and also examined the relationship of project design skills development in relation to students' psychological sense of community, which we discussed next.

Students' Psychological Sense of Community in the Learners-as-Multimedia-Designers Environment

Psychological Sense of Community---A Definition

Psychological sense of community is a concept that has widespread influences in the field of community psychology but has only recently been applied more in the field of education (i.e.: Misanchuck, 2003; Rovai, 2001, 2002a, 2002b). Psychological sense of community dated back to Seymour Sarason (1974), who, in his 1974 ground breaking book, The Psychological sense of community: Prospects for a community psychology, called for developing a discipline to focus on the concept of psychological sense of community. In response to this call, many researchers started devoting attention to the construct of psychological sense of community.

Among the numerous proposals about the dimensions of the psychological sense of community (PSOC) construct, McMillan and Chavis' (1986) definition and clarification of the PSOC has provided the best foundation and is the most well-accepted and validated theory in the field (Obst & White, 2004). McMillan and Chavis' (1986) model includes four criteria in judging sense of community: (1) Membership--the feeling of belonging or of sharing a sense of personal relatedness. Personal investment is an important contributor to a person's feeling of group membership and to his or her sense of community; (2) Influence--a sense of mattering, of making a difference to a group and of the group mattering to its members; (3) Integration and fulfillment of needs—a feeling that individuals' needs will be met through their membership in the community and that the needs of the community can be met by the individual; (4) Shared emotional connection—the commitment and belief that members have shared and will share based on history, common places, time together and similar experiences with their community members. McMillan and Chavis (1986) suggested that these four dimensions work together to create and maintain an overall sense of community.

According to Gusfield (1975), PSOC can develop in either a “territorial” community, defined by geographical boundaries (such as school, city, and neighborhood) or a “relational” community, defined by the nature and strength of relationships (work, political or recreational interest). Although PSOC can develop when both types of communities overlap, it is possible that PSOC can develop in a relational community without having geographical proximity, such as the virtual community. Likewise, geographical proximity in itself cannot guarantee the development of a psychological sense of community (Bateman, 1998). Furthermore, researchers (Hill, 1996; Rheingold, 1991) have also recognized that PSOC differs from setting to setting and has a context-specific attribute. Overall, there is an agreement in the field that PSOC should be studied in a variety of contexts and examined setting by setting.

So far research on psychological sense of community has been conducted on various settings covering many different issues and topics. For example, PSOC has been analyzed in the context of neighborhoods (Garcia, Giuliani, & Wiesenfield, 1999; Kingston, Mitchell, Florin, & Stevenson, 1999), workplace settings (Brodksy & Marx, 2001; Klein & D’Aunno, 1986; Mahan, 2000), politically constructed groups (Itzhaky & York, 2003; Sonn & Fisher, 1996), religious settings (Miers & Fisher, 2002), immigrant groups (Sonn, 2002), indigenous groups (Hazel & Mohatt, 2001), and cyberspace communities (Obst, Zinkiewicz, & Smith, 2002). Psychological sense of community has also been examined on a wide range of topics such as crosscultural perspectives (Sonn, Bishop, & Drew, 1999; Ying, Lee, & Tsai, 2000), attitudes and reactions to media coverage of terrorist acts (Keinan, Sadenh, & Rosen, 2003), feminism (Angelique &

Culley, 2003; Mulvey, Gridley, & Gawith, 2001), and science fiction fandom (Obst, Zinkiewicz, & Smith, 2002).

However, little research has systematically examined the construct of sense of community applied to school and classroom settings (Bateman, 2002; Pretty, Conroy, Dugay, Fowler, & Williams, 1996). Of studies conducted in classroom settings, many recent studies (Cadieux, 2002; Misanchuck, 2003; Rovai, 2001, 2002a, 2002b) in the field of education focus on examining adult learners' PSOC in cyberspace communities rather than in geographical communities. For example, Rovai (2001) analyzed a five-week online distance graduate-level education course using the Blackboard e-learning system. Gathering data from 10 male and 10 female adult learners, he found that these learners' psychological sense of community did grow significantly during the course (from the beginning of the course to the end of the course) and that gender did manifest differences. Female learners showed a stronger sense of community both at the beginning and at the end of the course than their male counterparts.

Cadieux (2002) examined community college students' PSOC in an online course and found that the face-to-face group experienced stronger sense of community than the online group and that no significant relationship was found between sense of community and students' course grade. Misanchuck (2003) also conducted a research with online graduate education students using both quantitative and qualitative methodologies. The quantitative measure did not find any significant relationship either between psychological sense of community and students' satisfaction of the course or between sense of community and student performance. However, the researcher's qualitative data did reveal that students felt a sense of community during the graduate program, although not during the course in the semester under investigation. Overall, these studies on virtual community have yielded interesting results and a Classroom and School

Community Inventory (Rovai, 2002b; Rovai, Wighting, & Lucking, 2004), targeting the online community and adult population, has been developed accordingly. These studies have provided insight onto the particular characteristics and requirements in a virtual community.

To date, there are only very few studies that can be found investigating geographical community and examining younger students in a classroom setting. Of these studies, Kim, Solomon and Roberts (1995) investigated classroom practices that may enhance students' sense of community. As part of a larger scale study, these researchers collected data from observations of 232 elementary classrooms and from student questionnaires. They identified from the observation data five teacher practices factors (warmth and supportiveness, emphasis on prosocial values, encouragement of cooperation, elicitation of student thinking and expression of ideas, use of extrinsic control) and three student behavior factors (positive behavior among students, student engagement, and student influence). Using these factors, these researchers constructed a questionnaire to check on students' psychological sense of community. The result indicated that each of the student behavior variables showed stronger relationship with students' psychological sense of community than did the teachers practice variables. That is, the relationships between teacher practices and students' psychological sense of community were indirect---through intermediate relationships with student behavior variables. Most of the teacher practices (except extrinsic control) significantly and positively influenced student behaviors in the classroom, which in turn led to students' psychological sense of community in the classroom. The researchers also found that cooperative interaction was a primary mechanism that provided students with opportunities to exert meaningful influence and to display positive behavior with others. The researchers concluded that it is important for teachers to create classrooms that encourage students' active participation, collaboration, and interpersonal support and called for future research to test more directly the link between a classroom environment that fulfills students' needs for belonging, autonomy and competence and students' sense of community.

Bateman (1998) also explored students' psychological sense of community in the classroom. She investigated whether the Schools for Thought (SFT) project had impact on sixth grade students' psychological sense of community. In SFT classrooms, students formed teams, conducted research and developed expertise in a domain of knowledge such as mathematics, science, social studies and literature. Then, students came back to share their knowledge and exchanged ideas with their peer through a computer-mediated environment called CSCILE or face-to-face discussions. In SFT classrooms, students had opportunities to: (1) work collaboratively to achieve important goals and to build a community, (2) plan and organize their own research, learning, and problem solving activities, and (3) share their products with parents and other members of the community (Bateman, 1998).

The participants in this study (Bateman, 1998), 94 students from four SFT classrooms and 65 students from the traditional classrooms, showed no significant differences in their academic achievement scores at the onset of academic year. At the end of academic year, the result showed that SFT students, compared with students in traditional classrooms, had significantly higher levels of psychological sense of community and that students in the SFT classrooms also had significantly higher levels of cooperative skills than students in the comparison classrooms. In addition, this study also found that psychological sense of community was positively correlated with students' academic achievement and other affective elements such as social skills, academic self-efficacy, task-mastery/learning goals, and interest in complex problem-solving.

These two studies have demonstrated interesting findings related to psychological sense of community within classroom settings. However, with the context-specific attribute of PSOC, different communities may develop different levels of psychological sense of community. Whether the learners-as-multimedia-designers environment would help students develop a better sense of community remained in question. As Bateman (1998) concluded in her study, “additional studies are needed in order to... empirically assess classrooms to identify characteristics of learning environments that promote students’ psychological sense of community” (Bateman, 1998, p. 63), more research was needed to examine students’ psychological sense of community in different environments. In the following section, we examined the potential of the learners-as-multimedia-designers environment to foster a higher sense of community in students.

Building a Sense of Community in the Learners-as-Multimedia-Designers Classroom

The learners-as-multimedia-designers environment shares the same theoretical background and many characteristics as the SFT classrooms. Both environments are constructivistic/collaborative in approach. Both encourage active construction of knowledge through inquiry and collaborative activities. Both use authentic activities or problems as opportunities for students’ extended and deep inquiry. Both apply technological tools, with the SFT classrooms using CSCILE and the learners-as-multimedia-designers environment using multimedia tools. However, the SFT classrooms do not place as much emphasis on projects or creation of end products as the learners-as-multimedia-designers environment does. With these similarities and differences in mind, the following section turned to examine the construct of psychological sense of community and its four dimensions in the learners-as-multimedia-designers environment.

Membership. The key to a sense of belonging and identification with a community requires personal investment from individuals. In other words, the more individuals invest their time and efforts in the community, the greater attachment and feelings of belonging he or she feels. Likewise, the harder individuals work at earning a place in the group, the more valuable and meaningful their membership in the group becomes. In the learners-as-multimedia-designers environment, students are placed in a position to take charge of their own learning and take responsibility for their own actions. They invest greatly their time and efforts to accomplish their projects. Due to the complex nature of cognitive tasks they are engaged in, they are also challenged more than by regular classroom activities. They need to work harder to arrive at their goal. It is proposed that the more students have invested their time and efforts, the more likely they will develop a sense of membership in the community

Influence. Influence is a bi-directional concept. In one direction, a member needs to have some influence over what the group does to be attracted to a group. In the other direction, cohesiveness of a group depends on whether it can effectively influence its members (McMillan & Chavis, 1986). In the learners-as-multimedia-learners environment, influence also flows in both directions. Because knowledge is distributed in the community (including the groups and tools), each individual becomes an integral part of the learning experience. Individuals need to rely on the group for understanding of the whole picture. Simultaneously, each student also develops special expertise and possesses special talents to offer their community. The success of a group effort rests on the contribution of each individual, so individuals also exert influence on their group. Further, since individuals provide feedback and evaluation to each other along the way, individuals also actively affect the performance of the group.

Integration and Fulfillment of Needs. Integration and fulfillment of needs refers to the condition that the individual-group association may be rewarding for its members. Otherwise, a group will not be able to maintain a sense of togetherness. In the learners-as-multimedia-designers classroom, each student's learning needs can be facilitated and enriched by his or her peers when they collaborate on the project activities. Through brainstorming, research, feedback and evaluation activities, each student can benefit from the combined efforts of the group. In addition, group members working together toward a common goal also can bring students a sense of accomplishment when the final product is successfully completed. The authentic nature of the project also helps provide students with a sense of meaning and relevance. All these elements in the group activities help fulfill individuals' needs for learning and social support.

Shared Emotional Connection. Shared emotional connection derives from group members' shared history and experiences in events. As group members interact with each other and invest considerable time, energy and effort over a period of time, an emotional bond can be gradually built. In the learners-as-multimedia-designers environment, students spend long periods of time learning and working in groups and in class. As a result, with a shared history, they may develop deep appreciation and understanding of each other and the topic they have worked on. They may develop shared emotional connection with each other and have a sense of identify with their community.

In conclusion, the learners-as-multimedia-designers environment, like the SFT program, has the potential of fostering students' sense of community. It was another objective of this study to examine the impact of the constructivist learners-as-multimedia-designers environment on students' psychological sense of community and to examine the relationship between project design skills and psychological sense of community.

CHAPTER 3: DESIGN

The literature review in the previous chapter indicated that the learners-as-multimedia-designers environment could be constructed and examined based on theories from the participation framework. The theories from the participation framework suggested that a learning environment should provide authentic contexts and activities, encourage collaborative learning, support student learning, and offer students opportunities to actively construct knowledge and discern from multiple perspectives. These theories also provided unique perspectives in examining the learners-as-multimedia-designers approach. The participation perspective was more interested in examining the "aspect of practice" in the community, the unique skills distributed and fostered in the community of practice, in this case, the project design skills, rather than in the individual "acquisition" of subject matter knowledge and software skills. The participation perspective helped focus this study on examining students' learning of higher-order cognitive skills such as project design skills, which are distributed and fostered in the learners-as-multimedia-designers learning environment.

Another aspect the participation perspective focused on was the community building process and the belonging, participating and communicating aspect within a community, namely, aspects related to a "sense of community". This researcher also chose to empirically examine whether a learning environment grounded on constructivism, situated cognition and distributed cognition theories had impact on students' psychological sense of community.

In addition, previous research has shown that psychological sense of community was positively correlated with academic achievement, academic self-efficacy, task-mastery/learning goals, interest in complex problem-solving, and students' cooperative skills (Bateman, 1998; Bateman, Goldman, Newbrough, & Bransford, 1998). It would be beneficial to examine whether psychological sense of community was correlated with the development of higher-order cognitive skills such as project design skills in the learners-as-multimedia-environment as well. Whether higher psychological sense of community could predict better learning of project design skills would be also the focus of this research. Finally, more information was needed on how to design the learners-as-multimedia-designers environment in order to guide the practice in real world. Research from classroom implementations could provide practical guidelines for future practice.

With those premises, this study aimed to investigate the following research questions:

1. What is the impact of the learners-as-multimedia-designers environment on the learning and development of middle school students' project design skills?
2. What is the impact of the learners-as-multimedia-designers environment on middle school students' psychological sense of community?
3. Is there any relationship between students' project design skills and their psychological sense of community as they engage in the learners-as-multimedia-designers environment?
4. Can students' project design skills development be predicted by students' psychological sense of community?

5. What needs to be taken into consideration in designing the learners-as-multimedia-designers environment?

Multiple research designs including a one-group pretest-posttest and a quasi static-group comparison design as well as qualitative data collection were used to answer the above research questions. This chapter described the design of the study including: (1) the sample, (2) the *Multimedia Masters* classes, (3) data source, (4) data collection procedures, and (5) data analysis procedures.

PARTICIPANTS

The participants of this study were students enrolled in an elective *Multimedia Masters* program and students in regular academic subject classes at a suburban middle school located in the southwestern part of the United States. The middle school had a racial makeup of approximately 63% white, 21% Hispanic, 14% African American and 2% Asian. Eight percent of the student population was economically disadvantaged. The city in which the school was located was near a fast-growing city with many high-tech industries, so most of the students had parents who were working professionals.

Three intact classes (N=15, N=14, N=15) from the *Multimedia Masters* program participated in this study and served as the treatment group. Of the three classes, 79.5% (N=35) were white, 15.9% (N=7) were Asian-American (including South Asian and Eastern Asian ethnic backgrounds), 2.3% (N= 1) was Hispanic and 2.3% (N=1) was African-American. The sample was 70.5% (N=31) male and 29.5% (N=13) female. 56.8% (N=25) were seventh graders and 43.2% (N= 19) were eighth graders. Student age ranged from 12 to 14 years. Most students had at least three years of computer experience. Some started using computers as early as kindergarten years. All students had computers at their home. In order to get into the *Multimedia Masters* class, students needed to have an A or B average in their core academic subjects during the previous academic year, positive recommendations from two academic team teachers who may have known them well and that they must indicate multimedia as choice 1 or 2 on their course choice sheets. Students also needed to write an essay explaining why they wanted to apply for the *Multimedia Masters* class. Most students indicated that they thought the class seemed interesting, believed that learning more computer skills may be useful for their future, and that parents encouraged them to apply.

The comparison groups were from four other intact classes (*N*=83). Random assignment was not possible. The classes were called the comparison groups rather than the control groups because it was impossible to have similar resources and project environment available to these students and have all elements under strict control. Nevertheless, these classes could provide comparison to the treatment group and offer some insights. Two TAG (Talented and Gifted) classes (one was an eighth-grade language-arts class and the other one was a seventh-grade math class) were recruited as the first comparison group (*N*=43) since the enrolled students in the *Multimedia Masters* programs often excelled in academic subject matters as well. Many students in the *Multimedia Masters* classes also belonged to these two TAG classes (Their responses to surveys and instruments were not incorporated into the results for the TAG classes.) Students in the TAG classes were also selected into the Talented and Gifted program because of their aptitude in these subject matters (language arts and math), just as the students in the *Multimedia Masters classes* had aptitude toward computers. Another two regular classes (one eighth-grade math class and one seventh grade language art class) (*N*=40) were recruited and served as another comparison group. The TAG classes and regular classes were instructed in the traditional style, with teachers giving lectures and students taking notes and doing exercises. The purpose of having two comparison groups was to examine if there was any difference between the *Multimedia Masters* class, TAG class and regular class in their psychological sense of community.

The treatment group had two teachers co-teaching these three participating classes. One teacher had experience working as a graphic designer in the multimedia industry. The other teacher had experience teaching the *Multimedia Masters* class in the previous two years. These two teachers worked as a team and taught the classes together (showed up in the classes together). All three classes had access to the same instructional content and materials. The treatment group met for 45 minutes every day from fall semester 2001 to spring semester 2002.

The *Multimedia Masters* classes had a designated multimedia computer lab for their use. Students had access to fifteen Dell computers, one scanner, one laser printer, two color inkjet printers, one video camera, and four digital cameras (Sony Mavica). Students also had designated server space to store their files. Inside the multimedia lab, teachers could use a multimedia projector to give lecture and presentation. Many of the lessons were presented on *Power Point* slides. On all the computers, the latest version of state-of-the-art multimedia software, including *Adobe Photoshop, Adobe Illustrator*, *Adobe Premiere*, *Macromedia Flash*, and *Microsoft Office* (including *Publisher* and *Front Page*) were installed.

THE *MULTIMEDIA MASTERS* CLASS

In the treatment group, the *Multimedia Masters* class, students went through three iterative phases: (1) learning software, (2) practicing skills with individual projects, and (3) working on group projects to help students develop their knowledge and skills. In Phase I, students learned different features of software through either lectures with hands-on practices or working with a tutorial (online or handouts). Students also went through several mini exercises to learn the software.

In Phase II, students used software to create products. Individual students completed small-scale practice projects, which allowed them to practice their skills in the new software. The teachers also introduced project design process and graphic design principles during this phase. One of the teachers, based on his experience working as a multimedia professional, discussed aspects of project design process and design principles. For the project design process, the teacher demonstrated process such as creating a strategic plan, creating flowcharts, and creating storyboards. These lectures focused on specific steps involved in the project design process, but did not specifically present the four-phase model. For the design principles, the teacher introduced concepts such as background colors, text, layout, and navigation in relation to graphic design, screen design and website design. The teacher used examples and non-examples to illustrate the design concepts and modeled the design process for students. These lessons were intended to help students have a basic understanding of how to start working on a project and design aesthetically sound products. Handouts on these topics were given out to students and they were later used as scaffolding tools (as procedures and checklists) during students' group projects.

Overall, for the first semester and some part of the second semester, students were engaged in Phase I and Phase II, learning software, creating individual projects and learning about project design and design principles. Students had opportunities to sharpen their software and design skills before embarking on group projects. The software programs students learned during phase I included state-of-the-art programs like Adobe Photoshop (graphic software), Adobe Illustrator, (graphic software), Adobe Premiere (video-editing software), Microsoft PowerPoint (presentation software), Microsoft Publisher (publication software), Microsoft Front Page (html editor software), and Macromedia Flash (animation software). The choice of having students learn software programs used by multimedia professionals was to help students gain a better understanding of what was involved in creating multimedia programs in the real world.

After Phase I and Phase II, Phase III focused on having students work together in a group to create group projects. All students in the *Multimedia Masters* class went through three group projects in the second semester: (1) Business in a Box; (2) Interactive Encyclopedia; and (3) Animated "Choose Your Own Adventure" Folk Story. For the Business in a Box project, students were asked to create a fictional company that produced a product for teachers. Students were asked to consider what teachers need and like when creating the product. The product of the fictional company was required to fit into a small box (2.5 in * 2.5 in * 2.5 in). Students then needed to market this company's product by creating a company logo, a business card, a product package, a magazine advertisement, a website for the product and a promotional CD-ROM label. Students spent about a month working on this project.

For the Interactive Encyclopedia project, students selected a topic of interest from the Smithsonian Encyclopedia website and created an interactive multimedia presentation to educate fellow students about the topic. The whole project spanned about 3 weeks. For the last group project, Animated "Choose Your Own Adventure" Folk Story, students created an interactive folk story with different choices for users to select. Different choices by the users would bring out different results, different developments and endings in the story. Students were required to initially base their stories on a storybook from the library and then they needed to include the original ending as well as create new endings for users to choose from. For this project, students were told to create folk stories for students of a younger age such as fifth grade students. This project also lasted about 3 weeks. The teachers of the class chose the first group project based on what the *Multimedia Masters* classes have done in previous years (previous classes only worked on one group project) but chose the other two group projects as the semester went on. Students spent the other time of the second semester learning the software program *Macromedia Flash* and taking tests (i.e. TASP).

When students started the group projects, they were first given a choice to form a 3 or 4-person team. Students were then given the design tasks, and explained the project goal, target audience and deadline for turning the product in. Students then gathered together in a team to brainstorm ideas on what to create (the content), whom to create for (the audience) and how to develop the product (the process). Each team also determined the timeline for finishing their project and then created flowcharts and storyboards, detailing the overall program structure and how each screen would look like. They also assigned roles to each group member. Depending on the project, students assumed the roles of a researcher/writer, a graphic designer, a programmer, a project manager, and an audio/video specialist. Due to the small size (3 or 4) of each team, students often assumed multiple roles in a project. When working on these tasks, the handouts given by the teachers were used as a checklist and a procedure reminder to help students go through the process.

Then, students turned the storyboards into actual products. Students first gathered all the multimedia elements by scanning pictures, taking digital photos and videos, creating animations and finding/writing text for the content and stored them in the designated server space. They then assembled all the elements (graphic, text, animation, video, and audio) together by programming in a software program. They either worked altogether on one computer or worked separately on different parts and came back to assemble them together.

The evaluation activities happened in an on-going basis. Students engaged in evaluation in several ways: (1) students provided and received feedback from each other during the process, (2) students received feedback from their teachers and the researcher, and (3) students were encouraged to self-evaluate their works using the assessment rubric provided by teachers before they turned in their products.

During the group projects, the teachers allowed students the freedom to take charge for their own projects, but they also stayed aside to provide students support. Specifically, they would provide technical support regarding software problems and guide students in the planning, designing and production process. For example, they would help students see the flaws in their flowcharts or storyboards and provide suggestions. They also offered tips, feedback, and reminders throughout the projects to help students design better products and finish the project on time. Additionally, the teachers also opened the computer lab during non-class time to allow students more access to work on their projects.

DATA SOURCE

The data source for this research study consisted of both quantitative data (instruments to the treatment and/or comparison groups) and qualitative data (classroom observation, open-ended questions and interviews from various perspectives). The use of both quantitative data and qualitative data was to seek triangulation of data. As Carver and her colleagues (Carver et al., 1992) stated, the assessment of students' project design experiences posed a significant challenge. Although teachers may have an intuitive sense of students' learning, traditional tests and grading schemes were not sufficient measures in evaluating students' learning (Carver et al., 1992). They concluded that multiple measures were needed to assess students' project design skills. For students' psychological sense of community, there was also a need to supplement the quantitative data with qualitative information to shed insights on the underlying reasons and conditions. Overall, triangulation of multiple data sources helped provide a better picture of the environment under study.

Quantitative Data

Several instruments and surveys were given to students to measure their project design skills and psychological sense of community. These instruments and surveys included the (1) Project Design Questionnaire, (2) Concept Mapping Survey, (3) Design Task Ranking Survey, and (4) Psychological Sense of Community in the Classroom (PSCC) Scale. In the following, we discussed each instrument.

Project Design Questionnaire

To understand how students acquire and use design skills during multimedia/hypermedia design projects, Lehrer and his colleagues (Lehrer et al., 1994) developed a sixty-item questionnaire to examine various design skills. It used a 7-point Likert scale with 1 being "does not describe me at all" and 7 being "describe me very well". These sixty items addressed nine categories of design: planning (8 items), searching information (8 items), presenting information (8 items), connecting ideas (5 items), audience (3 items), collaboration (8 items), mental effort and involvement (8 items), interest (8 items), and individualization (4 items). Examples of this questionnaire were " I make sure I understand all of the topics before I start putting my presentation together," and "Overall, I feel positively about working with others on a project." The Cronbach alpha reliability coefficient for this questionnaire was .97.

Due to the length of the original questionnaire and that some statements in the items were not directly linked to the project under study, the sixty-item questionnaire was shortened to twenty items to fit project needs and younger students' attention span (Liu & Hsiao, 2002; Liu & Pedersen, 1998). The shortened version used a 5-point Likert scale with 1 being “not true of me” and 5 being “very true of me”. The shortened version included items on audience (3 items), presentation (2 items), planning (3 items), interest (5 items), mental effort and involvement (2 item) and collaboration (5 items). This shortened version of the questionnaire (see Appendix A) has been used in previous studies (Liu & Pedersen, 1998; Liu & Hsiao, 2002). In some items, some wording was changed to better fit the current study. The reliability as determined by KR 20 (Kuder-Richardson formula) for this modified version was .82. Since the comparison groups did not have similar resources and project environment, this questionnaire was administered only to the treatment group as a pretest and as a posttest.

This instrument was used as one of the measures to examine students’ project design skills including audience, collaboration, interest, mental effort, presentation and planning. This instrument was used to address research question one “What is the impact of the learners-as-multimedia-designers environment on the learning and development of middle school students’ project design skills?”, research question three “Is there a relationship between students’ project design skills and their psychological sense of community as they engage in the learners-as-multimedia-designers environment?” and research question four “Can students’ project design skills development be predicted by students’ psychological sense of community?”

Concept Mapping Survey

This instrument consisted of a central idea in the middle (a circle with the words “creating multimedia programs” inside the circle) (see Appendix B) and students were asked to list their concepts related to the central idea in boxes and draw them like branches growing out of a tree. Concept mapping was considered a promising alternative teaching and learning method in that it could be used as a learning strategy, an instructional strategy, an assessment and evaluation strategy, and a strategy for planning curriculum (Novak, 1990). Research so far has shown that it provided a relatively straightforward and valid way of assessing cognitive understanding in various fields including biology, chemistry and psychology (Markham, Mintzes, & Jones, 1994; Ruiz-Primo & Shavelson, 1996; McClure, Sonak, & Suen, 1999; Jacobs-Lawson & Hershey, 2002). In multimedia design, this instrument has been given to students in a previous study (Liu & Hsiao, 2002) in showing students' concepts and knowledge. This instrument was chosen in this study to examine what students understood about multimedia design and what conceptual changes that may occur.

This instrument was given to the treatment group at two different time periods (at the beginning of the first semester and the end of the second semester) to examine if there were any changes in students' concepts about multimedia design between pretest and posttest. In addition, the concept maps of three experts in multimedia design were also solicited. Two of the experts taught multimedia design and production courses at a state university while the third one had experience working as a multimedia professional in the local multimedia industry. Their concept maps were used as reference maps in comparison with students' concept maps. This instrument was also used to examine students' development of project design skills and helped address the first research question "What is the impact of the learners-as-multimedia-designers environment on the learning and development of middle school students' project design skills?"

Design Task Ranking Survey

In the design task ranking survey, students were given a list of tasks relevant to their project development and asked to rank each task according to their relative importance, with 1 being the most important task and 2 being the second most important task, and so on (see Appendix C). Examples of the tasks were "Make the graphics very colorful", "plan and create a storyboard of what your program will look like", and “discuss with your group what information to include.” This instrument has also been used in previous studies (Lehrer et al., 1994; Liu & Rutledge, 1997; Liu & Pedersen, 1998; Liu & Hsiao, 2002) and was used to examine students’ ideas about what was important and what was not important in creating multimedia programs.

This instrument was given in the end of the first semester (before students started group projects) and the end of the second semester (after students finished group projects). This instrument was the third instrument used to measure students’ project design skills development and also addressed the first research question “What is the impact of the learners-as-multimedia-designers environment on the learning and development of middle school students’ project design skills?”

Psychological Sense of Community in the Classroom (PSCC) Scale

The Psychological Sense of Community in the Classroom (PSCC) scale, developed by Helen Bateman (1998), was used in this study. Based on McMillan and Chavis’ (1986) model of psychology sense of community, Bateman has developed and modified Pretty’s (1990) Psychological Sense of Community in the School Scale and used it in several research studies with adolescents. It used a 4-point Likert scale with 1 being “never, not at all” and 4 being “all the time”. The 24-item scale (see Appendix D) measured the overall psychological sense of community of students in the classroom. Four sub-categories (six items each), including membership, influence, integration and fulfillment of needs and shared emotional connection, could also be identified. Examples of the questions included “I feel I belong in this class”, “I feel I am a very important part of this class”, “I have no influence over what my class is like”, and “I can depend on students in my class for help if I need it”.

The scale has been administered to middle school students in Tennessee, Missouri, Florida, and Canada. The overall alpha value for the scale ranged from .89 to

.92, depending on the sample. When used in this study, the overall alpha (Cronbach alpha reliability coefficient) for multimedia class, TAG class and regular class was .85, .91 and .80 separately. The alpha value for each sub-category in the PSCC scale for each class was listed in the Table 3.

This instrument was given to both the treatment group and the comparison groups at the end of the second semester. Due to delay in obtaining IRB approval for this research and a shift in the research focus, the subjects in the comparison groups were not recruited until the beginning of the second semester. The researcher was unable to obtain the pretest data from all three groups in the beginning of the first semester. This instrument was used to measure students' psychological sense of community in their classroom and it addressed the second research question "What is the impact of the learners-as-multimedia-designers environment on students' psychological sense of community?", research question three "Is there any relationship between students' project design skills and psychological sense of community as they engage in the learners-as-multimedia-designers environment?" and research question four "Can students' project design skills development be predicted by students' psychological sense of community?"

Table 3: Cronbach's Alpha (Reliability Coefficient) for Each Class

Measure	**Multimedia Class**	**TAG Class**	**Regular Class**
Membership	.77	.76	.44
Influence	.66	.86	.74
Integration and Fulfillment of Needs	.80	.75	.83
Shared Emotional Connection	.76	.89	.78
Overall Scale	.85	.91	.80

Qualitative Data

Qualitative data was also collected in this study to help reveal a more robust picture of the research topics. Qualitative data consisted of open-ended questions, interviews, and classroom observations. All these qualitative data were used with quantitative instruments mentioned earlier to help examine the first (What is the impact of the learners-as-multimedia-designers environment on the learning and development of middle school students' project design skills?) and the second (What is the impact of the learners-as-multimedia-designers environment on middle school students' psychological sense of community?) research question. Interview data with teachers were used to answer the fifth research question "What needs to be taken into consideration in designing the learners-as-multimedia-designers environment?" In the following, each item was discussed.

Open-ended Questions

Open-ended questions were given out in the end of the first and the last group project to students to prompt their reflection and examine their thinking toward the process. Examples of questions were "What have you learned from this class? Include computer and non-computer skills." and "If a teacher from your math/science /language arts class or your parent wants to hire you to create some multimedia programs (a website, a flash program, etc.), what will you do first and next? What kind of material will you use in the process?" (See Appendix E for a list of open-ended questions.)

Interviews

While students worked on group projects, the researcher also conducted interviews with students (see Appendix F for a list of questions). Interviews were semi-structured in format and used the same questions as in open-ended questions. When students' answers to the open-ended questions were not clear enough or the researcher felt there was a need to follow up, interviews were conducted. Interviews with teachers were also conducted after the first and the last group project. These interviews were also semi-structured and the researcher followed the direction of conversation to pursue more topics. Examples of interview questions with teachers were "How are students doing for their projects so far?" and "What are the activities you have observed that students like to do and don't like to do?" (See Appendix G for interview questions with teachers).

Classroom Observations

The researcher also observed the classroom activities throughout the process. The researcher kept a journal detailing her observations of the classroom activities. These observations were aimed at helping the researcher keep a record of what happened during the project process and interpret the findings. Classroom observations could be divided into two types: one focused on the class as a unit of observation and the other focused on small group interaction during group projects. Written description of classroom observations was kept from daily to weekly, depending on the nature of the classroom activities. For example, when the same type of instruction activities repeated for weeks, only one record of general classroom observation was kept. However, when students interacted in groups during group projects, daily or weekly classroom observation journal was kept.

DATA COLLECTION PROCEDURES

In the beginning few weeks of the first semester, students in the treatment group were invited to participate and then sign consent form (for parents or legal guardians) (see Appendix I) and assent form (for students) (see Appendix K). Students in the comparison groups were invited to participate and sign consent form (see Appendix J) in the beginning of the second semester. Potential risks and requirements in the research were explained to students. Students were notified that they had the rights to discontinue their participation any time during the research period. Then students in the treatment group filled out a survey (see Appendix H) related to their demographic information and computer experience. Students were also given the pretest version of the project design questionnaire and the concept mapping survey to fill out in the class period. Approaching the end of the first semester, students filled out the pretest version of the design task ranking survey in class.

Approaching the end of the second semester, after students in the *Multimedia Masters* class had worked on group projects for the whole semester, students again filled out the posttest version of the project design questionnaire, and the posttest version of the concept mapping and design task ranking survey in class. Students in both the treatment group (multimedia classes) and comparison groups (TAG classes and regular classes) also filled out the Psychological Sense of Community in the Classroom (PSCC) Scale.

While students worked on group projects in the second semester, the researcher also conducted interviews with teachers and students and asked students to fill out open-ended questions. Classroom observation notes were taken on a daily to weekly basis to record the progress status of the classroom activities.

DATA ANALYSIS

Project Design Questionnaire

To understand whether students in the learners-as-multimedia-designers environment have developed project design skills, six paired samples T-tests were run with the pretest and posttest scores of the six measures in project design questionnaire (audience, presentation, planning, interest, mental effort and collaboration) as the paired variables. These tests were used to determine if the scores differed from pretest to posttest. As mentioned earlier, the Cronbach alpha reliability coefficient for this questionnaire was .97. Significance level for the result was set at .05.

Concept Mapping Survey

The concept mapping survey was used to determine whether the concepts of students in the learners-as-multimedia-designers project environment have changed between the first semester and the second semester. Three scores in students' concept maps were analyzed: (1) the total number of nodes and sub-nodes produced, (2) the total number of valid nodes/subnodes, as reflected in any of experts' concept maps and (3) the percentage of valid nodes/subnodes out of the total number of nodes/subnodes. Pretest scores and posttest scores were compared using Paired Samples T-tests to determine if there was any difference in the quantity and quality of students' concepts. Two raters scored the pretest and posttest concept maps. An orientation was held in which the raters discussed how to score the concept maps. Raters then scored the concept maps independently and assigned two scores for each concept map: one for the total number of nodes and the other for the valid concepts produced. Raters then reviewed the scoring together. If there were any discrepancies, the two raters double-checked and discussed the differences until agreement was reached for all of them, resulting in a 100% interrater reliability.

Design Task Ranking Survey

Students were asked to rank ten design tasks according to their relative importance in this survey in the end of the first semester (pretest) and in the end of the second semester (posttest). Students ranked 1 next to the most important task, 2 next to the second most important task and so on, following the survey instruction. To better reflect the hierarchy of ranking order, the rank number was reversed during analysis. For example, a rank of “1” became “10” and a rank of “6” became “5”. Paired sample T-tests were then used to analyze the pretest and posttest scores of each design task. Significance level was set at .05.

Psychological Sense of Community in the Classroom (PSCC) Scale

The Psychological Sense of Community in the Classroom (PSCC) Scale provided a composite overall score of the psychological sense of community and scores from four subscales (membership, influence, integration and fulfillment of needs, shared emotional connection). To understand if the learners-as-multimedia-designers environment had any impact on students’ psychological sense of community, a one way ANOVA was first run with the grouping (the multimedia class, the TAG class, the regular class) as the independent variable and the overall score of the Psychological Sense of Community in the Classroom (PSCC) Scale as dependent variable. Tukey’s HSD post-hoc analysis was conducted when there was a significant difference. Significance level was set at .05.

To further examine the psychological sense of community construct, the scores from the four subscales were also analyzed. However, to avoid type 1 error incurred by conducting multiple ANOVAs on the four subscales, a Multivariate Analysis of Variance (MANOVA) was conducted instead, with the grouping as the independent variable and the scores from each of the four subscales (membership, influence, integration and fulfillment of needs, and shared emotional connection) as dependent variables. Whenever there was a significant difference, Tukey’s post-hoc analysis was conducted. Significance level was set at .05.

To explore the relationship between project design skills and psychological sense of community, Pearson Product Moment correlation analyses were conducted, with variables from (1) the overall score of the Psychological Sense of Community in the

Classroom (PSCC) Scale and (2) the posttest scores of six different categories (audience, presentation, planning, interest, mental effort and collaboration) in the Project Design Questionnaire. Regression analyses were also conducted. In the regression analyses, the scores from PSCC were used as predictors and the scores from the Project Design Questionnaire were dependent variables.

Qualitative Data Analysis

The responses to open-ended questions, interview data and classroom observation data were analyzed using a two-level scheme, following the guidelines by Miles and Huberman (1994). At the first level, interviews were first transcribed. Based on the research questions and the existing categories in the project design questionnaire and PSCC scale, a starting list of themes was generated and used as a guide for coding. Statements from the survey responses and interview data were then coded and nested under the existing theme or a new theme will be created when no existing themes were appropriate. At the second level, codes were regrouped into more general categories. Patterns and relationships between the coded segments were compared and contrasted to examine common themes and shared relationships. The final qualitative findings were used to support and supplement the quantitative data analysis discussed previously in this section.

Chapter 4: Results

The results of the study were grouped by research questions and organized with quantitative and qualitative data for the research questions.

RESEARCH QUESTION 1: WHAT IS THE IMPACT OF THE LEARNERS-AS-MULTIMEDIA-DESIGNERS ENVIRONMENT ON THE LEARNING AND DEVELOPMENT OF MIDDLE SCHOOL STUDENTS' PROJECT DESIGN SKILLS?

Students' project design skills were tested with the following measures: (1) project design questionnaire, (2) concept mapping survey, (3) design task ranking survey, (4) open-ended questions and (5) interviews with teachers and students. In the following, the results for each measure were presented.

Project Design Questionnaire

The students in the learners-as-multimedia-designers classes have taken the pretest of the Project Design Questionnaire at the beginning of the first semester and the posttest at the end of the second semester. Table 4 summarized the differences between the pretest and posttest scores. The analyses of paired samples T-tests of the pretest and posttest scores showed that there were significant differences between the pretest and posttest scores for the treatment group on the measure of audience: $t(1, 41)=2.17$, $p<.05$ and there were significant differences between the pretest and posttest scores on the measure of presentation: $t(1, 41)=1.96$, $p<.05$. There was no significance on the measures of planning: $t(1, 41)=1.37$, interest: $t(1, 41)=1.37$, mental effort and involvement: $t(1,41)=1.20$, and collaboration: $t(1,41)=1.24$. However, when examining the scores further, one may notice that students had high scores on both pretest and posttest in the measures of interest, and mental effort and involvement. In other words, students were already very motivated and showed high degree of interest (4.23) and mental effort and involvement (4.02) out of a 5-point Likert Scale in the beginning of the year. They remained interested and maintained high levels of mental involvement throughout the year.

On the other hand, students did not show significant improvement in their planning skill and collaboration skill from pretest to posttest. Their planning and collaboration scores were at a medium range (between 3.0-4.0) and these two skills remained at the same level from pretest to posttest.

Table 4: Results of Paired Samples T-tests for the Project Design Questionnaire

Subscale	Pretest Mean (Std. Deviation)	Posttest Mean (Std. Deviation)	*t*
Audience	3.76 (.83)	4.03 (.67)	2.17*
Presentation	3.84 (.52)	4.06 (.71)	1.96*
Planning	3.17 (.62)	3.29 (.61)	1.37
Interest	4.23 (.50)	4.34 (.60)	1.37
Mental Effort	4.02 (.83)	4.16 (.82)	1.20
Collaboration	3.59 (.57)	3.69 (.45)	1.24

*Significantly different between the pretest and posttest scores, $p<.05$.

Concept Mapping

The use of concept mapping survey was aimed to identify if there were any changes in students' conceptual understanding regarding the process of creating multimedia programs between pretest (at the beginning of the first semester) and posttest (at the end of the second semester). Three Paired Sample T-tests were used to analyze

(1) the total number of nodes/subnodes produced in students' concept maps from pretest to posttest, (2) the total number of valid nodes/subnodes reflected in any of the experts' concept maps from pretest to posttest, and (3) the percentage of valid node/subnodes out of the total number of nodes/subnodes. All three experts' concept maps were used as reference maps to evaluate the validity of students' concept maps. Whenever students identified a concept shown in any of the experts' concept maps, a point was given.

To illustrate how the second score was scored, an example was given here. In the following, the experts' concept maps could be seen in Illustration 2, 3 and 4 and one student's pretest and posttest concept maps could be seen in Illustration 5 and Illustration 6. In this students' pretest concept map, the words "hardware", "software", "knowledge" and "tools" were all shown in experts' concept maps (see Illustration 2 & 4), so four points were given. The words "a working mouse and "computers" were concepts related to hardware, so no point was given again. In the student's posttest concept map, the words "planning", "time organization" and "creating" (resembling the production concept in the experts' maps) altogether scored three points since they appeared in the experts' concept maps. The words "creativity" and "motivation" were not given any points as they were not shown in any of the experts' concept maps.

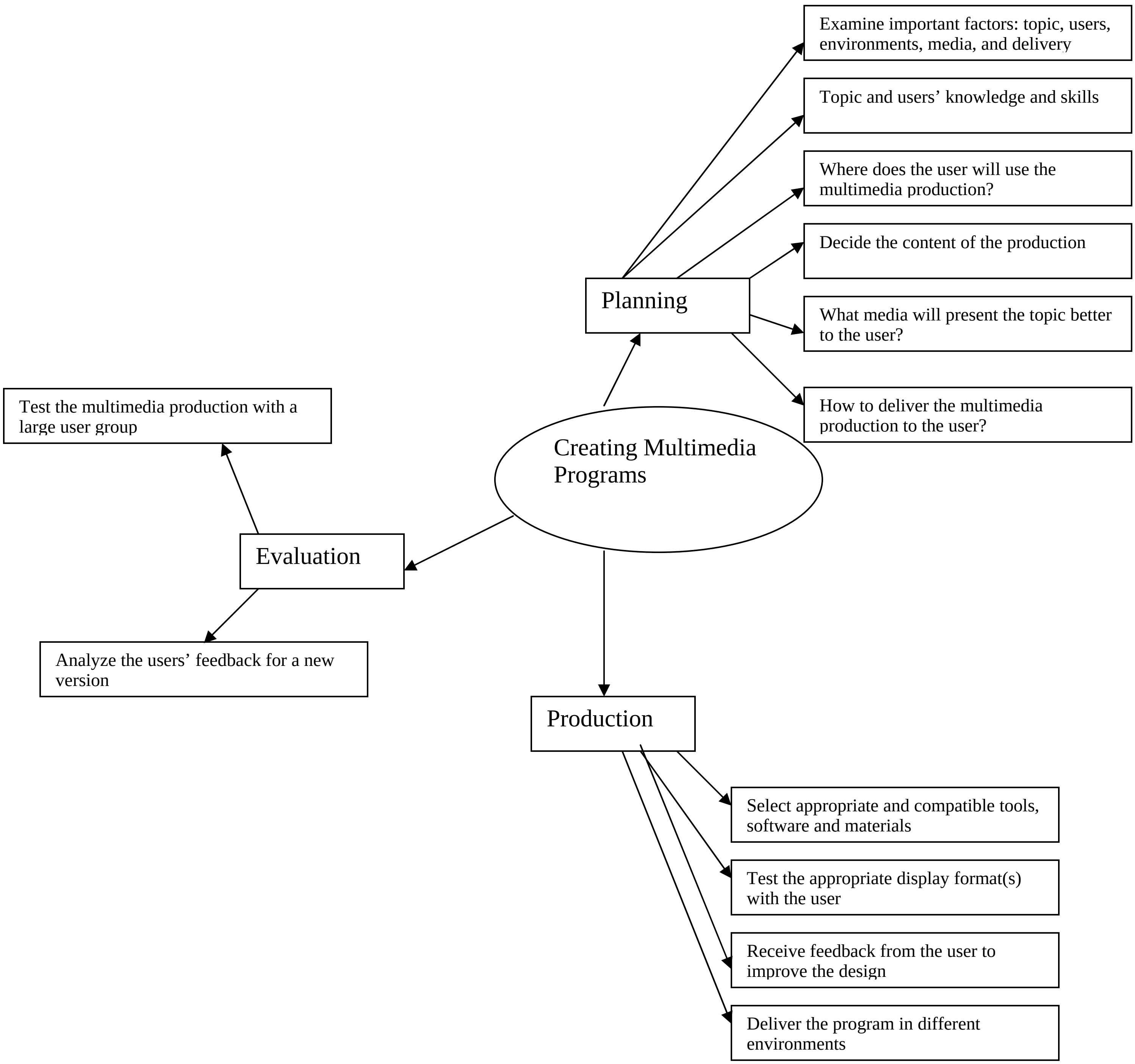


Illustration 2: Example of an Expert's Concept Map (1)

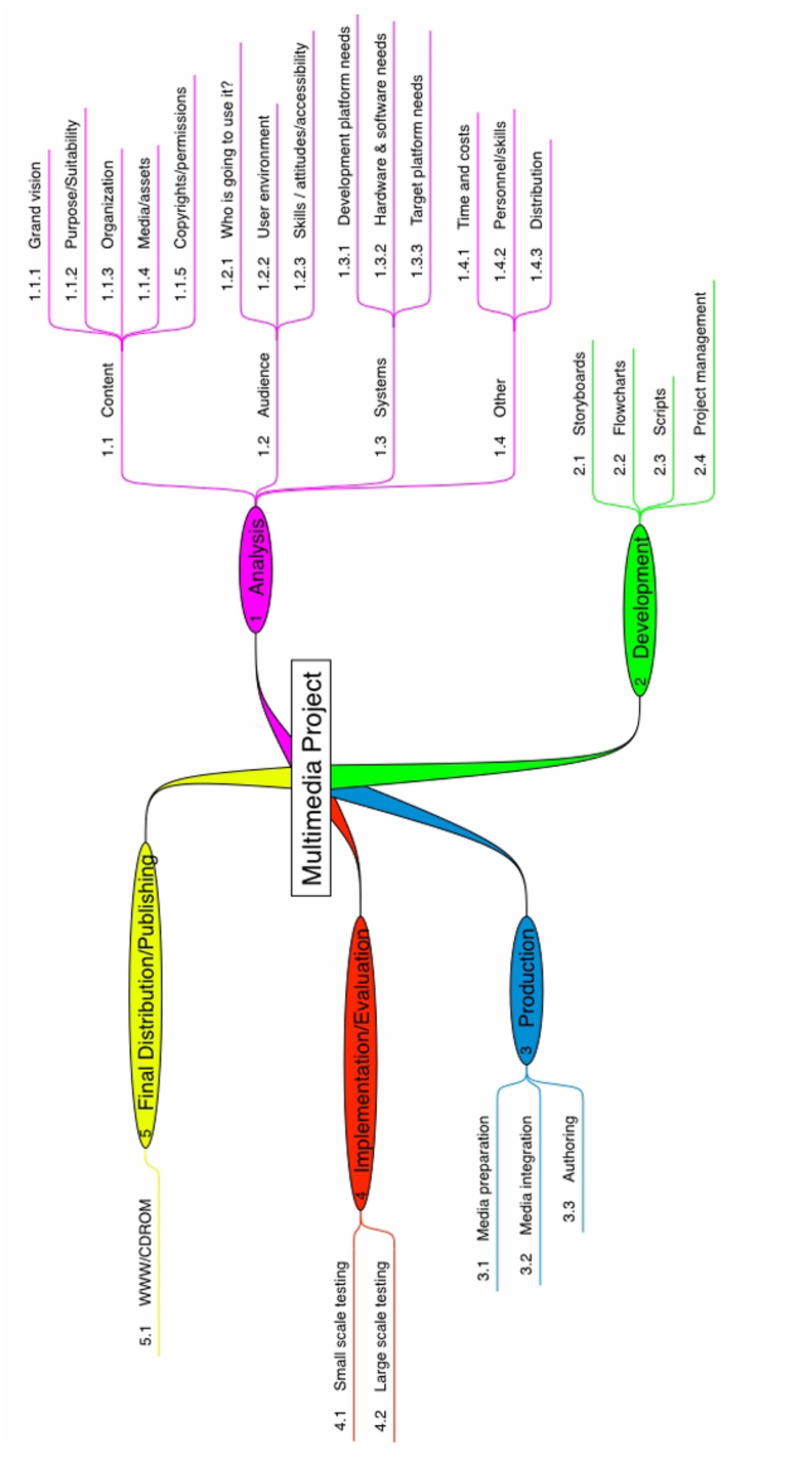


Illustration 3: Example of an Expert's Concept Map (2)

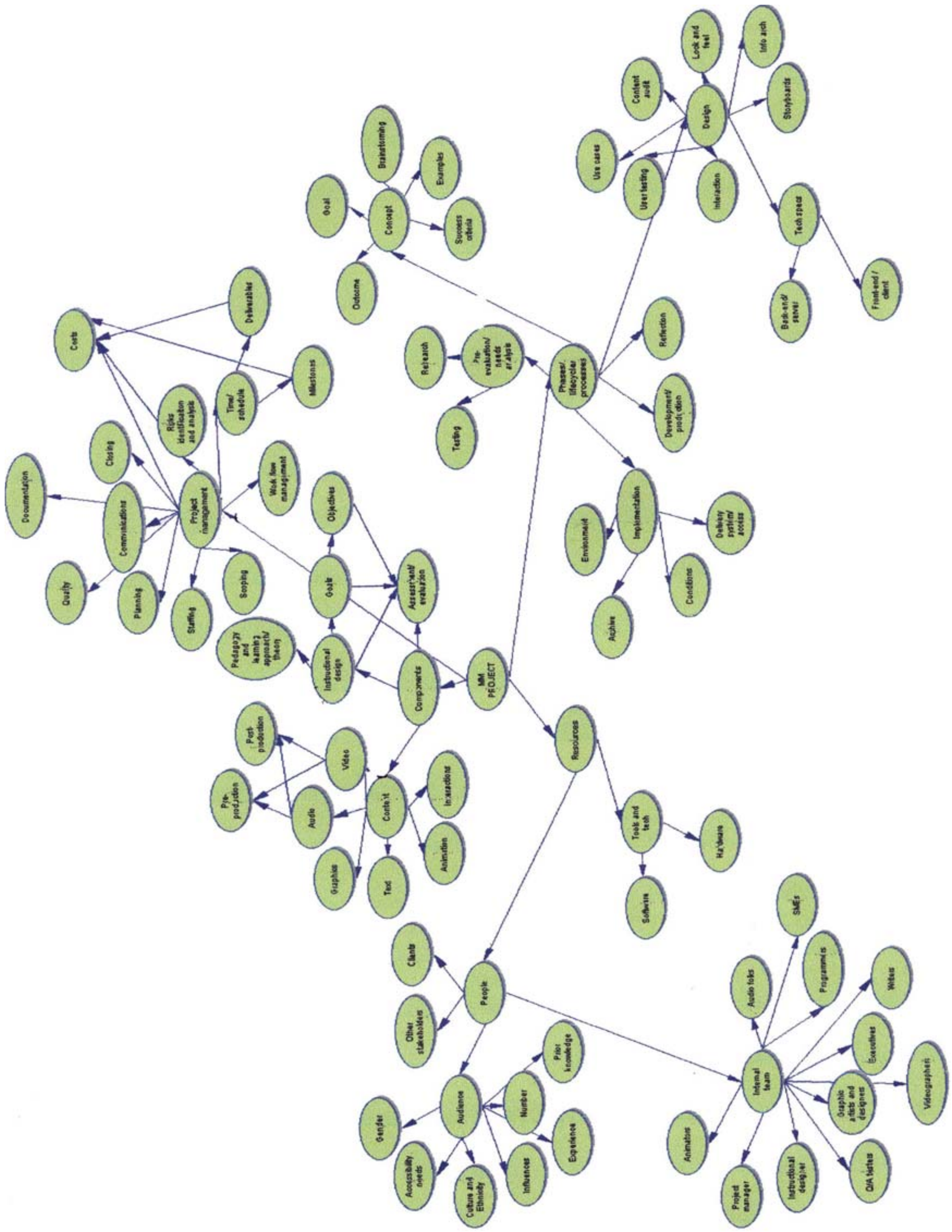


Illustration 4: Example of an Expert's Concept Map (3)

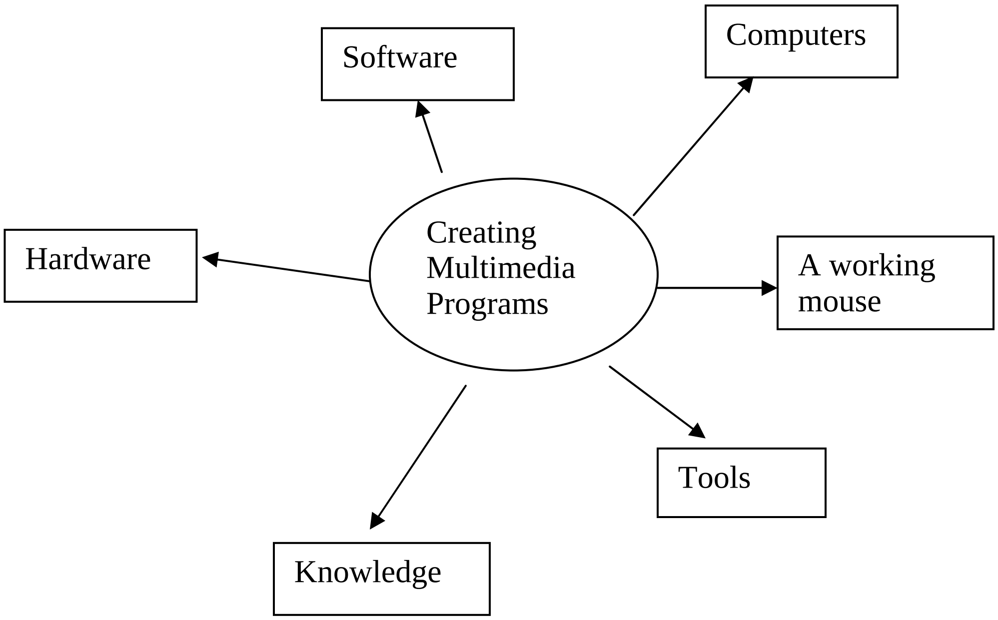


Illustration 5: Example of a Student's Pretest Concept Map

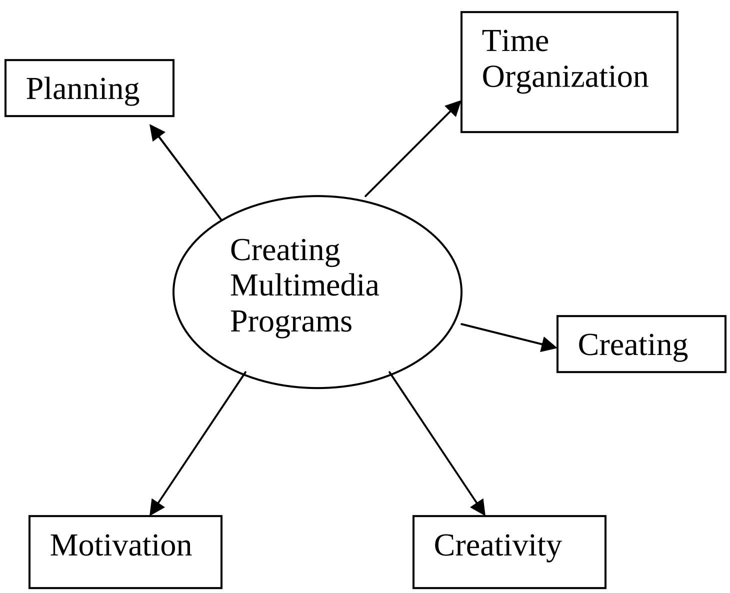


Illustration 6: Example of the Same Student's Posttest Concept Map

The result (shown in Table 5) indicated that there was a significant difference: $t(1, 43)=-2.32$, $p<.05$ in the total number of nodes and subnodes produced between pretest and posttest. There was also a significant difference: $t(1, 43)=-5.01$, $p<.001$ in the valid nodes produced by students from pretest to posttest. There was also a significant difference in the percentage of valid nodes/subnodes out of the total number of nodes/subnodes from pretest to posttest: $t(1, 43)=-4.06$, $p<.001$. In short, students not only have produced significantly more nodes in the posttest, but also have produced significantly more valid nodes in their posttest.

Table 5: Results of Paired Samples T-tests for the Concept Mapping Survey

	Pretest Mean (Std. Deviation)	Posttest Mean (Std. Deviation)	*t*
Total number of nodes and subnodes	7.35 (2.73)	8.63 (3.68)	-2.32*
Total number of valid nodes/subnodes	2.27 (1.39)	3.67 (1.61)	-5.01***
The percentage of valid nodes/subnodes out of the total nodes/subnodes	.31(.16)	.46(.22)	-4.06***

a.* Significantly different from the pretest to the posttest results, p<.05
b. *** Significantly different from the pretest to the posttest results, p<.001
c. df=42

Examining students' concept maps, one could see some differences between pretest and posttest. In the pretest, students listed general terms such as "computers, software, hard work, etc." to describe their concepts of creating multimedia programs. Some students had slightly better idea about the software programs, so they listed specific names such as "HTML, *Frontpage*, *Photoshop*, or digital camera". All the concepts were basic and seldom included higher level concepts related to the project process. In the posttest, students still wrote down specific software programs but added more design skills-related concepts such as planning, storyboard, design, etc. Students also included many concepts that were relevant to their experience during the project work such as background knowledge, ideas, accurate resources, talent, etc. However, few students could distinguish multimedia design as a multi-level process as the experts did and their list of concepts were not as detailed as those of the experts'. Overall speaking, students have begun to make some progress in their concepts about multimedia design after a year of learning and working on multimedia projects. However, most of them still lacked a holistic view of the whole process, unlike those of the experts'.

Design Task Ranking Survey

Students in the learners-as-multimedia-designers classes were given a list of ten design tasks and were asked to rank their importance first in the end of the first semester (before the group projects started) and then again in the end of the second semester (after the group projects finished). Paired Sample T-test analyses were conducted to analyze the data. The detailed result of the Paired Samples T-test of the Design Task Ranking Survey was shown in Table 6.

Table 6: Importance of the Design Tasks Ranked by the Students

Design Tasks (in order of importance as ranked by students)	Pretest Mean (Std. Deviation)	Posttest Mean (Std. Deviation)	*t*
1.Plan and create a storyboard of what your program will look like.	8.89 (1.26)	8.64 (1.22)	.91
2.Brainstorm/think about the best way to present an idea.	8.39 (2.33)	8.50 (2.33)	.17
3.Discuss with your group what information to include.	7.54 (1.77)	8.32 (1.16)	1.98*
4. Research and find relevant information.	7.54 (1.77)	7.68 (1.25)	.37

5. Make sure the buttons and colors are consistent from one screen to another.	5.04 (1.99)	4.54 (1.53)	1.00
6. Make the graphics very colorful.	4.29 (1.92)	3.29 (1.24)	2.43*
7. Scan in pictures.	4.29 (1.46)	4.54 (1.50)	.74
8. Get someone to try out the program.	3.46 (2.03)	2.75 (1.76)	1.51
9. Make animation.	3.29 (2.07)	4.57 (1.73)	2.92*
10. Make sounds.	2.61 (1.64)	2.18 (1.89)	.91

a. * Significantly different from the pretest to the posttest results, $p<.05$
b. The higher the mean, the higher the importance. The original score has been reversed to reflect the importance.
c. The lower the number, the higher students ranked the item.

Examining the tasks students ranked indicated that students placed the tasks of "planning and creating a storyboard of what your program will look like", "Brainstorming/thinking about the best way to present an idea", "Discussing with your group what information to include" and "researching and finding relevant information" as more important tasks from pretest to posttest. Students regarded tasks such as "making the graphics colorful", "scanning in pictures", "making sounds" and "getting someone to try out the program" as less important (in order of ranking) consistently in pretest and posttest. Students have in general ranked project tasks that required thinking and collaborating with other people higher, except for the task of "getting someone to try out the program." The result also showed that students already had this understanding in the pretest. One plausible explanation may be due to the time when students took the pretest, which occurred in the end of the first semester rather than the beginning of the first semester. During the first semester, students have gone through lectures on project design specifics such as brainstorming, assigning roles, setting timelines, creating storyboards. These lectures may have left an impression on students and students may have begun to have an understanding of what was important in a project.

From pretest to posttest, there were statistically significant changes in students' perception about some tasks. For example, students have ranked the task "Discussing with your group what information to include" significantly higher: $t(1, 41)=1.98$, $p<.05$ in the posttest than in the pretest. This may be due to that students have realized the importance of working with their group members during the group project work during the second semester, in contrast to their individual work during the first semester. On the other hand, their ranking of the task "making the graphics very colorful" has decreased significantly: $t(1, 41)=2.43$, $p<.05$ from pretest to posttest. Students already did not think "making graphics very colorful" of high priority in their pretest (4.29 in pretest), but in the posttest, they ranked this task even lower. This may be due to that they have learned more software as time went on. After learning more software, they have become more sophisticated in their thinking about the software skills, which may lead them to no longer regard "making graphics" and/or "making graphics colorful" as important. Meanwhile, students also ranked "making animation" significantly higher in the posttest than in the pretest: $t(1, 41)=2.92$, $p<.05$, which may be due to their exposure to the animation program *Flash* in the second semester. They seemed to have a newly-found interest and understanding on the capability of animation programs and they had higher regard for "making graphics very colorful."

Qualitative Data

Awareness of Audience

When working on group projects, students have learned to pay more attention to the audience that their final products were targeted at. In the beginning of the first semester, students were not aware of the needs to pay attention to audience for their products. As students worked on group projects, they have shown more awareness of audience. One student in the interview said,

> Yeah, you have to think about your audience because if it's not going to be appealing to your audience, then your audience isn't going to want to buy it or use it or anything, so your project just goes unused or pointless.

Students have learned to concentrate on the needs of audience while they created their programs.

The other aspect of this awareness of audience was to have their audience provide inputs and reviews for their products. One student described getting inputs from their audience,

> For Business in a Box, we thought of what would be helpful to teachers who we are selling to. What is something that they need, what they complain about, and what would be helpful for their everyday teaching life. I asked a few teachers and they said something that have to do with all the textbooks. So that is why we came up with the idea of electronic textbooks.

Another student talked about having their audience review their product,

> You got to make sure you know what they want… So you got to check with your audience. Next thing I will probably do is when you actually finish, you show it to them and they can voice their opinions.

Clearly, students have become more aware of the importance of audience by creating products that catered to their audience's needs and likes, and having their target audience evaluate their products. This was consistent with what we have found in the Project Design Questionnaire that students have significantly improved their audience score over time.

Design for Presentation

Students seemed to have paid more attention to presentation in their products during the group projects. Students were concerned about creating a good design for presentation. Students readily mentioned design considerations during their interviews. For example, one student noted, “mostly I consider about consistency of background, what kind of text you’re putting on there… Images that are appropriate for the text you put in, and they should blend in nice and easily.” Comments like this showed that they become aware of the importance of creating good presentation. This was consistent with the finding of significant increase in presentation score from pretest to posttest, as shown in the Project Design Questionnaire. In addition, the awareness was also shown in students’ concept maps and in students’ design task ranking. Students included wordings such as “background, layout, color” in their concept maps and ranked “Make sure the buttons and colors are consistent from one screen to another” as somewhat important (5.04) in the design task ranking survey.

Sustained Interest and Mental Effort and Involvement

Students in the multimedia class showed high levels of interest and mental involvement. From interviews, students talked about spending extra time working for the class:

> Me and one other girl in our group, we come in … and we’ve been working on it for the past week, pretty much on Monday, Tuesday, Wednesday, and Thursday, during study hall.

It was not surprising that students in this Multimedia class had high levels of interest and mental effort and involvement in the beginning of the year since most students applied to get into this class and were interested in learning more about computer programs to begin with. However, students were able to sustain their high levels of interest and mental effort and involvement over a year (from the beginning of the first semester to the end of the second semester), as shown in the finding of the Project Design Questionnaire.

There was no conclusive answer as to what exactly helped sustain students' interest and mental effort and involvement. Perhaps the sustained interest and mental effort and involvement could be at least partially attributed to students' project work in which they were engaged in autonomous, constructive activities in this class. From the interviews with students, one student compared this class with other classes using computers,

> When we go to regular classes in computer labs…Most of the teachers want us to put our hands in the lab and not to touch, experiment with stuff. They were like 'now you go to file and open…da, da, da' I don't think most teachers think we are capable of doing a lot of stuff. Here they let you experiment and learn by yourself. So it helps.

Students seemed to prefer the way this class was structured: students were allowed to explore and construct knowledge as well as being able to take charge of their own learning process. Perhaps this aspect, among other factors, helped sustain students' interest and mental effort and involvement.

Opportunities for Research

From the project process, students also had opportunities to develop research skills. For their projects, students often conducted research on the Internet and in the library, and they have also interviewed their target audience and clients for information. For their first group project "Business in a Box", students have gone to their target audience to get some insights on what kind of products teachers would like to have. For example, one student described the process and methodology their group came up with to narrow down on their product,

> We brainstormed a list of things that teachers might like, and I went around to all the teachers in the eighth grade and put a star by the one they like the most, and a mini digital camera was the winner, so that's what we did.

In addition, students also used the Internet extensively. The use of Internet was not limited to finding content. Students also used the Internet to look for images and ideas. For example, one student said, “Well, since we were doing a PDA watch, we went to certain sites that sold PDA watches and found out what their features were and what kind of processors and stuff they had.”

It was worthwhile to note that some students have realized the importance of having good content. One student pointed out the importance of good content when working on a project: “Gather(ing) info about it and research(ing) things so that I know how to make it look pretty good and thorough…because if you don’t have good info, your thing may not be very good.” With the opportunity to practice the research skill, students have recognized research as an important skill during the project design process. This was perhaps why students have ranked “Research and find relevant information” higher (7.0 and above) in their design task ranking survey and included research in their concept maps.

Collaboration and Group Dynamics

When students worked together as a group to accomplish their goals, not every group had a smooth working relationship. Some groups tended to work better than the others. For groups who had a good working relationship, they often described their interdependence on each other. For example, one student described her working relationship with her group,

> I would rather do it as a group because I work much better when I am in a group… And we are good friends and we like to work together.

However, some other groups seemed to have much trouble working with each other. In one group, one student commented,

> Working in my group I kind of noticed that every now and then, we don't get along very well. …We don't listen to ideas very well. It seems that when we are all together, we get a little less done.

Some groups had good dynamics and could accomplish tasks and tackle problems better as a group while some groups had trouble working with each other and working productively. From classroom observations, the difference in group dynamics was very evident. With groups working together for the whole semester, the one or two groups who worked really well together were able to develop a "system" of the group and worked more effectively as the semester went by while the one or two groups who did not get along in the beginning seemed to falter along the semester. The majority of the groups were able to work together with a steady, productive working relationship throughout the semester. This may help explain why students' collaboration score did not change from pretest to posttest, but remain in the medium range in the Project Design Questionnaire.

Individual Differences for Planning

Students seemed to be aware of the importance of planning in the process of working on projects. This could be seen by the universal responses from students when asked what they would do if given a project to work on. Typical answers were that they would start with planning. For example, one student said,

> First I will probably plan it out so that it helps me… If I just started right away, it doesn't end up being nice as it could have been if I planned it out.

They clearly recognized planning as an essential first step in their projects, which was echoed in students' concept mapping survey and design task ranking survey. In these two instruments, the majority of students have included planning as a concept in considering creating multimedia programs and ranked the task "plan and create a storyboard of what your program will look like" as the most important.

However, despite the general recognition of the importance of planning, some students showed reluctance in implementing it. These students simply disliked planning and preferred to "go straight to work on the computers". For example, one student admitted that " Well, I should plan it out, but I would probably go straight to the work part cause planning isn't my favorite thing to do. It's kind of boring." From the interview with teachers, one teacher also described the difficulty of having students plan during a project:

> For students, it (planning) is very much like pulling teeth. They dislike planning. Just in conversation with them, you can judge by the amount of moaning. Of course every one likes the actual assembly on the computer because that's fun… Kids at this age especially.

The responses from the teacher and students seemed to indicate that students at this age group showed great individual differences in their ability and predisposition towards planning. Some students were able to plan step by step as required from the beginning, while others could not resist the temptation to go "play on the computer right away". This tendency did not change by the project work they have experienced. Despite their general awareness of the importance of planning, some students of this age group may not have enough self-regulated control to carry out the task of planning if they lacked the predisposition. This phenomenon could probably help explain why students' score on planning, as shown in the Project Design Questionnaire, did not change significantly and remained in the medium range.

Lack of Emphasis for Evaluation and Revision

The evaluation and revision activities were "just-in-time" activities that occurred as needed. Teachers have provided assessment rubrics for each project to allow students to self-evaluate before turning in their products. Students also had opportunities to receive feedback from their peers, teachers and the researcher as the project went on.

However, based on the researcher's classroom observation, there was no particular emphasis to make sure that revisions were made. This was perhaps due to that the evaluation and revision activities occurred "just-in-time" and there was no time set aside to get the task done. Along with fixing technical problems and trying to meet the deadlines to finish their products, students usually did not go back to address the evaluations and improve their products. Due to lack of emphasis and lack of practice, students seldom considered evaluation and revision as a critical task, which was reflected in students' responses to the design task ranking survey and in students' concept maps. Students ranked "Get someone to try out the program" only slightly higher than making animation and making sounds in the design task ranking survey and seldom included evaluation and revision in their concept maps.

Summary of Quantitative and Qualitative Findings

Overall, we found the following from the quantitative and qualitative data: (1) students were aware of the importance of higher-level design tasks such as planning, collaboration, presentation and research, (2) students have changed significantly their audience and presentation skill from pretest to posttest, (3) students had opportunities to practice research skill, (4) students maintained high levels of interest and mental effort and involvement, (5) students' planning skill varied due to individual difference, (6) students' collaboration skill varied due to different group dynamics, and (7) students did not develop evaluation and revision skill due to lack of emphasis in class.

RESEARCH QUESTION 2: WHAT IS THE IMPACT OF THE LEARNERS-AS-MULTIMEDIA-DESIGNERS ENVIRONMENT ON MIDDLE SCHOOL STUDENTS' PSYCHOLOGICAL SENSE OF COMMUNITY?

Students' psychological sense of community was evaluated with both quantitative and qualitative data. Quantitative data came from the Psychological Sense of

Community in the Classroom (PSCC) Scale. Open-ended questions and interviews of students and teachers supplied the qualitative data. The results of both types of data were presented below.

Psychological Sense of Community in the Classroom (PSCC) Scale

To examine the impact of psychological sense of community, a one-way ANOVA was first conducted to test if there were differences between the multimedia class, regular class and TAG class. The independent variable was the grouping (multimedia class, Talented and Gifted (TAG) class, regular class), and the dependent variable was the overall score of the psychological sense of community. There was a significant group effect, $F(2, 117)=10.078$, $p < .001$ for the overall score of psychological sense of community. Since the ANOVA (see Table 7) was significant, Tukey's HSD post-hoc group comparisons were conducted to further assess the significant difference. The result indicated that the multimedia class had a significantly higher overall psychological sense of community than the TAG class ($p = .001$), and regular class ($p < .001$), whereas the TAG class and regular class did not differ significantly from each other ($p=.911$) (see Figure 1.)

Table 7: Analysis of Variance: Groups Comparison in the Overall Score of the PSCC Scale

	Sum of Squares	*df*	Mean Square	*F*	Sig.
Between Groups	5.893	2	2.946	10.078	<.001
Within Groups	34.204	117	.292		
Total	40.097	119			

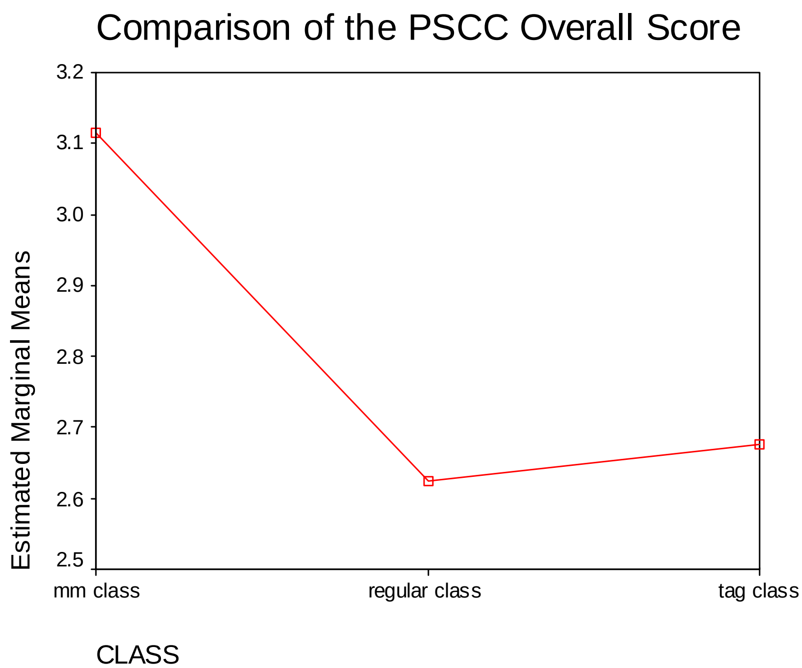


Figure 1: Comparison of the PSCC Overall Score among Multimedia Class, Regular Class and TAG Class

Table 8: Means and Standard Deviations of Psychological Sense of Community in the Classroom Survey

Measure	Multimedia Class Mean (Std. Deviation)	Regular Class Mean (Std. Deviation)	TAG Class Mean (Std. Deviation)
Overall Scale	3.11(.53)	2.62(.49)	2.68(.59)
Membership	3.33(1.00)	2.83(.61)	2.89(.66)
Influence	2.98(.40)	2.42(.42)	2.47(.58)
Integration and Fulfillment of Needs	3.07(.56)	2.53(.58)	2.60(.74)
Shared Emotional Connection	3.07(.59)	2.72(.61)	2.74(.73)

To avoid Type 1 error by conducting multiple ANOVAs on the four subscales of the PSCC Scale, a Multivariate Analysis of Variance (MANOVA) was conducted to analyze the data from the four subscales. The independent variable was grouping (multimedia class, TAG class and regular class) and the dependent variables were the scores of the four subscales (membership, influence, integration and fulfillment of needs, shared emotional connection). The means and standard deviations of the three different classes on the overall measure of psychological sense of community and each subscale (membership, influence, integration and fulfillment of needs, and shared emotional connection) were shown in Table 8. Table 9 showed the MANOVA table for the four subscales.

Table 9: Multivariate Analysis of Variance

Value	*F*	Hypothesis *df*	Error *df*	*p*
.730	4.848	8.000	228.000	<.001

The result indicated that Wilks' Lambda was significant (F=4.848) at the $p < .001$ level. Tukey's HSD post-hoc group comparison was therefore conducted to further test the differences between different classes in all four subscales.

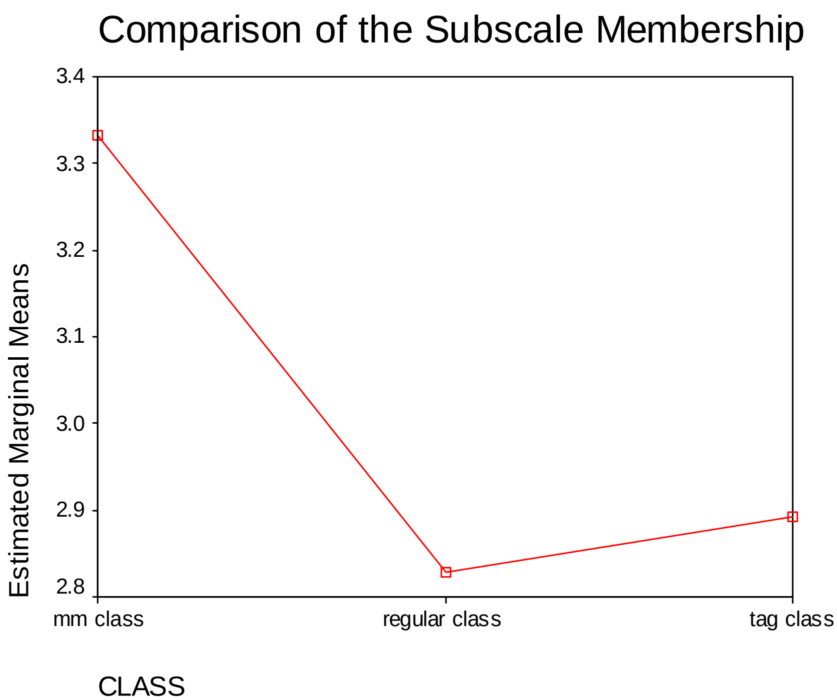


Figure 2: Comparison of the Subscale of Membership among Multimedia Class, Regular Class and TAG Class

For the subscale of membership, Tukey's HSD post-hoc group comparison indicated that the learners-as-multimedia-designers class had a significantly higher sense of membership than the TAG class (p <.05) and regular class (p <.05), whereas the TAG class and regular class did not differ significantly from each other in the subscale of membership (p =.931) (see Figure 2).

Similar results were shown in the subscale of shared emotional connection: Tukey's HSD post-hoc group comparison showed that the learners-as-multimedia-designers classes had a higher sense of shared emotional connection than the TAG (p <.05) and regular classes (p <.05). The TAG classes and regular classes didn't differ from each other significantly (p=.994) (see Figure 3).

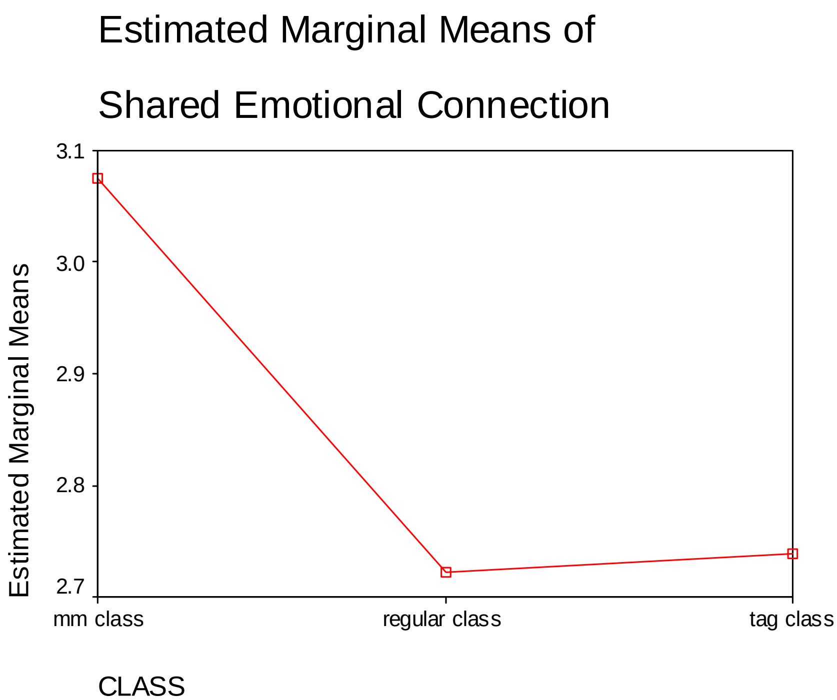


Figure 3: Comparison of the Subscale of Emotional Connection among Multimedia Class, Regular Class and TAG Class

For the subscale of influence, Tukey's HSD post-hoc group comparison indicated that the learners-as-multimedia-designers classes showed a higher sense of influence than the TAG classes (p <.001) and regular classes (p <.001). The TAG classes and regular classes didn't differ from each other significantly on the subscale of influence (p=.900) (see Figure 4).

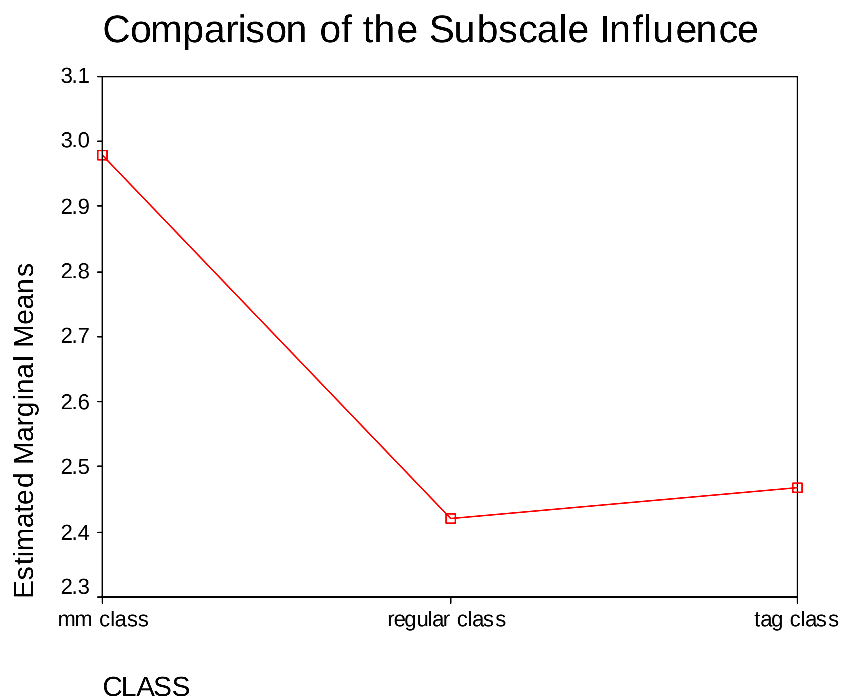


Figure 4: Comparison of the Subscale of Influence among Multimedia Class, Regular Class and TAG Class

For the subscale of integration and fulfillment of needs, Tukey's HSD post-hoc group comparison again showed that the learners-as-multimedia-designers classes showed significantly higher sense of integration and fulfillment of needs than the TAG classes ($p < .01$) and regular classes ($p < .01$). The TAG classes and regular classes did not differ from each other significantly ($p = .859$) (see Figure 5).

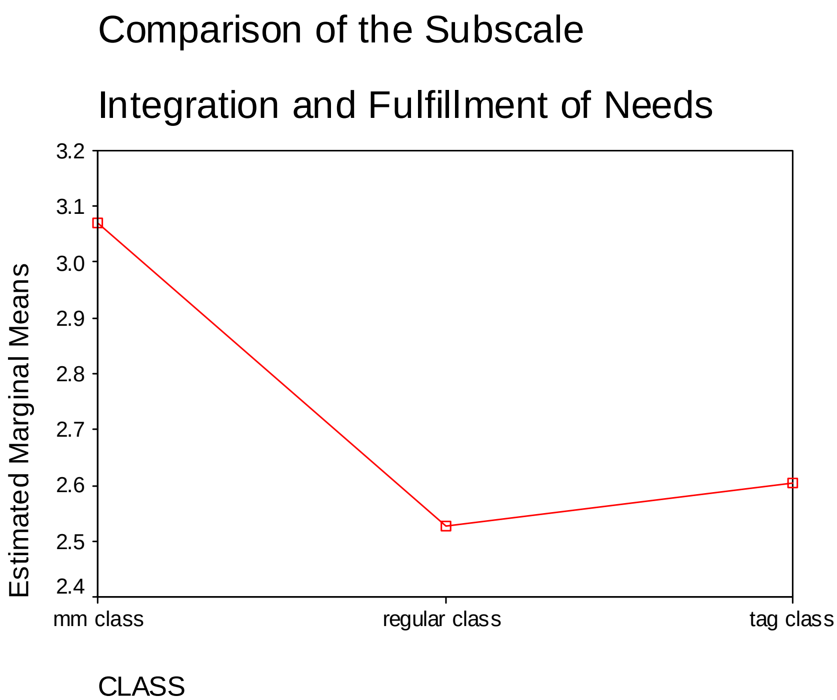


Figure 5: Comparison of the Subscale of Integration and Fulfillment of Needs among Multimedia Class, Regular Class and TAG Class

Qualitative Data

Membership

Most students in the learners-as-multimedia-designers class have shown strong membership through their high levels of mental effort and involvement. For example, one student made a comment about how much students in the class have spent time working for the class:

> I like to come in after school. I come in during study hall. I come in before school sometimes if I really need to get something done… Every time I come in, I'm never the only person in the lab. Never.

What was noteworthy was that these students seemed not to do this just for turning their project in on time, but they seemed to care about their products and were willing to spend time making the products better.

Most students mentioned that they would like to continue taking next advanced class and said that they would change nothing about the class. When asked if they would recommend this class to other students, most students said that they would. One student even went on to say, “If I could, this would be the only class I’d want to take.”

Students’ sense of membership in the Multimedia Masters Class was also reflected in the quantitative finding from the PSCC Scale, where their membership score was significantly higher than the students in either TAG class or regular class.

Shared Emotional Connection

Other than a strong sense of membership, students also seemed to develop good working relationship in this class. Many students talked about being able to know their group members and classmates better over time and developing friendship with them. One of the comments went like this:

> I’ve know ___ (student’s name was taken out to protect student’s identity) for a long time, but we’re not very close. But this class has helped us become better friends and work together better.

Through working together and relying on each other to accomplish tasks, students were able to know each other better and enhance the emotional bond. Another aspect of emotional connection was attributed to the communication students had shared when working. One student described the fun he had while working,

> If you do it all by yourself, you can’t have fun with it. You can’t communicate with the guys ...You find something cool and you have nobody to look behind you and go ‘that’s cool.’

Being able to communicate with others, and share ideas and discoveries in a project environment seemed to allow students to have more fun and develop deeper emotional connection. This finding was also consistent with the quantitative finding in the PSCC Scale where students in the Multimedia class had a significantly higher score in emotional connection than students in the regular class or TAG class.

Influence

Students felt a sense of influence in this class. While in the class doing projects, students felt that they could take charge of their own learning and were allowed an environment to explore and learn. One of the teachers commented,

> It is an exciting adventure because you know it takes me out of the driver seat. I sort of flow around and make sure everybody is on task, but they are determining the direction, that their company (for the Business in a Box project) is going and their project is going. They are really taking control and in fact, they kick me out of the conversation sometimes. They want to keep it a secret and you know, most groups feel like they get a real grasp on what they want to accomplish.

Students also felt a sense of influence from their group work. While working on projects, students developed expertise on different areas such as software skills or project design skills. Students could exert their influence by showing their expertise. For example, one student talked about knowing herself and other people's expertise,

> Everybody (in my team) is good at something. I mean maybe I'm not good with Photoshop, but I'm really good at Flash.

To sum up, students felt a sense of influence from being able to take charge o their own learning and being able to develop and use their expertise during group projects. This finding was consistent with what was shown in the influence score of the PSCC Scale. Students in the multimedia class showed higher sense of influence than students in the regular class or TAG class.

Integration and fulfillment of needs

In the learners-as-multimedia-designers class, students also seemed to be able to fulfill their needs. First, students felt that they have learned a lot of new skills from this class and the experience went beyond their expectation. One student commented on how they progressed with time in this class:

> I think I've learned a lot. Before I came to this class, I knew nothing... But now I know about … all these programs that I never thought anybody could use and do.

Second, students were able to fulfill their needs through the peer support. For example, one student talked about being able to rely on her group members because of the interdependence with each other,

> I think I can rely on them (my group members) to get stuff done… You have to depend on other people, and if you don't trust them or they're not reliable, then you don't always get it done.

The above finding was also consistent with the result of the PSCC Scale, in which students' integration and fulfillment of needs score was significantly higher than either TAG class or regular class.

Summary of Quantitative and Qualitative Findings

From the quantitative data, we found that students in the learners-as-multimedia-designers class had a significantly higher psychological sense of community than students in the regular class or the TAG class, as shown in the overall score and the score in four subscales (membership, influence, emotional connection, and integration and fulfillment of needs), whereas the regular class and TAG class did not differ from each other significantly. From the qualitative data, we found that students in the learners-as-multimedia class developed a sense of membership due to their high levels of mental effort and involvement. They exerted and received influence during group projects. They developed emotional connection through working and communicating with each other during group projects. They also could fulfill their needs through peer support and sharing their own expertise during group projects.

RESEARCH QUESTION 3: IS THERE ANY RELATIONSHIP BETWEEN STUDENTS' PROJECT DESIGN SKILLS AND THEIR PSYCHOLOGICAL SENSE OF COMMUNITY AS THEY ENGAGE IN THE LEARNERS-AS-MULTIMEDIA-DESIGNERS ENVIRONMENT?

To answer this research question, the Pearson Product-Moment Correlation analysis was used to evaluate if there was a relationship between students' project design skills and their psychological sense of community in the learners-as-multimedia-designers environment. A Pearson Product-Moment Correlation analysis was first run among the four subscales of psychological sense of community to test if there was any correlation among these variables. The results indicated that all four subscales (membership, influence, shared emotional connection, integration and fulfillment of needs) were highly correlated with each other. The Cronbach Alpha (Reliability Coefficient) was .9237. So the overall psychological sense of community was used as a composite variable instead. Table 10 showed the correlation between the four subscales.

Next, six Pearson Product-Moment Correlation analyses were run between the composite overall score of psychological sense of community and six project design categories (audience, presentation, planning, interest, mental effort and collaboration) from the Project Design Questionnaire to test if there was any correlation between psychological sense of community and the six categories. Table 11 showed the results.

Table 10. Correlation among the Psychological Sense of Community in the Classroom Subscales

Pearson Correlation	membership	shared emotional connection	influence	integration& fulfillment of needs
membership	1.00	.790**	.703**	.743**
shared emotional connection	.790**	1.00	.734**	.855**
influence	.703**	.734**	1.00	.702**
integration & fulfillment of needs	.743**	.855**	.702**	1.00

** Correlation was significant at the .01 level

Table 11: Correlation between the overall psychological sense of community and the Project Design Skills categories

Pearson Correlation	Audience	Presentation	Planning	Interest	Mental Effort	Collaboration
Overall Psychological Sense of Community	.509**	.313*	.292	.212	-.017	.554**
Sig. (2-tailed)	<.01	.049	.067	.189	.919	<.01

N= 40
a. *Correlation is significant at the .05 level (2-tailed).
b. **Correlation is significant at the .01 level (2-tailed).

Table 11 indicated that there was a significant correlation between the overall psychological sense of community and the category of audience and collaboration at the $p < .01$ level. There was also a significant correlation between the overall psychological sense of community and the category of presentation at the .05 level. The highest significant correlation, between the overall psychological sense of community and the category of collaboration, was .554, resulting in a coefficient of determination (r squared) of .31, $p<.01$. This indicated that students' psychological sense of community explained thirty-one percent of the variance in students' collaboration skill. The other significant correlation happened between the psychological sense of community and the category of audience: .509, $p<.01$, resulting in a coefficient of determination (r squared) of .26. This showed that twenty-six percent of the variance in the audience skill could be explained by students' psychological sense of community. Another significant correlation was between the overall psychological sense of community and the category of presentation: .313, $p<.05$, resulting in a coefficient of determination (r squared) of .10. This means that ten percent of variance in the presentation skill could be attributed to students' psychological sense of community. There was no significant correlation between psychological sense of community and students' planning skills, interest and mental efforts.

RESEARCH QUESTION 4: CAN STUDENTS' PROJECT DESIGN SKILLS DEVELOPMENT BE PREDICTED BY STUDENTS' PSYCHOLOGICAL SENSE OF COMMUNITY?

To answer this research question, a standard linear regression analysis was conducted to examine whether students' project design skills could be predicted by students' psychological sense of community. Due to the high correlation (see table 11) between the four subscales (membership, shared emotional connection, influence, integration and fulfillment of needs) of the psychological sense of community, a composite overall psychological sense of community score was used as a predictor variable. The six categories of project design skills (audience, presentation, planning, interest, mental effort, and collaboration) were used as dependable variables.

The Analysis of Variance (ANOVA) (see Table 12) indicated the statistical significance of the prediction equation. The data showed that audience skills was significant at the p=.001 (F=13.310) and the collaboration skill, at p<.001 (F=16.868) level. The presentation skill also had the significance level at the p<.05 (F=4.131) level. The data showed that the audience, collaboration, and presentation skill could be predicted with the psychological sense of community construct with statistical significance, while the categories of planning, interest, and mental effort and involvement could not be predicted with the psychological sense of community construct with statistical significance. The R^2 value for each of the six project design skills was also shown in table 13. The R-squared (R^2) value indicated how well a variable explained variation in the dependent variable. A strong model (high R^2) indicated that there was a large percentage of variation in a dependent variable. The highest R^2 value was .31 for collaboration skills. This indicated that 31% of students' collaboration skills could be explained by students' psychological sense of community. The second highest R^2 value was .26 for the audience skill, which indicated that 26% of audience skills could be explained by students' psychological sense of community. The presentation skill had .10 R^2 value, which showed that 10% of variation in presentation skill could be explained by students' psychological sense of community.

Table 12: Analysis of Variance: Regression

Dependent Variable	Sum of Squares	*F*	*p*	R^2
Audience	4.68	13.31	.001***	.259
Collaboration	2.457	16.868	<.001***	.307
Interest	.588	1.788	.189	.045
Mental Effort	7.282E-03	.001	.919	.000
Planning	1.257	3.551	.067	.085
Presentation	1.951	4.131	.049*	.098

a. *Regression is significant at .05 level.
b. ***Regression is significant at .001 level
c. Degrees of freedom is (1, 38).

Table 13: Regression Analysis: Coefficients for Different Dependent Variables

Dependent Variable	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	*t*	*p*
Audience	.648	.178	.509	3.648	.001***
Collaboration	.469	.114	.554	4.107	<.001***
Interest	.230	.172	.212	1.337	.189
Mental Efforts	-2.555E-02	.249	-.017	-.103	.919
Planning	.336	.178	.292	1.884	.067
Presentation	.418	.206	.313	2.032	<.05*

a. Dependent Variables: Audience, Collaboration, Interest, Mental Efforts, Planning, Presentation.

b. *Beta weight is significant at the .05 level.
c. ***Beta weight is significant at the .001 level.

Another index of statistical significance was the analysis of Beta weights (standardized coefficients). The standardized Beta coefficient provided a measure of contribution of the independent variable to the dependent variable. Table 13 showed the contribution of psychological sense of community to each dependent variable (audience, collaboration, interest, mental efforts, planning, and presentation). The *t* and *p* values indicated the impact of the psychological sense of community to each dependent variable. A large absolute *t* value and small *p* value suggested that the predictor variable (psychological sense of community) was having a large impact on the criterion variable. The highest significant *B* was .554 for the collaboration skill and was significant at the $p < .001$ level. The second highest *B* that was significant was .509 for the audience skill at the $p = .001$ level. The next significant *B* was .313 for the presentation skill at the $p < .05$ level. Psychological sense of community was therefore considered as contributing significantly to audience skill, collaboration skill, and presentation skill. Since the *B* was not significant for the interest, mental effort and involvement, and planning skills, psychological sense of community was not regarded as contributing significantly to these project design skills.

RESEARCH QUESTION 5: WHAT NEEDS TO BE TAKEN INTO CONSIDERATION IN DESIGNING THE LEARNERS-AS-MULTIMEDIA-DESIGNERS ENVIRONMENT?

In addition to the previous results, there were additional findings from the interview data of teachers, students and classroom observations. These findings helped address the fifth research question "what needs to be taken into consideration in designing the learners-as-multimedia-designers environment?" The findings could be categorized into two aspects: project process-related and group work-related. In the following, each aspect was discussed.

Project Process-Related Findings

Selecting Authentic Group Projects

From the classroom observations, the researcher observed that there was a need to be more cautious about selecting group projects. Well-chosen group projects could entail better learning opportunities. For example, of the three group projects students have gone through, the first group project, Business in a Box, was able to engage students in authentic activities, with a real audience and potential “buyers” of their products, and in tasks that resembled what existed in the real world. As a result, students were energized and engaged in many activities such as interview, market research and evaluation out of their own initiative. Students seemed to have better opportunities to develop various project design skills from such a project.

In contrast, the second, “Interactive Encyclopedia”, and the third group project, Animated “Choose Your Own Adventure” Folk Story, involved less authentic elements and were less complex. Even though students were still required to work for an audience and work for an extended period of time, these projects did not require students to work and collaborate as intensely as the first project, and it seemed that these projects were not authentic enough. Even though students were engaged in project activities, students did not have as many opportunities to develop higher-order project design skills.

It was important to have a project that appealed to students and was complex enough to entail the learning of all the project design skills. However, selecting such a project also placed a lot of burden on the teachers, who had to deal with many other instructional issues in their day-to-day life. Some solutions to this problem may be to (1) allow students to choose their own projects, and (2) have more projects related to students’ academic subjects or school events, as suggested by one teacher:

> I am going to give them more liberty to decide on projects, on what they want to build. What's interesting to them and helps, encourages them to do more school-related activities. They were working on a Texas heroes project in their Texas history class. How are we going to integrate that into multimedia? And let what's going on on-campus drives my curriculum.

Allowing students to work on projects that reflect their interest, academic subjects or campus events may ultimately provide authenticity and relevance to the group project experience.

Providing Facility Access

Another finding gleaned from the interviews was related to the facility issue. When considering the design of the learners-as-multimedia-designers environment, it would be beneficial to include consideration of facility access. Students in the treatment group have benefited from access to an exclusive computer laboratory with great convenience and availability. Unlike in regular middle schools where the computer labs may be locked up when there was no class going on, students have had full access to the computer lab to do their work as long as they signed in to the computer. This access helped students stay engaged and focused on what they needed to get done.

Another topic related to facility concerned a reserved space for students to store their data and files. The space referred to both a space in the network/server to store students' computer programs and a space literally in the lab to store students' disks, documents and other materials. As one teacher observed,

> I need to come up with a better organizational system for them (students) to help them keep their work. I want to build cubby holes along back there so that each group has its cubby to store their materials and their disks and things like that …

To allow students to work on group projects, the logistics of providing better access in the facility, including access to computer labs and access to storage space, may help create a better working environment for students to focus on projects and learning of project design skills.

Group Work-Related Process

Training Interpersonal Skills for Group Projects

The findings of the first research question also indicated that there were different group dynamics at work when students worked on group projects. The group dynamics affected students' ability to collaborate and learn project design skills. The problem with group dynamics seemed to circle around the way one or two of the group members interacted with each other. Often times, when conflicts or disagreements arose, some students of this age group did not know how to resolve the conflicts and disagreements. For example, one teacher described his observation of the problems the student groups had working together,

> Mostly, I think it was ___'s dominant personality. Basically, I don't think he thinks the other two could do anything …The other group is just immature… I don't think any of them was lazy or didn't want to go to work, but they all wanted to do all the work and gave no credit to the others that were trying….

It seemed to the researcher that lack of interpersonal skills sometimes prevented students from having good working relationship. Although training on interpersonal skills may not completely help with this problem, some training and/or discussion on how to work with others may potentially provide some help for this or younger age group.

Chapter 5: Discussion

AN OVERVIEW OF THE FINDINGS

This study set out to examine the following research questions:

1. What is the impact of the learners-as-multimedia-designers environment on the learning and development of middle school students' project design skills?
2. What is the impact of the learners-as-multimedia-designers environment on middle school students' psychological sense of community?
3. Is there any relationship between students' project design skills and their psychological sense of community as they engage in the learners-as-multimedia-designers environment?
4. Can students' project design skills development be predicted by students' psychological sense of community?
5. What needs to be taken into consideration in designing the learners-as-multimedia-designers environment?

This study provided a few interesting findings regarding students' project design skills learning and psychological sense of community. The previous chapter has presented the details of the results. This chapter further discussed the findings. The findings for research questions one through four were addressed in the following sections and the section of implications for practices presented the findings of the fifth research question.

Students' Learning and Development of Project Design Skills

There were several findings regarding students' learning and development of project design skills: First, students in the multimedia class have significantly improved their awareness of audience and awareness of presentation, as shown in the Project Design Questionnaire. The qualitative data also showed that they understood the importance of consulting with audience for project direction and feedback. They were increasingly mindful of designing their products for better presentation. They were also aware of the importance of other design tasks such as planning, collaboration, and research, as indicated in the design task ranking survey. This finding was consistent with the findings of other studies (Liu, 1998; Liu & Hsiao, 2001; Liu & Pedersen, 1998; Liu & Rutledge, 1997). Generally, students ranked design tasks that required thinking higher than tasks that required technical skills (creating graphics, animation or sounds). In other words, they placed more importance on the design tasks that required them to think and collaborate with others.

However, there was no significant difference between the pretest and posttest scores of planning and collaboration in the Project Design Questionnaire. Students maintained a medium range score (3.0-4.0) out of a 5-point Likert Scale from pretest to posttest. From the qualitative data, we were able to find some explanation: there were great individual differences when it came to planning for students and that there were also different group dynamics at work that remained unchanged from pretest to posttest. For this age group, some students were more than ready and preferred to plan for their projects while others were very reluctant and preferred "going straight to play on the computer", despite their recognition of the importance of planning. This characteristic of student predisposition towards planning was not affected by the learners-as-multimedia-designers environment in this study and resulted in the non-significant planning score.

Likewise, student groups of this age group also had different group dynamics when they worked on projects. Some groups had great rapport and developed good working mechanisms while others could not collaborate effectively and had trouble turning in their products. Perhaps due to this characteristic of varied group dynamics, there was also non-significant finding in the collaboration score.

As to the research skill, from the qualitative data, we also found that students had the opportunity to conduct research. Students were very resourceful in their research effort. They went to interview their target audience, and searched information from the Internet and school library out of their own initiative. They also developed their own research methodologies for implementation. For example, students were able to create a rating system to determine the right product when interviewing teachers for answers in the Business in a Box project. Overall, students enjoyed the opportunity to conduct research, which they may not have in other classes.

Second, students have shown high levels of interest and mental effort and involvement from the beginning of the first semester to the end of the second semester, as shown in the Project Design Questionnaire. This finding supported the finding of other research studies (Carlin-Menter & Shuell, 2003; Lehrer, 1993; Liu, 1998; Liu & Hsiao, 2002; Liu & Pedersen, 1998; Liu & Rutledge, 1997) that students were highly motivated in working on multimedia projects. Although it was likely that students may be simply interested in computers and stay motivated throughout the year, the qualitative data showed that students were not as motivated in other classes that used computers. The qualitative data indicated that when comparing this class with other classes, students preferred this class because it allowed students to take charge and have more freedom "experimenting" on their own. It seemed that the autonomy students have enjoyed in this class was one of the reasons that helped sustain their interest and mental effort and involvement throughout the year.

Finally, students were not aware of the importance of evaluation and revision and did not develop evaluation and revision skills as hoped. This study also found that the majority of students regarded "testing" and "getting someone to try out the programs" of low priority in their design task ranking survey, and evaluation and revision rarely appeared in their concept maps. This finding was consistent with what was found in Liu and Rutledge's study (1997). From the qualitative data, we could find some plausible reasons. There was not enough emphasis on the tasks of evaluation and revision in the class, despite that assessment rubrics were given to students to encourage students' self-evaluation before turning in their products. Students also neglected to evaluate and revise in the actual implementation when they lacked of time and struggled to meet the deadlines. Due to lack of emphasis, lack of time and lack of practice, students did not regard the task of evaluation and revision as important.

From the findings, we could find the impact of the learners-as-multimedia-designers environment on students. Students' improvement on audience skill and research skill could be attributed to the authentic characteristic in the environment. With a real audience, students were able to recognize the importance of consulting with audience and conducting research with them. Students' sustained interest and mental effort and involvement could be attributed to the characteristic of constructive investigation and student autonomy in the environment. Students reported that they preferred this class to other classes using computers because this class allowed them to "experiment on their own". It seemed that being able to take charge of their own learning and engage in constructive investigation activities was one of the reasons that helped students stay motivated and maintain high levels of mental effort and involvement. In addition, teachers' cognitive scaffolding (modeling, coaching, scaffolding) also helped students' learning of presentation skill, as shown in students' concept mapping survey that the majority of students have included aspects of design (background, color, etc.) as part of their concept in the posttest. The practice of cognitive apprenticeship by the teachers has allowed students to internalize the design concept and develop better presentation skill. Likewise, teachers' scaffolding has helped students become aware of the importance of planning and the steps needed to plan, but due to individual differences toward planning, planning skill was not equally developed for every student. As to the collaboration characteristic, even though students did not show significant change in their collaboration score in their Project Design Questionnaire, most students still recognized its importance and ranked it high among the design tasks. Overall, the characteristics (authenticity, collaboration, constructive investigation, student autonomy and cognitive apprenticeship) of the learners-as-multimedia-designers environment have directly or indirectly promoted students' learning of project design skills and sustained their interest and mental involvement.

Students' Psychological Sense of Community in the Classroom

Students' psychological sense of community was examined using the PSCC Scale and qualitative data including open-ended questions and interviews. The results of the PSCC Scale indicated that students in the learners-as-multimedia-designers class had a significantly higher sense of community in their overall score and in each of the four subscales (membership, influence, integration and fulfillment of needs and shared emotional connection) than students in the TAG class and regular class, whereas students in the TAG classes and regular classes did not differ significantly from each other in all of the measures. The qualitative data also indicated that students in the learners-as-multimedia-designers classes showed strong identity with the class through high levels of mental involvement, developed emotional connection through project work, felt a sense of influence through sharing expertise and learning from group members and felt their needs were fulfilled through teacher and peer support.

It was worthwhile to note that the students in the TAG class shared similar academic capabilities as the students in the learners-as-multimedia-designers class and that students in the TAG class also showed aptitude toward their subjects (language arts and math) and were selected into the TAG classes. However, in the TAG class, instruction was carried out in a more traditional way with teachers giving lectures and assigning homework, as in the regular classes.

It seemed that the difference in psychological sense of community between the learners-as-multimedia-designers classes and the TAG classes or the regular classes could be attributed to that the learners-as-multimedia-designers classes had an environment that engaged students in activities that promoted psychological sense of community whereas the other two groups did not. As Kim, Solomon and Roberts' study (1995) indicated, teacher/classroom practices had an indirect influence on students' behaviors, which were related to students' sense of community. Therefore, one may conclude that the significant higher sense of community in the learners-as-multimedia-designers classes could be, indirectly, attributed to the constructivist, project-based, learning environment. This result was consistent with the study finding by Bateman (1998) that students in the constructivist learning environment reported higher levels of membership and influence, and a higher sense of fulfillment of needs than traditional classrooms (In Bateman's (1999) study, level of emotional connection was not significantly different between the constructivist and the traditional groups.)

As described by students' comments, the traditional classes usually involved "doing a worksheet" and then "here's your homework" and required little constructive investigation or collaborative effort. For classes using computers, another student described them as like “now you go to File and open…da, da, da” without allowing students to have the freedom to “experiment and learn” by themselves. In contrast, in the learners-as-multimedia-designers classes, students were allowed more freedom to explore and experiment on their own. In other words, students had the opportunity to engage in constructive investigation and had the opportunity to take charge of their own learning. They were able to constructively investigate while collaborating with their peers and with support from their teachers. Moreover, the collaboration process in the environment also allowed students to fulfill their needs, feel a sense of membership, influence, and develop emotional connection. It seemed that some, if not all, the characteristics in the learners-as-multimedia-designers environment could have helped promote a higher psychological sense of community in students than the traditional classrooms.

The Relationship between Project Design Skills and Psychological Sense of Community

The relationship between psychological sense of community and the development of project design skills was analyzed using Pearson Product Moment Correlation Analysis and Regression Analysis. The results showed that there were significant positive correlations between the overall psychological sense of community and the audience skill, presentation skill and collaboration skill. The correlation between the overall psychological sense of community and the other project design skills such as planning, interest, and mental effort, though positive, were not significant.

The correlation indicated that there was especially a strong relationship between the psychological sense of community and students’ audience skill (.509) and collaboration skill (.554) while the relationship between the psychological sense of community and the presentation skill was weaker (.313). Furthermore, not surprisingly, students' psychological sense of community also significantly predicted the development of audience skill, collaboration skill and presentation skill but not students' interest, mental effort and planning skill. The psychological sense of community explained 31% of variance in the development of collaboration skill and about 26% of variance in the development of audience skill but only explained 10% of variance in the development of the presentation skill.

The significant positive correlation between students' psychological sense of community and students' collaboration skill was particularly interesting. This result was consistent with Kim, Solomon, and Roberts (1995)'s finding that cooperative interaction was a primary mechanism to promote students' sense of community in the classroom. This result also supported Bateman's study (1998) that students in the constructivist learning environment had significantly higher cooperative skill.

Although there could be many contributing factors to any correlation relationship, as we examined this collaboration aspect in the learners-as-multimedia-designers environment in relation to the subscales of PSCC, we could find some explanation for this correlation. As students collaborated in group projects, they needed to rely on their group for understanding of the whole picture and simultaneously they could also contribute their expertise to their group. Students would feel a sense of influence in both directions---from the group to the student and from the student to the group. Students in the learners-as-multimedia-designers environment also had the opportunity to have their needs fulfilled by their peers while collaborating in group projects, either through peers sharing responsibility or through accomplishing meaningful tasks together. Moreover, students in the learners-as-multimedia-designers environment could also have the opportunity to develop emotional connection from group projects. From working together, communicating ideas, and sharing responsibilities during group projects, students had the opportunity to understand and appreciate each other better, which helped them develop emotional bond. To summarize, collaboration allowed students to develop a sense of influence, fulfill their needs and develop emotional connection, which explained the strong correlation between student's psychological sense of community and their collaboration skill.

As for the significant correlation between psychological sense of community and audience and presentation design skills, there could be many confounding factors involved and no conclusive explanation could be given by this researcher. However, some of the plausible factors may be attributed to one or more characteristics in the learners-as-multimedia-designers environment. For example, students have become aware of audience and presentation issues from the process, as shown in the findings of the first research question. The authentic project characteristic in the learners-as-multimedia-designers environment involved the use of a real audience, which led to students' heightened audience awareness. The cognitive apprenticeship teaching allowed students to internalize design concepts and therefore became aware of presentation. Likewise, the characteristic of authentic projects may also cognitively challenge students and enable them to fulfill their learning needs. Authentic projects, being meaningful and purposeful, may also allow students to feel a sense of influence. In addition, the cognitive apprenticeship coaching and support provided by teachers may also allow students to feel that their learning needs were met. Students may also develop emotional connection with the teacher because of the guidance and mentoring the teacher has provided. The characteristics of authenticity and cognitive apprenticeship teaching, in this case, may possibly contribute to students' psychological sense of community and lead to the connection between students' psychological sense of community and their audience and presentation design skill.

Implications for Practice: How to Design the Learners-as-Multimedia-Designers Environment

The findings of this research study had some implications for designing the learners-as-multimedia-designers environment. First of all, in light of the finding that students did not value the evaluation and revision activities, there should be more emphasis on evaluation and revision in the class. For example, despite the "just-in-time" nature of the evaluation and revision activities, the class can set some time for sharing (as in presentation in class), critiquing and revision. Students can have two deadlines: one for finishing the product and one for finishing revising the product. After students finish their products, they can first present in the class and to the audience. After they receive some comments, they can have some more time to focus on revision based on the evaluation before turning in the product. As the real world multimedia design and production is often an on-going process, the multimedia class needs to infuse the idea of "reiterative evaluation and revision" to students and allow them opportunity and time for evaluation and revision activities. The time for evaluation and revision should be scheduled in the curriculum at the beginning of the semester to ensure its implementation.

Second, in terms of individual differences toward planning of this age group, computers can be incorporated into the process to help motivate students. Students could have some choices regarding how to plan: they could either work on paper to create flowcharts and storyboards, or they could create these materials directly on computer screen. For students who prefer "going straight to play on the computer", this can be a more motivating alternative to them.

Third, in the finding from the qualitative data, we also learned that there should be more caution regarding selecting group projects. Teachers can incorporate students' interest, academic subjects or campus events as group projects. Group projects should include an authentic audience and need to be complex enough to require group effort. Teachers can enlist the help of the school community and outside community in the search for projects and can build a database of projects.

Fourth, some interpersonal skills training or discussion on working with others for this age group before they start group work may help promote group dynamics during their group projects. Even though these training or discussion may not make any differences in students' group work, in some cases, these training and discussion may possibly help ease students into group work to reduce interpersonal conflict and help the members of the group take responsibility for one another and for what is happening in the group (Solomon, Watson, Delucchi, Schaps, & Battistich, 1988; Cohen, 1994). In addition, teachers can also build in an incentive structure to make students within the groups responsible for both individual and group effort. By being accountable for both individual and group effort may prompt students to work better with one another (Johnson & Johnson, 1987). These solutions may help improve the group dynamics for this or younger age group.

Finally, if possible, the learners-as-multimedia-designers environment should resolve the access issue in the facilities. Providing student convenient access to use computer labs and a space (either server space or physical space) for organizing files may free students from managing their resource constraints, given that students of this age group generally have not developed good time and resource management strategies (Liu & Hsiao, 2001). After being allowed access in their facilities, students can then concentrate on developing their skills in multimedia design and production.

LIMITATIONS OF THE STUDY

There are a few limitations of the study. First, participants in this study were from intact classes and random sampling was not possible. The treatment group (the

Multimedia Masters class) and the comparison groups (the regular class and the TAG class) were not taught by the same teacher. The treatment group and the comparison groups studied different disciplines. The treatment group and the comparison groups also did not share the same type of resources (computers and software). Furthermore, the school in which the study was conducted had state-of-the-art multimedia software and high-end computers (due to grants and industry funding) as well as a teacher with experience as multimedia professionals. The resources available in the school may not be so readily available for other school settings. All these characteristics in the participants may limit the generalization of the study.

Second, some of the findings derived from students' self-reported data and the researcher's own observation. Students' self-reported data may be different from what actually happened and the researcher may be subject to observer's bias. Furthermore, the Psychological Sense of Community in the Classroom Scale did not collect pretest data. The difference in students' psychological sense of community may be due to pre-existing difference in the participant classes rather than the treatment condition. Caution should also be taken regarding the concerns in the data.

RECOMMENDATIONS FOR FUTURE RESEARCH

Based on the participation framework, this current study examined the impact of the learners-as-multimedia-designers environment on students' project design skill and psychological sense of community, and explored the relationship between these two areas. Additionally, considerations from implementation were also gathered to help provide guidelines on how to better design the learners-as-multimedia-designers environment. We had some significant findings from this study. In this section, we discussed some recommendations for future research.

First, future studies should examine students' psychological sense of community from different time points (pretest-posttest). The current research study, due to the timing of the recruitment, did not collect pretest data from all three groups (treatment group, TAG group and regular group) in the beginning of the research. Future research studies should replicate by having quasi groups and multiple data-collection points to collect students' pretest and posttest data. The different data points may be helpful in examining whether time was a factor in students' psychological sense of community.

Second, future studies can also examine other project design skills and their relationship with psychological sense of community. The current research finding indicated that the developments of audience skill, presentation skill, and collaboration skill were all significantly and positively correlated with students' psychological sense of community whereas students' planning skill, interest, and mental effort were not significantly correlated with their psychological sense of community. Due to the attention span of middle school students in this study, an abbreviated version of the Project Design Questionnaire was used in this research study. However, the original, longer version of the Project Design Skills survey contained many other project design skills such as searching information, connecting ideas, and individualization skill. Future research can examine the relationship between psychological sense of community and the other project design skills, in order to replicate the current study with different population and to expand our understanding about psychological sense of community and its association with other project design skills.

CONCLUSION

This current study designed and examined the learners-as-multimedia-designers environment based on the perspective of the participation framework. This study has examined the impact of the learners-as-multimedia-designers environment on students' project design skills, students' psychological sense of community, the relationship between students' project design skills and their psychological sense of community. This study also sought insights on how to better design the learners-as-multimedia-designers environment.

The findings of this study indicated that the learners-as-multimedia-designers learning environment could indeed help students, aside from the learning of software skill, become aware of the importance of higher-order project design tasks such as planning, presentation, research and collaboration. Students also developed certain project design skills such as audience, research, and presentation skill as a result of this environment. However, due to individual difference and varied group dynamics, students had different implementation practices when it came to planning and collaboration. Students also were not aware of the importance of evaluation and revision due to lack of emphasis in the class.

On the other hand, the study showed that the learners-as-multimedia-designers classes had significantly higher psychological sense of community than either the TAG class or the regular class and that there was a significant positive correlation between students' psychological sense of community and students' audience skill, presentation skill and collaboration skill. The characteristics of the learners-as-multimedia-designers environment such as collaboration, student autonomy, constructive investigation, and cognitive apprenticeship teaching may have helped promote students' sense of membership, sense of influence, fulfillment of needs and/or emotional connection. Given the strong positive correlation between psychological sense of community and collaboration skill, the characteristic of collaboration in the learners-as-multimedia-designers environment was particularly noteworthy. This finding indicated that an environment like the learners-as-multimedia-designers environment that engages students in collaborative constructive investigation could help promote students' psychological sense of community. This finding implicated that teachers should create a classroom environment that engages student in constructive collaborative activities.

Finally, from the qualitative data, the research finding also pointed out several aspects that could help design the learners-as-multimedia-designers environment better. First, it was important to select projects that are complex and authentic. Projects can be selected by integrating students' interest, academic disciplines and campus activities into project work. Second, the environment needs to provide better access and provide better organization space in the facilities to free students from dealing with the resource constraints. Third, providing interpersonal skills training and/or discussion on group work before group projects begin may help reduce interpersonal conflicts and promote group dynamic for this age group.

The above findings can primarily make contribution to the research field by advancing our understanding about the impact of a constructivist, project-based learning environment like the learners-as-multimedia-designers environment and the possible underlying reasons. Secondly, the implications from the findings can also help teachers and administrators design such environment more effectively. To sum up, this research has answered to researchers' call to study "the benefits of technology-based methods as integral components of solutions to instructional problems" (Roblyer & Knezek, 2003, p.62), to understand "the impact of technology on the various domains of learning (Pollard & Pollard, 2004, p.148), and to examine how to design technology-enhanced learning environments.

Appendix A: Project Design Questionnaire

Please answer the following questions

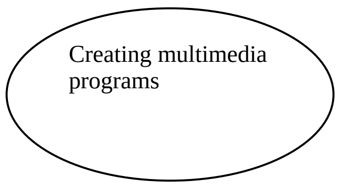
	Not True of me				Very True of me
1. I often ask myself about the best way to present an idea, like should I use a graphic or just write about it.	1	2	3	4	5
2. I think having other students look at my project is important.	1	2	3	4	5
3. Doing projects sure beats listening in class.	1	2	3	4	5
4. I like to show my project to other students	1	2	3	4	5
5. I prefer to know what to put in my project before I go to the lab and use the software.	1	2	3	4	5
6. I think doing multimedia projects is fun.	1	2	3	4	5
7. I learn more when I create a multimedia computer program than when I do other types of projects.	1	2	3	4	5
8. I prefer to work by myself on my computer project than in a group.	1	2	3	4	5
9. I think dividing up the tasks in a group is helpful.	1	2	3	4	5
10. I find myself doing preparation work before I actually use the software to create a program.	1	2	3	4	5
11. I find myself wanting to spend more time working on the project during the recess (or advisory time) or after school.	1	2	3	4	5
12. I don't want to plan when I start my project.	1	2	3	4	5
13. I learn from other students' comments after they looked at or used my project.	1	2	3	4	5
14. Overall, a group can accomplish more than I can by myself.	1	2	3	4	5

15. I really enjoy making multimedia programs as a way

of learning about different subjects such as science or language.	1	2	3	4	5
16. I try my best to make the main idea clear.	1	2	3	4	5
17. I find time goes by faster when I work on the multimedia programs.	1	2	3	4	5
18. When I have a question, my group members usually help me.	1	2	3	4	5
19. I remember more about a topic when I have made a multimedia project.	1	2	3	4	5
20. Working in groups really makes projects better.	1	2	3	4	5

Appendix B: Concept Mapping Survey

Please list all the concepts/ideas you can think of at this moment that relate to "creating multimedia programs."



Appendix C: Design Task Ranking Survey

Suppose that you have a week to create a multimedia program (i.e. Powerpoint presentation, web site, etc.) about a topic of your choice. Below is a list of things you can do, but you do not have time to do them all. Which ones are the most important?

Write 1 next to the most important task, 2 next to the second most important task, and so on.

________ Make the graphics very colorful.

________ Get someone to try out the program.

________ Plan and create a storyboard of what your program will look like.

________ Discuss with your group what information to include.

________ Scan in pictures.

________ Make sounds.

________ Brainstorm/Think about the best way to present an idea.

________ Make animation.

________ Make sure the buttons and colors are consistent from one screen to another.

________ Research and find relevant information.

Appendix D: Psychological Sense of Community in the Classroom Scale

Classes are different from each other in how participants work together, what they think and feel **about each other in the class**. **How well do the following items describe what you may say about your class?** Please **circle the number** that is best describes how you feel for each item.

	Never Not at all 1	Sometimes A little 2	Very often A lot 3	All the time 4
1. In this class we help each other learn.	**1**	**2**	**3**	**4**
2. All students in this class want to learn a lot and be nice to each other.	**1**	**2**	**3**	**4**
3. Students in this class accept me for who I am.	**1**	**2**	**3**	**4**
4. I like this class.	**1**	**2**	**3**	**4**
5. I hope I can be with the same student in my class next year.	**1**	**2**	**3**	**4**
6. Everyone is an important part of this classroom.	**1**	**2**	**3**	**4**
7. I feel I am a very important part of this class.	**1**	**2**	**3**	**4**
8. In this class everyone is really good in something (like Photoshop, Premiere, Frontpage, Flash, etc.)	**1**	**2**	**3**	**4**
9. We make a lot of choices about what to learn in class.	**1**	**2**	**3**	**4**
10. I would prefer to be in another class.	**1**	**2**	**3**	**4**
11. I know most of the students in this class very well.	**1**	**2**	**3**	**4**
12 . I feel I belong in this class.	**1**	**2**	**3**	**4**
13. I feel comfortable in this class.	**1**	**2**	**3**	**4**
14. I have very few close friends in this class.	**1**	**2**	**3**	**4**
15. I care about what students in this class think of me.	**1**	**2**	**3**	**4**
16. I have no influence over what my class is like.	**1**	**2**	**3**	**4**
17. If students do not like something in the class they can get it changed.	**1**	**2**	**3**	**4**

18. I would pick this class over another class any time.	**1**	**2**	**3**	**4**
	Never Not at all **1**	**Sometimes A little** **2**	**Very often A lot** **3**	**All the time** **4**
19. Most of the time, students in this class do not get along with one another	**1**	**2**	**3**	**4**
20. All the students in this class agree that we want to learn a lot and be nice to each other.	**1**	**2**	**3**	**4**
21. I can depend on students in this class for help if I need it.	**1**	**2**	**3**	**4**
22. What I think and say is very important to the rest of the class.	**1**	**2**	**3**	**4**
23. Most of the time students in this class get along with each other.	**1**	**2**	**3**	**4**
24. This class is a good class for me to be in.	**1**	**2**	**3**	**4**

Appendix E: Open-ended Questions

This survey is about your overall impression about the *Multimedia Masters* class. Please write down as much as you can.

Please try your best to write as much as you can. Please write down honestly what you feel.

1. Do you like working in a group? If the answer is yes, why? (In what way is working in a group helpful for your project?) If the answer is no, why not? (In what way is working in a group not helpful for your project?)

2.Describe your group members here. Try your best to describe your impression about working with them.

3. Do you think your group follows what is required in class well enough? If it is yes, say why. If is it not, please explain why not.

4. What have you learned from working in a group? Do you think your group manages the project well?

Appendix F: Interview Questions for Students

1. What do you think about the *Multimedia Masters* class?

2. What have you learned from this class?

3. Other than technical skills, what else have you learned?

4. Do you enjoy this class?

5. Do kids in this class help each other learn? Do you like your group?

6. Which type of activity do you enjoy the most? Lecture time? Individual project? Group project? Why?

7. Do you ever come to work in the lab during your own time (e.g. advisory hours)? When and for what reason?

8. Would you recommend this class to other people (e.g. your friend)? Why?

9. After this class, what do you think you can do for your future? What kind of job do you think you may be interested in working on in the future?

10. What do you think about your multimedia skills? What is your strength and weakness?

11. If you can suggest something to change in this class, what will be your recommendation?

Appendix G: Interview Questions for Teachers

1. How are the students doing for their project (are they on task, are they having difficulty, did they plan well, can they follow the steps….)?

2. What things did you observe the students like to do and what things did you observe the students do not like to do?

3. How are the groups working so far? Please give one or two examples if you can.

Appendix H: Demographic Information

1. Gender: (circle one)   Male   Female

2. Class level: (circle one)
   6th grade   7th grade   8th grade

3. Ethnic background (circle one)

Afro-American or Black	Asian-American	Caucasian or White	Hispanic or Spanish Speaking	Other

4. How many hours a week do you study/work for this course? _______________

5. How many years of computer experience do you have? ____________________

6. What kind of software do you know? (list as many as possible.)
____
____
____

7. Do you have a computer at home? (circle one)   Yes   No

8. Approximately, how many hours do you use computer every week? (circle one)
   0-7   8-14   15-21   22-28   More than 28 hours

9. Reasons for taking this class (circle yes or no for each item)

a. fulfills course requirement	Yes	No
b. content seems interesting	Yes	No
c. is required of all students at middle school	Yes	No
d. will be useful to me in other courses	Yes	No
e. is an easy elective	Yes	No
f. will help improve my academic skills	Yes	No
g. was recommended by a friend	Yes	No
h. was recommended by a teacher/counselor	Yes	No
i. will improve career prospects	Yes	No
j. fit into my schedule	Yes	No

Appendix I: Consent Form for Students in the Treatment Group

Engaging Middle School Students as Multimedia Designers
---Students' Sense of Community and Project Design Skills Development

Your child is invited to participate in a project of looking at how middle school students use the interactive multimedia technology. My name is Yuping Hsiao (pronounced as Shaw), and I am a graduate student in the Instructional Technology Program of Department of Curriculum and Instruction at the University of Texas at Austin. I hope to learn, from this project, whether a multimedia project environment can support learning. This project will be an integral part of the curriculum. All students in the multimedia classes will be invited to participate in this project and some students in the regular classes will also be invited to participate as comparison groups. Through this project, your child will be able to acquire skills and create multimedia computer programs in groups that will help prepare him or her for further study and even job-market. I will use the information that I get from this study for completion of my dissertation. Your child was selected as a possible participant in this study because he or she is enrolled in the multimedia masters program at the Cedar Valley Middle School. There will be approximately 144 students involved in total.

Your child will answer some survey questions about working in groups and learning multimedia programs during the spring semester. These survey questions will be given two times to gather pretest and posttest information. Answering these questions will in general take less than ten minutes. Your child's grade in the multimedia class will not be affected by these answers he/she gives. Any information that is obtained in connection with this study and that can be identified with your child will remain confidential and will only be disclosed with your permission. There may be some interviews and audiotaping involved during the study. If you have chosen not to allow your child to be audiotaped, your child will not be audiotaped. The audiotapes will only be used in the analysis of the data. No information identifying your child will be disclosed. There will be no known risk or discomfort involved with your child.

I have gotten the permission from the school principal to proceed with this project. I will be working closely with the classroom teachers on this project. Your decision whether or not to let your child to participate will not affect your future relations with the University of Texas at Austin or the Cedar Valley Middle School. If you decide to participate, you are free to discontinue at any time. During the interview, your child can also choose not to answer every question in the interview. If you have any questions at any time, you may contact me, Yuping Hsiao, at (512) 452-2630 or Professor Min Liu at (512) 471-5211. If you would like a copy of this form, I would be happy to provide you with one.

Thank you very much for participating in this study. Your signature indicates that you have read the information provided above and have decided to allow your child to participate. You may withdraw your permission at any time after signing this form if you choose to do so.

signature of parent or legal guardian	date
name of child	date
signature of investigator	date

Appendix J: Consent Form for Students in the Comparison Groups

Engaging Middle School Students as Multimedia Designers
---Students' Sense of Community and Project Design Skills Development

Your child is invited to participate in a project of looking at how middle school students use the interactive multimedia technology. My name is Yuping Hsiao (pronounced as Shaw), and I am a graduate student in the Instructional Technology Program of Department of Curriculum and Instruction at the University of Texas at Austin. I hope to learn, from this project, whether a multimedia project environment can support learning. This project will be an integral part of the curriculum. All students in the multimedia classes will be invited to participate in this project and some students in regular classes will also be invited to participate as comparison groups. There will be approximately 144 students involved.

Your child will answer some survey questions about working in groups during the spring semester. These survey questions will be given two times to gather pretest and posttest information. Answering these questions will in general take less than ten minutes. Your child's grade in the class will not be affected by these answers he/she gives. Any information that is obtained in connection with this study and that can be identified with your child will remain confidential and will only be disclosed with your permission. There may be some interviews and audiotaping involved during the study. If you have chosen not to allow your child to be audiotaped, your child will not be audiotaped. The audiotapes will only be used in the analysis of the data. No information identifying your child will be disclosed. There will be no known risk or discomfort involved with your child.

I have gotten the permission from the school principal to proceed with this project. I will be working closely with the classroom teachers on this project. Your decision whether or not to let your child to participate will not affect your future relations with the University of Texas at Austin or the Cedar Valley Middle School. If you decide to participate, you are free to discontinue at any time. During the interview, your child can also choose not to answer every question in the interview. If you have any questions at any time, you may contact me, Yuping Hsiao, at (512) 452-2630 or Professor Min Liu at (512) 471-5211. If you would like a copy of this form, I would be happy to provide you with one.

Thank you very much for participating in this study. Your signature indicates that you have read the information provided above and have decided to allow your child to participate. You may withdraw your permission at any time after signing this form if you choose to do so.

_______________________________ ________________
signature of parent or legal guardian date

name of child date

signature of investigator date

Appendix K: Assent Form

Engaging Middle School Students as Multimedia Designers
---Students' Sense of Community and Project Design Skills Development

I agree to participate in a study that is interested in finding the effects of having students learn multimedia software and work on multimedia projects. I understand that my mother/father/guardian has given permission for me to participate. I understand that I may decide at any time that I do not wish to continue this study and that it will be stopped if I say so. Information about the answers I give or what I say will not be given to anyone else.

I understand that I will be asked questions about the activities during the multimedia master class. I will be asked questions about my learning from working on a multimedia project and working with other group members. I understand that nothing bad or wrong will happen to me if I decide to stop my participation in this study at any time.

When I sign my name to this page I am indicating that this page was read to (or by) me and that I am agreeing to participate in this study. I am indicating that I understand what will be required of me and that I may stop the study at any time.

________________________________ ________________________

Student's signature Date

________________________________ ________________________

Signature of Principal Investigator Date

Glossary

The following are terms used in this study and their operational definitions within the contexts of this investigation:

Cognitive Apprenticeship: Cognitive Apprenticeship is a method of teaching the thinking processes experts use to handle complex tasks. Like an apprenticeship, it refers to learning through guided experiences. Unlike a traditional apprenticeship, the focus is on learning cognitive processes rather than physical skills (Collins, Brown, & Newman, 1989).

Multimedia: Multimedia refers to combining multiple media formats such as sound, text, graphics, video, and 3-D programs in one presentation format.

Project-based learning: Project-based learning is an instructional approach in which students are engaged in doing a project to collect resources, make decisions, solve problems and create a final product (Thomas, 2000).

Scaffolding: Scaffolding is support provided to learners to help them perform tasks that they would not be able to perform on their own. Scaffolds can be tools, verbal assistance or physical support. When students develop skills to handle the tasks independently, scaffolding is gradually faded or withdrawn (Collins, Brown, & Newman, 1989).

Psychological Sense of community: Psychological Sense of community refers to one's psychological experience and identity of one's community (Bateman, Newbrough, Goldman & Bransford, 1999).

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Vita

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