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Development and Application of a Framework for Observing Problem Solving by Teachers and Students in Music

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Development and Application of a Framework for Observing Problem Solving by Teachers and Students in Music

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Development and Application of a Framework for Observing Problem Solving by Teachers and Students in Music

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The development of problem solving capabilities is an essential part of intellectual independence, yet the nature of problem solving in music instruction has not been investigated systematically. The purposes of the current study were to describe the process of problem solving in the context of music learning and to elucidate the relationship between teacher behavior and learners' active participation in solving musical and technical problems.

I analyzed approximately 43 hours of private and small-group lessons taught by five internationally-renowned artist-teachers in music. I also analyzed in greater detail 161 rehearsal frames (intervals of instructional time devoted to definable proximal goals) excerpted from recorded lessons by describing the behaviors of teachers and students that led to productive learning outcomes.

The process of problem solving was found to comprise five components: establish goals, evaluate performance, conceive and consider options, generalize and apply principles, and decide and act. In assessing the extent of teachers' and students' involvement in problem-solving, I found that teachers promoted change-effecting behaviors in learners by instigating the pursuit of a goal, and then prompting learners to assume responsibility for one or more of the subsequent problem-solving components. In

this way these teachers not only brought about change in learners' performance, but also structured ways for learners to practice bringing about change in their own performance.

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Chapter 1: Introduction

Most learners engage in music study with the intention of accomplishing musical goals. Whether those goals are defined by teachers, parents, or the learners themselves, success in music instruction and practice is best measured by the extent to which goals are achieved (Duke, 1999). The extent and complexity of goals vary throughout the course of music learning. Expanding the tonal palette, increasing facility and speed, playing a double-stop in tune, or conveying an expressive idea in a phrase in Beethoven's *Emperor* Concerto are all goals to which learners may aspire. As goals are met, progress is made. Until goals are met, they are problems to be solved. Thus, music learners make progress as teachers and learners solve perceptual, physical, expressive, and intellectual problems.

It is often the case that learners' problems are solved more quickly and effectively under the guidance of teachers than when learners are working on their own (Hallam, 2001), which is why learners seek training from "more knowledgeable others" (Vygotsky, 1978). Skillful teachers lead the way through the morass of challenges in guiding students toward positive change, and make it possible for learners to move along the path to competence.

Armed with a rich knowledge base and keen perceptual skills, excellent teachers employ a vast repertoire of strategies as they guide learners through the identification, prioritization, and solution of problems. They hear differences to which learners have not yet become attuned. They can model techniques or musical ideas that learners have not attempted or mastered.

Yet most dedicated music students spend the majority of their practice time outside the presence of their teachers, confronting problems on their own. To be effective during independent practice, learners must decide which problems to pursue in the moment and must determine how to overcome them without the aid of their teachers. Further, to learn new material, even when related to what was learned during instruction, students must apply learned skills in other contexts that have not been taught explicitly. What happens when guidance from the "more knowledgeable other" is removed? Will skills acquired in lessons be sustained during individual practice? Will learners be able to continue improving during the interim between lessons, when they will inevitably encounter problems that have not been addressed by their teachers?

Teachers may expect students to solve problems independently. But the capacity to do so seldom develops on its own; it is taught and nurtured by skillful teachers who recognize learner independence as a requisite component of successful musicianship.

WHY LEARNER INDEPENDENCE?

Teachers share many common aspirations for their students: achieve a high standard of performance, perform expressively, participate in music throughout life, experience joyful music making. The attainment of each of these objectives is, at least in part, related to the attainment of another objective: developing independence. Accomplishing most meaningful music goals is possible only if learners can continue to progress beyond the presence of their teachers. Learners who are dependent on their teachers, who learn only through the active involvement of their teachers, are limited in their ability to acquire and refine the skills and thinking required or successful music making. Learners learn more, learn better, and learn more happily if they receive opportunities and develop the capacity for independent learning (Deci & Ryan, 2000; Hmelo-Silver, 2004; McPherson & McCormick, 1999; Smolej Fritz & Peklaj, 2011;

Zimmerman & Pons, 1986). Learner independence can encompass multiple learner behaviors and attitudes. Many research terms are related to learner independence, including autonomy (Deci & Ryan, 2000), agency (Contento, Koch, Lee, Sauberli, & Calabrese-Barton, 2007), self-regulated learning (McPherson & Zimmerman, 2002), self-directed learning (Loyens, Magda, & Rikers, 2008), and problem-based learning (Hmelo-Silver, 2004). Autonomy refers to one's freedom to act on the basis of internal motivation as opposed to external controls. It includes the opportunity to make choices rather than be directed by another. Agency, as used in the literature, refers to one's attribution of causality to self. If one has agency, she feels and acknowledges she has been the impetus behind a resulting action or circumstance. Self-regulated learning research has investigated learners' behaviors during independent learning tasks, and has described planning, evaluating, and seeking help from other sources as components of these processes.

The aspects of learning listed above have all been investigated in relation to their contributions to learners' success in acquiring knowledge and skills. For example, learner motivation has been found to increase as learner autonomy increases. Under some circumstances, intrinsic motivation has been found to decrease with the use of external rewards, threats, deadlines, directives, and other external controllers (Amabile, DeJong, & Lepper, 1976; Deci, 1971; Deci, Koestner, & Ryan, 1999, 2001; Deci & Ryan, 2000; Koestner, Ryan, Bernieri, & Holt, 1984; Lepper, Greene, & Nisbett, 1973; Reeve & Deci, 1996), whereas intrinsic motivation has been associated with opportunities for choice and self-directed behavior (Deci et al., 1999; Isen & Reeve, 2005; Reeve & Deci, 1996; Zuckerman, Porac, Lathin, Smith, & Deci, 1978). Further, students in classroom environments that are supportive of autonomy are more curious and willing to take on challenges than are those in more controlling classroom environments (Deci, Nezlek, & Sheinman, 1981; Ryan & Grolnick, 1986).

Other authors have also found connections between self-regulated learning and motivation (e.g., McPherson & McCormick, 1999; Smolej Fritz & Peklaj, 2011). Zimmerman and Pons (1986) found that self-regulated learning was a predictor of achievement in school, and independent learning has been shown to increase the effectiveness of learning activities (Hmelo-Silver, 2004). A similar link has been found between self-regulated learning abilities and achievement in music (Cantwell, Jeanneret, Sullivan, & Irvine, 2000). Chung (2006) observed a correlation between music students' use of self-regulated learning strategies and higher music jury scores.

Musicians' health has also been linked to self-regulating abilities (Williamon, Wasley, Burt-Perkins, Gingsborg, & Hildebrandt, 2009), which is perhaps not surprising, since, to avoid injury, many musicians must solve problems in technique that may be physically detrimental. Technical problems, especially those involving tension, are sometimes difficult for an observer to detect; yet a music learner, through his own awareness and problem solving, may identify and ameliorate physical practices that are ultimately unhealthy.

Expressivity and creativity are particularly dependent on learners' ability to act for themselves. Students are more likely to explore, extend themselves, risk, and think creatively when teachers and parents provide opportunities for choice (Benware & Deci, 1984; Grolnick, Deci, & Ryan, 1997; Grolnick & Ryan, 1987). Consider that a learner who has limited independence also has limited opportunities to be creative. Learners who develop the ability to solve problems have a greater capacity for creativity than those who do not (see Isaksen & Treffinger, 2004; Lin & Cho, 2011). Learner creativity is thus contingent on learners' abilities to act for themselves—to organize the materials and skills available to them to accomplish goals they pursue. Broomhead (2009) found that expressivity increased as learners had opportunities to develop the skills of problem solving.

All of these findings provide a rationale for ensuring that learners receive opportunities to learn independently and, at least as important, develop skills that increase their success in doing so. This is particularly consequential in music, given the fact that learners commonly spend a majority of their music learning time outside the presence of teachers, and that learners' capabilities for independent progress are consistently found lacking (Bergee, 1993, 1997; Hewitt, 2002, 2005, 2011a; McPherson, 2005). Both Bergee (1993, 1997) and Hewitt (2002, 2005, 2011) found that music learners often struggle to evaluate themselves accurately. Rohwer and Polk (2006) reported that 8th-grade students could identify few practice strategies that they used in practice. Students interviewed by McPherson practiced largely without purpose; they reported that much of their independent practice time was spent playing through pieces, not seeking to accomplish positive musical change (McPherson, 2005).

Problem solving in practice is a hallmark of expert musicianship and separates successful from unsuccessful music learners (Chaffin & Imreh, 2001; Rohwer & Polk, 2006). Rohwer and Polk (2006) found that 8th graders whose practice involved proactive error correction made significantly higher practice gains than did those who played through pieces holistically without correction. Teachers who increase learners' capability to progress independently thereby increase the productivity of learners' practice and the quality of their music experience.

WHY NOT LEARNER INDEPENDENCE?

Several obstacles may limit the opportunities students are afforded to increase their independence. These obstacles may include limited rehearsal or lesson time, or a lack of positive results when teachers relinquish some control of the learning process to their students.

One challenge in pursuing learner independence as an instructional priority is simply the time it requires. Music instruction time is often extremely limited given its expected outcomes. Looming performances, difficulty of repertoire, and other pressures demand the most efficient use of instruction time. Teachers often solve problems far more quickly than learners do, and many teachers are loath to sacrifice efficiency and pacing and relinquish decision-making to learners.

Another obstacle teachers often encounter when seeking to develop learner independence is that attempts to allow learners to solve problems on their own are often unsuccessful (Bergee, 1993, 1997; Hewitt, 2002, 2005) and can be negative experiences for teachers and learners. An anecdote provided by Broomhead (2005) exemplifies the discrepancy between teachers' *expectations* about student independence and students' ability to apply skills and knowledge independently:

> I taught a high school chamber ensemble composed mostly of senior students whom I had taught continually since the eighth grade. What a wonderful experience it was to conduct students who had received the expressive training I offered to eighth graders and who had been sensitized to my conducting gestures for years. This was the most expressively responsive group I had ever conducted. I thought that if ever a group of ensemble students was ready to strike out on its own musically, this was the group.
>
> I assigned the students to select and prepare a song with no help from me and perform it at their graduation ceremony. The performance was disheartening. After all those years of great training, the students sang with no noticeable phrase shaping. What could have gone wrong? They

> had been carefully watching an expressive conductor and skilled interpreter of music for a long time. They had also heard countless verbal explanations regarding musical expression. They had even demonstrated an ability to shape phrases! But somehow their training had not been enough to establish independent expressiveness. (Broomhead, 2005, p. 64)

As did Broomhead, teachers and learners may fail to anticipate the challenges involved in solving what seem to be conquerable problems, and as a result teachers may simply avoid ceding decision-making responsibilities to their students.

Many teachers are surprised by the extent to which learners experience such difficulty solving problems on their own. Broomhead (2005) acknowledges above that he had not provided learners the means to create expressiveness independently.

Of course, experienced teachers and musicians have largely automatized many of the skills required for performing and teaching music. Clearly identifying the components of problem solving in music may assist teachers in their planning and teaching by increasing their attention to the aspects of problem solving that can be cultivated in their students. This has yet to be accomplished in music research. Learner independence in music has not been adequately defined, the skills involved in promoting learner independence have not been identified, and no consensus exists as to the means of investigating these skills.

Considering the benefits of learner independence and difficulties associated with its development, it is surprising that there is a dearth of literature on the subject within music education research. One reason for this may be that there is no systematic means for describing and analyzing this aspect of learning. As can be seen in the research cited above, different terms have been used to express various facets of learner independence. The definitions of these terms overlap to some degree, but there is a lack of clear consensus as to their precise meanings and the relationships among them. What is learner independence? How is it measured? How does it manifest itself in learners' behavior?

Certain aspects of learner independence are included in studies involved in self-regulated learning (Byrne, 2005; McPherson & McCormick, 1999; McPherson & Zimmerman, 2002; Nielsen, 2001; Smolej Fritz & Peklaj, 2011; Zimmerman & Pons, 1986), which examine behaviors such as goal setting, self-evaluation, self-monitoring, and seeking assistance from teachers and peers. These studies reveal benefits of self-directed learner behavior, but they do not clearly identify or explain learner behaviors that lead to solutions of specific problems. It is thus difficult to determine which learner behaviors contribute to learners' success. What is needed is a means of measuring learner independence and a framework that explains the skills involved in learner independence.

Active participation in problem solving

Measuring the extent to which learners become independent is a daunting challenge that is beyond the scope of the current research. Yet, it seems clear that if learners are to function independently, they must actively participate in solving musical problems while they acquire knowledge and develop skills. If learners are not actively participating in problem solving in the presence of their teachers, it is likely the case that their capacity to do so in the future will be limited.

If learners are to become independent, they must assume a more active role as agents of change—active contributors in formulating solutions to the problems they encounter. In other words, learners who can function independently in the future must practice doing so in the present, when their teachers are available to provide scaffolded opportunities to try and fail and adjust and succeed.

As students engage in various aspects of problem solving in the presence of teachers, making meaningful contributions to their own progress, they make steps toward learning on their own. This central feature of musical development is the focus of the current study: the means by which learners engage in problem solving while in the presence of their teachers.

Goal pursuit as problem solving

The stuff of human progress is the accomplishment of goals. Human activity comprises conscious and subconscious goal pursuits. Out of a desire to see indoors at night, people invented candles, gaslights, and light bulbs. People who wish to eat initiate behavior that makes eating possible, such as planting and harvesting, or obtaining money and driving to the store. People who wish to communicate purchase cell phones and set up chat accounts. Goal pursuit also includes short-term intentional action, such as grabbing a fork to eat food, smiling to express friendship, and opening a door to enter a room.

Goals that are not yet accomplished can be conceived as problems to be solved. Progress in learning, then, is a sequence of goal setting, problem solving, and eventual attainment.

The accomplishment of instructional goals (targets) is the fundamental element that defines progress in music instruction. It is for this reason that Duke (1999) recommended that systematic research be organized around units of analysis he dubbed rehearsal frames, periods of instructional time in which attention is devoted to accomplishing identifiable proximal goals. Prior to Duke's proposal, research analyses had typically been conducted over entire rehearsals or lesson without regard for learners' accomplishment moment to moment (e.g. Francisco, 1998; Menchaca, 1988). Instead, Duke argued, analysis of music learning will be most effective when analyses are structured around the achievement of proximal goals.

Since Duke's call to action, a number of authors have analyzed music learning at the instructional target level. Studies utilizing the rehearsal frame as the unit of analysis thus far have focused on pacing as measured by the duration of student and teacher activity (Cavitt, 2003; Colprit, 2000; Worthy & Thompson, 2009), rehearsal frame target categorization (Colprit, 2000; Worthy & Thompson, 2009), duration and extent of modeling (Colprit, 2000; Worthy, 2003), and type and frequency of feedback associated with various target categories (Cavitt, 2003).

Although these extant observations are instructive and important, they do not fully describe the actual process by which targets are accomplished. Given the assertion that learners' achievement of instructional goals should guide the analysis of teaching effectiveness, then the process by which these goals are achieved is a critical element demanding illumination. It seems important to define with some precision the individual components that contribute to the solution of problems in music study.

Before learner problem solving and its development can be considered, the process of problem solving in music settings must be described clearly. A description of the problem solving process to guide future analyses is an important step in understanding the means by which learners attain independence and learn to solve problems on their own. For the purposes of my work in this dissertation, I sought to observe the degree to which learners actively participated in problem solving while in the presence of teachers.

PURPOSES OF THE STUDY

The purposes of the current study were to develop a framework for describing the problem-solving process in music learning and to apply the framework in the analyses of music instruction by master teachers. My analyses describe learners' involvement in problem solving and how teachers promote learners' involvement in problem solving.

The study was designed to answer the following questions:

1. What are the components of the problem solving process? How do they interact to bring about change?
2. To what extent to teachers and students assume responsibility for each component of problem solving?
3. What teacher behaviors precede learner problem-solving?

I sought to accomplish the following goals:

1. Describe the components of musical problem solving and the role of each component in accomplishing musical targets. (Chapter 3)
2. Identify the problem-solving components that are performed by teachers and students within individual rehearsal frames. (Chapter 3)
3. Identify teacher behaviors that precede learner problem solving, and describe the extent of learners' involvement in problem solving following specific teacher behaviors. (Chapter 4)
4. Describe teacher behaviors that do not prompt learner problem solving in the moment, but may affect learner problem solving over the long-term. (Chapter 5)
5. Measure the rates of teacher and learner problem solving components during the course of full-length lessons and rehearsals. (Chapter 6)

Limitations of the study

The observations in the current study focused on problem solving, starting from initial observations during which I identified instances of productive changes in student performance or thinking. Although I observed problem-solving components outlined throughout the course of the recorded lessons I analyzed, other aspects of teaching and learning that I did not include in my definitions of problem-solving activity most certainly affected teacher and student behaviors and their interaction in ways not accounted for in my analyses.

The current study does not involve experimental comparisons of successful and unsuccessful teaching. All of the observations involved teachers and students performing at the highest levels of accomplishment, and as such the results I obtained from this sample may not generalize to other levels of instructional or musical skill. Although there are many similarities among the teachers I observed, the sample was relatively small and was not selected randomly; therefore generalizations even to other teachers of this caliber should be made with appropriate cautions.

Further, the analyses involve one-on-one teacher-student interactions in private studio settings, with the exception of two chamber music rehearsals. The application of this framework has yet to be investigated in large ensemble settings. Further investigation is required to assess the generalizability of these findings to large groups.

I assessed the frequency and relative timing of behaviors by the teachers and students I observed. Although it would be tempting to ascribe causality to the relationships among behaviors I observed, such assertions are unjustifiable without considerable additional research.

Chapter 2: Review of Literature

Progress in music performance comprises the realization of numerous intermediate goals, each acquired through the application of a host of behavioral and perceptual skills. In the process of developing technical capacity or preparing repertoire, musicians make numerous corrections, adjustments, and decisions about what they do. Ideally, their ongoing behavior is guided by clearly defined goals that help focus attention and effort advantageously. Each performance goal, each technical goal, each communicative goal, until realized, is a problem to be solved. Thus, the process of musical development is replete with goal pursuit, requiring ongoing problem solving.

Problem solving, the process by which learners achieve goals (see Blech & Funke, 2010; Gerlach, et al., 2011), is a critical human activity that has been widely discussed in the literature of mathematics education (e.g., Erbas & Okur, 2012; Kotsopoulos & Lee, 2012; Levav-Waynberg & Leikin, 2012; Moore & Carlson, 2012; Reed, et al., 2012), science education (e.g., Camacho & Good, 1989; Solaz-Portolés & Sanjosé-López, 2009; Tsai, Hou, Lai, Liu, & Yang, 2012), information processing, (e.g., Argelagós & Pifarré, 2012), creativity (e.g., Isaksen & Treffinger, 2004; Lin & Cho, 2011; Walinga, et al., 2011), corporate business (e.g., Buijs, Smulders, & van der Meer, 2009), infant and child development (e.g., Lee, Koh, Cai, & Quek, 2012; Elsner & Schellhas, 2012; Keen, 2011; Madhavi, 2008; Ryu, 1994; Willatts, 1999), educational psychology (e.g., Price & Driscoll, 1997), educational neuroscience (e.g., Ablin, 2008), crime analysis (e.g., Celik, 2011), health care (e.g., Hill-Briggs & Gemmell, 2007; Hill-Briggs, 2003; Hill-Briggs et al., 2011; Wang et al., 2012), and occupational health (e.g., Schmitt, Zacher, & Frese, 2012). As illustrated by this great diversity of domains that depend on successful problem solving, it is a nearly ubiquitous human activity. It follows, then, that improving the effectiveness of music teaching and learning would also benefit from the study of problem solving.

In this review I describe the studies cited above in some detail and explain their contributions to a general understanding of problem solving. The research included in this review investigates problems encountered in varied domains of human activity, and in so doing includes different populations of participants performing a wide range of different activities. The target tasks, the end goals, and the consequences associated with solving the problems participants encounter all vary in terms of their nature and complexity. Yet, all of the research considers basic elements of problem solving that are generally applicable. From infants learning spoon-feeding (McCarty, Clifton, & Collard, 1999) to children making monetary decisions (Lee et al., 2012) to adults stabilizing blood glucose levels (Hill-Briggs, 2003), the problems encountered represent the process of problem solving and thus are germane to the topic of the present investigation: the process of problem solving during music learning.

WHAT IS INVOLVED IN PROBLEM SOLVING?

Examination of studies of problem solving in varied human experiences reveals common components of thinking and behavior that individuals encounter as they confront problems. To begin the review, I first describe two experiments that investigated problem solving by infants. The method of describing the infants' behavior and the findings from the studies illustrate the fundamental features of working toward solutions to problems. The fact that the participants were nonverbal infants performing a very basic operation helps clarify the process under investigation while demonstrating the difficulties involved in conducting research of this type.

Consider the challenges an infant encounters as he attempts to bring food to his mouth with a spoon (McCarty et al., 1999; McCarty & Keen, 2005). McCarty et al. (1999) investigated the development of spoon-feeding ability in 9-, 14-, and 19-month-olds. They presented a spoon with food to infants over multiple trials, varying the orientation of the spoon relative to the infants' hands. In their analysis of the infants' behaviors, they described the following sequence: First, to initiate action, the child must want the perceived food—this is the desired goal, which presents a problem to be solved. In pursuing the goal, he must grasp the spoon and bring it to the mouth. This action requires the infant to choose which hand and what kind of grip to use in order for the bowl of the spoon to face the right direction. He then must hold and balance the spoon as the food travels to the mouth, then close the mouth over the bowl of the spoon. At this point, he evaluates whether he obtained the food. When presented a spoon with food again, the process begins again.

This analysis offers a detailed description of components of problem solving: seeking a goal (eat food), considering options for actions that may contribute to the attainment of the goal (manipulating the spoon orientation, choice of grasping hand, and grip on the spoon), making a decision about which option(s) to choose (evidenced by what the child actually does), and evaluating the extent to which the goal is achieved (was the food received?). This description reveals that something as seemingly simple as spoon-feeding actually involves a rather complex problem-solving process requiring a number of behavioral and perceptual skills.

Other studies offer similar descriptions of identifiable behaviors that can be observed within various human pursuits. As another example, consider monetary decision-making. What thought processes occur as one determines how money is spent? Lee et al. (2012) sought to identify these cognitive and metacognitive behaviors by investigating the monetary decision-making of 136 5th-grade students through focus groups, drawings, and one-to-one interviews. The authors considered a decision to be made as a problem to be solved (Jonassen, 2012). They gathered data and identified the component behaviors that contributed to solving the problem of monetary decision-making.

Their results reveal the components of participants' financial decisions, including establishing goals, evaluating, acquiring and applying knowledge, and considering options. Participants reported various goals that they sought when confronting a financial decision; these included meeting needs such as transportation, filling wants such as eating cake or acquiring a model airplane, purchasing a gift, or saving for future needs or wants. Participants' descriptions of the decision-making process also included evaluations, such as evaluating the quality and price of products; acquiring and applying declarative knowledge such as financial principles learned from parents or knowledge as to why prices differed; and the consideration of options available such as different models of products, different places to buy the same products, and different prices. All of these components were found to influence participants' final financial decisions.

As yet another example, consider patients with diabetes who must solve problems to regulate their blood glucose each day (Hill-Briggs, 2003). In a study establishing a model of patients' self-management behavior, Hill-Briggs also describes evaluating, considering options, acquiring and applying knowledge, and making decisions. First, patients evaluate their glucose. If patients' glucose monitors indicate they are hyperglycemic or hypoglycemic, there is a problem to be solved. In order to alter blood glucose, these adults must consider the food options available to them and decide which foods to eat and how much to eat. They may also consider altering their physical activity, or they may take medication. In order to make effective decisions, they must acquire knowledge regarding the effects of foods, activities, and medication on glucose levels. As they make decisions about whether to change their behavior and how to act, they observe the effects of these decisions, potentially informing future decisions.

The components of problem solving that are present as children attempt spoon-feeding are strikingly similar to the components involved monetary decision-making and responses to a glucose monitor. Within all of these situations, participants seek goals (e.g., eat food, save money, or normalize glucose level), evaluate their current status and possibilities (e.g., assess food acquisition, the quality of products, or blood glucose levels), consider options (e.g., ways to grasp the spoon, products to be purchased, strategies that may alter glucose levels), apply knowledge (e.g., stores that have the best prices, or how often to take medication), and make decisions (e.g., turn the spoon, buy a plane, or eat less sugar).

Several studies have been conducted that describe the process of problem solving as a whole (Buijs et al., 2009; Camacho & Good, 1989; Lee et al., 2012; Hill-Briggs, 2003; S. G. Isaksen & Dorval, 1993; Kotsopoulos & Lee, 2012; McCarty et al., 1999; Osborn, 1953; Parnes, 1967; Polya, 1957; Zelazo, Carter, Reznick, & Frye, 1997). Although different authors and different disciplines describe the process of problem solving using varied language, nearly all of the studies I reviewed identify common components of the process. I identified five problem-solving components that appear within these various problem-solving analyses, and I use them as an organizing scheme for clarifying the current understanding of the process of problem solving. The five components are

- Establish goal
- Evaluate performance
- Consider options

- Apply principles
- Decide and act

Identifying these components is important for the informed investigation of problem solving in any field, including music instruction. In the sections that follow I first review the models of the problem solving process, and then consider studies that have examined the components of problems solving individually.

Models describing the process of problem solving

Models describing the components of problem solving have been developed through observing the problem solving experiences encountered in business (Buijs et al., 2009; Isaksen & Dorval, 1993; Osborn, 1953; Parnes, 1967), science and math learning (Camacho & Good, 1989; Kotsopoulos & Lee, 2012; Polya, 1957; Zelazo et al., 1997), infant spoon feeding (McCarty et al., 1999), and daily decision making pertaining to money (Lee et al., 2012) and personal health (Hill-Briggs, 2003). Strikingly similar models of problem solving emerged independently from these very different settings. Figures 1, 2, 3, and 4 illustrate these models. Tables 1, 2, 3, and 4 provide a comparative synthesis of the models to illustrate their parallel components, labeled with the terms I listed above.

Creative problem solving within corporate business

The Creative Problem Solving (CPS) model found in literature related to the field of business, as reviewed by Buijs et al. (2009), has evolved since Osborn's original model (Osborn, 1953). Osborn first conceived of a model that described two stages: a divergent stage, labeled "generating options," and a convergent stage, labeled "focusing options." Other models followed. Parnes (1967) built on Osborn's model but expanded it to include five components: fact finding, problem finding, idea finding, solution finding, and acceptance finding.

Later, Isaksen and Dorval (1993) generated a model with components similar in function to the components of the model by Parnes

(1967): understanding the problem, generating ideas, planning for action, and task

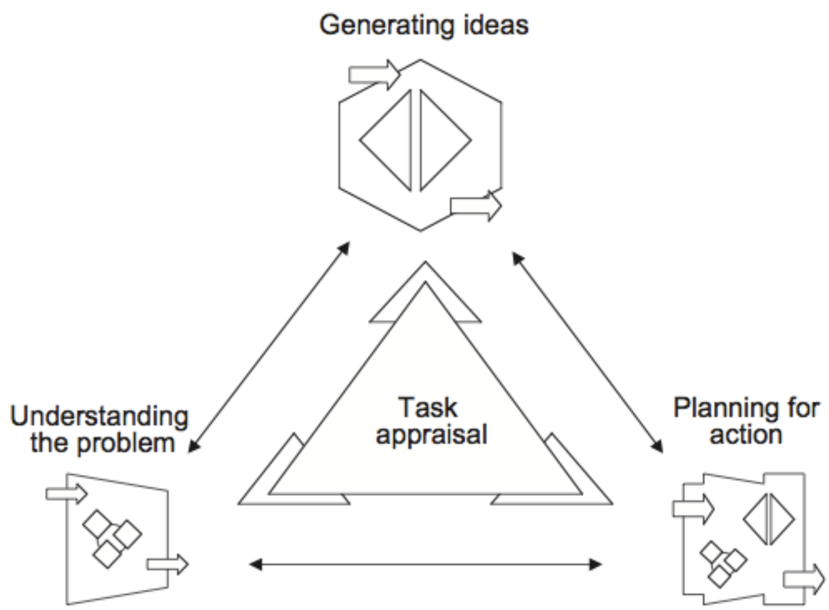

Figure 1. Description of problem-solving components in business by Isaksen and Dorval (1993), from Buijs et al. (2009), p. 287.

appraisal. Although the component behaviors are similar, Isaksen and Dorval's model represents a departure from previous models of creative problem solving, in that the four components in their model are *interdependent* rather than sequential (see Figure 1).

Others have described components of problem solving as having an interdependent nature, including the following two studies involving daily decision-making.

Problem solving during children's monetary decision-making

Lee et al. (2012) established the interdependent nature of behavioral components of problem solving through their analysis of children's monetary decision making. The

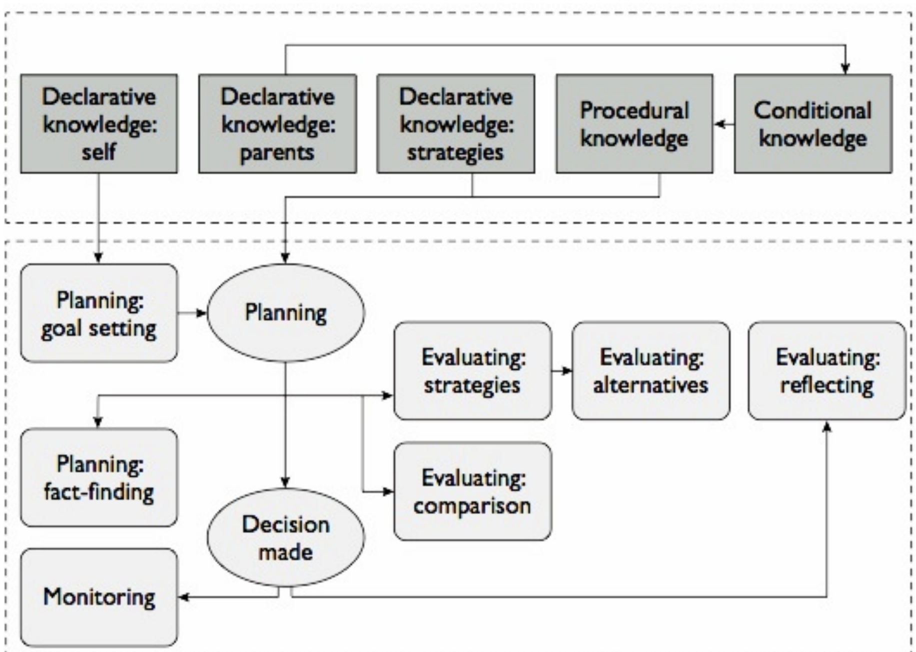

Figure 2. Description of problem solving components of monetary decision making, from Lee et al. (2012), p. 29.

Table 1
Problem-solving components of models developed through analysis of creative problem solving in business

Problem solving components	**Osborn (1953)**	**Parnes (1967)**	**Isaksen and Dorval (1993)**
Establish Goals	Divergent stage:	Problem finding	Understanding the problem
Consider Options	Generating options	Idea finding	Generating ideas
Apply Principles	Convergent stage:	Fact finding	Understanding the problem
Make Decisions	Focusing options	Solution finding	Planning for action
Evaluate		Acceptance finding	Task appraisal

Table 2
Problem-solving components of models developed through analysis of daily decision-making pertaining to money (Lee et al., 2012) and personal health (Hill-Briggs, 2003)

Problem solving components	**Lee et al. (2012)**	**Hill-Briggs (2003)**
Establish Goals	Planning: goal setting	Seek to normalize blood glucose
Consider Options	Evaluating: strategies, alternatives	Consider controlling responses (nutrition, physical Activity, or medication)
Evaluate	Evaluating: comparison, reflecting	Monitor blood glucose (SMBG)
Generalize and Apply Principles	Declarative knowledge Planning: fact-finding	Observe change in blood glucose to inform further controlling responses
Make Decisions	Decision made	Choose controlling response(s)

researchers acquired data about decisions, thoughts, and experiences that children reported through focus groups, individual interviews, and drawings. In the description that emerged, knowledge and skills are shown to be reciprocal and interactive (Figure 2).

Problem solving by patients with diabetes

Patients with diabetes are required to solve problems related to their health care (Hill-Briggs, 2003; Wang et al., 2012). Hill-Briggs (2003) identified four behavioral categories as patients self-manage blood glucose levels: self-monitoring of blood glucose, nutrition, exercise, and medication. The relationship among these behaviors is illustrated in Figure 3. Further, Hill-Briggs emphasized the importance of domain-specific knowledge: an understanding of diabetes and how each strategy outlined affects glucose levels. And she acknowledged that evaluation of the effects of choices potentially informs subsequent choices—knowledge is gained through experience. This description therefore corroborates those by Lee et al. (2012) and Isaksen and Dorval (1993) in establishing problem-solving components as interdependent.

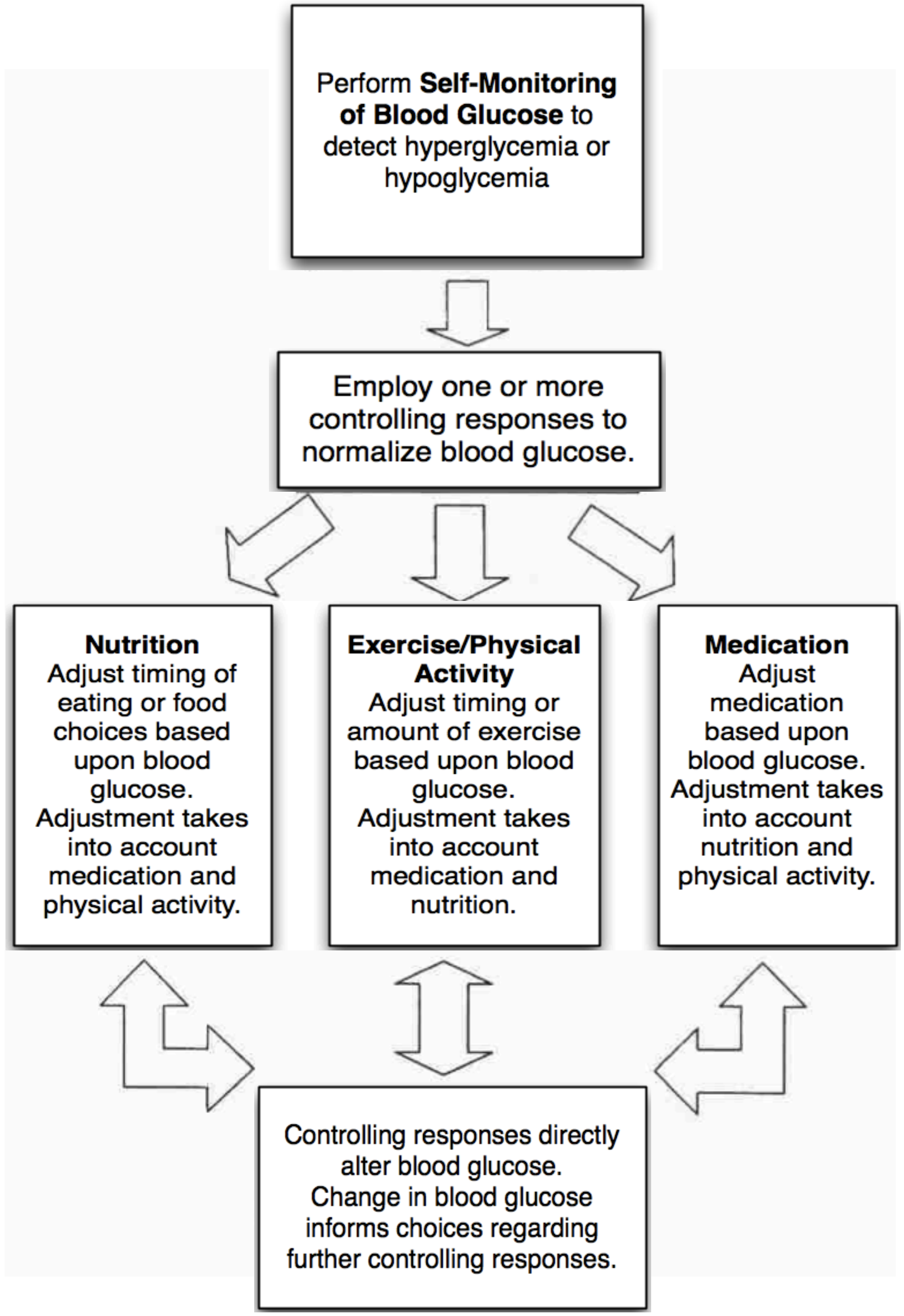

Figure 3. "A schematic of disease self-management behaviors in diabetes," from Hill-Briggs (2003), p. 183.

Mathematics problem solving

Problem solving has long been a topic of concern in the field of mathematics education. Polya (1957) developed a four-step model for analyzing the process of mathematical problem solving:

1. Understanding the problem
2. Devising the plan
3. Carrying through the plan
4. Looking back and evaluating the outcome

Zelazo et al. (1997) developed a model of problem solving which they applied in their analysis of executive function:

1. Problem Representation
2. Planning
3. Execution
4. Evaluation

Kotsopoulos and Lee (2012) note that the four steps of Zelazo et al.'s model align with the model Polya (1957) developed.

These models have been applied in mathematics education research (e.g. Kotsopoulos & Lee, 2012; Lee, Ee Lynn Ng, & Swee Fong Ng, 2009) and in efforts to improve classroom learning (e.g., Leong, Toh, Tay, Quek, & Dindyal, 2012). For example, Kotsopoulos and Lee (2012) applied the model by Polya (1957) in a naturalistic setting, observing students working through mathematical homework problems. They found differences among types of executive function that were involved during each phase of mathematical problem solving, thus establishing at the cognitive level that the components are differentiable within the process of problem solving.

Table 3

Problem-solving components of models developed through analysis of science (Camacho & Good, 1989) and mathematics (Polya, 1957; Zelazo, Carter, Reznick, & Frye, 1997) learning

Problem solving components	**Camacho and Good (1989)**	**Polya (1957)**	**Zelazo, et al. (1997)**
Establish Goals	Careful analysis and reasoning of the task	Understanding the Problem	Problem Representation
Consider Options	Procedural and strategic knowledge	Devising the Plan	Planning
Generalize and Apply Principles	Use of related principles and concepts to justify answers	Understanding the Problem	Problem Representation
Make Decisions		Carrying through the plan	Execution
Evaluate	Frequent checks of consistency of answers	Looking back/evaluating	Evaluation

Science problem solving

The field of science education has also extracted components from analyses of problem solving behavior. Observations of successful and unsuccessful problem solvers by Camacho and Good (1989) reveal the following characteristics of successful problem solvers:

- Careful analysis and reasoning of the task
- The use of related principles and concepts to justify their answers
- Frequent checks of consistency of answers and reasons
- High quality of procedural and strategic knowledge

Infant problem solving during spoon-feeding

As mentioned earlier, problem solving has also been studied in the context of infant and child development. McCarty et al. (1999) observed infants attempting to use a spoon to bring food to the mouth. They outline four stages of the learning process: feedback-based, partially planned, fully-planned, and habitual solution. Their analysis includes categorizations of perception, action, and thought processes. These are illustrated in Figure 4.

The models and analyses above offer an important depiction of the interactive yet distinctive behavioral components of problem solving. Although developed independently in essentially unrelated domains, all of these models have elements in common. Problem solving in science requires behavioral and perceptual abilities similar to those involved in problem solving by infants desiring food and problem solving in

Table 4

Problem-solving components identified in behaviors of infants attempting to spoon feed, within 3 stages of development as outlined by McCarty et al. (1999)

Feedback-based Stage		Partially Planned Stage		Fully Planned Stage	
Behavior	PS Behavior	Behavior	PS Behavior	Behavior	PS Behavior
Goal: Eat food	Establish Goal	Goal: Eat food	Establish Goal	Goal: Eat food	Establish Goal
Perceive spoon with food	Evaluate	Perceive spoon with food	Evaluate	Perceive spoon/food orientation	Apply principle Evaluate
				Decide how to get spoon to desired end state	Consider options
Grasp spoon	Make decision	Grasp spoon	Make decision	Grasp spoon with the correct grip	Make decision
		Perceive spoon/hand relationship	Apply principle		
		Error detected	Evaluate		
		Rotate wrist or switch hands	Consider options Make decision		
Bring to mouth	Make decision	Bring to mouth	Make decision	Bring to mouth	Make decision
Food in mouth?	Evaluate				
Manipulate spoon	Consider options Make decision				
Eat food		Eat food		Eat food	

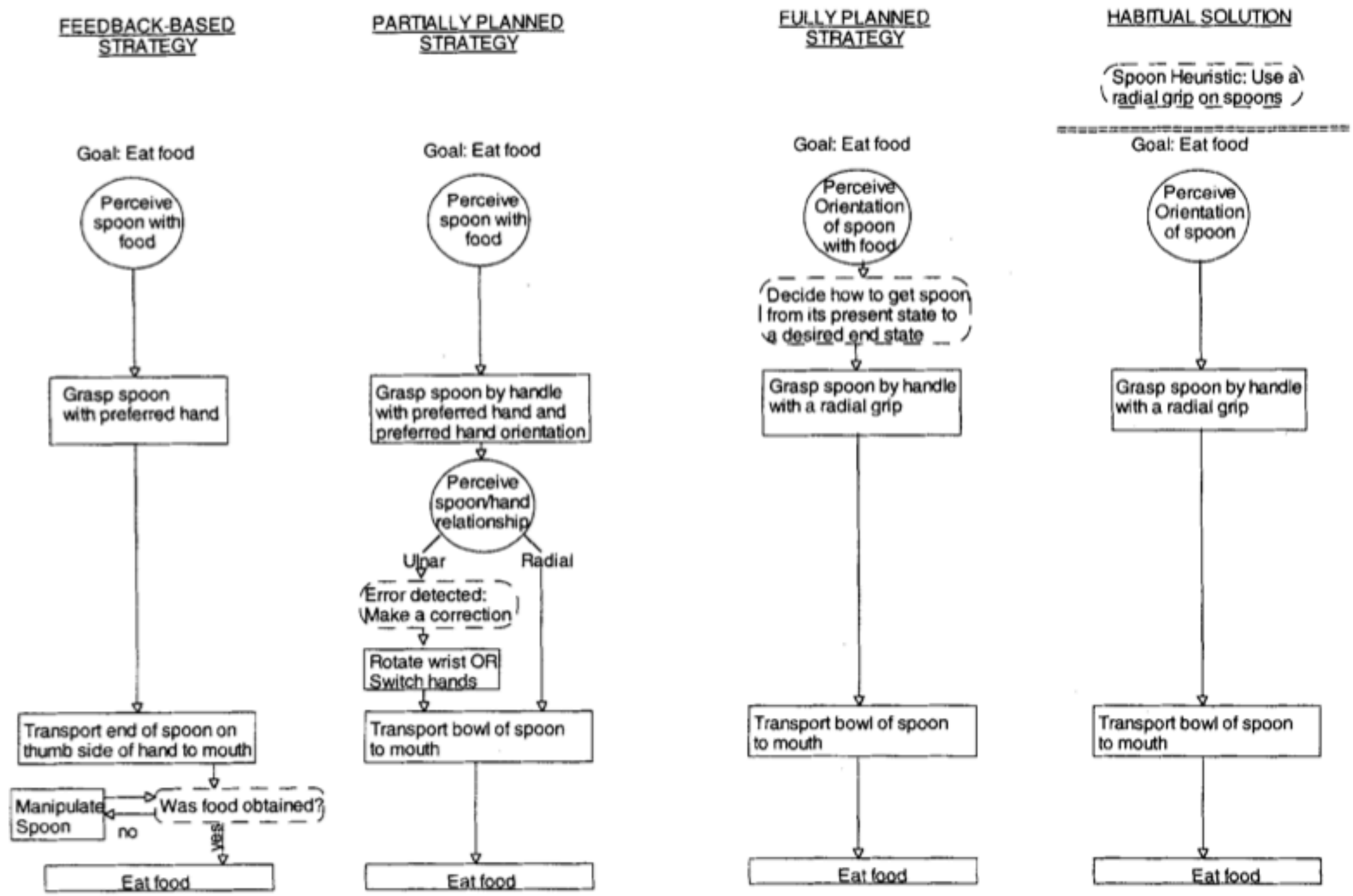

Figure 4
Analysis of four stages of infant spoon-feeding, from McCarty, et al. (1999), p. 1100.

corporations. These universally critical abilities may likewise be found to be necessary for successful problem solving in music.

The studies cited above provide a reference point for developing a framework for analyzing problem solving in music, which to date has not been accomplished. In the sections that follow, I describe the literature that has addressed these components either individually or in combination.

Establish goal

A goal is defined by a desired outcome. In a learning situation in which structured change occurs, teachers and/or learners are seeking a defined goal or goals (see Aarts & Elliot, 2012). Both Wickelgren (1974) and Mayer (1992) identified pursuing a goal as the first component of problem solving. Goals are the building blocks of progress and the instigating feature of problem solving. If there is no goal sought, there is no perceived problem to be solved.

Instructional goals are the organizing element of units of analysis called rehearsal frames (Duke, 1994). A rehearsal frame is defined as an interval of instructional time devoted to the pursuit of a particular goal. As mentioned in Chapter 1, Duke proposed that analysis of music learning is most meaningful if done in consideration of specific goals sought.

Several researchers have conducted analyses that consider the type of musical target (proximal goal) identified by teachers and conductors (e.g., Cavitt, 2003; Doerksen, 1999; Worthy & Thompson, 2009). Doerksen (1999) identified some of these possible musical goals as he categorized teachers' comments in response to music performance in nine target categories: tone quality, intonation, blend/balance, rhythm/precision, articulation, technical facility, musical interpretation, phrasing, and dynamics.

Many goals comprise complex structures made up of smaller, intermediate subgoals (Catrambone, 1995a, 1996, 1998; Elsner & Schellhas, 2012; Fishbach, Dhar, & Zhang, 2006; Willatts, 1999). To achieve a given goal, one must first consider the possible actions that might lead to the desired end and be capable of performing those actions. Subgoals are often the focus of a problem to be solved: what one does (subgoals) to achieve the desired end (superordinate goal), or, as Catrambone (1998) expressed, subgoals are "mini-problems in the context of solving the overall problem" (p. 357).

Musical goals are outcomes of creation and communication. A performer with a musical goal desires to represent her own or a composer's ideas and communicate them to an audience. Within musical goals are many, often technical, subgoals—specific skills that serve a musical end, such as tonguing or shifting accurately.

Goals direct the attention of teachers and learners (Dreisbach & Haider, 2009; Simons & Chabris, 1999; Vogt, De Houwer, & Crombez, 2011; Vogt, De Houwer, Moors, Van Damme, & Crombez, 2010), and because attentional capacity is limited, all of the goals that may be identified at a given point in a music learning sequence cannot be pursued at once (Johnstone & El-Banna, 1986; Solaz-Portolés & Sanjosé-López, 2009; Tsaparlis & Angelopoulos, 2000). Colprit (2000), for example, observed that Suzuki teachers usually pursued only one performance goal at a time in lessons. Pursuing goals, then, is a function of choice and priority (Vogt et al., 2011). Attention may be directed toward certain stimuli and away from others depending on the goal sought. As a result, some events, errors in music performance for example, may go unnoticed (Simons & Chabris, 1999). Thus, the definition of goals influences other components of problem solving and, therefore, the effectiveness of music teaching and learning.

Evaluate performance

Evaluation is another central component of problem solving. Evaluation describes the extent to which goals have been met by comparing the current level of performance with the desired goal, which is often an auditory image of a musical outcome. Assessing the discrepancy between present behavior and a desired outcome guides future action and influences the pursuit of a goal (see Fishbach & Finkelstein, 2012; Zelazo et al., 1997).

In addition to evaluations that consider the extent to which goals are met, evaluations may also be made between two or more options (or subgoals) in relation to their projected accomplishment of the ultimate goal. For example, a fifth grader who desired a model airplane (the ultimate goal) evaluated the price and quality of two different airplanes available to him (Lee et al., 2012). He decided to buy the less expensive of the two, after evaluating the quality of the planes compared to their prices. Children who learned to spoon-feed evaluated options in hand, grip, and spoon direction according to the projected outcome of these options in relation to the ultimate goal of receiving food (McCarty et al., 1999; McCarty & Keen, 2005).

Evaluation requires auditory, visual, and physical discrimination. If a learner cannot discriminate among individual performance trials, effective self-evaluation is of course impossible. Recognizing differences in how instruments sound and how movements feel from one performance trial to the next is a critical feature of evaluation, as is the ability to conceive and differentiate among possibilities for future behavior (see Duke & Simmons, 2006).

Of the components of problem solving, evaluation has occupied a prominent place in music education literature. Evaluations made by teachers during a rehearsal or lesson are most often communicated through verbal and nonverbal feedback. Cavitt (2003), for example, found high rates of negative feedback (1.22 comments per minute) and positive feedback (.59 comments per minute) as she analyzed error correction, a type of problem solving, in rehearsals of 10 experienced band directors. The prominence of feedback in such an analysis of error correction illustrates the centrality of evaluation in the error correction process.

The effectiveness of evaluations in some ways distinguishes expert from non-expert teachers. Doerksen (1999) compared evaluations made by pre-service and skilled teachers with regard to various aspects of music performance and found that expert teachers rated intonation more negatively than did pre-service teachers in each of four levels of performance quality and task difficulty. More expert teachers than pre-service teachers also rated balance/blend and musical interpretation as the weakest aspects of performance. These findings illustrate expert teachers' higher expectations for these important aspects of quality music making.

Studies investigating music learners' error detection and evaluation abilities have obtained mixed results. Some have found that music learners are generally lacking in self-evaluation skills (Bergee, 1993, 1997; Hewitt, 2002, 2005, 2011). On the other hand, Byo and Brooks (1994) found that music learners' evaluations of high-quality and low-quality moments of performances were similar to evaluations made by the students' teachers, but learners rated performances higher than did their teachers, overall. Bergee and Cecconi-Roberts (2002) observed that peer evaluations were more consistent with one another than with self-evaluations, although peer evaluations were generally higher than teacher evaluations. These results suggest that learners' evaluations of others' performances can correspond with teachers' evaluations, although learners' evaluations may be less critical than teachers'. Self-evaluations, however, may involve more confounding factors such as individual self-concept, which further complicate the process.

In studies described above that addressed musical evaluations and self-evaluations, student performances were assessed based on goals that were not clearly defined (with the possible exception of Byo and Brooks, 1994). Research investigating evaluations of specific, proximal musical goals has yet to be conducted.

Conceive and consider options

Problem solving in natural situations is often a complex experience requiring flexible thinking and originality. Although some types of problems yield only one correct solution (e.g., 2 + 2 = x), many problems in the real world, like those musicians encounter, are not always so straightforward. Often problem solvers must consider multiple paths to accomplishing goals, paths that include varied arrangements of subgoals, imagining multiple options that may contribute to productive solutions (e.g., Elsner & Schellhas, 2012; Willatts, 1999). In music as in other domains of endeavor, teachers and learners are advantaged when they can conceive of a variety of possibilities for future behavior and can evaluate their relative potential to achieve desired goals. Thus, conceiving, performing, and differentiating among options are central components of problem solving.

Creativity has been measured in terms of the number of possibilities one can generate in a given situation or in response to a given problem (Haylock, 1987; Levav-Waynberg & Leikin, 2012; Smolucha & Smolucha, 2012). Haylock (1987), for example, asked individuals to "find as many shapes as possible by connecting the given dots" or "write down as many things as you can think of that the numbers 16 and 36 have in common" (Haylock, 1987). Also, creative individuals can think of many uses for various objects, like using a basket as a boat (Smolucha & Smolucha, 2012).

Creativity in musical decision making could likewise be considered in terms of individuals' ability to flexibly conceive of various applications of skills and procedures. Musicians who are able to generate and consider multiple ways of performing a passage (with regard to tempo, phrasing, inflection, and articulation), for example, may be better able to formulate decisions about future actions. A performer who is unaware of more than one possibility for the execution of a passage has no opportunity to choose.

Of course, the only viable options are those that learners are capable of performing, if not immediately then in the near term. If a learner or teacher determines that a given course of action (choice) will likely lead to the solution of a problem, the learner understandably must demonstrate that she is capable of following that course if the proximal goal is to be achieved. If a given conception of a phrase involves producing a specific tone from the instrument, for example, then creating the desired tone in a limited context is defined as a subgoal on the path to the ultimate goal of successfully playing the phrase (see Willatts, 1999).

Apply principles

Much of learning is directed toward specific instances of immediate behavior (e.g., raise the pitch of the C-sharp; relax your wrist, play louder at the end of the line), but nearly all of these instances are related to broader principles that are applicable across a wide range of circumstances. Because they are unbounded by a specific context, principles may be generalized from specific situations to other related situations (Price & Driscoll, 1997; Salomon & Perkins, 1989; Sweller, van Merrienboer, & Paas, 1998; Yang, Bushnell, Buchanan, & Sobel, 2013; Yang, Sidman, & Bushnell, 2010). In this way, learning obtained from prior experiences informs future experiences.

This phenomenon, in which knowledge or skill learned in one situation may be applied in another, has been referred to as transfer of learning or transfer of training (Salomon & Perkins, 1989). Deliberate transfer of knowledge has been described as "mindful abstraction," a process of making connections among situations that lead to generalized knowledge or knowledge structures. "[A]bstraction leads to transfer: It yields a re-representation that subsumes a greater range of cases" (Salomon & Perkins, 1989, p. 125).

Transferrable knowledge is expressed in terms of rules, principles, labels, schematic patterns, prototypes, or categories (Salomon & Perkins, 1989). Bodies of knowledge connected through abstract and generalized structures are often referred to as schemata or schemas. Schemas serve to organize knowledge in categorical or hierarchical forms, influencing how individuals view the world and interact with experiences. Schemas facilitate the learning of additional knowledge and the transfer of that knowledge to novel situations by providing a structure within which to organize knowledge. Principles may be generated by and subsumed within these knowledge structures; principles connect specific situations with general, categorical knowledge, and subgoals with ultimate goals in a hierarchical relationship (Eiriksdottir & Catrambone, 2011).

In the literature, formulating and applying generalized knowledge are termed "forward and backward" transfer (Salomon & Perkins, 1989). Forward-reaching transfer refers to generalizing knowledge for future use, imagining in the moment how the information or skills that are currently the focus of attention may be applied in other circumstances in the future. Forward-reaching transfer describes learners' consideration of generalizable applicability, which requires decontextualizing the immediately applied knowledge or skills in ways that reveal their potential applicability in the future.

Backward-reaching transfer occurs when knowledge that has already been abstracted from previous experience is applied in present circumstances. (I also focus on the application of principles in the next section.)

Knowledge related to a particular skill domain includes understanding of hierarchical relationships or concepts that explain how subgoals lead to ultimate goals (see Willatts, 1999). These representations of goal structures are themselves schemas (Catrambone, 1995a, 1996, 1998). Catrambone (1998) describes a subgoal as a "meaningful conceptual piece of an overall solution procedure" (p. 357). Goals, then, aid in the organization of knowledge (Aarts & Dijksterhuis, 2000; Collins, Brown, & Newman, 1989; Mayer, 1996).

These goal-subgoal relationships are the foundation for intentional means-end behavior (Elsner & Schellhas, 2012; Willatts, 1999; Yang et al., 2013; Yang et al., 2010). Such relationships exist everywhere, and observing them through experience develops hierarchical schemata. As means-end relationships are generalized, the resulting principles guide intentional behavior. Willatts (1999) and Elsner and Schellhas (2012) illustrate the importance of developing hierarchical representations to guide means-end behaviors within the context of infant and child development. Catrambone (1995a, 1996, 1998) investigated means-end behaviors during learners' attempts at solving structured problems and found that hierarchical concepts aid problem solution and transfer. Principles of knowledge that explain means-end relationships explain the consequences of actions, developing causal knowledge, and causal knowledge is a key to decision making and action planning (Klossek & Dickinson, 2012; Perales, Shanks, & Lagnado, 2010).

Decide and act

Decisions occur when action is planned and carried out. Several authors have gone so far as to equate decision-making and problem-solving (e.g., Lee et al., 2012), whereas others identify decision-making as a component of problem-solving (e.g., Jonassen, 2012). For the purpose of this study, I identify decision-making as a component of problem solving that leads to the accomplishment of musical goals.

In his analysis of teachers' responses to music performance, Doerksen (1999) included "prescriptions" as the last of several categories of teacher behaviors, after "ratings," "rankings," and "diagnoses." These prescriptions were a component of a larger cognitive process and were formulated after performance was evaluated, options were considered, and principles were applied.

Teachers and learners make meaningful decisions by applying principles and evaluating options while considering desired goals. Decisions may be based on organized structures of knowledge that clearly define what actions are likely to lead to desired outcomes (Price & Driscoll, 1997; Sweller et al., 1998). Decisions are made as options are considered, and often the available options are construed based on principles that connect subgoals and ultimate goals (Catrambone, 1998). This is true in many aspects of human experience, including infant tool use (Elsner & Schellhas, 2012; McCarty et al., 1999), mathematics problem solving (Kotsopoulos & Lee, 2012; K. Lee et al., 2009), golf (Beilock, Bertenthal, Hoerger, & Carr, 2008), and occupational decisions involving value judgments (Goethals, Dierckx de Casterlé, & Gastmans, 2012). Goethals et al. (2012), for example, found that nurses' decision-making about the use of physical restraint was influenced by values (principles) and consideration of available options. Elsner and Schellhas (2012) observed that infants decided to use a tool a certain way to accomplish a goal based on how they learned to use the tool in previous situations.

Decisions can also be made absent the conscious recognition or application of generalized knowledge, of course. To illustrate varying degrees to which decisions may be informed by generalized knowledge, I return to McCarty et al.'s (1999) analysis of the problem solving of 9-, 14-, and 19-month olds. McCarty et al. outline four strategies infants demonstrated in their analysis: feedback-based strategy, partially-planned strategy, fully-planned strategy, and habitual solution (see Figure 4). The children tended to use different strategies to obtain the food depending on their ages.

Each of these strategies illustrates different levels of planning capability. As children develop, the decision that occurs in relation to the grip and spoon orientation happens earlier in the process. At first, the infant evaluates goal attainment only when food is expected in the mouth. Later, the infant anticipates success or failure before he brings the spoon to the mouth: he considers the spoon orientation in relation to the goal while the spoon is in hand and decides whether or not to change either the hand or the direction of the spoon. In the third stage, the infant anticipates attainment of the goal before picking up the spoon: he grasps the spoon with a different grip or a different hand depending on the orientation of the spoon. As McCarty et al. define this stage, a period of deliberate problem solving must occur before picking up the spoon. In the last stage, "habitual solution," the process of spoon-feeding requires little effort; the infant consistently picks up the spoon and successfully brings food to the mouth, regardless of the orientation of the spoon when it is presented. In this stage the infant has "generalized a heuristic" (p. 1099); knowledge has become generalized and behaviors have become habitual, allowing quick decision-making informed by previous experience.

In a later study McCarty and Keen (2005) acknowledge a question as to whether infant spoon-feeding and other infant learning is a deliberately cognized event or is implicitly learned through trial and error, below conscious awareness. Evidence indicates that this is indeed cognized and not implicitly learned. McCarty and Keen observed that 12-month olds improved in ways that 9-month-olds did not, suggesting that higher-order processes were at work, executive processes that had developed in the 12-month-olds that had not developed in the 9-month-olds. Further, McCarty et al.'s (1999) analysis of problem solving in stages showed a longer "think" time in the middle, partially-planned strategy stage—the stage after trial-and-error guessing and before the stages in which principles guided decisions and habits formed. In this stage, before bringing food to mouth, children took longer, inferring an evaluation of the spoon orientation in relation to the goal. Eventually, action became more rapid and accurate. Learners' generalization of knowledge in the form of principles was critical to successful learning.

Observations of infants' actions reveal that their decisions appeared quite random at first. Thus, the infants could determine the usefulness of their problem solutions on the basis of receiving feedback from the environment—whether or not food went in the mouth. As the infants continued to assimilate the feedback their actions produced, they developed principles that guided the planning for each subsequent decision. In what McCarty et al. (1999) labeled the fully-planned strategy stage, the infants' decisions seemed based not on feedback from the environment but on knowledge already acquired and stored in memory. This knowledge connected potential options (different hands, different grips) with the ultimate goal. The principle that developed (always grasp the spoon in a way that positions the spoon head on the mouth side of the hand) could then be applied within variations in context (different kinds of spoons, different presentations of spoon orientation, or variations in proximity to the right or left hand).

Knowledge gained from past experiences and other sources can aid learners in the decision-making elements of problem solving. However, decision making and problem solving are especially challenging when knowledge structures are weak, when several options appear viable, or when options are not readily apparent. Conceiving options for future behavior, understanding their applicability, and assessing their potential to contribute to the accomplishment of goals are important for successful decision-making.

PROBLEM SOLVING IN MUSIC SETTINGS

Music making is an activity rich in goal-driven behavior, and developing music skills and learning repertoire comprise ongoing problem solving. The components found in research exploring problem solving in many domains are also found indirectly in research exploring aspects of problem solving in music; however, no substantial body of literature exists that directly explores the process of problem solving by music teachers or learners, nor is there a framework available that allows for systematic evaluation of problem solving within music.

There are a number of investigations in music that consider various components of problem solving in isolation. Included are studies of error detection (Byo, 1993, 1997; DeCarbo, 1982; Gruner, 1993; Ramsey, 1979; Sheldon, 2004; Stuart, 1979; Thornton, 2004; Waggoner, 2011), error correction (Cavitt, 2003; Doerksen, 1999; Duke & Simmons, 2006), practice behavior (Ali, 2010; Barry & Hallam, 2002; Chung, 2006; Duke, Simmons, & Cash, 2009; Hallam, 1997; Nielsen, 2001, 2002; Rohwer & Polk, 2006), and self-regulated learning strategies (McPherson & McCormick, 1999; McPherson & Zimmerman, 2002; McPherson, 2005). In the sections that follow I first describe studies of teacher behavior and then studies of learner behavior. I then discuss how further research directly related to problem solving may answer questions that are raised by the findings of the published research.

Problem solving by music teachers

In order to effect change in students, teachers solve problems throughout the course of music instruction. The process of problem solving in the course of music tuition or music practice has not been the focus of systematic research in music, but the following studies address aspects of teacher activity in music instruction that contribute to problem solving.

It is clear that detecting errors in performance or perception is a necessary component of effecting change, and in many ways error detection reveals problems to be solved. Studies of error detection in music (Byo, 1993, 1997; DeCarbo, 1982; Gruner, 1993; Ramsey, 1979; Sheldon, 2004; Stuart, 1979; Thornton, 2004; Waggoner, 2011) have assessed teachers' and students' ability to detect errors in auditory stimuli in relation to music notation. Their findings reveal that students generally struggle with error detection, particularly on complex problems, but that error detection can improve with practice.

These studies in error detection are limited in their generalizability to other types of problem identification, however; they include the pursuit of pitch and rhythm goals, generally, as established by a written score, but many more goals related to music making are not addressed, such as tone production and interpretation. Further, although error detection is subsumed within problem solving, it represents only a piece of a larger process.

Cavitt (2003) acknowledged the need to consider more than the detection of errors in investigations of teachers' ability to effect change. She examined experienced teachers' error correction in the context of instrumental music rehearsals, asserting that error *correction* encompasses more than error *detection*. "The correction of errors," she says, "involves additional skills beyond error detection. Error correction involves knowing what, when, and how to bring about positive changes in student performance" (p. 219). Cavitt found that certain aspects of expert teacher behavior such as instructional pace varied depending on the type of error addressed, that episodes of teacher behaviors such as talking and modeling were relatively brief and frequent, and that teachers gave negative feedback frequently, more so than positive feedback. All of these findings suggest that problem solving activity is a highly interactive process between teacher and student, involving a great deal of evaluation. Further, her findings suggest that musical problem solving differs depending on the nature of particular musical goals, and that problem-solving behaviors must be examined not as isolated or general behaviors but as components of a process occurring in relation to specific learning targets.

Doerksen (1999) investigated the "aural-diagnostic and prescriptive skills" of pre-service and expert music teachers who responded to music performances in four combinations of musical difficulty and performance quality: difficult music and excellent performance, difficult music and average performance, moderate (intermediate-level) music and excellent performance, and moderate (intermediate-level) music and average performance. Doerksen compared teacher responses within each of nine "target categories," identifying various aspects of music performance: tone quality, intonation, blend/balance, rhythm/precision, articulation, technical facility, musical interpretation, phrasing, and dynamics. He found differences in evaluations between pre-service and expert teachers, as well as interactions between performance type and teacher experience, suggesting that evaluation ability may be a function of teacher expertise and effective problem solving.

In their analysis of expert music teaching, Duke and Simmons (2006) identified 19 elements of successful music teaching, many of which are components of problem solving. The authors organized the elements they observed into three broad categories of teaching behavior—Goals and Expectations, Effecting Change, and Conveying Information—each of which expresses an aspect of problem solving. Of the 19 elements described by Duke and Simmons, the following seem directly involved in problem solving:

- Teachers have a clear auditory image of the music that guides their decisions.
- Teachers tenaciously expect a high standard of quality in learners' performances.
- Teachers establish technically and musically important lesson targets.
- Students are capable of lesson targets.
- Errors in student performance elicit teachers' stops.
- Teachers make fine discriminations between sounds and movement.
- Teachers give negative feedback clearly and frequently.
- Teachers give positive feedback at times, less frequently than negative feedback.
- Teachers make comparisons between present and past performances, and positive and negative performances.
- Teachers model performances, including positive and negative imitations of student performances.
- Teachers give attention to fundamental technique.
- Teachers give attention to the effects of physical movement on sound.
- Teachers and learners make interpretive choices.

This analysis increases understanding as to what effective teaching looks like and what characterizes the work of effective teachers. Interestingly, although Duke and Simmons were not explicitly observing these behaviors as such, many of these behaviors express components of problem solving that appear in other literature: establishing important and tractable targets (establishing goals), detecting errors and discriminating performance (evaluating), making comparisons between performances (considering options), giving attention to fundamental technique and the effects of physical movement on sound (principles connecting goals and subgoals), and making interpretive choices (making decisions). These findings expressing expertise in teaching also express expertise in problem solving.

The results of studies exploring elements of problem solving in music raise questions that may be answerable through a more deliberate study of the problem solving process within music instruction. Cavitt (2003) found that certain aspects of teacher behavior such as instructional pace varied depending on the type of error addressed. An analysis of the process of problem solving could explicate the reasons for these variations in teacher behaviors in relation to the target type.

Doerksen (1999) found differences in evaluations between pre-service and expert teachers, as well as interactions between teacher experience and the quality of the performances that were evaluated. Reasons for these differences, however, remain unclear without a comprehensive, goal-based analysis. Although Doerksen identified target categories that defined broad performance goals, he conducted the analysis without regard for specific problems addressed individually.

The findings reported by Duke and Simmons (2006), regarding the behaviors found in common among effective music teachers, raise questions as to how the teacher behaviors they identified relate to one another and interact to bring about change. Why were these particular characteristics found in common among these three expert teachers? Do they represent behaviors that are part of a larger, interdependent process involved in effective teaching? For example, Duke and Simmons identified frequent feedback and appropriate targets as common teacher behaviors. One might ask, what is the relationship between feedback and the selected lesson targets? They also observed that learners' errors elicited teachers' stops, raising additional questions: When a learner makes an error, what teacher behaviors follow, and in what sequence?

Further, these findings raise questions as to the function of these teacher behaviors. What is the purpose of attending to fundamental technique and the effects of physical motion on sound? Do some of these behaviors prepare learners for independent problem solving? And how often and in what circumstances do learners make decisions?

These findings and the questions they raise illustrate the need to gain further understanding of the problem-solving process. It seems important to investigate the components of problem solving in relation to the pursuit of specific, identifiable goals.

Problem solving by music learners

To effect change in their own playing, music learners must also solve problems on their own. Effective practicing is problem solving, and the study of practice behavior is, in many ways, the study of problem solving. Some aspects of music learners' problem solving abilities are included in an important body of work analyzing the motivational behaviors and practice strategies of music learners (Ali, 2010; Barry & Hallam, 2002; Chung, 2006; Duke, Simmons, & Cash, 2009; Hallam, 1997; McPherson & Zimmerman, 2002; McPherson, 2005; Nielsen, 2001, 2002; Rohwer & Polk, 2006). These studies explore questions about the practice strategies and behaviors that lead to successful music performance: planning and goal-setting, self-monitoring, self-evaluation, error correction and detection, and repetition. These studies do not directly address problem solving as a process, but some elements of problem solving can be identified within the findings.

Duke et al. (2009) found that learners who were successful in music practice (i.e., those who performed most successfully on a delayed retention test) exhibited a set of behaviors during practice that their less successful peers did not. The practice behaviors of learners whose performances ranked highest included playing with inflection early on; early error detection, preemption of errors, and successful error correction; indications of thoughtful practice; and appropriate tempo choice. The greatest predictors of performance quality following practice were the number of correct and incorrect performance trials during practice. These results suggest that those who were the most successful at practicing were those who were the most effective problem solvers; they quickly detected and eliminated errors.

A large body of literature exists outside of music investigating learners' use of self-regulated learning strategies (e.g., Bernacki, Byrnes, & Cromley, 2012; Clark, 2012; Kolovelonis, Goudas, Hassandra, & Dermitzaki, 2012; Zimmerman & Pons, 1986). These studies address aspects of human behavior related to problem solving, such as goal setting, self-evaluation, and self-monitoring, and they consider the motivational, reasoning, planning, and metacognitive strategies learners use in various learning situations such as technology-enhanced learning environments (Bernacki, et al., 2012) and physical education classes (Kolovelonis, et al., 2012).

McPherson (2005) applied the ideas contained in self-regulated learning analysis to music learning scenarios, conducting observations over a 3-year period of young music learners' self-regulated learning strategies. Each year children ages 7-9 years were tested on performing rehearsed music, sight reading, memorization, and playing by ear. Further, they were interviewed about the strategies they used while practicing. Practice strategies were categorized as either "organizational strategies" (e.g., keeping a practice diary; the sequence of practice activities) or "improvement strategies" (e.g., responses to errors). Participants' strategies were categorized as conceptual, kinesthetic, or musical approaches to the tasks.

The participants' abilities to sight-read, play from memory, and play by ear were related to the mental strategies they employed prior to performance, such as observing the key signature prior to sight-reading or singing while fingering to memorize music. McPherson found no relationship between the strategies learners reported using in practice and their ability to perform rehearsed music, however; children's self-reports of their strategies did not provide sufficient information to predict success.

An analysis of specific problems and solutions may be more fruitful. For example, most children reported playing through pieces rather than working to achieve specific performance goals. McPherson suggests, as do Barry and Hallam (2002), that learners may lack the ability to detect errors, and practice strategies are unlikely to be successfully employed without the essential knowledge base that facilitates error detection. Further investigation, such as analyzing children's practice to determine how often and how they corrected errors, is required to confirm this supposition.

These studies of self-regulated learning and music practice have revealed cognitive and metacognitive skills that are involved in successful learner problem solving, although the authors generally do not describe them as such. Establishing goals, evaluating, generalizing and applying principles, and making decisions are all described in the research cited above, but these behaviors have not been analyzed during online problem solving, illuminating the cognitive and perceptual skills that set apart the most successful problem solvers from those who are less effective.

There is as yet no complete explanation of how goals, knowledge, and skills work together to effect change and promote musical progress. A problem-by-problem analysis of these behaviors may better describe the process of error correction.

PROBLEMS WITH PROBLEM SOLVING

Considering all that is involved in problem solving, it is not surprising that learners are often unsuccessful at solving problems independently. This seems especially true in music, given that many students are afforded few opportunities to practice solving problems in the presence of their teachers. Most young musicians are generally found lacking in self-evaluation and error-detection skills (Bergee, 1993, 1997; Byo, 1993, 1997; Hewitt, 2002, 2005, 2011b), important components of problem solving. Hewitt (2011), for example, found that even after training, middle school music learners were unable to evaluate themselves accurately; that is, they were unable to describe their performances the way that experts did. Byo (1993, 1997) found that undergraduate music majors struggled to detect discrepancies between audio recordings and printed music notation.

Efforts to improve the problem-solving capacities of music learners must begin with a clear understanding of the factors involved in problem solving and the problems associated with problem solving. What explains learners' struggles to solve problems independently? What explains their successes in doing so?

Problems with components of problem solving

Several studies illustrate the importance of the components of problem solving that are the subject of this chapter (K. C. Moore & Carlson, 2012; Tsai et al., 2012; Wang et al., 2012). Their results demonstrate how problems with problem-solving components inhibit the formulation of successful solutions.

Moore and Carlson (2012) interviewed nine pre-calculus students while they worked to solve two problems. Students explained the thought processes leading to their decisions as to which graphs and formulas to use. Students also drew diagrams of the problems to show their understanding of each problem's concept. Moore and Carlson observed that learners' problem-solving abilities were related to their conceptions of the problems. Those who created an accurate diagram of each problem were more successful in making decisions about what procedures to apply than were those who did not define the problem accurately (as evidenced by their diagrams). Moore and Carlson also observed that students identified and corrected errors in their problem solutions by refining their understanding of problems and adjusting their diagrams accordingly. In other words, individual students' success varied based on the clarity of goals and subgoals that lead to solutions.

The students who participated in Moore and Carlson's study made decisions as to which procedures to employ based on their conception of the problem; they made decisions about subgoal options based on their understanding of the each problem's goal. The conception of the problem and the decisions about which options to pursue and which techniques to employ were directed by students' knowledge base: their understanding of the concepts that clarify the intent of the problem and their understanding of how various options may contribute to problem solutions.

Tsai et al. (2012) also established the importance of clearly understanding goals and determining which factors of a complex problem are relevant to goals. Participants in their investigation were directed to determine which of four visual scenes (presented at the same time) contained landslide hazards, based on four factors presented in the scenes. Using an eye-tracking device and think-aloud protocols to assess the focus of students' attention, Tsai et al. observed that students who were successful in solving the problem spent more time on factors relevant to the problem than did those who were unsuccessful. Those who were unsuccessful spent more time decoding the problem. Like Moore and

Carlson's (2012) participants, Tsai et al.'s participants struggled with these critical behaviors because they failed to fully understand the problem.

Wang et al. (2012) observed differences in decision-making ability among patients with diabetes, noting that not all patients who monitored blood glucose levels acted in response to low or high readings. These patients evaluated, but they did not take appropriate action in response to the information they received. The authors recommended teaching patients disease-specific information, relating this information to past experiences, increasing patients' awareness of response strategies, and role-playing to practice using these strategies. These recommendations are related to components of problem solving: awareness of options available, application of knowledge, and deciding to take action.

The studies examining problem solving in mathematics (K. C. Moore & Carlson, 2012), earth science (Tsai et al., 2012), and health care (Wang et al., 2012) illustrate the application of the essential components of problem solving: identifying goals, considering options, evaluating the relevance of factors in relation to outcomes, applying knowledge, making decisions and taking action. Solving problems successfully depends on the capacity to perform each of the components successfully.

Music learners may also struggle to correct errors for reasons related to components of problem solving. Music students' success in problem solving is often affected by the goals they pursue while practicing and performing. Learners who lack understanding of stylistic or expressive goals may make decisions that do not support the concept of a piece of music. A student who does not understand the style associated with Mozart, for example, may choose articulations or tempos that are inconsistent with music of the period.

Music learners likewise may struggle with prioritizing goals, given the many physical, intellectual, and expressive challenges with which they are confronted while practicing. They may lack the clarity of focus that is necessary to persist until problems are solved. Children's reports that they often only play through pieces in practice rather than systematically correcting errors (McPherson, 2005) suggest that their attention may focused in ways that do not facilitate the solution of problems.

All of these possibilities are related to one or more components of problem solving: goals, evaluating, considering options, applying principles, making decisions. If there are problems with problem solving, there may be problems with these component skills.

Working memory capacity

Problem solving places high attentional demands on learners. The ability to manipulate and maintain awareness of information and execute procedural skills is affected by working memory capacity. Problem solving requires that learners attend simultaneously to many procedural and perceptual skills while also drawing upon acquired declarative knowledge. Difficulties arise when problems with which learners are confronted exceed working memory capacity (Johnstone & El-Banna, 1986; K. Lee et al., 2009; Passolunghi & Mammarella, 2012; Solaz-Portolés & Sanjosé-López, 2009; Song, He, & Kong, 2011; Stamovlasis & Tsaparlis, 2003; Sweller, 1988; Tsaparlis & Angelopoulos, 2000; Zheng, Swanson, & Marcoulides, 2011).

Passolunghi and Mammarella (2012), for example, found that severe mathematical learning disabilities were related to limitations of working memory. Song et al. (2011) found that verbal working memory was related to learners' ability to solve high-difficulty mathematical word problems, but had no effect on solving medium- or low-difficulty word problems. They described this phenomenon as a bottleneck effect, which occurred as working memory demand increased with problem complexity. Research by Stamovlasis and Tsaparlis (2003) corroborated this finding within chemical-equilibrium science problems; they found that learners' experienced a sudden drop in achievement on problems whose complexity exceeded working memory capability.

These findings are consistent with error detection studies in music. Byo (1993, 1997) found that it was easier for graduate and undergraduate music majors to detect errors in simpler musical material than in more difficult examples; increases in number of parts, number of timbres, or rhythmic complexity all resulted in poorer performance.

Problem complexity is not the only factor affecting attentional demands on a learner, however. The extent of learners' knowledge and their capacity to engage procedures fluently are of course related to the attentional demands that a given problem presents (Kotsopoulos & Lee, 2012; K. Lee et al., 2009; Zheng et al., 2011). Zheng et al. (2011) found that, although working memory capacity predicted learners' ability to solve mathematical word problems, basic reading and math skills mediated those differences. Lee et al. (2009) likewise found that working memory capacity, literacy, and perception of quantitative relationships were all factors that predicted success in mathematical problem solving.

When critical physical and perceptual skills are not well learned, attentional demands are high for each component skill necessary for attainment of the ultimate goal. Sight reading ability, for example, correlates with a number of component skills, including basic kinesthetic abilities (Kopiez & Ji In, 2006). Those who scored low on motor skills as seemingly removed from sight reading as trilling showed limited sight reading ability. The ability to trill on an instrument is a correlate of general facility, and as such represents the degree of motor skill automaticity in relation to the instrument. According to Kopiez and Ji In, learners' automatization of these motor skills affected the cognitive load during sight-reading.

Achieving automaticity to gain fluency is not only pertinent to motor skills; cognitive and perceptual skills may also be automatized. Evaluation, consideration of options, weighing options against known principles, and making decisions all require some amount of attention. How much attention is necessary for each of these skills depends on the degree to which they have been practiced to automaticity (S. Brown & Bennett, 2002; T. L. Brown & Carr, 1989).

Knowledge base

Another feature of expertise that distinguishes experts from non-experts is the extent of knowledge and repertoire of skills that individuals have acquired and can draw upon when they are confronted with problems. Nonexperts often struggle to solve problems that experts solve seemingly effortlessly because nonexperts simply lack the knowledge needed to make accurate assessments and arrive at productive decisions (Barry & Hallam, 2002; McCarty et al., 1999; Moore & Carlson, 2012; Tsai et al., 2012). Experience and well-learned knowledge and skills allow learners to accurately evaluate whether goals have been accomplished, understand available options from which to choose and evaluate those options, and finally make decisions as to how to proceed toward accomplishing goals.

Multiple authors in the medical field have reported that an increase in knowledge and competence was accompanied by increased self-assessment accuracy (Davis et al., 2006; Fitzgerald, White, & Gruppen, 2003; Hawkins, Osborne, Schofield, Pournaras, &

Chester, 2012; Lew, Alwis, & Schmidt, 2010; Sargeant, 2012; Sargeant et al., 2010). A meta-analysis of physicians' self-assessment, for example, revealed that those who were least competent and those who were most confident were least likely to make accurate self-assessments (Davis et al., 2006). Hawkins (2012) found that increasing medical students' knowledge of performance standards ("benchmarks") increased their ability to accurately evaluate videos of their own performances. Fitzgerald et al. (2003) found a relationship between self-assessment accuracy and students' familiarity with tasks. These results suggest that more domain knowledge leads to increased self-evaluation accuracy.

Studies in music have obtained similar results. In a cross-sectional study investigating the effect of self-evaluation training on self-evaluation accuracy, Hewitt (2011) found an effect of grade level and time on learners' self-evaluation scores. Fifth, sixth, and seventh graders showed increased self-evaluation scores after training, but eighth graders did not. These effects of grade level and time were stronger predictors of performance than was explicit instruction in self-evaluation, which produced no significant effect on student accomplishment. Hewitt proposed that the general ability of the students to evaluate their own work increased with their skill in playing their instruments and with their cognitive development.

Hallam (2001) suggested that young musicians may struggle to correct errors because they lack the aural schemas that guide the detection of errors. To investigate the monitoring behaviors and practice strategies of music learners, she interviewed and observed the practice behaviors of string players aged 6-18 as they practiced for 10 minutes before performing a piece. She found that practice strategies alone did not predict successful performance; careful error detection was required. She attributed music learners' abilities to detect and correct errors to their ability to monitor and evaluate performance, based on the aural schemas learners had acquired. She recommended that teachers spend time assisting learners in acquiring generalized knowledge that can be applied when learners sight read and practice independently.

McPherson (2005) likewise recommended that teachers spend more time developing learners' knowledge and aural abilities by engaging learners in the process of listening and analyzing music instead of only giving prescriptive directives. He asserted that lack of this knowledge may explain why young musicians' practice sessions, as reported by learners themselves, largely comprised playing through pieces without regard for the accomplishment of specific targets.

Inappropriate transfer

Sometimes problem solving is unsuccessful because learners apply principles unsuccessfully. They may apply a principle in a context in which it should not be applied.

Inappropriate transfer such as this was observed in an investigation by Elsner and Schellhas (2012) in which they examined childrens' attempts to solve problems using tools. Children were to acquire chips from within a transparent box by using a tool to either stab and lift the chips through a hole in the top or to push them through a hole in the side. Only the top hole or the side hole was uncovered at one time. The researchers then covered one hole (e.g., the top) and uncovered the other (e.g., the side) and learners were then required to use the same tool with a different strategy (e.g., pushing instead of stabbing).

Once the tool's function had been learned in one context (e.g., hole in the top of the box), the strategy for using the tool as it was used in the first task was applied in the new context (e.g., hole in the side) in which the strategy was ineffective. Once the tool had become associated with a certain action to accomplish a goal, the children found it difficult to change the way the tool was used. On the other hand, children who had had no previous experience with the tool were able to use the tool in the manner necessary to accomplish the task, irrespective of which context they encountered.

Music learners are often unsuccessful at meeting performance targets due to inappropriate transfer. Violinists may use a bow stroke or vibrato that achieves a style appropriate to Brahms instead in Bach. Wind players may use tonguing in passages that would be more effective with little or no use of the tongue. Cellists may use the finger pattern appropriate for one key in a key that requires a different fingering. Pianists may attempt to balance a melody in a passage but neglect bringing out necessary harmonies. In all of these examples, learners possess an incomplete understanding of principles connecting subgoals to the accomplishment of ultimate musical goals. They require an understanding of the appropriate contexts in which subgoals are to be pursued to successfully meet desired ends.

TEACHER ASSISTANCE WITH LEARNER PROBLEM SOLVING

What can teachers do to structure learning in ways that increase learners' success in problem solving and ensure that learners are capable of solving problems on their own? I present in the section that follows several studies that describe attempts to facilitate learner problem solving. First, literature outside the field of music is considered, followed by a review of studies investigating the training of music learners in all or some of the components of problem solving.

Literature investigating how to facilitate problem solving

Recent research in problem-based learning represents a shift in the degree of teacher involvement in problem-solving, focusing not on what teachers do, but on what *learners* do to learn (Hmelo-Silver, 2004; Langendyk, 2006; Loyens et al., 2008). Hmelo-Silver (2004) explained that in this approach, "the roles of the student and teacher are transformed. The teacher is no longer considered the main repository of knowledge; she is the facilitator of collaborative learning" (p. 239). The learner, through action, is the constructor of knowledge.

In many learning situations, however, learners may lack the resources necessary to solve problems without teacher intervention or assistance. Learner independence develops as teachers create a balance between autonomy and structure. Seirens et al. (2009), drawing on Deci and Ryan's self-determination theory (e.g., Deci & Ryan, 2000), found that self-regulated learning increased in an environment including both "autonomy support" and "structure." Autonomy support, in this context, refers to the degree of choice teachers afford learners. Structure refers to teachers' establishing expectations and providing feedback. Seirens et al. found that learner independence increased as teachers provided some guidance but also refrained from controlling every aspect of learners' experiences.

Learners' capacity to solve problems may be facilitated when teachers carefully structure experiences while strategically providing learners degrees of autonomy. I discuss in the section that follows various proposed strategies by which teachers may facilitate learner problem solving, and their respective functions in involving learners in components of the process.

Promoting generalization and transfer of knowledge through principles and examples

Having observed music learners' difficulty with problem solving even when learners utilized various practice strategies, Hallam (2001) recommended that teachers assist learners in developing domain knowledge with which to monitor their own music performance. She emphasized the need for generalized aural schemas to facilitate transfer of learning to independent practice. A number of studies have investigated means by which learners may gain generalized knowledge and transfer that knowledge to novel problems, including the use of principles and examples during instruction.

Eiriksdottir and Catrambone (2011) reviewed the research regarding the facilitation of generalization and transfer in problem solving. One of their main observations was that teachers facilitate transfer by providing general instructions rather than only prescriptive instructions. Although initial learning may not be as rapid when general instructions are given, transfer is more likely to occur. Further, Catrambone (1995b) found that initial learning could be facilitated by the use of examples and principles, and that principles, or knowledge as to how and why things work (Eiriksdottir & Catrambone, 2011), were particularly useful in aiding transfer.

Catrambone (1995) investigated the effects of examples and principles on learning and transfer by participants learning to use a word processing program through written instructions. He found that examples illustrating the instructions were beneficial for initial learning but did not aid transfer. Principles, on the other hand, aided initial learning as well as transfer.

In a later study, Catrambone (1996) found that learning and transfer were aided by providing labels identifying subgoal components of solution sequences, rather than only providing sequences of procedural instructions. Identifying the subgoals enabled learners to notice subgoal-goal (hierarchical) relationships, and then generalize and transfer knowledge.

Loewenstein, Thompson, and Gentner (2003) found that comparing examples aided in the generalization of knowledge in subjects studying business negotiation. Those who were directed to compare two scenarios and identify a principle were more likely to apply that principle in a novel face-to-face scenario, whereas those who studied the same two cases separately performed no better than those who had no training. Kotovsky and Gentner (1996) similarly found that categorization and comparison of examples led children to recognize relationships.

McCarty and Keen (2005) attempted to facilitate learning and transfer as infants learned to spoon feed. As in an earlier study investigating the spoon-feeding of 9-, 14-, and 19-month infants (McCarty et al., 1999), they presented 9-month- and 12-month-old infants with a spoon holding food and observed children's actions in their efforts to obtain the food. In previous studies, the spoon was presented in several different orientations relative to the infant. With every alternation of spoon direction, the child was either required to switch hands or turn the spoon around in order to successfully obtain the food. In this study, three additional conditions were added beyond the first (one-spoon mixed orientation) condition: presenting the spoon the same direction in 6 consecutive trials before changing the direction of the spoon for another 6 trials (one-spoon blocked condition), presenting two spoons facing opposite directions and alternating on each of 12 trials (two-spoon mixed condition), and presenting two spoons facing opposite directions presented identically for 6 trials before presenting the spoons the other direction for 6 more trials (two-spoon blocked condition).

The 12-month-old infants in the single spoon blocked condition were more successful at taking a spoon with an effective grip than were subjects in the other conditions. The single-spoon blocked condition provided learners the opportunity to try several times within the same context, which seemed to facilitate learners' accurate decisions. They were able to evaluate the effects of their actions several times in a row. The researchers postulated that this facilitated the development of a planning strategy that could be applied and tested in the following trial. When the spoon changed direction after the first block of trials, however, the infants struggled with adapting to the change at first.

McCarty and Keen cite another blocked-versus-mixed presentation study (Siegler & Stern, 1998) in which math learners were given an equation that could be solved without calculation ($a + b - b = \_\_\_$). Those presented with this type of equation in a blocked condition learned more rapidly and solved the equations more quickly than did learners who were presented the equations in a mixed condition; however, learners from the blocked condition sometimes inappropriately applied the no-calculation-necessary principle in equations that actually required calculation. Those who learned a single type of equation over several examples rather than multiple equation types inappropriately transferred the principles learned.

It appears, then, that there is a balance between providing learners multiple opportunities to solidify knowledge and skills within single task contexts and also generalizing knowledge to be applied appropriately over related contexts. When teachers direct learners to observe hierarchical relationships and draw principles from various examples, knowledge is more likely to generalize and transfer to related contexts than when teachers only provide prescriptive instructions.

Presenting contrasting options, positive/negative exemplars

Principle formation, evaluation, and decision-making can be facilitated in learners as contrasting options are presented. Recognition of the various possibilities that may serve to reach a given goal have a clarifying, connecting effect on general knowledge germane to that goal (Levav-Waynberg & Leikin, 2012). As teachers or learners demonstrate options that may serve to accomplish a goal, comparisons between those options increase understanding.

Hawkins et al. (2012) tested the effect of providing video examples of both learners' performances and an expert performance on the accuracy of student self-assessment. After medical students performed a suturing task, they evaluated their performances using a rating scale. Learners were then shown videos of their performances of the task, and again rated their performances. Students were then shown a video of an expert performing the same task, after which they evaluated their own performance a final time, in comparison with the expert exemplar. After learners watched videos of their own performances, self-assessment did not improve. Self-assessment accuracy increased only when they watched the expert performance video in addition to videos of their own performances.

It is possible, however, to confound problem solving through the presentation of too many options. McCarty and Keen (2005) presented contrasting options to learners as they explored possible scenarios in which children would more quickly acquire the correct habit of spoon feeding. The presentation of two spoons was not successful in facilitating learning in this case. Children brought food to their mouths more successfully in the one-spoon, blocked condition. The attempt to facilitate problem solving by demonstrating contrasting options was unsuccessful in this case, possibly because there were too many variables in the two-spoon condition, causing an attentional overload.

Adjusting the complexity of the goals learners seek

Researchers have considered various strategies to assist learners in solving complex problems. Some have advocated the use of “goal-free problems” in science and mathematics education (Sweller et al., 1998). Goal-free problems are actually not without goals, but they are limited in their complexity in ways that focus attention on subgoals rather than on superordinate goals. For example, a geometry learner might be directed to “solve for as many angles as you can” rather than to solve for a specific angle.

Of course, learners who are to be truly independent must be able to solve both simple and complex problems. As learning progresses, the complexity of problems must be adjusted in ways that optimize learners’ capabilities.

The attentional demands of a given problem are lower when the skills required to obtain a solution are to some extent automatized (S. Brown & Bennett, 2002; T. L. Brown & Carr, 1989; Jancke, Shah, & Peters, 2000; Johnstone & El-Banna, 1986; Kopiez & Ji In, 2006; Ruthruff, Johnston, & Van Selst, 2001). As a skill becomes more automatic it requires less attention, thus freeing up attention that can be devoted to other aspects of a given problem. Skills to be automatized may include any motor or cognitive skill, including technical skills of music performance or the perceptual skills required for music evaluation.

Automaticity is achieved through goal-oriented practice (Ruthruff et al., 2001). Learners who successfully perform skills over many repetitions become more efficient in doing so. Physical habits such as effective breathing, finger coordination, and accurate shifting develop through meaningful practice. Cognitive and perceptual skills such as error detection, evaluation, and decision-making increase in efficiency through practice as well (Dolbeer, 1969; Grunow, 1980; Johnstone & El-Banna, 1986; Ross, Hogaboam-Gray, & Rolheiser, 2002; Tsaparlis & Angelopoulos, 2000).

Scaffolded problem solving

Additional approaches to development of problem-solving skill and transfer of learning include strategies that incrementally fade or remove teacher assistance. Anderson, Corbett, Koedinger, and Pelletier (1995) recommended the use of teaching strategies that "facilitate successive approximations to the target skill" (p. 181). Authors promoting "cognitive apprenticeship" (Collins et al., 1989) also encourage a fading process, in which teacher involvement is gradually reduced from a point of teachers' modeling problem solving to teacher-assisted scaffolded problem solving to independent learner problem solving.

A line of research investigating learners' ability to solve structured problems has developed in response to less productive approaches to teaching, in which learners first observe solutions to sample problems and then are asked to solve problems independently. This kind of stark transition is comparable to what some music learners experience upon leaving their teachers' influence to attempt independent practice. Researchers have, instead, attempted to facilitate the development and transfer of problem-solving skill by providing incompletely solved problems and by fading the number of problem components that are explained for learners.

Stark (1999) investigated learners' abilities to complete practice problems and transfer problems in two conditions: providing incomplete example problems with "blanks" learners were required to fill in, and providing example-problem pairs, in which learners viewed a worked-out problem with explanation followed by a problem with no explanation. Learners in the incomplete-example condition performed better on problems and on subsequent transfer problems.

Renkl, Atkinson, Maier, and Staley (2002) found that learners became more capable of solving structured problems independently through a process of fading. Learners received assistance on problems in two conditions: example-problem pairs, in which learners viewed a worked-out problem with explanation followed by a problem with no explanations; and a faded example problem condition, in which learners received problems that were worked out increasingly less. Learners who received the "faded" examples performed better on independently-solved problems than did those who received example-problem pairs. Further, Renkl et al. found that removing the solution to the last step of the problem first, followed by the last two steps, and so forth ("backward fading") promoted more efficient problem solving than did forward fading, in which the solution to the first step of the problem was removed first, and so forth. They suggested that this greater efficiency may be attributed to a lower cognitive load during the backward-fading learning process.

Scaffolded problem solving, or fading, is a teaching strategy that has been shown to increase the likelihood of transfer. It is conceivable that this technique may be applied to any multi-component skill, including music skills. Further investigation may confirm this possibility.

Feedback and goals

Learner independence has been shown to vary according to the frequency or type of feedback received during training. A line of research involving a bimanual motor learning task has demonstrated a guidance effect from feedback, in which the learned skill did not maintain accuracy and stability once visual feedback received during training was removed (Buchanan & Wang, 2012; Kovacs, Buchanan, & Shea, 2009; Swinnen, Dounskaia, Walter, & Serrien, 1997; Winstein & Schmidt, 1990); however, dependence on feedback was reduced by manipulating the frequency (Kovacs & Shea, 2011; Winstein & Schmidt, 1990) and type (Buchanan & Wang, 2012) of feedback.

Originally, researchers sought to diminish or remove the guidance effect by manipulating the frequency of feedback (Winstein & Schmidt, 1990). In studies finding a guidance effect, visual feedback in the form of a cursor on a visual template was provided constantly (Kovacs et al., 2009; Swinnen et al., 1997); training enabled the execution of the skill but the skill broke down when feedback was removed. A later study eliminated the guidance effect by providing visual feedback only intermittently (e.g. Kovacs & Shea, 2011). Although manipulating the frequency of feedback diminished the guidance effect, training in the intermittent-feedback condition required a longer training period (Kovacs & Shea, 2011).

More recently, Buchanan and Wang (2012) found that altering the nature of feedback, rather than the frequency of feedback, decreased dependence on the feedback without affecting the duration required for acquisition of the skill. In this study, subjects learned bimanual movements in a 1:2 speed ratio by attempting to match a template of a Lissajous figure on a screen. Feedback was provided in the form of a cursor on the screen indicating the movement of learners' hands (the cursor did not leave a trace). Treatment groups differed in the placement of the template in relation to the cursor window. One group viewed the template directly behind the cursor. The other group viewed the template in a different window, to the side of the cursor window.

Both groups performed equally well in terms of accuracy and speed at the end of training; however, when the visual feedback (the cursor) was removed, those who had moved the cursor directly over the template decreased in accuracy and speed, whereas those who viewed the template in a window separate from the cursor window showed no significant diminution in accuracy and speed in the no-feedback condition. Those who had learned moving the cursor over the template were dependent on the feedback; those who moved the cursor in a separate window were not.

The researchers attributed this difference in performance to a difference in feedback systems to which learners attended. Learning differed as a result of attention to visual feedback versus proprioceptive feedback. Observing the relationship between the movements of the cursor and the template provided enough information to complete the task, perhaps obviating attention to proprioceptive feedback and inhibiting the development of a motor representation of the task. Buchanan and Wang explained that the distance between the template and visual feedback in the separate-window condition caused a disruption in the processing of visual feedback sufficient to require learners to attend more closely to proprioceptive feedback, thus facilitating development of a motor representation of the task and enhancing the stability of the skill when visual feedback was removed.

The nature of the goals in each condition also possibly affected the learning process. Learners received feedback based on two different types of goals: the ultimate holistic goal or proximal subgoals. The goal for learners who moved the cursor over the template was to stay on the line of the template. The feedback gave them information simply as to whether or not they were on the line. Any time the cursor strayed from the template line, the goal was simply to get the cursor back on the line. It is possible they did not attend to a larger representation of the goal: the shape as a whole.

The group whose cursor moved in a window separate from the template window, on the other hand, possibly pursued a more holistic goal to create "that shape." The cursor feedback gave them information only concerning the general shape formed by their hand movements. Participants were required to focus on the ultimate goal of creating the whole shape, and less on the subgoals or submovements that were a part of that shape. In this case, the more holistic representation of the task appeared to be more enduring upon removal of feedback.

The visual feedback provided during this motor learning task is, of course, very different from the type of feedback music learners receive from their teachers. But it is also the case that music teachers promote or hinder learner independence by arranging experiences and feedback in optimal ways.

Several studies have found that learning improves when learners participate in self-evaluation rather than only receiving teacher evaluations (Balch, 1998; Moore, 1976; Ross et al., 2002). Is this increase in learning due to an increase in learners' awareness of their own abilities through the act of self-evaluating? Further investigation is required to answer this question.

Although music teachers' feedback has been investigated to a great extent (Cavitt, 2003; Colprit, 2000; R. A. Duke & Simmons, 2006; Ferguson, 2004; Henninger & Duke, 1998; Henninger, 2008; Karlsson, Liljeström, & Juslin, 2009; Madsen & Duke, 1993; Nápoles & Bowers, 2010; Rutkowski & Miller, 2003; Schmidt, 1995; Siebenaler, 1997), little has been investigated regarding learners' dependence upon teacher feedback in music. Several studies confirm that feedback is an important teacher behavior leading to learners' positive musical change (Cavitt, 2003; Colprit, 2000; Duke & Simmons, 2006; Siebenaler, 1997); however, no known research exists investigating the effects of varied frequency or type of feedback on learners' abilities to solve problems independently.

Literature investigating teacher-facilitated learner problem solving in music

Despite the benefits that come to music learners who develop independence (Deci & Ryan, 2000; Hmelo-Silver, 2004; McPherson & McCormick, 1999; Smolej Fritz & Peklaj, 2011; Zimmerman & Pons, 1986), few studies in music have investigated how teachers facilitate the development of independence in music learners (Bergee & Cecconi-Roberts, 2002; Broomhead, 2005; Dolbeer, 1969; Grunow, 1980; Hewitt, 2011b; Ramsey, 1979). Although a number of authors have examined the practice behaviors of young musicians (Ali, 2010; Chaffin & Imreh, 2001; Chung, 2006; Duke et al., 2009; Hallam, 2000; McPherson & Zimmerman, 2002; Nielsen, 2001, 2002; Rohwer & Polk, 2006), there are no systematic studies of the teacher's role in the development of learners' ability to solve problems independently. Of those studies that do investigate the impact of training on improving problem solving or one or more of its components, most involve training in the detection of errors (Dolbeer, 1969; Grunow, 1980; Ramsey, 1979) or self-evaluation (Bergee & Cecconi-Roberts, 2002; Hewitt, 2002).

Training error detection and self-evaluation

Dolbeer (1969), Grunow (1980), and Ramsey (1979) found that error detection, an important component of evaluation, improved after training. Grunow (1980) investigated the effect of four types of score preparation on error detection performance: study of the score, study of the score with recorded examples, study of recorded examples, and no preparation. He found that all four methods were equally effective. Ramsey (1979) investigated the effect of different durations of the same training method on error detection, and found that the longest training yielded the most positive results. These studies indicate that error detection ability can be learned, but they reveal little about which methods, if any, are most effective. Also, these studies are not necessarily generalizable to other types of musical problem solving involved with the pursuit of goals such as tone production, phrase shaping, or interpretation; they simply involve the detection of agreement or disagreement between sound and symbol.

On the other hand, self-evaluation studies in music cover a much wider range of potential musical goals, including tone, intonation, rhythm, articulation, and interpretation (Bergee & Cecconi-Roberts, 2002; Bergee, 1993, 1997; Hewitt, 2002, 2005, 2011b), though attempts to improve self-evaluation through the use of peer discussion have shown only modest results (Bergee & Cecconi-Roberts, 2002). Bergee and Cecconi-Roberts (2002) attempted to increase learners' self-evaluation ability by placing them in peer groups and having them comment on group members' recorded performances. Self-evaluation, as measured by consistency with experimenter evaluation, did not improve as a result of peer self-evaluation discussions. Initial self-evaluation scores were generally higher than experimenter evaluation scores and lower than peer evaluation scores. Over time, self-evaluation scores rose closer to peer evaluation scores, moving away from experimenter evaluation scores. Learners' perceptions were influenced by their peers, but not in a way that increased the accuracy of their evaluations.

Hewitt (2011) also investigated the effects of self-evaluation instruction and, like Bergee and Cecconi-Roberts (2002), found that self-evaluation accuracy was not improved by training. In Hewitt's study, students were given five weeks of training on evaluating seven specific areas of music performance: tone, melodic accuracy, rhythmic accuracy, tempo, intonation, technique/articulation, and musical interpretation. Students were tested on self-evaluation at the end of each week on the areas for which they had received training in all previous weeks. Students evaluated themselves by using a standard evaluation form, giving themselves summative scores in each of seven subareas.

The training included guidance in using rubrics, evaluation of students' performances, discussion and feedback from teachers regarding the evaluations, student self-evaluation of their own performances with subsequent goal-setting, and feedback from teachers on the goals students set.

Students' self-evaluation accuracy was measured by comparing students' scores with evaluators' scores. Groups who received training in evaluation showed no significant improvement in self-evaluation compared to groups who received no training, although it is unclear why. This result is not consistent with studies examining self-evaluation training in other subjects, in which self-evaluation has been shown to improve with training (e.g., Ross et al., 2002). Hewitt proposed several possible causes for the lack of improvement observed, including the duration of the training period and the number of areas of evaluation that participants were asked to assess. Although training on evaluation focused on only one or two areas at a time, student evaluations during assessment focused on all seven aspects of performance at once. Hewitt suggests that investigating self-evaluation in only one or two areas of music performance, such as rhythm and melody, may be more productive.

This possibility is supported by findings related to working memory and problem solving (Johnstone & El-Banna, 1986; Solaz-Portolés & Sanjosé-López, 2009; Tsaparlis & Angelopoulos, 2000). Problem solving often involves a high volume of attention and may exceed working memory capacity. Even a component skill of problem solving such as evaluation requires the sifting and selection of stimuli while considering knowledge and goals. Hewitt may be correct that learners were not capable of evaluating multiple aspects of a musical performance at once, but may achieve more success by attending instead to limited, specified performance goals for evaluation.

Additionally, training in other problem-solving component skills could impact self-evaluation capabilities. During Hewitt's (2011) investigation, self-evaluation was considered in isolation, without assessing learners' abilities in components of problem solving and their impact on learners' ability to evaluate performance. If problem-solving components are interactive, as several studies illustrate (Buijs et al., 2009; Lee et al., 2012; Hill-Briggs, 2003; Kotsopoulos & Lee, 2012; McCarty et al., 1999; K. C. Moore & Carlson, 2012; Tsai et al., 2012), it is possible that capability in these other components of problem solving may affect capability in evaluation. For example, learners' ability to evaluate performance may be affected by their focus of attention (i.e., the goals they seek), their ability to apply domain-specific knowledge, or their ability to discriminate among performance options. Further investigation is needed to reveal the effect of these skills on music evaluation.

Training expressive performance through problem solving

Broomhead (2009) investigated the effects of problem-solving opportunities on a choir's expressive performance and found that learners could be trained successfully in a problem-solving task. Training encompassed self-evaluation, decision-making, and evaluating.

Participants were trained on two different types of musical material. One involved excerpts from repertoire from rehearsals; the other was a hymn familiar to the group that had not been rehearsed. Training took place during seven rehearsals of the full choir. Choir members were invited to plan how they would perform target melodies in relation to their knowledge of speech inflection, and then tried out their plans with the full choir. The teacher imitated the choir's interpretation with his own voice, providing additional feedback about the effects of the choir's decisions, and invited them to plan again. The choir then sang their second version, after which the teacher provided further feedback describing the differences between the two renditions of the melody.

The components of problem solving that are identified in studies mentioned earlier (Buijs et al., 2009; Lee et al., 2012; Hill-Briggs & Gemmell, 2007; McCarty et al., 1999) are reflected in the training procedures used in Broomhead's (2009) study. A goal was established: to sing a melody and communicate its verbal meaning. The learners were directed to draw principles from their own understanding of verbal inflection and apply them to vocal inflection in singing. Learners were given the opportunity to evaluate the instructor's imitative performance, then make further decisions based on the evaluations learners had made.

Participants were tested individually, four times over the course of a semester. The training took place between the second and third tests. Learners' inflection and phrase shaping showed the greatest improvement immediately after training. Overall expressiveness, however, did not improve significantly.

Consider the factors affecting learners' ability to solve problems. First, training included applying principles that had been strongly established through learners' previous experiences. As part of training that aimed to increase musical expressiveness, Broomhead instructed learners to apply their understanding of verbal inflection to musical phrasing. Learners had experienced verbal inflection daily, throughout their lives; they had a strong knowledge base from which to draw.

Also, Broomhead (2009) included a reconstruction model imitating learners' performance, including both sung and spoken imitations of the inflection learners used, possibly assisting learners with discriminating between performances, and facilitating learners' evaluation of their own performances. Each training session also included feedback comparing the two learner performances. It is possible that this part of the training promoted learners' problem solving to create expressive performance.

Broomhead's training method is an example of scaffolded problem solving: a teacher guiding learners in their own decision-making as to how to communicate musically by applying what learners already knew about verbal inflection.

Because participants were not tested on novel material, it is impossible to know whether they were capable of generalizing what they had learned to melodies that had not been practiced with the full group. Further investigation is required to fully explain how best to facilitate learners' independent problem solving regarding musical decisions.

Further investigation recommended

Many questions remain as to the means of developing the problem solving skills that enable independence in music learners. Given the critical role of problem solving in musical development, the teacher's role in assisting the development of problem-solving capability in learners is worthy of exploration.

The role of music teachers in developing learners' problem solving capabilities has not been investigated systematically. A few authors have commented on the subject (Ali 2010; Byrne 2005), but no substantial line of research exists that explores the relationship between teacher behavior and learners' active involvement in problem solving in music. Considering its importance and the dearth of literature on the subject, the nature of problem solving in music teaching and learning demands examination.

Chapter 3

Development of a Framework for Describing Problem Solving: A Model for Analysis

The purposes of the present study were to develop a model that describes the components of problem solving in music, and then to apply that model to analyze the involvement of teachers and students in the process of problem solving during lessons and rehearsals. As mentioned in Chapter 1, a primary measure of teacher effectiveness is the extent to which students accomplish proximal performance goals (targets), and analyses of the behaviors involved in accomplishing targets are facilitated by observations of rehearsal frames, defined intervals of instructional time devoted to identifiable proximal goals (Duke, 1999).

I was particularly interested in determining the relative contributions of teachers and learners in deriving solutions to problems. In order to conduct such an evaluation of teacher and learner involvement in problem solving, it was necessary to understand the components of effecting change; that is, the components of the process of problem solving. The first objective of this study was to develop a meaningful description of the problem-solving process by analyzing problem solving during teacher-student interactions during one-to-one instruction. The second objective was to apply the description in identifying teacher and learner contributions to the formulation of solutions to identifiable problems.

PARTICIPANTS

Teacher participants were selected through participation in the Butler School of Music's Center for Music Learning Distinguished Teachers Series at The University of

Texas at Austin. The Center for Music Learning website ("Distinguished Teachers Series") describes this series as follows:

> Each year the Center for Music Learning hosts 3-5-day residencies by internationally recognized artist-teachers. The individuals selected as Distinguished Teachers represent the very finest musicians who have dedicated themselves to teaching music. The diversity of the Distinguished Teachers selected—performing artists, private teachers, public school teachers, college faculty—reflects the Center's working philosophy that there are common principles that underlie all music teaching and learning, irrespective of instrument, genre, culture, and age and experience of the learner. It is this set of common principles that the Distinguished Teacher Series serves to illuminate.

From this pool of distinguished teachers, five teachers were selected based on high quality video and variety in instrumental expertise: Joseph Alessi (Professor of Trombone at The Juilliard School), Stephen Clapp (Professor of Violin at The Juilliard School), Richard Killmer (Professor of Oboe at Eastman School of Music), Donald McInnes (Professor of Viola at The University of Southern California), and Nelita True (Professor of Piano at Eastman School of Music). Their biographies are presented below.

Joseph Alessi is currently on the faculty of The Juilliard School; his students now occupy posts with many major symphony orchestras in the U.S. and internationally. As a clinician for the Edwards Instrument Co., he has also given master classes throughout the world and has toured Europe extensively as a master teacher and recitalist. Mr. Alessi was appointed Principal Trombone of the New York Philharmonic in the spring of 1985. He was a soloist with the San Francisco Symphony before continuing his musical training at Philadelphia's Curtis Institute of Music. Prior to joining the Philharmonic, Mr. Alessi was second trombone of The Philadelphia Orchestra for four seasons, and principal trombone of LÃ-Orchestre symphonique de Montreal for one season. In addition, he has performed as guest principal trombonist with the London Symphony Orchestra in Carnegie Hall led by Pierre Boulez. Mr. Alessi has also participated in numerous festivals, including the Festivale Musica di Camera in Protogruaro, Italy; Cabrillo Music Festival; Swiss Brass Week; and Lieksa Brass Week in Finland. He was featured in the 1997 International Trombone Festival in Feldkirch, Austria, and the International Meeting of Brass Instruments in Lille, France. He is a founding member of the Summit Brass ensemble at the Rafael Mendez Brass Institute in Tempe, Arizona. In 2002 Mr. Alessi was awarded an International Trombone Association Award for his contributions to the world of trombone music and trombone playing. Further information about Mr. Alessi can be found on his website, www.slidearea.com.

Stephen Clapp, Dean Emeritus of The Juilliard School, has held several posts at institutions of higher education in the performing arts and enjoys an extensive performing career as a violinist. As Associate Dean of Juilliard from 1991 to 1994, Dean Clapp supervised all orchestral and chamber music activities at the School; he has been a member of the violin and chamber music faculties since 1987. He has served ably in many policy and curriculum-related positions at Juilliard, including the Admissions, Financial Aid, Vocal Arts Executive, and DMA Governance committees; Faculty and Administrative Councils; and the Committee on Scholastic Standing. Dean Clapp has been a member of the President's Senior Staff since 1991. He also has served as Dean of the Aspen Music Festival and School, and Acting Dean of the Oberlin Conservatory. A deeply committed teacher of talented young performing artists, Dean Clapp continues teaching violin at Juilliard. He began his teaching career at The Juilliard School Preparatory Division (now called the Pre-College) in 1962, while earning his master of science degree from Juilliard. Subsequent teaching affiliations were with Aspen Music School, Peabody College in Nashville, The University of Texas at Austin, and the Oberlin College Conservatory of Music. His musical education includes studies with Dorothy DeLay and Ivan Galamian at Juilliard; with Andor Toth at the Oberlin Conservatory, where he earned his bachelor of music degree; and at the Mozarteum Akademie in Salzburg, Austria.

Richard Killmer, Professor of Oboe at the Eastman School of Music, was the recipient of the Eisenhart Award for Excellence in Teaching. His performing career includes principal oboe positions in the St. Paul Chamber Orchestra, the Aspen Festival Orchestra, the Lake Placid Sinfonietta, the Oklahoma City Symphony, and the NORAD Band, United States Army. He is a founding member of the American Reed Trio. His academic experience includes public school teaching as Director of Orchestras, Longmont (CO) Public School System and university faculty positions at the University of Oklahoma, Oklahoma City University, Central State University, Macalester College, Hamline University, Eastman, and Yale.

Donald McInnes, Professor of Strings at the University of Southern California, holds the position formerly held by his teacher, William Primrose. Professor McInnes is renowned for his performances with major orchestras, in recitals, chamber music, and master classes, and as a resident member of the Camerata Pacifica Chamber Music Ensemble. He has appeared with the New York Philharmonic, Boston Symphony, Orchestre Nationale de France, Pittsburgh Symphony, Zurich Chamber Orchestra, CBC Radio Orchestra, and Toronto Symphony, among many others. His career includes close associations with such artists as Leonard Bernstein, Yehudi Menuhin, Janos Starker, Martin Katz, Menahem Pressler, Yo-Yo Ma, and Brooks Smith. Professor McInnes is an active recording artist who can be heard on Columbia, RCA, Deutsche Grammaphone, and Angel (EMI) recordings. He has introduced many new works for viola including those commissioned for him by such composers as William Schuman, Vincent Persichetti, Paul Tufts, and Robert Suderburg. He regularly appears at leading summer music festivals in North America and abroad such as Banff, Marlboro, Gstaad, Ambler, International String Workshop, and the Music Academy of the West. His students have received the first prize at the Lionel Tertis International Viola Competition, the Friday Morning Musical Club National Competition at the Kennedy Center in Washington, DC, and the CBC National Competition in Vancouver, BC.

Nelita True, Professor of Piano at the Eastman School of Music, gave her New York debut with Juilliard Orchestra in Avery Fisher Hall. Since that time, she has appeared as soloist with Chicago, Baltimore, and National Symphony Orchestras and with orchestras throughout Europe. She has recorded over 100 works, and she gives recitals, master classes, and lectures throughout North America, Europe, Asia, South America, and Australia. She was the first American invited to be visiting professor at a conservatory in the former Soviet Union (Leningrad Conservatory). Many of her students are prizewinners in national and international piano competitions, and she has served as an adjudicator for the Gina Bachauer and William Kappell International Piano Competitions, Concours de Musique du Canada, Queen Sonja International Competition in Norway, the First China International Piano Competition, and many others. Her academic experience includes faculty positions at the Interlochen Music Camp, the University of Kansas, the University of Maryland, where she held the title, Distinguished Scholar-Teacher, and Eastman.

Student participants were those regularly receiving instruction within these teachers' studios and with whom teachers had already established an ongoing relationship. Students were selected to represent variety in age and educational experience. These included adolescents (5 total: 2 with McInnes and 3 with Clapp), and college-aged students (43, including those in chamber rehearsals).

The artist-teachers consented to videotaping their lessons in their regular teaching environments, on location at their respective schools and with their own students. Lessons were videotaped by various doctoral students from the Butler School of Music within the year following these teachers' residencies at The University of Texas at Austin: Nelita True (2002), Richard Killmer (2003), Donald McInnes (2003), Stephen Clapp (2008), and Joseph Alessi (2010). Lessons occurring within each teacher's studio were videotaped within a few days of one another. Each recorded lesson was with a different student. A description of student and teacher characteristics is given in Table 5.

Much of the video footage used in this study has been analyzed in previous research (Duke & Chapman, 2011; Duke & Simmons, 2006). Using the recordings from lessons with Killmer, McInnes, and True, Duke and Simmons (2006) observed 19 characteristics these three teachers held in common. Duke and Chapman (2011) confirmed the same 19 characteristics in the teaching of Stephen Clapp.

Table 5

Characteristics of Teachers

Artist-Teacher	Instrument	Place of appointment	Number of lessons/ Rehearsals	Students' educational experience	Year videotaped
Joseph Alessi	Trombone	Juilliard School	4	college	2010
Stephen Clapp	Violin	Juilliard School	13	3 adolescents 10 college	2008
Richard Killmer	Oboe	Eastman	8	college	2003
Donald McInnes	Viola	University of Southern California	10	2 adolescents 8 college	2003
Nelita True	Piano	Eastman	8	college	2002

I viewed recordings from 43 lessons: Joseph Alessi (4 lessons), Stephen Clapp (12 lessons and 1 string quartet rehearsal), Richard Killmer (7 lessons and 1 trio rehearsal), Donald McInnes (10 lessons), and Nelita True (8 lessons). To develop and confirm the present description of problem solving, I viewed a total of 30 of these lessons in their entirety, 11 of which I watched multiple (2-4) times. Further, I extracted and analyzed 161 rehearsal frames from the 43 lessons. I viewed each rehearsal frame 3-10 times.

DEVELOPMENT OF THE MODEL

I began with unstructured observations of these five teachers teaching individual lessons with their own students. I identified moments in which positive changes occurred in learners' playing, and I extracted rehearsal frames surrounding each of these positive changes. I then examined observable behaviors leading to each discernible change in students' playing and categorized them according to their function.

Preliminary analysis of full-length lessons

At the outset, I observed 13 lessons with Stephen Clapp and his students, seeking to identify ways in which he prepared learners to be successful in their independent practice. As I watched, I recorded notes as to the changes that were sought and achieved in learners' playing, and how those changes came about. I also noted teacher and learner involvement in problem solving. I asked questions such as, "Who is solving the problem in this instance, the teacher or the learner?"

I analyzed 6 of these lessons systematically using observation templates I designed with Scribe observation software (Duke & Stammen, 2011). In these preliminary analyses I recorded the frequency, timing, and duration of various teacher and learner behaviors. These behaviors included verbal directing of attention to learning targets, learners' successful and unsuccessful performances, questions asked by the teacher and learners, and learners stopping to fix a problem. I also observed these behaviors in relation to one another.

As patterns emerged, I adjusted the analysis based on those patterns. For example, I initially sought to identify moments in which learners solved problems, but as I observed I noticed that sometimes learners stopped themselves to solve problems, while other times the teacher stopped learners but allowed learners to make decisions to solve problems. In both cases learners were involved in problem solving, but I observed differences in who initially directed attention to problems. Because of this observation, I changed my analysis framework to observe not only whether teacher or learner solved a problem, but also to observe whether teacher or learner first established the pursuit of the goal. As my analysis continued in this way, other components of problem solving emerged as differentiable behaviors that were performed by either teacher or student.

Analysis of rehearsal frames

In addition to viewing full-length lessons as described above, I also identified rehearsal frames, periods of time dedicated to the accomplishment of specific targets. These rehearsal frames made it possible to observe and compare the problem-solving process based on the pursuit of identified musical goals rather than over the course of full lessons. The aim of this part of the analysis was to find components of problem solving common between every rehearsal frame regardless of the specific musical goal sought.

Selection of rehearsal frames

From these 43 lessons with these 5 teachers, I selected a total of 161 rehearsal frames. Rehearsal frames were identified through the following method: (1) I identified instances in which there was a discernible positive change in the learner's performance. Most of the time, these changes were both observable to me and recognized by the teacher. In a few instances, changes were difficult to observe but acknowledged by the teacher; others were not explicitly acknowledged by the teacher, but clear to me as I watched and listened to learners' performances. (2) When such a change was observed, I determined the moment at which that change was first sought—the moment in which a goal was first identified. (3) I isolated the period during which this identifiable goal was pursued, from just prior to the occurrence of the problem and the direction of attention to the goal, until attention was directed away from that goal. Duration of rehearsal frames ranged between 10 seconds and 4 minutes, 29 seconds.

72 of these rehearsal frames had been selected from 26 of the lessons (those with Killmer, McInnes, and True) for a previously-published study (Duke & Simmons, 2006). These rehearsal frames were included in the 161 rehearsal frames I analyzed. Although these rehearsal frames had been selected previously, I analyzed them for a purpose separate from that for which they were originally selected, and my analysis is independent of that by Duke and Simmons (2006).

These 161 rehearsal frames represent approximately 5-15 minutes from each lesson, approximately 10-25% of each lesson's total time (lessons were approximately 50-60 minutes in duration). Rehearsal frames were not selected randomly. I included two types of rehearsal frames in my analysis: those in which learner involvement in problem solving was apparent, and those in which the teacher was primarily responsible for problem solving. The majority of rehearsal frames (138) included instances in which the learner was somehow involved in the process of effecting change. These rehearsal frames enabled me to analyze how learners were involved and how teachers may have encouraged their involvement in problem solving. As a point of comparison, I also included 23 rehearsal frames in which there was apparently little or no learner involvement in problem solving.

SYSTEMATIC DESCRIPTION OF THE COMPONENTS OF PROBLEM SOLVING

After examining the recordings using methods described above, I arrived at the following framework for describing the component skills involved in problem solving in music:

Establish goal(s)

> Direct attention and action to accomplish desired ends. A goal is established when it is identified and intent toward the goal is evident through actions and verbalizations.

Evaluate performance

> Determine the extent to which goals have been met. Evaluations include non-specific value statements such as "good" or "ouch," or value statements specifically referencing the goal such as "the tone is not good." Non-verbal behaviors, such as a nod, a moan, or a grimace, may express evaluations. Evaluations may also be inferred through actions that indicate a learner or teacher is pursuing a goal that is not yet met; for example, a learner may stop and repeat a note several times, differently; or a teacher may stop the student and have them repeat a passage.

Conceive and consider options

> Create and/or consider multiple possibilities that may lead to the accomplishment of a goal, or consider the selection of alternative goals. This also includes making discriminations among possibilities. Teachers or learners may *demonstrate* possibilities in sound, fingering, position, etc.; or they may *verbalize* one or more possibilities in sound, fingering, position, etc.

Generalize and apply principles

Generalize principles: Formulate and connect knowledge to be applied over many situations by analyzing movement or music, therefore guiding further analyses and decisions toward the successful accomplishment of goals.

Apply principles: Use existing knowledge to analyze movement, guide or explain evaluations, and make decisions.

Principle statements often contain a cause-effect relationship, connecting actions with goals: "If you [do this], then [this will happen]." Or, they explain how or why results occur: "[this did/didn't happen] because [you did/didn't do this]." Principle statements may contain words indicating the generally applicable nature of the knowledge within a context, such as "the articulation in Mozart…"

Decide and act

Select from among possible options those that will be implemented to accomplish desired ends. Teachers express a decision through giving a directive—an instruction to take a certain course of action, or they may model a musical decision. Of course, during music instruction, a teacher's directive is a plan of action that the learner must implement. For the purpose of this study, teacher directives are considered decisions. Learners make decisions when they express intended action or direct their own actions, most often seen as changes in their performances.

Examples of problem solving

The following five examples serve as a representation of the problem-solving process as observed in each of the five teachers. In each sample rehearsal frame below, one from each teacher I analyzed, every problem solving component is outwardly observable. These examples illustrate instances in which teachers are the primary directors of the solution to a problem.

Transcript of Action	PS Behavior
"It's good except for one thing. The tone is too thin.	GOAL EVALUATE
"You won't be heard… It's not just a matter of what you can do it's a matter of style."	PRINCIPLE
McInnes plays, demonstrating big tone, then weak tone. "Out there that would sound like…"	OPTIONS PRINCIPLE EVALUATE
He demonstrates an even smaller sound. *He demonstrates a longer passage with the big tone he has in mind.*	 OPTIONS
"Mine sounds better. Right?"	EVALUATE
"Why? … Because I have much more energy [in the bow], more weight, faster bow speeds, and I don't stop my vibrato. You start this all by yourself; the orchestra doesn't come in until here."	PRINCIPLE
"You can't produce that type of sound. It sounds… You know the word we use, 'puny'? You can't play with a puny tone. You can produce a beautiful sound."	EVALUATE GOAL

Rehearsal Frame 1: Problem solving by Donald McInnes

Transcript of Action	PS Behavior
The student plays.	
"Get your money's worth out of that D.	GOAL
The student plays.	DECISION
He sings it two ways.	OPTIONS
"Absolutely connect."	GOAL
The student plays.	DECISION
"The staccato of the D before the last bar – you isolate it, and it doesn't go where it's supposed to go. It stops at the bar line.	EVALUATE PRINCIPLE
"So, make sure the D goes to the C. There again, don't make it so short.	DECISION GOAL
"I think incidental staccato, which is on your way, or isolated staccato, which is actually separate, and vertical	OPTIONS PRINCIPLE
and this is definitely incidental, and not isolated."	DECISION

Rehearsal Frame 2: Problem solving by Richard Killmer

Transcript of Action	PS Behavior
True: "Now he says *violento*, which means…"	
Student: "Violent."	GOAL
True: "Violent. And you're so nice."	EVALUATE
True demonstrates both "nice" and "violent" sound.	OPTION
Student: "Do I need to be aware of the balance here?"	GOAL
True: "Yes, you always have to be aware of the balance."	PRINCIPLE
The student plays.	
"Now, Ok, you're too good because what I'm not getting	EVALUATE
is the dissonance."	GOAL
True demonstrates.	OPTIONS
The student plays differently.	DECISION
"It seems to me that since he's got 8th notes here [demonstrates] and then quarter notes,	PRINCIPLE
that they'd have a different sound	DECISION
so it isn't just" [demonstrates]	OPTIONS
The student plays differently.	DECISION

Rehearsal Frame 3: Problem solving by Nelita True

Transcript of Action	PS Behavior
Alessi stops the student's playing.	EVALUATE
Student: "Yeah, those first two notes…"	EVALUATE
Alessi: "Yeah, they lack any meat	GOAL EVALUATE
because you're tight with the air stream.	PRINCIPLE
So," *Alessi plays*	OPTIONS
The student plays.	DECISION
"Yeah – that's the idea.	EVALUATE
Try to get more of that.	DECISION GOAL
If you practice with no tongue, you will get really good at that."	PRINCIPLE

Rehearsal Frame 4: Problem solving by Joseph Alessi

Transcript of Action	PS Behavior
The student attempts a shift	GOAL
Clapp: "K. Not quite there.	EVALUATE
You're kind of rounding your finger and you end up a half step flat.	PRINCIPLE EVALUATE
Keep the finger straight until you get there."	OPTIONS DECISION
The student plays again, as directed	
"Perfect!"	EVALUATE
"So that tells you that in motion your finger is going to go from kinda like this to kinda like this" (*he demonstrates*).	PRINCIPLE OPTIONS

Rehearsal Frame 5: Problem solving by Stephen Clapp

Observations of problem solving components

In this section I further explain each of these component and their critical and interactive nature during problem solving. I also provide epitomic examples of each of the components as they occur within rehearsal frames, including examples when learners encountered difficulty with problem solving because they lacked capability with one or more of these components.

Establish goals

In every situation in which I observed improved performance, the teacher and/or learner pursued an identifiable goal or goals. Teachers pursued goals in target categories already mentioned in literature cited in Chapter 2, such as tone, intonation, technique, or rhythm. Additionally, teachers usually connected these goals with goals of musical interpretation and communication. Killmer's discussion above about articulation, for example, was not just about articulation; he focused on getting the right articulation for the musical phrase. In this situation, articulation functioned as a subgoal that enabled the musical goal. This is frequently the case in the teachers I observed; subgoals and goals were consistently connected.

Both learner- and teacher-initiated goal pursuit were observed in these lessons. Learners directed their own attention deliberately toward goals, or teachers directed learners' attention toward goals through directives and feedback. For example, I observed directives such as "make a bigger sound," directing the learner to pursue the goal of tone production. Directives and questions that initiated goal pursuit included the following:

"Let's connect it with air."

"Really release that."

"Play a full quarter."

“Let’s get the sound back… get that richness back.”

“Pedal please.”

“Can that just roar?”

“Get your elbow up at the frog.”

“How are you grouping these chords?”

“Get to the tip of the reed.”

“Oo. More oo.”

“Get to 5th position in the beginning of the measure.”

“Let’s just have plain rhythm.”

“Be careful of the quality of the sound.”

“Look at your fingers.”

“What are you thinking of here in terms of character?”

“Think insects.”

Teachers also gave specific feedback that referenced the goal indirectly through evaluations. I observed teachers giving feedback such as “the tempo is too fast,” directing attention to the goal of appropriate tempo.

I also observed learners independently seeking goals; for example, they asked questions, verbalized their goals, or stopped to correct themselves without teacher intervention. For example, learners verbally expressed the following goals:

“I want [ed]…no edge to the sound.”

“I didn’t take a breath there, did I?”

In rehearsal frames in which positive change occurred, goal pursuit directed all the other problem solving behaviors I identified. Evaluations were made as to whether goals were achieved. Knowledge was called up based on goal pursuit. Options were considered relative to goals. Decisions were made based on goals sought. The goal that was pursued was therefore critical to problem solving.

Learners' difficulties in identifying and attending to the paramount goals in a situation led to difficulties solving problems (see the following rehearsal frames in the Appendix: Options2-True, FeedbackS1-Killmer, LearnerChoice2-True, Principle6-McInnes, DirectiveO1-Clapp).[1] For example, the example above involving Nelita True and her student pursuing a "violent" sound epitomizes the effect of goal pursuit on other problem-solving behaviors. The learner had in her mind the goal of balance, and so she had called up principles of balancing melody and harmony and made decisions in regard to which notes to bring out. True, however, had a different goal in mind: the dissonance that creates the violent sound. Based on that goal and the principles involved in bringing out the dissonance for a violent sound, True, and eventually the learner, decided on a different balance than that heard in the learner's original performance. A change in the goal affected the evaluation of options and consideration of principles that informed the decision.

Evaluate performance

In rehearsal frames in which change occurred, teachers or students were observed evaluating performance. Teachers communicated evaluations of student performances by providing verbal and nonverbal feedback. Some teacher evaluations were specific as to the goals evaluated, such as,

"Your tempo is too fast."

"The C is still sharp."

[1] Transcripts of rehearsal frames found in the Appendix are labeled according to their categorizations of teacher behaviors as described in Chapter 4.

“That’s too heavy.”

“That’s the tone. That’s just fabulous… That’s the control.”

Other teacher evaluations were less specific, such as the following:

“Good”

“Yes”

“No”

“Ouch”

“That’s not what it says”

A grimace

A nod

I categorized all of the above as nonspecific evaluations. Simply stopping the student often implied a negative evaluation and identification of an error, as understood by what preceded and followed the stop.

In addition to evaluations made by teachers, I also observed learners evaluating themselves. Occasionally learners verbalized evaluations specifically. The following are examples of evaluations verbalized by learners:

“I always felt like I accented that last note.”

“I like the sound. I didn’t like the D.”

“I could have been a little more decisive.”

“The F is flat.”

“The intonation’s not good.”

“My natural slurs aren’t smooth at all.”

“[my fingers] are staying close.”

Because learners did not often verbalize their thinking, I made inferences at times, based on their actions. Learners were seen evaluating as evidenced by behaviors such as stopping to correct or gesturing or making sounds like a grunt of frustration.

Learners struggled with evaluating at times (DirectiveO2-McInnes, Options7-Clapp, LearnerChoice4-True, FeedbackO1-Alessi). In these examples, learners struggled to differentiate between sounds, or were not listening carefully to evaluate the sounds they made. As a result, learners did not solve problems because they did not discern the problems that were present. In an epitomic example, one of McInnes's students had difficulty correcting pitch; she repeatedly played an interval incorrectly, even after receiving specific negative feedback. McInnes finally directed the pianist to play it for her, at which point she was able to adjust pitch correctly. Once she could discriminate between sounds, she evaluated that she had not accomplished the goal of accurate intonation; there was a problem to be solved.

Conceive and consider options

Both teachers and students demonstrated awareness of more than one option for performance. Teachers frequently described or demonstrated available options rather than giving only one directive, as in the following examples:

> "How are you grouping these chords? Are you going [*demonstrates*]? You could also do [*demonstrates a different option*]."
> (Options3-True)

> "Now, you and I approach that completely differently. You did [*demonstrates*] and I went [*demonstrates*]."
> (Options8-True)

> “So that tells you that in motion your finger is going to go from kinda like this to kinda like this [*demonstrates*].”
> (Options1-Clapp)

> “Those notes sound accented. Right here [*demonstrates an exaggeratedly accented sound*].”
> *Alessi demonstrates unaccented, correctly.*
> (Options6-Alessi)

Learners also demonstrated various ways of playing passages; they demonstrated possibilities for articulation, interpretation, and technique, sometimes in response to teacher direction, as below:

> “If you try to make it too chirpy, it just doesn’t work.
> Do it once, just chirpy.”
> *The student plays “chirpy.”*
> “Now put the bow back on the string.”
> *The student plays longer.*
> (Options9-Killmer)

Teachers also called attention to differences between learners’ performances. They used learners’ own performances as means of comparison:

> “Now let’s get the sound back though. ‘Cause I liked the sound you were doing in the etude, just a second ago. I’d like to get that richness back.”
> (Options5-Alessi)

Learners demonstrated difficulty with solving problems when they were not aware of possible options in sound or body movement that could accomplish goals (Options4-True, Principle4-Clapp, Options1-Clapp, LearnerChoice2-McInnes). For example, one of Clapp’s students had difficulty shifting accurately because he had not considered changing his hand shape (Principle4-Clapp). In this example, the student played a shift inaccurately, stopped himself, and attempted several times to correct the shift, demonstrating that he had detected a problem and intended to correct it. He was not able to effect positive change, however, until Clapp demonstrated for him another possibility in hand shape. After he was made aware of this possibility, the learner could shift accurately. This learner pursued a goal and evaluated accurately, but he was not able to solve the problem until a viable option leading to the solution had been presented to him. If learners are unaware of options that lead to solutions, they struggle to solve problems.

Generalize and apply principles

There were numerous instances in which teachers intended to facilitate change not only in learners' behavior but also in their thinking. This was evidenced by the many situations in which teachers directed learners' attention to general knowledge rather than providing only specific prescriptive directives. These instances found teachers and/or students generalizing principles, calling attention to similarities or differences between situations, thinking out loud, explaining why, analyzing how, and engaging in similar efforts to connect knowledge in general ways. These teachers were interested in learners' gaining general knowledge from specific situations, thus making it possible for learners to change their own behavior in the future.

Teachers often explicitly stated principles for students as gleaned from the present situation. This sometimes occurred after providing a prescriptive solution to a problem. Having already identified the issue, evaluated, diagnosed, and prescribed the appropriate solution, they then followed up with a general statement of principle, sometimes preceded by the connecting word "so…" or "therefore…" In these situations the teacher directed everything to reach the solution to problems, but they did not stop at the solution; they called attention to the generalized principle to be applied in other situations.

Both types of transfer mentioned above occurred frequently in the teaching observed: teachers and learners sought to generalize principles from the current situation for future use, and teachers and learners drew from general principles to apply them to the current situation, making it possible to diagnose the cause of problems.

Statements identified as principles often included knowledge as to the consequences of actions, often "the effect of physical motion on sound" (Duke & Simmons, 2006), connecting actions with goals: "If you [do this], then [this will happen]," as in, "Now sometimes you're pushing the body away, which…takes the weight of the body out of the sound" (True). Or, they explain how or why results occur: "[this did/didn't happen] because [you did/didn't do this]." These examples demonstrate the relationship between goals and the options (subgoals) leading to goals:

> "Why [does mine sound better]? Because I have much more energy [in the bow], more weight, faster bow speeds, and I don't stop my vibrato."
> (Principle1-McInnes)
>
> "The chords in Bach should enhance the beauty or direction of the phrase, rather than get in the way of it."
> (Refrain1-McInnes)
>
> "I think there's a very good reason for keeping the staccato that way because it really makes a nice line out of it."
> (Options9-Killmer)
>
> Alessi: "Do you know why the pitch is off?"
> Student: "Is it because I'm not holding [*gestures the slide*]?"
> Alessi: "Yes. It's because you're not holding the slide. You're just kind of bouncing around. …I know exactly where the pitches are because I do this for everything [*gestures holding the slide*]."
> (QuestionP1-Alessi)

In other instances teachers communicated generalizations less overtly. Although they did not state principles explicitly for learners, they revealed their own thinking. In this way they drew attention to general knowledge and its application. For example, teachers explained why they performed a passage a certain way, or what led them to concern themselves with one goal above another, or how they came to their diagnosis of a technical problem. By giving learners a window into their own thought processes, teachers provided learners opportunities to observe principles at work in the problem solving teachers do to effect change. Often teachers coupled these verbalized analyses with demonstrations of the options being considered; they modeled performance possibilities, including imitations of learners' performances, and verbalized their analysis of the differences.

Learners rarely verbalized principles that guided their thinking and actions, unless they were invited to do so. The teachers usually invited learners to state principles by asking them questions. For example, Alessi asked a learner, "Do you know why the pitch is off?" The learner answered, "Is it because I'm not holding [gestures the slide]?" "Yes!" Alessi answered (QuestionP1-Alessi).

Learners sometimes answered these questions incorrectly, demonstrating that they lacked understanding of the pertinent principles that would guide their evaluations and decisions. For example, I observed two of Clapp's students on separate occasions struggle with shifting due to wrist movements that caused inaccuracy (QuestionP2-Clapp, QuestionP3-Clapp). Clapp asked both of these students, "Where does the shift come from?" Both of them responded, "the wrist." He demonstrated correctly for both of them so they could see what really happened with the arm during accurate shifting. One of them answered, "Oh, the elbow" (QuestionP3-Clapp). She quickly changed her arm movement and shifted accurately. When she gained understanding as to the arm movement that led to precise intonation, she was able to solve the problem.

Decide and act

Both teachers and students were observed making decisions. Moments of decision involved the planning or executing of behavior. In this analysis I determined that a decision had been made when there was a discernible change in the learner's performance, or a plan to make a change.

Teachers and students were observed making decisions after goals had been established, options considered, and evaluations made. In these situations most often it was apparent that there were principles applied to solve problems. Sometimes they were stated specifically; sometimes they were at work implicitly.

Examples of decisions follow:

> "Change the pedal when you get to [the top]." (DirectiveS1-True)
>
> "Try it without the tongue once… just take a breath and play with your air." (FeedbackS1-Killmer)
>
> "Get your elbow up at the frog." (DirectiveS2-McInnes)
>
> "Keep the finger straight until you get there." (Options1-Clapp)
>
> "Absolutely connect." (Principle2-McInnes)
>
> "Don't breathe there. …Try breathing here." [*He marks it*.]
> (Refrain2-Alessi)

Note that these all resemble specific directives that I discussed above under "establishing goals." Indeed, these are specific directives: subgoals that lead to the original superordinate goal. The process of problem solving involves exactly this: making decisions to pursue subgoals that accomplish desired outcomes (Willatts, 1999).

Students usually demonstrated their decisions by making changes in their performance. A few times they verbalized their decisions, such as, "I changed the fingering." A lesson with one of Alessi's students (QuestionE1-Alessi, QuestionE2-Alessi) demonstrated that learners may be capable of all of the above four component skills of problem solving—establishing goals, evaluating, considering options, and applying principles—and yet still lack the initiative to make decisions leading to solutions. In this lesson, Alessi and his student listened together to the learner's recorded audition while Alessi asked the learner a series of questions, such as, "What do you think about that?" The learner was able to identify paramount goals, evaluate his sound, and demonstrate his knowledge of options in hand movements and air use, and how these affected the resulting sounds. Yet, he had not made decisions to make positive changes in his performance. If learners fail to act, no changes are made, and problems are not solved. Decision-making is a critical component of problem solving.

APPLICATION OF THE MODEL TO DEFINE TEACHERS' AND LEARNERS' CONTRIBUTIONS TO PROBLEM SOLVING

The second purpose in the present study was to apply the model in analyzing the extent to which teachers and learners participated in problem solving in individual rehearsal frames. When I began this dissertation project I initially sought to determine how teachers increase learners' abilities to bring about changes in their own performance. I determined that learners' success could be measured in terms of their abilities to accomplish proximal performance goals, just as Duke (1999) recommended that teacher effectiveness would best be measured in terms of teachers' abilities to accomplish proximal performance goals. I found that organizing the observation of teaching and learning around the time devoted to accomplishing proximal performance goals afforded me the opportunity to identify the extent to which learners and teachers contribute to the solution of each problem (i.e., the accomplishment of each goal).

Observation procedure

I coded every behavior in the 161 rehearsal frames I had extracted. I also coded every behavior observed within 15 full-length lessons (3 lessons with each teacher) and 2 chamber music rehearsals (a string quartet rehearsal with Stephen Clapp and a trio rehearsal with Richard Killmer). The lessons and rehearsals were selected based on variety in age (two of Clapp's students and two of McInnes's students were adolescents; the others were college-aged, including graduate and undergraduate students) and preliminary impressions that they represented a variety in approach. The 2 chamber music rehearsals were the only footage I had obtained of full-length multi-student rehearsals with these five teachers. Scribe Version 4.2 observation software (Duke & Stammen, 2011) was used to collect data for all 15 full-length lessons and 2 chamber music rehearsals.

Behavior Codes

Teachers and learners were observed communicating verbally, communicating non-verbally, and performing. These behaviors were coded as follows:

Verbalizations

Almost every teacher verbalization was labeled as one of the above problem-solving component behaviors. The following exceptions were not labeled as problem-solving behaviors:

- Some teacher verbalizations were coded as teacher behaviors that influence learner problem solving behaviors (see the following chapter), but not as problem solving behaviors. For example, the question, "What do you think about that?" is a nonspecific evaluation question prompting learner evaluation; the question acts as a cue for the learner to problem-solve.
- Simple rehearsal sequence directives, such as, "start at measure 6," were not included in this analysis. Although the places where teachers or learners choose to begin and end are central to learners' success in problem solving, this was not the focus of the current analysis. I considered these decisions peripheral to my purposes in analyzing the *process* of musical problem solving.
- Teachers' restatements of learners' verbalizations or learners' restatements of teachers' verbalizations were not included (i.e., repeating what the other said).
- Chit-chat (off-task behavior) was not included. This usually occurred at the beginning or end of a lesson or during small breaks in the lessons, as also observed by Duke and Simmons (2006).
- A long story was usually not included in the analysis. In some cases stories were used to illustrate principles, in which cases they were coded as such.

Inferences based on non-verbal behaviors

One of the inherent challenges of analyzing problem solving is the sometimes unseen and implicit nature of the activity. Sometimes the components of problem solving behaviors are readily observable. At other times, the components are more ambiguous and less explicit, particularly during learner problem solving. Often, learners do not verbalize the cognitive activity directing their behavior as often as teachers verbalize their thinking when they direct learners' behaviors.

One feature of this analysis and the resulting framework is an allowance for making inferences based on observable behaviors and context. This strategy is not unlike that employed by McCarty, Clifton, and Collard (1999) and McCarty and Keen (2005) to investigate intentional behavior in non-verbal infants. As did they, I sometimes inferred learner problem solving based on evidence in the form of non-verbal behaviors. Further, I made inferences based on contextual understanding, rather than by considering behaviors in isolation. This flexibility in interpreting behaviors beyond what is explicitly observable is a necessary part of the analysis.

I assumed that all of the components outlined in the model are necessary for problem solving, and I also acknowledged that sometimes components are not directly observable and must be inferred. I decided *a priori* that when positive change in performance was observed, each problem-solving component had to have been executed by either teacher or learner, or both, in order for that change to have come about. With every rehearsal frame, I asked, "Is a goal established? When and by whom? Does an evaluation occur? When and by whom?" and so forth. If there was no observable indication that a particular problem-solving component occurred, I did not identify that component as part of the analysis of the rehearsal frame, because there was not enough evidence to justify its attribution to teacher or learner.

Non-verbal behaviors, therefore, provided evidence for inferred problem-solving components. For example, sometimes teachers non-verbally directed attention to goals or communicated decisions through gestures or touch (e.g., conducting a phrase or tempo, a gesture mimicking raising an instrument up higher, or a touch on the elbow to draw attention to a position). A grimace, a nod, and a moan were all coded as evaluations of performance when occurring during or directly after a performance. A learner stopping and repeating a note or passage was coded as evaluating and identifying a goal, when occurring within an apparently goal-driven context and accompanied by a subsequent change in the learner's performance.

As an example situation, when a teacher gave non-specific negative feedback without further information, and this was followed by a positive change in the learner's performance, I inferred that the learner evaluated her performance and identified a goal (evidenced by repeating a note or passage), considered a different option in sound or movement (as she demonstrated playing it two different ways), and made a decision (observed in the change of sound). This learner may also have drawn from previously-acquired knowledge that the teacher had not explicitly expressed; however, if a principle related to previous knowledge was not verbalized, I did not record Apply Principles, as there was no observable evidence from which an inference could be made.

Teacher and learner performances

Teacher and learner performances required explicit definitions. The following codes and definitions were applied to teacher and learner performances:

Teacher model—contrasting options

> The teacher performs or sings more than one way of producing sounds. There may or may not be an evaluation/decision additionally expressed. This behavior was labeled "demonstrate options."

Teacher model—negative example

> The teacher performs a passage purposefully wrong. The learner may further be invited to evaluate. This behavior was labeled "demonstrate options."

Teacher model—decision

The teacher performs the passage the way the teacher intends the learner to play it, with no other possibility expressed. This behavior was labeled "make decision."

Teacher model—showing the location of a target

Directing attention to a location in the passage or bringing out a particular aspect of the passage, without prescribing a decision. These were short, expressionless performances, similar to and often accompanied by a verbalization such as, "start at measure 6." This behavior was not labeled as a problem-solving behavior.

Learner performance—decision

The learner plays a passage differently than it was played previously, without the teacher providing a decision model or explicit directions as to how to attain the goal, and accomplishes the goal. These performances were labeled "make decision." Further, playing a note or passage again without receiving direction from teachers was labeled "evaluate" and/or "establish goal"; and playing a note or passage more than one way, without receiving information as to other options from the teacher, was labeled "demonstrate options."

Learner performance—unsuccessful decision

The learner plays a passage differently than it was played previously, without the teacher providing a decision model or explicit directions as to how to attain the goal, but is not successful in accomplishing the goal. These performances were labeled "make decision."

Learner performance—follow teacher directions

The learner performs as the teacher specifically directs, or imitates the model the teacher has provided. These performances were not labeled as problem-solving components.[2]

Learner performance—follow teacher directions unsuccessfully

The learner attempts to perform as the teacher directs, but does not succeed. These performances were not included within a category. Although an unsuccessful learner attempt to follow specific teacher directions may indicate that substantial problem solving is required of the learner, I did not attempt to describe the potential problem solving in such cases, for reasons similar to those stated in the paragraph above.

Learner extended performance

The learner plays a long segment or an entire piece without stopping. Although this is most likely a highly goal-driven activity, problem-solving is not usually apparent in this circumstance. These performances were not included in the analysis.

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[2] I acknowledge that some amount of problem solving is likely necessary when learners are trying to follow teacher directions, but these problem-solving behaviors are not usually observable. The problem solving required of learners when they attempt to follow directions or imitate a model depends, among other things, on the automaticity of the behavior (Aarts & Elliot, 2012; S. Brown & Bennett, 2002; T. L. Brown & Carr, 1989; Jancke, Shah, & Peters, 2000). I did not attempt to infer differences among varying degrees of problem solving that may be required of the learner when following specific directions; I did not see enough evidence to justify such an attempt. Further analysis of context, such as considering prior and subsequent successful or unsuccessful performances on the part of the learner, or a more controlled experimental environment may be in order to make that differentiation successfully, if indeed it is possible.

Reliability

Assessment of reliability was conducted as follows:

From the 161 total rehearsal frames, 35 rehearsal frames were chosen randomly (22% of rehearsal frames). Rehearsal frames were numbered 1 to 161. A random number list was generated for integers up to 161. I selected rehearsal frames that had been assigned numbers that were the same as the first 35 random numbers from the list.

I divided these 35 rehearsal frames randomly among 3 reliability observers. After a training period, each observer analyzed 10-13 rehearsal frames using the same method I had used.

I created a text version of each rehearsal frame, transcribing all verbalizations and describing all observable behaviors. Reliability observers were provided the following list of problem solving components, with definitions: establish goal, evaluate, consider options, state principle, make decision. Observers were also provided the list of behaviors presented above and the definitions of verbalizations, non-verbal behaviors, and teacher and learner performances, with directions as to whether to include each observation within a problem-solving category.

I explained each of these behaviors verbally and showed examples of each from rehearsal frames that were not included in the 35 rehearsal frames I selected for reliability purposes. Observers were trained in identifying each problem-solving component behavior within rehearsal frames by analyzing several practice rehearsal frames with me. After training, for each rehearsal frame, observers were first directed to label each line of text with any problem solving components they could identify from the list. They then watched the video for that rehearsal frame, adding to or changing any labels they had identified. Observers were allowed to watch the rehearsal frames as many times as they chose. After they labeled the problem-solving components, they labeled whether teacher or learner had performed each component.

Observers were directed to consider the stipulation that all of problem-solving components had been executed by either teacher or learner, or both, in order for a change to have come about. With every rehearsal frame, I instructed observers to ask, "Is a goal established? When and by whom? Does an evaluation occur? When and by whom?" and so forth. However, if observers did not see any observable indication that one or more particular problem-solving component behaviors occurred, they were instructed not to identify that behavior as part of the analysis of the rehearsal frame.

Reliability observers labeled 370 total problem-solving components within 35 rehearsal frames. Total observer responses agreed with mine in 322 of 370 total responses, or 87.0% agreement in 35 randomly selected rehearsal frames. Reliability between each individual observer and myself was as follows: Observer 1, 87.9 % (109 agreements in 124 responses); Observer 2, 83.1% (103 agreements in 124 responses); Observer 3, 90.2% (110 agreements in 122 responses).

Results

Frequency of problem solving behaviors across full-length lessons and rehearsals

Table 6 reports the average frequency of each of the problem-solving behaviors of teachers and students as I observed in 3 full-length lessons with each of the five teachers. Because lessons varied in duration (ranging from 40-60 minutes), I converted each frequency count to a rate per hour; each data point in the table represents the rate per hour of each component within each lesson.

Table 6

Rates per hour of teacher and student problem-solving behaviors within 15 lessons

	Lesson														
	A1	A2	A3	C1	C2	C3	K1	K2	K3	M1	M2	M3	T1	T2	T3
	Teacher PS														
Goal	55	65	78	73	72	62	65	77	85	51	42	41	75	71	63
Evaluation	62	75	88	96	41	67	74	104	75	57	42	45	86	27	74
Options	31	45	50	40	65	41	65	55	65	43	30	29	39	39	61
Principle	28	29	50	40	38	33	62	61	42	51	47	30	47	32	54
Decision	23	48	55	46	64	48	54	58	71	43	23	27	18	47	52
	Learner PS														
Goal	10	8	10	19	13	7	8	2	8	3	6	3	1	1	1
Evaluation	16	23	24	36	31	15	27	14	20	5	17	9	16	8	12
Options	12	16	14	32	22	11	11	12	13	2	9	3	9	4	24
Principle	3	0	5	4	4	2	5	2	1	3	8	2	5	3	3
Decision	37	49	49	46	24	21	35	32	32	9	17	6	58	23	42

Note. *A = Alessi, C = Clapp, K = Killmer, M = McInnes, T = True.*

I then averaged the each teacher's rate per hour across the three lessons in order to summarize the general tendencies of each teacher (Table 7). I also observed the same behaviors within two chamber music rehearsals. Rates per hour in the rehearsals are reported in Table 8.

The data show that all five problem-solving components were explicitly observable in every lesson. Components of problem solving controlled by the teachers occurred frequently, at a rate of approximately 1-2 per minute over the course of each lesson. Learners were also engaged in all of these components of problem solving, but not as frequently as teachers.

Table 7

Mean rates per hour of teacher and learner problem-solving behaviors within 15 lessons (3 lessons per teacher)

	Alessi	Clapp	Killmer	McInnes	True	**Mean**
			Teacher PS			
Goal	66	69	75	45	70	**65**
Evaluation	75	68	84	48	62	**68**
Options	42	49	61	34	46	**46**
Principle	36	37	55	43	44	**43**
Decision	42	53	61	31	39	**45**
			Learner PS			
Goal	9	13	6	4	1	**7**
Evaluation	21	27	20	10	12	**18**
Options	14	21	12	5	13	**13**
Principle	3	4	3	4	4	**3**
Decision	45	30	33	10	41	**32**

Through this analysis of 15 full-length lessons and 2 chamber music rehearsals, I determined that each of the components was present in every lesson, thus demonstrating their prominence in music learning. Aside from the exceptions described above, almost every teacher and learner behavior observed during lessons and rehearsals could be coded as one of these problem-solving components.

Though not every component was explicitly observable in every rehearsal frame, all were explicitly observable multiple times throughout the course of each lesson and rehearsal. Additionally, I observed many rehearsal frames in which every component was outwardly observable through verbalizations, performances, or nonverbal behaviors.

Table 8

Rates per hour of teacher and learner problem-solving behaviors within two chamber music rehearsals

	Killmer Trio	Clapp String Quartet
Teacher PS		
Goal	71	58
Evaluation	85	78
Options	33	32
Principle	36	25
Decision	68	32
Learner PS		
Goal	5	12
Evaluate	13	32
Options	5	20
Principle	3	10
Decision	17	42

Examples of combinations of teacher and learner problem-solving behaviors

In the transcripts that follow I illustrate various combinations of teacher and learner involvement in problem solving. Each rehearsal frame transcript identifies which component is attributable to which individual.

Transcript of Action	Teacher	Learner
The learner plays a passage with moving notes.		
Clapp: “Can you play any part of that from memory?		
Learner: “Yeah.”		
Clapp: “I want you to look at your fingers.”	GOAL	
The learner plays again and changes his behavior.		EVALUATE OPTION DECISION
Clapp: “Good!	EVALUATE	
“Do you know what you’re doing differently?”		
Learner: “They’re staying close.”		PRINCIPLE
Clapp: “They’re not flying.”	Confirm PRINCIPLE	

Rehearsal Frame 6: Problem solving by Stephen Clapp and his student

Transcript of Action	Teacher	Learner
The learner plays.		
Killmer: "Get your money's worth out of that D.	GOAL	
The learner plays.		
Killmer sings it two ways.	OPTIONS	
"Absolutely connect."	DECISION GOAL	
The learner plays.		
"The staccato of the D before the last bar – you isolate it, and it doesn't go where it's supposed to go. It stops at the bar line.	EVALUATE PRINCIPLE	
"So, make sure the D goes to the C. There again, don't make it so short.	DECISION GOAL	
"I think incidental staccato, which is on your way, or isolated staccato, which is actually separate, and vertical…	OPTIONS PRINCIPLE	
…and this is definitely incidental, and not isolated.	DECISION	

Rehearsal Frame 7: Problem solving by Richard Killmer and his student

Transcript of Action	Teacher	Learner
McInnes: "I think your tempo is a little too fast."	GOAL EVALUATE	
"On viola the strings are a little farther apart than they are on fiddle…"	PRINCIPLE	
"…Start on measure 6"		
Learner: "At the tempo I was doing, or…?"		
"No, at what tempo you can comfortably break chords without disturbing the pulse.	GOAL	
The chords in Bach should enhance the beauty or direction of the phrase, rather than get in the way of it."	PRINCIPLE	
The learner plays slower.		DECISION
"That time you backed off enormously with your bow, tonally;	GOAL EVALAUTE	
"But it was much more comfortable for you, wasn't it?"	GOAL EVALUATE	
Student: "I felt I could keep the pulse the same."		GOAL EVALUATE

Rehearsal Frame 8: Problem solving by Donald McInnes and his student

Transcript of Action	Teacher	Learner
"Be careful of the quality of the sound on the two Bb's."	GOAL EVALUATE	
The learner plays.		
"Maybe it would help if you think [demos phrase]. And I'm not necessarily saying that that is the grouping; that just might help you."	OPTIONS	
Learner: "I'm trying not to play them too…So we don't want them too short, right?		GOAL EVALUATE DECISION
"It just suddenly changes the character I think there."	GOAL EVALUATE	
Learner: "Yeah. I changed the fingering, just to… I was trying to sweep…" [demos] "to make it so it's not so…[demos]		DECISION PRINCIPLE OPTIONS
True tries the fingering. "So you're doing…"	OPTIONS	
The learner demonstrates the fingering.		OPTIONS
"I always felt like I accented that last one."		EVALUATE
"But I'm thinking that you're doing, maybe too big a deal. I mean with the [demos sweeping motion] with this kind of thing."	EVALUATE	
Learner: "I want… so that there was no edge to the sound."		GOAL
"Well I appreciate that, needless to say,	EVALUATE	
but I think if you just… [demos] if you just stay close…"	OPTION DECISION	
The learner plays.		
"Good good."	EVALUATE	

Rehearsal Frame 9: Problem solving by Nelita True and her student

Transcript of Action	Teacher	Learner
"I have a way I like to do it. I'm not saying you have to do it that way… but let's look at it together. You took a breath here, and not here…?	GOAL	DECISION
Let's go with that idea for now…" *The learner plays.*		
The learner stops. "I didn't take a breath there, did I?"		EVALUATE GOAL OPTION
"Should I breathe there?"		
"You figure it out."		
The learner breathes in a different place than the immediately previous performance. Alessi accepts this choice of breath.		OPTION EVALUATE DECISION
The learner takes an additional breath later in the passage.		DECISION
Alessi: "No. Don't breathe there.	EVALUATE	
Try breathing here." *Alessi marks it.*	DECISION	
Alessi: "This is good. This will work."	EVALUATE	

Rehearsal Frame 10: Problem solving by Joseph Alessi and his student

The preceding examples all illustrate various combinations of teacher and learner involvement in problem solving.

Other examples of combinations of teacher and learner problem-solving behaviors observed

Table 9 provides selected examples of rehearsal frames that included combinations of teacher and learner problem solving. I organized the table in a continuum of increasing learner involvement based on the number of problem-solving components teachers and learners perform in each rehearsal frame. (For the full text of each of these and other rehearsal frames, see the Appendix.)

Table 9

Number and type of problem solving behaviors attributed to teachers and learners within 10 rehearsal frames, in order from least to most learner involvement

	Rehearsal Frame Code																			
	O1C		O9K		O8T		P3A		LC2M		04T		QP2C		QE2A		FN1C		P5C	
Teacher/Learner	**T**	L	**T**	L	**T**	L	**T**	L	**T**	L	**T**	L	**T**	L	**T**	L	**T**	L	**T**	L
n of Components	**6**	0	**7**	1	**5**	1	**8**	1	**7**	3	**9**	3	**5**	5	**3**	4	**1**	4	**0**	5
	G		**G**		**G**		**E**			D	**G**		**E**			G	**E**			G
	E		**E**		**O**			E		O	**O**		**G**			E		G		E
	P		**P**			E	**G**		**O**			E		E		P		E		P
	O		**O**		**E**		**P**			D	**G**			O		O		O		O
	D			O	**P**		**O**		**D**		**O**			D	**E**			D		D
	P		**E**		**G**		**D**		**E**		**E**		**E**		**O**					
			O				**E**		**P**			D		E	**P**					
			D				**D**		**G**		**O**		**E**							
							P		**O**		**P**			P						
									E			E	**P**							
											E									
											G									

Note. G = Goal, E = Evaluation, O = Options, P = Principle, D = Decision. Components in each rehearsal frame column are listed from top to bottom in the order in which they occurred. Components performed by the teachers are in bold.

DISCUSSION

Teachers and learners performed the component behaviors involved in problem solving in various combinations across rehearsal frames. The results demonstrate that these components can be reliably identified and attributed to teacher or learner and show that the extent of learner problem solving may be measured in terms of the problem solving components in which learners participate.

Perhaps the most important contribution of this analysis is the illustration of how teachers can provide learners opportunities to practice the components of problem solving. As a learner's attention is directed toward the accomplishment of a goal, the teacher can remove herself from one or more components of the problem-solving process and instead allow the learner to perform those behaviors critical to accomplishing the goal. As teachers perform certain problem-solving component behaviors, but not others, learners are prompted to perform the necessary behaviors to improve performance. It is in this way that these teachers not only bring about change in learners' performance, but also structure ways for students to practice bringing about change in their own performance.

I also observed learners, rather than teachers, initiate the pursuit of a goal, though this occurred infrequently. In these situations learners often struggled in one or more subsequent problem solving component skills or asked for assistance in solving the problem. In response, teachers assisted in the component skills in which learners were weak, thus enabling learners to achieve success as they pursued goals they had established independent of the teacher.

Note that different rehearsal frames with the same teacher showed various combinations of learner involvement in problem solving, from no observable leaner involvement, to independent learner problem solving without teacher intervention (as in

Options1-Clapp compared with Principle5-Clapp, the first and last examples within the continuum above). It is reasonable to conclude that these teachers involve learners in problem solving to various degrees based on teachers' perceptions of learners' readiness to do so, depending on the difficulty of the problem and the skills of the learner. It is also possible that the pacing of lessons may influence the extent to which teachers hand over problem solving to the learner.

This study involved first developing a model and then applying that model to describe problem solving by teachers and learners. Further analyses are reported in the following three chapters. After I analyzed whether teacher or learner performed each problem-solving component (directly above), I then identified teacher behaviors preceding learner problem-solving behaviors, and determined the frequency of specific learner problem-solving behaviors that followed each of the teacher behaviors I identified (Chapter 4). I also identified frequently-occurring teacher behaviors that may influence learner problem solving, but in which the relationship between teacher and learner behavior was not observable within a rehearsal frame (Chapter 5). Finally, I analyzed the frequency of teacher and learner problem-solving behaviors across 15 full-length lessons and 2 chamber music rehearsals (Chapter 6).

Chapter 4

Teacher Behaviors Preceding Learner Problem Solving

In the previous analysis (Chapter 3), I observed various combinations of teacher and learner involvement in problem solving. In some instances, learners had virtually no involvement in devising solutions to problems; in others, they were engaged in some or all aspects of the process. In light of this variation in the extent of learner involvement, I set out to examine the relationship between the behavior of the teachers and their students' involvement in problem solving. I was particularly interested in the specific teacher behaviors that were associated with learners' participation in the five components I identified in the previous analysis.

Through the development and application of a model of problem solving, I established that the interactive nature of music instruction affords teachers opportunities to engage learners in the process. By performing some of the components of problem solving, but not others, teachers led learners to carry out the problem-solving skills teachers had not done for them.

The purpose of the following analysis was to reveal *specific* teacher behaviors that may have served to promote learner problem solving in this way, using terms typically employed in descriptions of music teaching. I sought to identify teacher behaviors that preceded the learner problem-solving behaviors within each rehearsal frame and to describe the relationships between teachers' and learners' involvement in problem solving.

METHOD

For the present analysis I used the data I had collected reporting learners' performances of problem-solving behaviors in each of the 161 rehearsal frames described in Chapter 3. As I observed learners performing problem-solving behaviors across multiple rehearsal frames, I identified the teacher behaviors that preceded these learner problem-solving behaviors.

Definitions of teacher behaviors preceding learner problem solving

Through observations of instances in which learners were at least partially involved in the process of problem solving, several identifiable teacher behaviors emerged preceding learners' involvement in effecting change. Each of these teacher behaviors serves the same general function: they each promote learner participation in components of the problem-solving process by instigating or carrying on the pursuit of a goal while also holding back from performing some or all necessary problem-solving behaviors for learners. I identified these teacher behaviors as follows:

- Varying specificity of directives
- Varying specificity of feedback
- Conceiving, demonstrating contrasting options
- Stating principles
- Asking questions that invite practice of problem solving skills
- Deliberately refraining from solving the problem for learners

Many of these teacher behaviors are components that contribute to solving a problem, but occur without completing the problem (i.e., without making a final decision leading to action). Through these behaviors, teachers initiate or continue the pursuit of a goal, but leave the problem unsolved so that learners may instead contribute to or complete the process. These teacher behaviors are attention directives (establishing a goal); non-specific, attention-directing, or specific negative feedback (evaluating); conceiving or demonstrating contrasting options; and stating principles. Additionally, teachers' questions often verbalized goals ("How is the tone?" or "Do you know why the pitch is off?").

Other teacher behaviors cue or prompt learners to perform one or more problem-solving component behaviors, but are not in themselves behaviors that lead to the solutions of problems. These are non-specific directives ("Do it again"); deliberately refraining from answering a learner's question ("You figure it out"); and non-specific questions ("What do you think about that?").

The behavioral definitions for each of the above teacher behaviors follow.

Varying specificity of directives

I divided teacher directives into three levels of specificity: non-specific directive, attention directive, and specific directive.

Non-specific directive: The learner is directed to play without information about the problem or goal. Examples include, "Play it again," "Play those last 4 measures again," "Practice that a few times." The learner is expected to make progress and solve problems without the teacher directing attention to particular goals.

Attention directive: The learner's attention is directed to a particular broad goal. Examples include, "Make a phrase out of that," "Be careful of the quality of the sound," "Play and figure out who has the melody."

Specific directive: The learner is directed to accomplish decisions made by the teacher. Examples include, "Vibrate the F#," "Get your elbow up at the frog," "Get to the tip of the reed," "Change the pedal when you get to [plays notes]," "Start to ritard [conducts]."

Varying specificity of feedback

All feedback I analyzed in this category is negative feedback, as negative feedback indicates that a problem remains to be solved.

I identified three levels of feedback:

Non-specific negative feedback: The teacher communicates that the learner has done something that does not meet a goal. The goal, however, is not specified. Non-specific negative feedback was delivered through verbal expressions such as, "No," "Ouch," "That's not what it says," or "Wait, wait." Teachers also communicated non-specific negative feedback through gestures and expressions such as the shake of the head or a grimace.

Attention-directing negative feedback: The teacher communicates that the learner has not met a general goal, without giving further information as to why it has not been accomplished or what specifically needs to change. Attention-directing negative feedback includes comments such as, "The sound isn't good," "It's out of tune," "You're not getting all the notes."

Specific negative feedback: The teacher communicates that the learner has not met a specific goal. Sometimes statements of principles (defined below) are coupled with specific feedback. Examples include, "The B-flat is sharp," "Your sound lacks meat because you're tight with your air stream," "You're rounding your finger and you end up a half step flat."

Conceiving and demonstrating contrasting options

Teachers present more than one option as possible means of accomplishing goals. They call attention to differences between possible performances or differences between learner performances and the target performance as negative and positive exemplars. They may demonstrate to show learners the differences between these possibilities.

Conceiving options: Verbalizing more than one performance option without demonstration.

Demonstrating options: Demonstrating contrasting performance possibilities through modeling, either by singing or playing.

Reconstructing problems: Modeling a negative performance that imitates a learner's performance, and then placing the learner in the position of the teacher. This teacher behavior was labeled as *demonstrating options*.

Stating principles

Teachers make statements of ideas that have application over many situations. This term is used broadly here to encompass any attention given to general knowledge that guides decisions.

Principles can be stated plainly and overtly, perhaps beginning with "So…" or "Therefore…" as in, "So that tells you that, in motion, your finger is going to go from…this [demonstrates] to…this [demonstrates]" (Clapp).

Principles may be stated within an evaluation, explaining the reasons for problems or successes, as in, "Those notes lack any meat, because you're tight with the air stream" (Alessi), or "Now sometimes you're pushing the body away, which of course takes the weight of the body out of the sound" (True). These statements contain a cause-effect relationship between a subgoal and goal; they explain why a goal is or is not accomplished.

Principles are also found in teachers' verbalizations of their own thinking, as teachers discuss with learners the reasons for decisions. For example, "If you play it longer, it tells us it's going forward. That doesn't make any sense" (McInnes), or, "Within the context of everything slurred, that seems strange" (Killmer).

I also included under this definition moments in which teachers called learners' attention to other contexts for the purpose of generalizing principles. For example, "You've done the Stravinsky *Elegy* so you've experienced this…" (McInnes).

Asking questions that invite practice of problem solving skills

I labeled types of questions according to the behaviors that the questions prompted, as follows:

Evaluation questions prompt learners to evaluate performance. Some of these questions were non-specific, also inviting the learner to decide upon the goal to evaluate, such as, "What do you think about that?" (Alessi).

Principle questions, often opening with, "How?" or "Why?" invite learners to state principles that would explicate the accomplishment of or failure to accomplish a goal. For example, "What hinge takes your finger there?" (Clapp), or, "Do you know why the pitch is off?" (Alessi).

Decision questions ask learners to make decisions or reveal their decisions: "What are you thinking of here in terms of character?" (True), or, "What fingering are you using?" (McInnes).

Deliberately refraining from solving the problem for the learner

Teachers deliberately refrain from parts of the problem solving process when solicited to do so by the learner. In these instances learners ask questions that teachers do not answer immediately or at all. Instead, learners remain engaged with the problems they have asked teachers about.

All of the teacher behaviors identified above were observed preceding learner problem solving. Although they are described as differentiable behaviors, they perform a common function. When teachers perform these behaviors, they initiate goal pursuit in the learner without performing every necessary problem-solving component, allowing learners to perform those behaviors teachers had not done for them.

Learner problem solving behaviors following each teacher behavior

Once I established the behavioral definitions for teacher behaviors that influenced learner problem solving, I identified the teacher behaviors within each of the 161 rehearsal frames I had selected for previous analyses. I totaled these teacher behaviors across all rehearsal frames, whether or not I observed learner problem solving behaviors following these behaviors.

I then identified the learner problem solving behaviors that followed each of the identified teacher behaviors when both the teacher behavior and learner behavior(s) occurred in relation to the same target. I then counted the number of each learner problem-solving component behavior following each category of teacher behavior across all rehearsal frames. Sometimes more than one target was pursued in a rehearsal frame; learner behaviors that occurred in relation to a target other than the target toward which a teacher behavior intended were not included in conjunction with that teacher behavior.

In determining teacher behaviors that preceded learner problem solving behaviors, I needed to differentiate between learner problem solving behaviors that came about as a result of teacher involvement, and learner problem solving behaviors that occurred independent of teacher influence, as learners directed their own attention. If learners initiated the pursuit of a goal that was different from a goal the teacher had identified through behavior or directives, subsequent learner problem-solving behaviors were not included in the analysis below. A few teacher behaviors assisted or encouraged learners' continued pursuit of a goal (e.g., by deliberately refraining from answering the student after the student had instigated the pursuit of a goal). Learner behaviors following these teacher behaviors were included in the analysis.

Reliability

After reliability observers labeled teacher and learner problem-solving behaviors as described in Chapter 3, they were then directed to identify teacher behaviors that preceded learner problem solving behaviors. To do so, they were provided the following list with definitions: specific negative feedback, attention-directing negative feedback, non-specific negative feedback, specific directive, attention directive, non-specific directive, evaluation question, principle question, decision question, state principle, demonstrate contrasting options, or deliberately refraining from answering.

Observers labeled 96 total teacher behaviors preceding learner problem solving behaviors within 35 rehearsal frames. Reliability between observers' labels and my own was 94.8% (91 of 96 behaviors). Reliability between each individual observer and myself was as follows: Observer 1, 91.9% (34 agreements in 37 responses); Observer 2, 97.2%

(35 agreements in 36 responses); Observer 3, 95.7% (22 agreements in 23 responses). This procedure lends support to the notion that these definitions are clearly applicable.

RESULTS

Table 10 presents instances of observable learner behaviors following the identified teacher behaviors in the rehearsal frames analyzed. The total number of each teacher behavior in all 161 rehearsal frames is in the leftmost column. Each learner behavior on the right was observed following one teacher behavior on the left. The total numbers of teacher behaviors occurring prior to learner problem-solving are in the column labeled Prior to Learner PS. Learner problem-solving behaviors on the right include those that followed a given teacher behavior when both occurred in relation to the same goal. In some instances there were two or more teacher behaviors that directly preceded learner problem solving, therefore a given learner problem-solving behavior may follow more than one teacher behavior.

I used the data in Table 10 to calculate the rate at which individual learner problem-solving behaviors followed each teacher behavior. I divided the total number of each learner problem-solving component behavior by the total of the preceding teacher behavior. For example, learners were observed evaluating 19 total times following teachers' demonstrations of contrasting options. I divided this number by the 116 total instances of teachers' demonstrations of options across rehearsal frames to determine the rate of learner behavior following each instance of teacher behavior. Figure 5 is a graphical representation of these data.

Table 10

Learner problem-solving behaviors following each teacher behavior across 161 rehearsal frames

Teacher Behaviors			Learner Problem-Solving Behaviors					
	Total	Prior to Learner PS	**Total Learner Behaviors**	Establish Goal	Evaluate	Options	State Principle	Decide Action
NS Neg. Fb	14	13	**39**	10	11	8	1	9
AD Neg. Fb	19	16	**31**	0	8	7	2	14
Sp. Neg. Fb	115	15	**25**	0	7	2	1	15
NS Directive	8	7	**18**	2	5	4	0	7
Att. Directive	33	32	**70**	2	19	16	2	31
Eval. question	25	22	**34**	7	19	1	5	2
Prin. question	19	17	**26**	1	2	4	17	2
Dec. question	19	18	**30**	0	2	7	3	18
Principle	137	26	**38**	1	9	7	2	19
Demo options	116	45	**56**	0	19	7	5	25
Ref answering	3	3	**7**	0	2	2	1	2
			Total:	**23**	**103**	**65**	**39**	**144**

Some teacher behaviors typically preceded a broader range of learner problem-solving behaviors than others. For example, non-specific negative feedback and non-specific directives were followed by a wide variety of learner problem solving behaviors; at times I observed many in one rehearsal frame. On the other hand, decision questions were followed most frequently by learner decisions, sometimes accompanied by learners' observable consideration of options, and rarely followed by evaluations and principle statements.

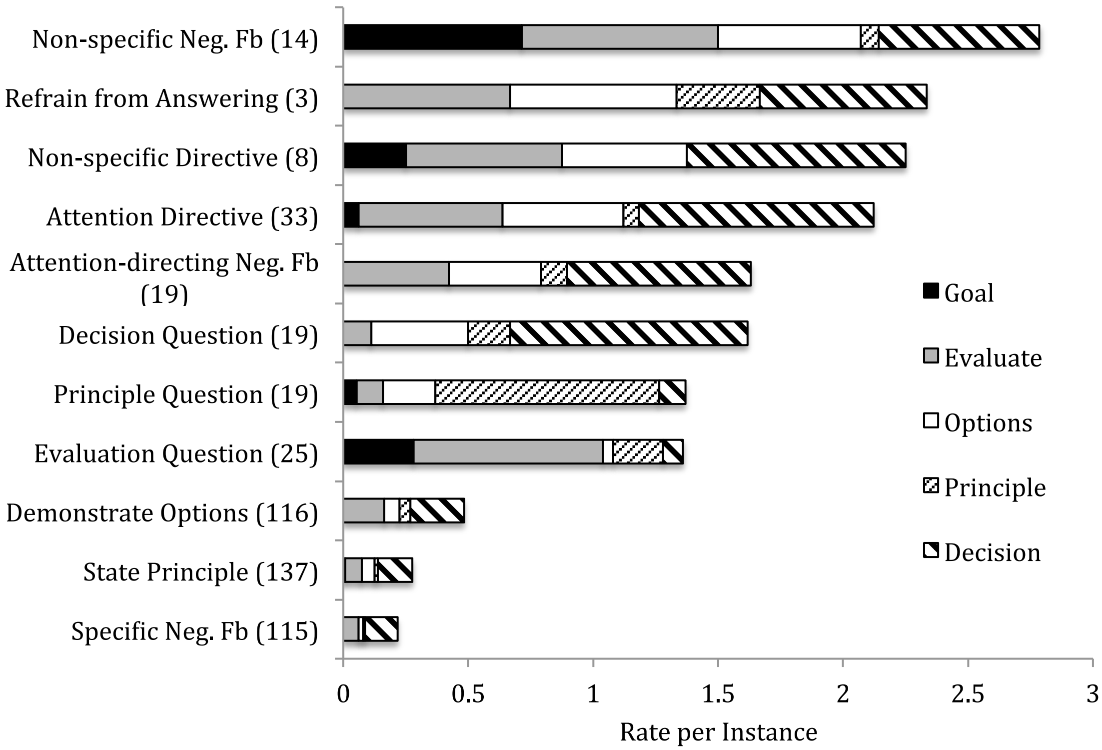

Figure 5. Rate at which each learner problem solving behavior followed each teacher behavior across 161 rehearsal frames.

The student problem-solving behaviors that followed each teacher behavior varied. Some learner problem-solving behaviors tended to follow particular teacher behaviors. For example, I never or rarely observed learners establish goals after principle questions, decision questions, principle statements, or teachers' demonstrations of options. On the other hand, learners established goals as frequently as other problem solving behaviors following teachers' non-specific feedback.

Further, the rate at which these learner behaviors occurred in relation to teacher behaviors also differed. Learners performed some behaviors at a rate of nearly one problem-solving behavior per teacher behavior. For example, learners made decisions nearly every time they were given non-specific directives or asked decision questions. Alternatively, although deciding on a course of action was the most prominent learner behavior following specific negative feedback, learners only made observable decisions following about 1 out of every 8 specific negative feedback statements.

There were also differences in the extent of learner problem solving following given teacher behaviors. The overall number of problem solving behaviors that followed a particular teacher behavior ranged from an average of .22 (following specific negative feedback) to 2.79 (following non-specific feedback). The teacher behaviors that preceded the most learner problem solving activity (e.g., non-specific negative feedback, refrain from answering, and non-specific directives) were far less frequent than were those teacher behaviors that preceded the least learner problem-solving activity (e.g., specific negative feedback and principle statements).

DISCUSSION

This analysis sought to determine the frequency, rate, and extent of learner problem solving following specific teacher behaviors. One of the most interesting findings is the variation in the types and rates of learner behaviors that follow given teacher behaviors. Some teacher behaviors seemed to promote greater learner involvement in problem solving than did others.

As teachers asked seemingly simple questions that prompted learners' participation in the intended component of problem solving, learners were often observed performing more problem-solving behaviors than only the behavior prompted by the question. For example, by definition, "evaluation questions" prompted learners to evaluate, and "decision questions" prompted learners to make decisions, but often learners were observed establishing goals, stating principles, or considering options after being asked these questions. This observation indicates, first, that even what appear to be simple problems may actually be rather complex and demand more of learners or teachers than might previously have been supposed. Second, it confirms the highly interdependent nature of the problem solving process.

Learners in these lessons received opportunities to practice certain skills more than others. Learners evaluated and made decisions frequently; however, they verbalized principles very little, unless specifically invited to do so. Additionally, learners received little opportunity to establish goals and direct their own attention in these lessons.

To be successful in their independent practice, learners must be competent in all the components of problem solving. Not every teacher behavior I identified provided opportunities for learning to practice all aspects of problem solving. It seems important for teachers to consider ways in which learners can practice all the components of problem solving while in teachers' presence, so that teachers can shape learners' problem-solving capabilities.

One of the most important findings of this analysis is that, even in lessons taught by highly skillful artist-teachers, learners received few opportunities to establish goals, and only few teacher behaviors appeared to encourage learners to do so. Non-specific feedback, non-specific directives, and non-specific evaluation questions most frequently preceded learners' establishing goals. Considering the importance of the selection of proximal and long-term performance targets in successful independent practice, this is an important finding that demands further investigation.

From the data I gathered in Chapter 3, I noticed that some rehearsal frames with a high number of learner problem-solving behaviors contained a great deal of teacher activity and lasted a long time (e. g., Options4-True, QuestionE1-Alessi, QuestionP2-

Clapp); whereas other rehearsal frames also with a high number of learner problem solving behaviors contained little teacher activity and lasted only a short time (e. g., FeedbackNS1-Clapp, FeedbackNS2-Clapp, FeedbackAD1-Killmer). These data may illuminate what accounts for this difference in pacing among rehearsal frames in which learners' performance of problem-solving components was similar. Certain teacher behaviors appear to yield more learner problem solving than others.

One of the most important findings of this analysis is that differences in the level of specificity of feedback and directives were related to differences in subsequent problem solving on the part of learners. More learner problem-solving behaviors followed non-specific negative feedback and directives than followed attention-directing negative feedback and attention directives; the least learner problem-solving occurred following specific negative feedback in this analysis. No learner problem-solving behaviors were observed following prescriptive teacher directives (decisions). It is important to note, however, that the teacher behaviors that preceded the greatest amount of learner problem solving did not occur nearly as frequently as did most that preceded less learner problem solving. Instances in which learners were prompted to do a great deal of problem solving on their own were relatively few in comparison.

The relationship between feedback specificity and learners' problem-solving behaviors observed here supports findings in motor learning which show changing the nature of feedback type can diminish a dependence effect in learners (Buchanan & Wang, 2012). Buchanan and Wang (2012) found that a motor task could be learned just as quickly through feedback that created no dependence effect as it could with feedback that created a dependence effect. The difference in feedback created a different representation of the task for the learner. Feedback could be manipulated to increase cognitive engagement that was necessary to continue the task in the absence of feedback. Likewise, changing the specificity of feedback potentially changes the cognitive engagement necessary for the completion of the task. As Buchanan and Wang found, the training environment can encourage learners' engagement in processes that are necessary for continued success outside the training environment.

These findings are important for several reasons. First, teachers concerned with lesson pacing and accomplishment may be hesitant to pursue the development of problem solving skills in learners because of the impact this priority may have on pacing and accomplishment. If, however, problems can be solved at least in part by the learner with little impact on pacing, there is little reason not to pursue this important priority. If learners are to become increasingly independent, it would be helpful to discover successful teacher behaviors that bring about change with as little teacher intervention as possible.

Decreasing the specificity of feedback and directives can serve to decrease learner dependence on the teacher. This may not be desirable at all phases of the instructional sequence, but as an important element in the weaning process when the learner is ready.

Discussion of examples of each teacher behavior preceding learner problem solving

The following discussion considers each of the individual teacher behaviors identified above and their roles in promoting learner problem solving.

Specificity of directives

I observed variation in the level of specificity of teacher directives. Some directives were specific and prescriptive, such as, "Change the pedal when you get to the top" (DirectiveS1-T). Attention directives were broad, offering a goal without a prescription, for example, “Be careful of the quality of the sound” (LearnerChoice2-True) or “Make something out of that phrase” (DirectiveA2-McInnes). Non-specific directives simply invited learners to problem-solve without teacher assistance, for example, “Do it again” (DirectiveNS1-Alessi).

The specificity of the directive affected the level of evaluation and other problem-solving skills expected of the student. Specific instructions directed learners to accomplish simple subgoals, guiding learners step-by-step to accomplish superordinate goals (see Fishbach, et al., 2006; Willatts, 1999). This highly prescriptive teaching involves the most problem solving from teachers and the least problem solving from learners. As teachers gave prescriptions for specific behaviors, learners demonstrated little independence in accomplishing the superordinate goals that the proximal goals were designed to accomplish.

On the other hand, attention directives directed learners’ attention to complex goals, requiring the execution of multiple subgoals. Non-specific directives invited learners to decide where to direct their attention and then to pursue appropriate subgoals. As teachers gave broader directives without specific prescriptions as to proximal goals, learners demonstrated greater independence in the lesson.

Rehearsal Frame 11 contains non-specific directives. In this example, Alessi first tells the learner why he is not achieving a clear sound on the lower note. He then directs the learner to play several times, applying that principle. Later, the learner detects the same error on his own. Alessi does not explain what to do to fix it; he only gives the non-specific directive, “Do it again.” The learner must recall how he achieved the sound from the previous performance—just as he would be required to do in independent practice. He does so, successfully solving the problem on his own.

Transcript of Action	Teacher	Learner
The learner plays; he does not achieve a clear sound on a low note. Alessi: "You puffed out—you just collapsed. I would rather have you keep working the corners, or working [points to his cheeks]. Collapsing is not a good idea."	GOAL EVALUATE OPTIONS PRINCIPLE	
Through several non-specific directives, Alessi provides the learner several opportunities to achieve this change with little further teacher intervention.		
"Just Practice that." *The learner plays with a similar problem.* "Try again." *The learner plays.* "There you go." *The learner plays.* "That's it, that's it." (With approving shoulder slap) (Later) *The learner plays the same passage with the same problem.* Learner: "Agh." *(shakes his head)*	EVALUATE EVALUATE	EVALUATE OPTIONS DECISION DECISION GOAL EVALUATE
Alessi does not tell the learner why the note did not sound clearly. He only gives a non-specific directive to play again, allowing the learner to apply the principle previously taught.		
Alessi: "Do it again." *The learner plays again, without the problem.*		OPTIONS DECISION

Rehearsal Frame 11: Transcript of DirectiveNS1-Alessi identifying Alessi's non-specific directives.

Rehearsal Frame 12 provides an example of an attention directive. Through Clapp's attention directive, the learner does everything necessary to solve the problem on his own except direct his attention to his fingers. The learner has demonstrated that if he pays attention to his fingers, he is capable of fixing the finger height.

Transcript of Action	Teacher	Learner
The learner plays a passage with moving notes. Clapp: "Can you play any part of that from memory? Learner: "Yeah."		
Clapp directs the learner's gaze; he does not without give any evaluation or further information.		
Clapp: "I want you to look at your fingers." *The learner plays again and changes his finger height.* Clapp: "Good!	GOAL EVALUATE	 EVALUATE OPTION DECISION
To be certain the learner understands, Clapp invites the learner to verbalize the change.		
"Do you know what you're doing differently?" Learner: "They're staying close." Clapp: "They're not flying."	 Confirm EVALUATION	 EVALUATE

Rehearsal Frame 12: Transcript of DirectiveA1-Clapp identifying Clapp's attention directive.

Specificity of feedback

In addition to variation in the specificity of teacher directives, I also observed variation in the level of specificity of teacher evaluations in the form of feedback. This variable also influenced how much problem solving was required of the learner. For example, if feedback was more detailed, learners needed do little evaluating; the teachers had done it for them. When feedback was less specific (such as “no” or “ouch”), learners were required to do what the teacher had not done for them: evaluate all elements of the task to decide upon the pertinent goal. This was often followed by other change-effecting behaviors (i.e., consider options and decide on a solution).

Through non-specific negative feedback, teachers initiated goal pursuit in learners while leaving learners the task of identifying appropriate goals. Non-specific feedback indicated to the learner that there was a problem to be addressed. The learner’s attention was thus directed to identify the goal, evaluate the situation relevant to the goal, and then find ways to accomplish the goal.

Rehearsal Frame 13 provides an example of non-specific feedback.

Transcript of Action	Teacher	Learner
The learner plays a scale. One note is flat.		
Clapp communicates that something is wrong, without saying more.		
Clapp: “Ouch!”	EVALUATE	
The learner is required to evaluate what is wrong and decide on a change.		
The learner stops and explores a different finger placement.		GOAL EVALUATE OPTIONS
The learner extends her finger farther for a higher pitch.		DECISION

Rehearsal Frame 13: Transcript of FeedbackNS1-Clapp identifying non-specific feedback.

Attention-directing feedback, in which broad goals were identified for learners but specifics as to the problem were withheld, provided learners opportunities to evaluate and then accomplish all other problem solving behaviors, if teachers did not intervene.

Rehearsal Frame 14 provides an example of Killmer giving attention-directing negative feedback.

Transcript of Action	Teacher	Learner
The learner plays.		
Killmer identifies a problem with the sound without directing how to fix it.		
Kilmer: "It sounds like there's cotton in your reed."	GOAL EVALUATE	
The learner is required to decide how to effect the desired change.		
The learner plays again with a different sound.		OPTIONS DECISION

Rehearsal Frame 14: Transcript of FeedbackAD1-Killmer identifying attention-directing feedback.

In this rehearsal frame, the learner applies his own knowledge, considers options, and decides how to fix the problem that Killmer brought to his attention. The learner improves his sound with minimal teacher assistance.

Conceiving, demonstrating contrasting options

The teachers I observed frequently presented more than one option as a means of accomplishing goals. Teachers called attention to differences between possible performances or differences between learner performances and the target performance. Teachers frequently demonstrated to learners the differences between these possibilities. Often, after more than one option had been illuminated, evaluation and choice-making occurred; teachers sometimes asked students to evaluate following the demonstration of options ("Which one is better?"). I also observed teachers asking learners to decide between options that the teacher provided. Thus, in rehearsal frames in which teachers provided options for learners, learners often received opportunities to practice evaluating and/or decision-making, as in Rehearsal Frames 15 and 16 below.

Transcript of Action	Teacher	Learner
"I talked to you the other day about [*demonstrates*] that kind of pedaling or [*demonstrates with no pedal*]."	GOAL OPTIONS	
Learner: "Too dry?"		EVALUATE
"Well the thing is he says according to what I've read that this is supposed to be the insects of the night.	GOAL	
And this [*demonstrates without pedal*] does not sound as much like insects." [*demonstrates with pedal*]	OPTIONS EVALUATE	
Learner: "I think use some pedal maybe."		DECISION
"Yeah, but the thing that I was missing was this glaze of pedal. You find the spot on the pedal that just catches the sound. [*demonstrates*]	OPTION	
If I go all the way down to the bottom [*demonstrates*].	PRINCIPLE OPTIONS	
Learner nods: "It's too much."		EVALUATE
"Of course it's a mess. So… kind of creepy crawly. Try it see if you can find that spot on that pedal."	EVALUATE GOAL	
The student plays.		

Rehearsal Frame 15: Transcript of Options4-True identifying True's demonstrations of options and the learner's subsequent evaluations.

Rehearsal Frame 15 shows True demonstrating possible options in sound and movement three times, after which the learner participates in evaluating and decision-making. This rehearsal frame illustrates how the demonstration of options enables problem-solving activity in learners.

Transcript of Action	Teacher	Learner
"How are you grouping these chords? Are you going? *[True demonstrates]* *The learner nods.*	GOAL 	 DECISION
True demonstrates another option, and invites the learner to decide between the two options during her independent practice.		
"You could also do [demonstrates different option]. Fool around with that in your practicing."	OPTIONS	

Rehearsal Frame 16: Transcript of Options3-True identifying True's demonstration of options from which the learner may choose.

Learners' own performances as options

In some situations, teachers compared learners' own performances, treating them as options among which learners could choose and consider. The following statements by Alessi demonstrate how teachers called attention to differences in learners' performances:

> "Now let's get the sound back though. 'Cause I liked the sound you were doing in the etude, just a second ago. I'd like to get that richness back."
>
> Later:
> "I'm looking for the most resonant sounds you can make. Almost the sounds you made in the beginning in the lesson; you're not getting that sound."
>
> Later:
> "Remember the low E you got in the Ostrander. You had a nice low E there. That's what you want to shoot for. (Options5-Alessi)

Reconstructing problems, components of problems

At times teachers reconstructed problems, modeling incorrectly for learners without showing a correct model. As they did so they prompted learners to diagnose problems and demonstrate their understanding. Often the teachers imitated what a learner was doing and invited a learner to observe from the position of the teacher. They often asked questions that prompted evaluation and diagnosis. For example, Clapp imitates the student's playing in a passage and says to her, "This is what was happening. Can you tell me how to fix it?" (Options7-Clapp).

Alessi also reconstructed a student's playing, allowing the learner to evaluate (Rehearsal Frame 17).

Transcript of Action	Teacher	Learner
The learner plays. Alessi: "Those notes sound accented.	GOAL EVALUATE	
Alessi imitates the student's playing.		
Right here." [*Alessi demonstrates the passage with an exaggeratedly accented sound.*]	OPTIONS	
Learner: "Oh." *[Nods.]*		EVALUATE
Alessi demonstrates unaccented, correctly	OPTIONS DECISION	
The learner plays again, differently.		

Rehearsal Frame 17: Transcript of Options6-Alessi identifying Alessi's reconstruction of the learner's performance.

Stating principles

All five of the teachers I observed made an effort to establish generalizable principles in learners' minds. These teachers stated principles, brought learners' attention to related situations to which the principles pertained, and gave learners a window into the teachers' thinking by verbalizing their thought processes.

These observations are consistent with the notion that knowledge of generalizable principles is critical to learner independence. Generalized knowledge makes it possible to transfer from a present situation to multiple future situations (Salomon & Perkins, 1989).

When teachers generalized principles for learners, they often provided learners opportunities to practice applying those principles. The teachers often followed a statement of a principle with a prompt to solve problems in various ways. In my analysis, teacher activity generalizing a principle was often followed by student activity evaluating, diagnosing problems, or attempting to solve problems based on the principle provided, as in Rehearsal Frame 18.

Teachers often verbalized their own thinking. By giving learners a window into their own thought processes, teachers provided learners opportunities to observe principles at work when teachers solve problems. For example, when faced with a choice of interpretation as to the marked articulation, Killmer verbalizes his thinking:

> Within the context of everything slurred, [the marked articulation] seems strange. …And so you say, hmmm, is that just an error, or did he actually mean that? I'm looking here, and …the context tells me otherwise. It doesn't look right. Like the Saint-Saens Sonata….So…the slur seems to be missing. (Killmer)

Often teachers coupled these verbalized analyses with demonstrations of the options that were being considered; they modeled performance possibilities, including imitations of learners' performances; and they verbalized their perceptions of the differences.

Transcript of Action	Teacher	Learner
"I think your tempo is a little too fast." "On viola the strings are a little farther apart than they are on fiddle…" "…Start on measure 6" Learner: "At the tempo I was doing, or…?"	GOAL EVALUATE PRINCIPLE	
Here McInnes refrains from answering the question directly; he does not provide a tempo. He answers instead with a goal and a principle to guide the learner's decision.		
"No, at what tempo you can comfortably break chords without disturbing the pulse. The chords in Bach should enhance the beauty or direction of the phrase, rather than get in the way of it."	OPTION GOAL PRINCIPLE	
The learner solves the problem of selecting a tempo by applying the principle.		
The student plays slower.		DECISION
McInnes reinforces the student's decision and the effect the tempo choice had on other aspects of the student's playing.		
"That time you backed off enormously with your bow, tonally "But it was much more comfortable for you, wasn't it?"	GOAL EVALUATE GOAL EVALUATE	
Following the teacher's encouragement, the student elaborates on his evaluation of the last iteration.		
Student: "I felt I could keep the pulse the same."		GOAL EVALUATE

Rehearsal Frame 18: Transcript of Refrain1-McInnes identifying the principle McInnes provided to guide the learner's decision.

Sometimes teachers directed learners' thinking to moments in the past, drawing upon previous experience and increasing the connectedness among learners' various experiences. McInnes does this when he remarks that the problem the learner is experiencing in the moment is the same one that was addressed in a previous piece: "You've done the Stravinsky Elegy so you've experienced this" (Principle6-McInnes). McInnes does not overtly say what that issue is; the learner is expected to discern the connection between the present situation and the previous piece, then to apply that same principle in the present situation.

Asking questions that invite practice of proble-solving skills

The teachers I observed frequently asked questions, inviting learners to accomplish components of problem solving. Questions prompted learners to evaluate, generalize and apply principles, and make decisions.

In Rehearsal Frame 19, Alessi asks the learner a series of questions. Several questions prompt the learner to evaluate, and another prompts the learner to apply a principle. Rehearsal Frame 20 shows how True invites the learner to make a decision by asking a question and demonstrating options.

Transcript of Action	Teacher	Learner
Alessi and his student listen to an electronic recording of the student's audition. Alessi stops the recording after hearing the opening phrase and asks a series of questions prompting the learner to evaluate what he hears.		
Alessi: "How did you like the opening?"		
Learner: "I like the sound. Didn't like the D."		GOAL EVALUATE
Alessi: "What did you not like about it?"		
Learner: "It wasn't very stable, it was flat."		GOAL EVALUATE
Alessi: "What about that first interval, you happy with that?"	GOAL	
Learner: "The F's sharp."		EVALUATE
Alessi: "Can you sing that interval?"	GOAL	
Transcript of Action continues (Rehearsal Frame 19)		

Transcript of Action, continued (RF 19)	Teacher	Learner
The student sings.		OPTIONS
Alessi: “Play it again.”		
The learner plays the recording of the interval.		
“Play it again.” “Sing it again.”		
The student sings. “Play it again.”		OPTIONS
“What do you think about the Bb and the F? Happy with it?”		
Learner: “So so. I could have been a little more decisive.”		GOAL EVALUATE
Alessi: “But I’m talking about the pitch.”	GOAL	
Learner: “The F’s flat.”		EVALUATE
Alessi continues asking questions without further comment for over 2 minutes. *Later, he addresses the learner’s understanding of the identified pitch problems by asking a question inviting the learner to apply a principle.*		
(Later) Alessi: “Do you know why the pitch is off?”		
“Is it because I’m not holding…?” *The student gestures the slide.*		PRINCIPLE
“Yes. It’s because you’re not holding the slide. You’re not able to figure out where the pitches are because you’re just bouncing around. I know exactly where the pitches are because I do this for everything.” *Alessi gestures holding the slide.*	EVALUATE PRINCIPLE OPTIONS DECISION	

Rehearsal Frame 19: Transcript of QuestionE1-Alessi and QuestionP1-Alessi identifying Alessi’s questions prompting the learner to evaluate and later apply a principle.

Transcript of Action	Teacher	Learner
True and her student have considered several musical aspects related to creating the composer's intended sound, which True identified as "the insects of the night."		
True: "Frankly I can't think of any other spot in the repertoire that has exactly this kind of sound. I think this is a unique movement. So it's worth the time to figure out what you're going to do with both hands.	GOAL	
True demonstrates options while asking the learner to choose between them.		
Is it going to be more the left hand [demos left hand heavier]? Or is it going to be [demos right hand heavier]?"	OPTIONS	
The learner comes up with another possibility to choose from.		
Learner: "What about even?"		OPTION DECISION
True acknowledges the learner's conceived option. She reinforces the learner's decision by teaching a principle that explains the decision in relation to the goal.		
[True demos] "It's possible. But I definitely agree with you that it's not going to be the bass, because that's too heavy for insects crawling around in the night."	DECISION PRINCIPLE EVALUATE GOAL	

Rehearsal Frame 20: Transcript of QuestionD1-True identifying True's question prompting the learner to make a decision.

Deliberately refraining from solving problems for learners

Within the rehearsal frames I analyzed, there were instances in which teachers deliberately refrained from directly answering learners' questions. In these instances, learners asked the teacher for help with one or more components of problem solving: "What tempo should I take?" (Refrain1-McInnes), "How do you get the notes to be shorter if the air keeps moving?" (Refrain3-Alessi), or, "Should I take a breath there?" (Refreain2-Alessi). The teachers did not answer the questions asked, but instead stated a principle to be applied (Refrain1-McInnes), demonstrated several times without words (Refrain3-Alesi), or directed the student to "figure it out" (Refrain2-Alessi).

Rehearsal Frame 21 provides an example. Here Alessi expresses that he has an opinion regarding where to breathe in this passage; however, he works with the learner's original idea rather than the way he likes to do it. Even when the student asks, he allows the student time to work with choices. He then modifies those decisions for the most successful performance, while still upholding the learner's basic concept of the passage.

Transcript of Action	Teacher	Learner
"I have a way I like to do it. I'm not saying you have to do it that way… but let's look at it together. You took a breath here, and not here…?	GOAL	DECISION
Let's go with that idea for now…" *The learner plays.*		
The learner stops. "I didn't take a breath there, did I?"		EVALUATE GOAL OPTION
"Should I breathe there?"		
Alessi does not tell the learner where to breathe. He instead invites the learner to answer his own question.		
"You figure it out."		
The learner breathes in a different place than the immediately previous performance. Alessi accepts this choice of breath.		OPTION EVALUATE DECISION
The learner takes an additional breath later in the passage.		DECISION
Alessi: "No. Don't breathe there.	EVALUATE	
Try breathing here." *Alessi marks it.*	DECISION	
Alessi: "This is good. This will work."	EVALUATE	

Rehearsal Frame 21: Transcript of Refrain2-Alessi identifying Alessi's deliberate restraint from answering the learner's question.

Consider that when learners, as evidenced by their questions, already have a clear goal in mind, they are motivated and mentally prepared to participate in other parts of the problem-solving process. Teachers can capitalize on this moment by keeping learners involved in the pursuit of the goal, rather than jumping in to solve the problem for them and possibly shutting down learner problem-solving activity.

All of the teacher behaviors described above, identified as preceding learner involvement in problem solving, have a common element: they engage or assist learners in the pursuit of a goal, without performing every behavior necessary for the accomplishment of the goal. Through this strategy, teachers involve learners in the problem solving process while in teachers' presence. By engaging learners in all of the skills necessary for problem solving, teachers can assess learners' readiness for independent problem solving.

Chapter 5

Teacher Behaviors That Address Future Learner Problem Solving

In addition to observing teacher behaviors that preceded observed learner problem-solving within single rehearsal frames (Chapter 4), I also looked for other teacher behaviors that addressed learner problem solving over the long-term. These teacher behaviors did not serve to prompt observable learner problem solving in the moment, but I considered them important in that they seemed to be intended to encourage independent learner problem solving in the future. I looked for these behaviors both within rehearsal frames and in full-length lessons. The potential and actual function of the behaviors I describe in this chapter is unknown, of course. But these aspects of teaching occured frequently in the behavior of these expert teachers, indicating that they may be important part of involving learners in problem solving.

Not all important aspects of teacher behavior are observable in brief rehearsal frames. In part of the analysis reported in this chapter, I observed full-length lessons in search of aspects of teaching that are evident only over time. I examined how teacher behaviors change over the course of a lesson and how various points of focus recur.

TEACHER BEHAVIORS

In the present analysis, I observed the following teacher behaviors.

- Acknowledging learners' choices or goals
- Acknowledging learners' agency
- Giving practice directives
- Gradually decreasing teacher involvement over time
- Applying the same principle in many contexts

Examples and discussion of each teacher behavior

The following examples serve to illustrate the contexts within which I saw the teachers perform the defined behaviors. I also discuss the significance of each for learners' independent problem solving.

Acknowledging choices, goals of learners

The teachers I observed demonstrated an awareness of goals sought by learners. These teachers sometimes acknowledged the present concern in the mind of learners, whether it was brought to their attention as an explicitly stated concern such as a question or as an unverbalized concern evidenced by the behavior or performance of learners. Teachers were also observed acknowledging conscious artistic decisions learners had made, as in, "I'm trying to reconcile what you're really feeling here and how we can make it sound—not just hurrying the tempo" (LearnerChoice1-True). Or, "I have a way I like to do it. I'm not saying you have to do it that way… but let's look at it together. …You took a breath here, and not here…? Let's go with that idea for now" (Refrain2-Alessi).

Learners' goals and decisions led to various teacher responses. Sometimes learners made effective decisions and teachers reinforced those decisions. Killmer acknowledged a learner's successful choice (LearnerChoice5-Killmer), for example, while attempting to improve her sound. He had provided the goal and provided feedback verbally and through modeling a number of times, without satisfactory change. The learner's own choice eventually enabled her success: she let her body go. He recognized this choice and reinforced it. Musical change occurred as a result of the learner's action.

At times, after learners had established goals for a passage, teachers provided further possibilities for the more successful accomplishment of those goals. This was the case with True and one of her students (Rehearsal Frame 22 below). She acknowledged his concept of the piece he was playing, and worked with him to accomplish his goal convincingly.

As discussed in Chapter 3, learners' decisions, unlike their teachers,' were not always informed by appropriate goals, correct evaluations, or generalizable principles. When learners' decisions were less successful, teachers guided learners toward other elements of problem solving rather than only addressing the choice itself. For example, teachers directed learners toward different goals, changing their attention and priorities to pursue a more successful path. In Rehearsal Frame 23, True guides the learner through better choices that address the learner's concern while also achieving the paramount goal of musical character. She provides the learner different ways of thinking about the passage without a dogmatic prescription.

Transcript of Action	Teacher	Learner
The learner plays.		
True approaches a problem she hears from the standpoint of the learner's intention.		
True: "I'm trying to reconcile what you're really feeling here and how we can make it sound—not just hurrying the tempo.	GOAL EVALUATE	GOAL
She conceives an option that solves the problem while still accomplishing the learner's expressive objective.		
And I think the way you can get around it is to start the 16ths later." *True demonstrates.* "See what I'm hearing now is this [*demonstrates, hurrying*]. So it sounds—particularly the third beat sounds as if you're really pushing ahead." Learner: "Oh yes." *The learner plays differently with True's second option.*	OPTION DECISION OPTIONS EVALUATE	 EVALUATE

Rehearsal Frame 22: Transcript of LearnerChoice1-True.

Transcript of Action	Teacher	Learner
"Be careful of the quality of the sound on the two Bb's."	GOAL EVALUATE	
The learner plays.		
"Maybe it would help if you think [demos phrase].	OPTIONS	
True attributes the final decision to the learner.		
And I'm not necessarily saying that that is the grouping; that just might help you."		
Learner: "I'm trying not to play them too…So we don't want them too short, right?		GOAL EVALUATE DECISION
True directs the learner's attention to the effect of her decision on the goal—the piece's character.		
"It just suddenly changes the character I think there."	GOAL EVALUATE	
Learner: "Yeah. I changed the fingering, just to… I was trying to sweep…" [demos] "to make it so it's not so…[demos]		DECISION PRINCIPLE OPTIONS
True considers the learner's choice and tries playing the fingering.		
"So you're doing…"	OPTIONS	
The learner demonstrates the fingering.		OPTIONS
"I always felt like I accented that last one."		EVALUATE
"But I'm thinking that you're doing, maybe too big a deal. I mean with the [demos sweeping motion] with this kind of thing."	EVALUATE	
Learner: "I want… so that there was no edge to the sound."		GOAL
True acknowledges the importance of the learner's concern, then provides an option that addresses the learner's concern while also creating the desired character.		
"Well I appreciate that, needless to say, but I think if you just… [demos] if you just stay close…"	EVALUATE OPTION DECISION	
The learner plays.		
"Good good."	EVALUATE	

Rehearsal Frame 23: Transcript of LearnerChoice2-True.

Similarly, McInnes works within the learner's general intent by adjusting his choice to accomplish the paramount goals of a passage (Rehearsal Frame 24).

Transcript of Action	Teacher	Learner
McInnes: "What fingering are you doing?"		
Learner: [demos] "Stay on the G string; I just changed it.		DECISION
I was actually going [demos]."		OPTIONS
McInnes accepts the learner's general decision but provides another option.		
"I think if you want to play it up on the C string you need to play the whole thing on the C string."	DECISION OPTION	
Learner: "Yeah."		
The learner attempts change in fingering.		DECISION
McInnes provides a more successful means of accomplishing the learner's intention.		
McInnes: "Get to 5th position in the beginning of the measure." [sings]	DECISION OPTION	
The learner plays.		DECISION
"Work it out; that's better.	EVALUATE	
McInnes provides the goals and principles as a rationale for adjusting the learner's choice.		
Because the change in the color if it's just the last 5 notes…	GOAL PRINCIPLE	
Also it sounds too light weight."	GOAL EVALUATE	
[he sings light sound, then full sound]	OPTIONS	
"Because right now it sounds like [sings light sound with heavy ending] and that doesn't make any sense."	EVALUATE	

Rehearsal Frame 24: Transcript of LearnerChoice3-McInnes.

Acknowledging learners' agency

In addition to acknowledging learners' outward choices, teachers also acknowledged that it was the learners' thinking, intention, and attention that would be the means of bringing about change. They attributed changes in learners' performance to the learners themselves, particularly future changes that learners were to make in their performance.

Teachers frequently directed learners toward the goals that *should* be in their minds, both in the present and in future situations. Clapp (Principle4-Clapp), for example, acknowledged the importance of the learners' future attention when he said, "every time you come to those shifts you've got to tell yourself [that]." Alessi spoke frequently about how the goals in the mind of the learner bring success. He was observed frequently saying, "Tell yourself…" and, "Be relentless…"

The following are examples of teachers' statements acknowledging learners' agency:

"I can't do it for you" (Alessi)

"Tell yourself…" (Alessi)

"I know you have the critical facilities…to be able to do this all by yourself" (Clapp).

"No one can do that but you." (Clapp)

"And again, you have that control." (Killmer)

"Now I imagine the reason you did that was a very good reason…" (True)

"Do them the way you want them to be." (Killmer)

"Don't go by what I do; figure out what is good for you." (Alessi)

"Why would you want to do any other kind of attack there?" Learner: "I wouldn't." Alessi: "Well you did." (Alessi)

"You control it; I don't control the thing. I can't push a button: 'Ok, [learner], play this attack.' …You have to do it; I can't do anything about it." (Alessi)

As teachers acknowledged learners' goals and choices, teachers reinforced these acts of decision-making and promoted an atmosphere that allowed for learner agency. The teachers encouraged learner decision making to various degrees through various means. Sometimes teachers provided feedback within the parameters of learners' choices. They also sought to help students understand the effects of their choices, whether the results were positive or negative.

Giving Practice Directives

Among the statements that direct learners' attention to actions that lead to positive change are directives that specifically address learners' independent practice. These directives include goals for learners to accomplish during practice and strategies for successful practice. Examples include the following:

> "Watch in front of a mirror…" (Alessi)
>
> "Bracket that spot [for practice]." (Clapp).
>
> "Find all the brackets [segments needing practice] and then stitch them into the quilt."
>
> "Take a mental catalogue of the things we've talked about that apply to every future issue" (Clapp).
>
> "[Accents and bowings] must be added to your memory track [as you] memorize it." (Clapp)
>
> "Fool around with that in your practicing" (True)
>
> "Practice with no tongue on a daily basis." (Alessi)
>
> "Question your sound at all times when you practice." (Alessi)
>
> "When you practice with the metronome subdivide as you play." (Alessi)
>
> "Whenever you feel that when you practice, you should stop." (Alessi)

Gradually decreasing teacher involvement

I observed a few instances in which teachers deliberately changed their level of involvement in solving a particular problem during the course of a single lesson. This within-lesson reduction in teacher involvement serves as a compressed example of what can happen over the course of several lessons, increasing the extent of learner involvement in problem solving.

Clapp provides one such example. Within a single lesson, Clapp's role changes from being the primary means of change to doing little more than directing the learner's attention. During a break in the lesson, he outwardly expresses that he senses the learner is becoming dependent on him to fix things for her:

> There are stories about teachers who make their students very dependent on them. And I feel as if I am making you dependent on me. Because after we talk about something, miraculously it's fixed. However, I know you have the critical facilities, the mathematical skills, and the concentration powers to be able to do this all by yourself, and that's what I'd love to hear.
>
> Furthermore you've got to memorize it. So – the more times you play it wrong, the harder it is to memorize. So, if you want to play this, you're going to have to do some scrutinizing, very carefully examining what you do….

He seems to consciously do less for the student as the lesson progresses. He skillfully reduces the level of specificity of feedback to the student. Moments from this lesson play out as follows:

> *The learner plays a scale in different rhythmic subdivisions.*
>
> Clapp: "Same rhythm. Ok hold on. You just did 6. " [*He sings 6 per beat, snapping*]. "Now for 8." [*He sings 8 per beat, snapping*.] "Same proportion of rhythm."
>
> *She plays again, correctly.*
>
> …

Clapp: “Tell me what your counting unit is.”

Learner: “8th note.”

Clapp: “8th note? Ok…” [*He sings the piece, counting the rhythm as he goes*.]

She plays again.

….

The learner plays.

Clapp: “Oh – ouch!”

She plays a different rhythm.

He nods.

….

The learner plays.

Clapp: “Hold on that’s not what it says.”

She plays different notes.

He allows her to go on.

…

The learner plays.

Clapp: “Wait wait wait…”

She plays a different rhythm.

“Yeah.”

(FeedbackNS2-Clapp)

At the beginning of the lesson Clapp is the primary agent of change. He directs the learner’s attention to problems with rhythm, evaluates, generates the pulse, and sings the rhythm for her; the learner simply imitates his modeling. Although the learner plays correctly, she has does not solve the problems she encounters; Clapp does this for her.

As the lesson progresses, the learner plays several passages incorrectly only to receive a non-specific “Ouch” or “Wait, wait” or “That’s not what it says” from Clapp. The learner’s attention is directed to a problem, but she is not told what it is or how to fix it. She must evaluate and solve the problem on her own. She does so, usually very quickly. Clapp skillfully increases the learner’s independence while also increasing the pace of the lesson by giving only as much feedback as is necessary for the student to fix the problem.

It seems clear that Clapp intentionally uses non-specific negative feedback. He expresses that he is concerned about his student’s dependence upon him, and adjusts his behavior so that the learner must do more to solve problems she encounters. Instead of singing the rhythm for her, she receives more and more non-specific negative feedback.

Lessons such as this, in which teachers are heavily involved in problem solving at first and gradually decrease their involvement throughout the course of a lesson, illustrate the means by which teachers may gradually increase learners’ involvement in problem solving over the course of many weeks, lessons, or years. To wean learners from their teachers, teachers can adjust the degree of help they provide learners in solving problems.

Applying the same principle in different contexts throughout a lesson

Lessons that proceeded with gradually decreasing teacher involvement, as described above, usually contained a concomitant feature: Teachers addressed a single principle throughout many experiences in a lesson. Once a principle had been established, teachers continued to call learners’ attention back to the same principle in many situations, providing learners many opportunities to connect those situations with the principle.

This was the case in an epitomic lesson with one of Clapp's students (Rehearsal Frame 25). In this situation, the learner is able to evaluate a problem with a goal he has identified (shifting accurately), as evidenced by his several unprompted attempts to shift. However, he must be taught the principle that would provide him consistent accuracy: the hand shape and position of the thumb must change when shifting over the block. The music practiced throughout the lesson presented many opportunities to practice the application of this shifting principle. Later, after consistently applying the principle in multiple contexts, the learner successfully detects and solves the problem without teacher intervention.

Other lessons I observed also kept a single principle in play throughout many situations within the lesson. For example, True reminded her student to "be close to the keys" throughout the course of her lesson. Alessi frequently reminded one of his students the importance of the attack at the beginning of notes. Clapp frequently reminded another of his students that the sounding point is an important factor in tone production. Learners received many opportunities to practice applying these fundamental principles in multiple musical contexts.

Transcript of Action	Teacher	Learner
The learner plays a piece and shifts incorrectly; he is flat.		
The learner stops himself		GOAL EVALUATE
He tries several times to hit the note correctly.		DECISION
Clapp: "So there's a little bit of a barrier there. The brick wall is stopping you."	PRINCIPLE	
Clapp demonstrates the shift correctly and incorrectly.	OPTIONS	
"So in addition to a lift, you've got to open the hand before you start moving."	PRINCIPLE	
The learner plays again, successfully hitting the shift by bringing the hand around.		OPTIONS DECISION
"Beautiful! It's so simple, isn't it?	EVALUATE	
But there are several re-education components. One is the pressure of the finger, one is the releasing of the hand from pressing in. And every time you come to those shifts you have to tell yourself that information."	PRINCIPLE GOAL for future situations	
For approximately 15 minutes, multiple instances follow in which this goal and principle is applied in different contexts.		
(Later)		
The student plays a different passage with a shift. He shifts incorrectly and immediately stops himself. "Ah! Should have been up." (Referring to his hand.)		GOAL EVALUATE PRINCIPLE
Clapp adds, "and too late!"	EVALUATE PRINCIPLE	
The learner plays again, shifting accurately on the second iteration.		OPTIONS DECISION

Rehearsal Frame 25: Transcript of Principle4-Clapp and Principle5-Clapp discussing the learner's ability to independently apply a principle practiced frequently in different contexts throughout a lesson.

Returning frequently to the same principle was shown to be one of the most powerful means of increasing learner independence I observed. Six rehearsal frames in which learners performed four or more problem solving behaviors without teacher intervention involved learners' application of a principle that the teacher had previously applied during the lesson. Three of these situations happened without any teacher initiation; the learners stopped themselves during performance to solve the problem. After multiple experiences applying a principle, learners successfully solved problems independent of their teachers.

The teacher behaviors I described in this chapter illustrate teachers' intentional shaping of independent learner problem solving. These teachers allowed and reinforced learners' decision-making as they acknowledged the choices learners made. They gave directives that extended beyond the present moment into learners' anticipated independent practice time. And, within a few lessons, I observed teachers increase learners' involvement in problem solving during the course of a lesson by gradually decreasing their involvement as teachers.

Chapter 6

Frequency of Teacher Behaviors and Learner Problem-Solving Behaviors in Full-length Lessons and Chamber Rehearsals

FULL-LENGTH LESSONS

To investigate the frequency of teacher and learner problem-solving behaviors in full-length lessons, I tallied teacher problem-solving behaviors, learner problem-solving behaviors, and teacher behaviors I had identified as preceding learner problem solving (Chapter 4) within three full-length lessons taught by each of the five teachers. The lessons/rehearsals were selected based on variety in age (two of Clapp's students and two of McInnes's students were adolescents; the others were college-aged, including graduate and undergraduate students) and my preliminary impressions that they represented a variety in approach.

In this analysis, nearly every behavior in every lesson was coded as a component of problem solving or as a type of teacher behavior that tended to precede learner problem solving.

Definitions and examples of problem solving behaviors and teacher behaviors preceding learner problem solving behaviors are given in Chapters 3 and 4. In the present analysis I did not intend to make connections between teacher and learner behaviors, only report the frequency of these behaviors.

I used Scribe Version 4.2 observation software (Duke & Stammen, 2011) to collect data. Because lessons varied in duration (ranging from 40-60 minutes), I report the data in terms of rates per hour.

Results

The data that emerged from this analysis are presented in Tables 11 and 12. Table 12 shows the data for teacher and learner behaviors from Table 11, averaged across the three lessons by each teacher, and the mean rates of teacher and learner behaviors across all 15 lessons.

These data illustrate both the prevalence and variation of these behaviors among lessons and teachers. First, as noted in Chapter 3, all problem-solving behaviors occurred at rates of approximately one or two per minute. Learners were involved in problem solving in all lessons taught by all five teachers.

Table 11

Teacher problem-solving behaviors, learner problem-solving behaviors, and other teacher behaviors per hour in 15 lessons

	Lesson														
	A1	A2	A3	C1	C2	C3	K1	K2	K3	M1	M2	M3	T1	T2	T3
							Teacher Problem Solving								
Goal	55	65	78	73	72	62	65	77	85	51	42	41	75	71	63
Evaluation	62	75	88	96	41	67	74	104	75	57	42	45	86	27	74
Options	31	45	50	40	65	41	65	55	65	43	30	29	39	39	61
Principle	28	29	50	40	38	33	62	61	42	51	47	30	47	32	54
Decision	23	48	55	46	64	48	54	58	71	43	23	27	18	47	52
							Learner Problem Solving								
Goal	10	8	10	19	13	7	8	2	8	3	6	3	1	1	1
Evaluation	16	23	24	36	31	15	27	14	20	5	17	9	16	8	12
Options	12	16	14	32	22	11	11	12	13	2	9	3	9	4	24
Principle	3	0	5	4	4	2	5	2	1	3	8	2	5	3	3
Decision	37	49	49	46	24	21	35	32	32	9	17	6	58	23	42
							Other Teacher Behaviors								
NS Directive	7	5	4	2	0	0	2	1	2	2	0	0	0	0	0
Att. Directive	13	18	14	10	7	4	18	22	14	2	3	2	18	8	11
NS Neg. Fb	1	1	6	22	0	2	0	1	7	0	0	0	1	0	0
AD Neg. Fb	5	21	13	9	5	9	2	8	6	9	5	2	12	4	2
Sp. Neg. Fb	44	30	40	23	16	31	24	53	41	36	20	29	46	11	39
Eval. Question	0	2	2	13	4	7	8	6	2	3	3	3	5	1	5
Prin. Question	2	0	2	10	0	2	2	3	1	7	9	3	2	0	4
Dec. Question	1	5	5	4	4	4	2	3	0	2	3	0	13	7	18
Demo Options	3	5	13	7	8	10	3	29	28	17	5	18	32	16	40
State Principle	28	29	50	40	38	33	62	61	42	51	47	30	47	32	54
Refrain Answer	0	3	0	0	0	0	0	0	0	0	3	0	0	0	0
Practice Dir.	9	14	10	15	0	10	0	5	0	0	12	8	4	1	3
Ack. Agency	1	5	5	4	3	3	8	12	4	0	9	2	13	3	13

Note. Students in lessons C1, C3, M1, and M3 are adolescents. All others are college-aged. A = Alessi, C = Clapp, K = Killmer, M = McInnes, T = True

Table 12

Teacher problem-solving behaviors, learner problem-solving behaviors, and other teacher behaviors per hour, averaged across three lessons for each teacher

	Alessi	Clapp	Killmer	McInnes	True	*Mean*
			Teacher Problem-Solving			
Goal	66	69	75	45	70	65
Evaluation	75	68	84	48	62	68
Options	42	49	61	34	46	46
Principle	36	37	55	43	44	43
Decision	42	53	61	31	39	45
			Learner Problem-Solving			
Goal	9	13	6	4	1	7
Evaluation	21	27	20	10	12	18
Options	14	21	12	5	13	13
Principle	3	4	3	4	4	3
Decision	45	30	33	10	41	32
			Other Teacher Behaviors			
NS Directive	5	1	2	1	0	2
Att. Directive	15	7	18	2	12	11
NS Neg. Fb	3	8	3	0	0	3
AD Neg. Fb	13	8	5	5	6	7
Specific Neg. Fb	38	23	39	28	32	32
Evaluate Question	2	8	5	3	4	4
Principle Question	2	4	2	6	2	3
Decision Question	3	4	2	2	13	5
Demo Options	7	8	20	13	29	16
State Principle	36	37	55	43	44	43
Refrain Answering	1	0	0	1	0	0
Practice Directive	11	8	2	7	3	6
Ack. Learner Agency	3	4	8	4	10	6

I observed all of the teacher behaviors that preceded learner problem solving in the teaching of every teacher, with a few exceptions. All teachers stated principles and gave specific negative feedback at relatively high rates in every lesson. All teachers demonstrated contrasting options and gave attention directives and feedback in every lesson. Teachers also asked questions in every lesson, and within most lessons teachers asked a variety of types of questions. In every lesson except one, teachers acknowledged learners' agency and choices.

Non-specific negative feedback, non-specific directives, and deliberately refraining from answering a learner's question occurred within the teaching of one or two teachers more often than in lessons taught by the other teachers. Alessi gave non-specific directives and attention-directing feedback more often than the other teachers did, whereas Clapp gave non-specific feedback more often than others, particularly with one student. Killmer stated principles most frequently, perhaps related to the frequency with which he directed attention to goals. True most frequently asked decision questions and demonstrated contrasting options.

Discussion

Full-length lessons show proportions of teacher and learner behaviors that are similar to what I found within the rehearsal frames. For example, non-specific, attention-directing, and specific negative feedback appear in approximately the same proportions during full-length lessons and rehearsal frames, with a high frequency of specific negative feedback, less attention-directing feedback, and only occasional non-specific feedback. Similarly, teachers stated principles frequently both in the rehearsal frames and in the full-length lessons, whereas few instances occurred during lessons or rehearsal frames in which teachers observably refrained from answering students' questions. Rehearsal frames I selected therefore seem representative of the behaviors that occurred during the lessons from which they were excerpted.

All of these teachers involved learners in problem solving during the course of lessons, although teachers typically did most of the problem solving. There may be an optimal proportion of teachers leading students' learning and teachers handing over some of the problem-solving responsibility to learners. Learners received opportunities to problem-solve while also progressing quickly through rapidly paced lessons.

These results show the prevalence of the identified teacher behaviors over the course of lessons and among teachers. Each of the teachers I studied used the majority of the strategies I identified that seem to promote learners' involvement in problem solving, although the teachers varied in terms of the extent to which they applied these strategies. This illustrates that all of these expert teachers involved learners in the problem-solving process, although there were differences in their emphases and in their precise means of doing so. The individual differences are interesting to note in light of the teachers' personalities and general approaches.

True, for example, frequently asks decision questions, demonstrates options, and recognizes learners' agency and choices. She frequently considers learners' own conceptions of their pieces, asking questions about their decisions and acknowledging their independence as musicians.

Killmer approaches lessons at a very rapid pace, and the strategies he uses to involve learners in problem solving support that pace. He frequently takes the lead in problem-solving, and he is able to make quick changes in learners' performances. But in doing so he also explicitly demonstrates options and states principles. His questions generally invite rather brief answers, and at times he also uses attention-directing feedback and directives, which, when learners are successful, also contribute to a rapid pace.

Alessi, on the other hand, highly prioritizes learners' efficient practice. He frequently has learners practice within his presence; he gives non-specific directives such as, "Practice that," giving learners a chance to work through problems on their own and giving himself an opportunity to observe their doing so. Alessi also refers to and directs learners' practice more frequently than do the other four teachers.

Though the teachers I studied appear to have individual priorities that differ slightly in emphasis, all of them commonly involve learners in problem solving. The differences observed among lessons and teachers may be attributable to differences among the instruments, personality differences, or the needs of learners. Consider, for example, the high prevalence of non-specific and attention directives used by those teaching wind players compared with string players. Killmer and Alessi averaged 20 non-specific or attention directives per hour, while Clapp and McInnes averaged 8 and 3 non-specific or attention directives per hour, respectively. Why might this be? It is possible, when playing wind instruments, compared to strings or piano, many physical mechanisms affecting sound production are only within the learner's capacity to change; they exist physically on the inside of the performer and are not directly observable. Wind instruments teachers—and learners—by the nature of the instrument may need to rely on outcomes rather than observable physical changes.

I also observed a great deal of variation among lessons with a single teacher (see Table 11), perhaps attributable to adjustments teachers made to accommodate the needs of learners. An epitomic example of this is found by comparing two lessons with Clapp. In one lesson (C1), Clapp uses a great deal of non-specific negative feedback (a rate of 22 per hour); in another lesson (C2) he uses none. Further, in lesson C1 Clapp asks more questions than in lesson C2 and gives many practice directives, compared to no practice directives in C2. It is apparent that these differences are related to the needs and abilities of the learner. The learner in lesson C1 is an adolescent (9th grade). Incidentally, this is the same lesson I discuss under the heading, "Gradually decreasing teacher involvement," during which Clapp acknowledges the need to increase this student's independence. The other lesson (C2) involves a college student who is largely self-initiating; many of the problem-solving behaviors I saw her perform occurred without teacher prompting. She volunteered evaluations and possible note changes and established goals by asking questions.

Whatever their means of doing so, these teachers all engaged learners in problem solving during lessons. These teachers did not relinquish control of the flow or pace of the lesson necessarily, but had among their repertoire of strategies means by which learners, according to their individual needs, could demonstrate the skills needed to practice alone, without the aid of teachers.

TWO CHAMBER MUSIC REHEARSALS

Because of the prevalence of group music instruction in the field of music education, I felt it would be valuable to analyze the video footage I acquired capturing two full-length chamber music rehearsals: one string quartet rehearsal with Stephen Clapp, and one trio (oboe, viola, piano) rehearsal with Richard Killmer. These two rehearsals were the only on-site chamber music rehearsals I had recordings of.

Data were coded, collected, and analyzed exactly as described above in the analysis of full-length lessons.

Results and Discussion

Data from this analysis are presented in Table 13. Although the sample is small, these data illustrate that (1) the same teacher and learner problem-solving behaviors that occur in one-to-one music lessons also appear in ensemble rehearsals; (2) the same teacher behaviors that promote learner problem solving in one-to-one music lessons also appear in ensemble rehearsals; and (3) as in one-to-one instruction, ensemble rehearsals can vary greatly as to the degree of learners' involvement in problem solving and the teacher behaviors that precede learner problem solving.

These rehearsals demonstrate that teachers and students in ensemble settings exhibit the same problem-solving behaviors I observed in individual lessons. Likewise, the same teacher behaviors promoting learner problem solving I observed within one-to-one instruction can occur within an ensemble setting. Problem-solving behaviors and teacher strategies occurred at rates similar to those I observed during one-to-one instruction. Further, these behaviors seemed to have a similar effect on learners and their participation in the problem-solving process.

Notable differences between one-to-one and ensemble instruction were observed: Clapp asked more questions prompting students' decisions in the quartet rehearsal than he did in individual lessons. It is possible that he felt the ensemble, as its own entity, should have a higher level of autonomy, or he may have felt that it is an ideal setting for such decision-making discussion. On the other hand, Killmer gave non-specific and attention directives and feedback less frequently in the rehearsal than he did in individual lessons. He may have approached the rehearsal as a group he was to lead, which was evidenced by the extent to which he conducted the ensemble.

Table 13

Teacher problem-solving behaviors, learner problem-solving behaviors, and other teacher behaviors per hour during two chamber music rehearsals

	Killmer Trio	Clapp String Quartet
Teacher PS		
Goal	71	58
Evaluation	85	78
Options	33	32
Principle	36	25
Decision	68	32
Learner PS		
Goal	5	12
Evaluate	13	32
Options	5	20
Principle	3	10
Decision	17	42
Other Teacher Behaviors		
Non-specific Directive	1	1
Attention Directive	5	16
Non-specific Neg. Fb	0	1
Attention-directing Neg. Fb	7	10
Specific Negative Fb	47	38
Principle Question	3	8
Evaluation Question	5	7
Decision Question	1	18
Demonstrate Options	19	10
State Principle	36	25
Refrain Answering	0	0
Practice Directive	1	0
Acknowledge Learner Agency	1	0

As in one-to-one instruction, rehearsals vary in terms of the degree to which learners are involved in problem solving and in the teacher behaviors that precede learner problem solving. During the string quartet rehearsal, learners performed each learner problem-solving behavior more than twice as often as did learners in the trio rehearsal. Similarly, teacher behaviors differed widely between these two rehearsals; Clapp asked questions over three times more often than did Killmer, and Clapp gave attention-directing feedback and directives more often than Killmer. Killmer gave specific negative feedback, demonstrated contrasting options, and stated principles more frequently than did Clapp. Killmer also directed attention to goals more frequently than did Clapp, which indicates a slightly faster pace of instruction.

Individual lessons and chamber music rehearsals by effective teachers involve frequent problem solving on the part of teachers and learners. The teachers I observed solved problems more frequently than learners, generally, but both teachers also used various strategies that involved learners in the problem-solving process. Based on my observations of these two chamber music rehearsals, it seems conceivable that effective large ensemble rehearsals may also include both teacher and learner problem-solving behaviors. The strategies by which teachers involve learners in problem solving during large rehearsals may vary from chamber ensembles, due to the nature of large-group instruction. It seems possible, however, that non-specific and attention-directing feedback and attention directives may be as effective in large groups as in small group or one-to-one instruction. Further research is necessary to confirm this possibility.

Chapter 7: Discussion

The purposes of the current study were to describe the process of problem solving in the context of music learning and to elucidate the relationship between teacher behavior and learners' active participation in solving musical and technical problems. I first developed a description of the problem-solving process and the component behaviors it comprises. I then applied this model to determine, within 161 rehearsal frames, whether teacher or learner performed these component behaviors to solve specific problems. I performed an additional analysis in which I identified the teacher behaviors that preceded learner problem-solving.

SUMMARY OF FINDINGS

Problem solving model

The model of problem solving that I developed in this dissertation came about as I observed shared involvement in problem solving between teacher and learner. Five components emerged from my analysis: establish goal, evaluate, conceive and consider options, generalize and apply principles, and decide and act. These components encompass nearly all of the on-task instruction time within 161 rehearsal frames, 15 full-length private lessons, and 2 full-length chamber music rehearsals that I analyzed in detail.

The model is consistent with other models of problem solving that had been developed within the literature of other fields (Buijs, Smulders, & Van der Meer, 2009; Camacho & Good, 1989; Lee, Noi Keng Koh, Xin Le Cai, & Choon Lang Quek, 2012; Kotsopoulos & Lee, 2012; McCarty, Clifton, & Collard, 1999). That music learning (a highly goal-driven activity with a high cognitive demand) involves the same problem-solving components that are found in other domains of human endeavor demonstrates the ubiquitous nature of problem solving.

The components of problem-solving that I described are topics of study in diverse disciplines. There are examples of research that addresses goal setting (Cavitt, 2003; Colprit, 2000; Duke, 1999; Vogt, De Houwer, Moors, Van Damme, & Crombez, 2010; Willatts, 1999; Worthy, 2003), evaluating (Cavitt, 2003; Doerksen, 1999; Fishbach & Finkelstein, 2012), conceiving and considering options (Elsner & Schellhas, 2012; Haylock, 1987; McCarty & Keen, 2005; Smolucha & Smolucha, 2012; Willatts, 1999), generalizing and applying principles (McCarty et al., 1999; Osman & Shanks, 2005; Perales et al., 2010; Price & Driscoll, 1997; Salomon & Perkins, 1989; Sweller et al., 1998), and decision-making (Elsner & Schellhas, 2012; Goethals et al., 2012; Jonassen, 2012; Wang et al., 2012). The present investigation confirms the importance of these components in music study, and further elucidates their interactive nature, best considered in relation to each other rather than as separate, isolated aspects of teaching and learning.

My description of problem solving corroborates and further explicates previous findings in music education research that describe teacher error correction behaviors (Cavitt, 2003; Doerksen, 1999; Duke & Simmons, 2006) and learner practice behaviors (Ali, 2010; Barry & Hallam, 2002; Duke, Simmons, & Cash, 2009; Hallam, 1997; McPherson & Zimmerman, 2002; McPherson, 2005; Nielsen, 2001, 2002; Rohwer & Polk, 2006).

Observing shared involvement in problem solving between teacher and learner provided an advantage in identifying the components of problem solving. Observing the behaviors of only one person at a time, rather than observing a shared involvement between teacher and learner, may make it more difficult to differentiate among the component skills involved in problem solving.

The development of a framework for describing problem solving in music also provides a method for observational research that has been perhaps less common in music than in other disciplines. Complete explanations of complex processes of human interaction often require making justifiable inferences that are based on contextual evidence. The present description of problem solving came about by my observing explicit behaviors and making informed inferences based on non-verbal behaviors within the contexts of the goals sought.

Problem solving by teachers and learners

Teachers and students performed the five components of problem solving in various combinations across 161 rehearsal frames and throughout 15 full-length lessons and 2 chamber rehearsals. The degree of learner problem-solving involvement varied across rehearsal frames. In some rehearsal frames, I observed teachers outwardly perform all of the behaviors related to problem solving while learners simply followed the teachers' directions; other rehearsal frames evinced different levels of shared involvement (e.g., the teacher established a goal, the learner evaluated whether the goal was accomplished, and the teacher decided how to accomplish the goal, drawing from his knowledge of principles and available options; or the teacher directed a learner's attention to a goal and the learner performed all other components).

I identified specific teacher behaviors that often preceded the learner problem-solving: teachers varied the specificity of feedback and directives, asked questions, stated principles, demonstrated contrasting options, and deliberately refrained from answering students' questions. Some of these teacher behaviors, such as non-specific feedback and directives and deliberately refraining from answering, preceded a higher number of learner problem-solving behaviors, on average, than did others. Further, certain learner problem solving behaviors commonly followed certain teacher behaviors. For example, I often observed learners considering options and making decisions following teacher decision questions, and I observed learners evaluating, generalizing principles, and making decisions following teachers' demonstrations of options. I observed learners establishing goals only following non-specific feedback and directives and non-specific evaluation questions.

DISCUSSION OF FINDINGS

Perhaps the most important finding of these analyses is that learners were most involved in problem solving as these teachers did *less* for their students. By strategically doing less, teachers provided learners the opportunity to do more of what teachers do. Although the teachers whose work I analyzed differ in their personal styles and approaches to their instruments, all consistently provided students opportunities to practice the components of problem solving. These teachers facilitated situations in which learners received opportunities to practice the skills needed to successfully teach themselves.

Teachers can remove themselves from any one part of the change-effecting process and give learners the opportunity to fill that role in lieu of the teacher. For example, a teacher may establish goals, evaluate, identify options, and outline a principle for a student, but then withhold any demonstration about how a passage should be executed, thereby allowing the student to make a decision based on the goal and principles outlined. Teachers may also instigate the pursuit of a goal but refrain from performing other components that are necessary to achieve the goal. Teachers also may break down or reconstruct situations in such a way that the problems are tractable for learners; teachers may ask questions, isolate more specific component goals for a given music passage, or re-create situations through modeling.

In many instances, the teachers in my sample demonstrated that they are all capable of solving problems more efficiently and effectively than learners. At times lessons proceeded at a very fast pace; teachers explicitly carried out all components of problem solving, bringing about noticeable improvements in learners' performances. But these teachers did not always solve problems for learners in this way; instead, they periodically, strategically withdrew themselves from part or all of the components of problem solving, allowing learners to do what the teachers did not do for them.

I concluded from my observations that these five teachers managed to bring students into the process of problem solving by performing one or more problem-solving components, then removing themselves from one or more of the other components. These teachers thus provided their students opportunities to practice the skills of problem solving in the presence of the teacher. These findings suggest that learners may develop skills required for teaching themselves through a scaffolded, incremental process.

Complexity and interrelatedness of problem solving: Why students may struggle

Problem solving is a complex cognitive activity. Five components, each complex in its own right, emerged during this analysis of the problem solving process. Each of these components have been studied extensively in the literature of other fields, and some have been researched in music (e.g., evaluation: Byo & Brooks, 1994; Doerksen, 1999; Hewitt, 2002, 2005, 2011).

The description of problem solving I present indicates that the nature of problem solving may be more involved than it at first may seem. It is particularly deceiving when excellent teachers are able to effect change rapidly in their students, as do the five highly experienced teachers I observed. To a naïve observer, these teachers may appear to do very little before a change is observed in learners. After more careful scrutiny, however, it becomes clear that these teachers work so efficiently not because of the simplicity of the process, but because their skills have been largely automatized. Not unlike world-class musicians who evince an apparent effortlessness while performing, these teachers carry on the act of teaching seemingly effortlessly.

Both performing and teaching involve the application of highly complex skills that have become habituated over years of practice. Playing a piece of music involves performing multiple difficult skills simultaneously at a rate faster than the mind would be able to consciously process. Likewise, musical problem solving is a complex process in which many behavioral and perceptual skills must be performed simultaneously while also drawing on relevant knowledge in long-term memory. The skills of problem solving require practice in order for learners to become effective problem-solvers, just as performers must practice the skills of performance.

My observations indicate that there is a need for training in each of the components of problem-solving. I observed that when learners exhibited a deficiency in any one or several of the skills of problem-solving, they had difficulty solving problems. As Moore and Carlson (2012) and Tsai, Hou, Lai, Liu, and Yang (2012) observed, I saw learners encounter difficulty because they lacked a clear concept of the goal (OptionsTrue-2), struggled to evaluate (DirectiveA2-McInnes, Options7-Clapp), were not aware of or capable of more successful options from which to choose (Principle4-Clapp, Options1-Clapp, ChoicesMcInnes1), or lacked sufficient knowledge of principles that would guide choices (Principle4-Clapp, Options1-Clapp, QuestionP2-Clapp, Refrain1-McInnes).

Further, I observed some learners who did *not* lack sufficient knowledge and evaluation skills as above, but failed to act upon their knowledge (QuestionE1-Alessi, QuestionE2-Alessi); Wang et al. (2012) similarly observed some patients with diabetes who monitored blood glucose levels but did not change their behavior in response to their evaluations. Even though they had begun the problem-solving process, they failed to make a decision that led to a solution.

Given the complexity of problem solving, it is perhaps not surprising that learners and teachers often experience difficulty solving problems. Music learners interviewed by McPherson (2005), for example, reported that they spent a majority of their practice time simply playing through pieces rather than making systematic corrections in their playing. Hewitt (2011) found no change in learners' abilities to self-evaluate after 5 weeks of training. Yet, during lessons with the five expert teachers I studied for this project, I witnessed learners participating successfully in problem solving. Other studies have also shown that learners are capable of effectively solving problems (Duke et al., 2009; Rohwer & Polk, 2006) and that training in musical problem solving can be effective (Broomhead, 2009).

Toward learner independence: Scaffolded problem solving

Instead of suddenly throwing learners into the process of learning unassisted, the expert teachers I observed provided learners with opportunities to do some part of the problem solving and musical decision making on their own. The teachers refrained from making all decisions and from fully guiding learners' behavior, and instead strategically removed themselves from parts of the process in order to bring in the student to act as the teacher.

As I observed differences in the amount of learner involvement among the rehearsal frames I analyzed, I asked whether the differences reflected a gradual removal of teacher involvement and a concomitant increase in learner problem solving. If I had continued to observe these teachers and learners over time, would learners eventually solve more and more problems on their own? There are some indications that this may be the case. I observed several lessons in which teachers were, at first, heavily involved with solving a particular problem or problems, but later in the lesson learners became more involved in solving problems. Most often this was the case when learners were confronted with problems related to the same goal and principles throughout the course of the lesson (discussed in Chapter 5), such as rhythm (FeedbackNS2-Clapp), shifting technique (Principle4-Clapp and Principle5-Clapp), or tone on an attack (DirectiveNS1-Alessi). In these lessons, teachers first solved problems within one or more contexts, teaching learners the principles guiding their decisions, and then provided learners many opportunities to apply those principles in additional contexts. Eventually, learners were observed solving problems by applying principles with little or no teacher intervention. Further study is required to determine whether these observations are representative of a similar process happening on a larger scale over the course of many lessons.

As with the development of any desired skill, learner problem-solving skills may be developed through a gradual shift in responsibilities from teacher to learner. Teachers may develop problem solving ability in learners by taking them through a sequence of gradually imparted agency, creating approximations of the goal of independent problem solving.

In light of humans' limited working memory capacity and the complexity of problem solving, learners will struggle solving problems if they are thrown into the process unassisted. Teachers assist learners by involving them in one or more parts of the problem-solving process, thereby scaffolding the task of problem-solving. This gives learners a chance to practice component skills even in the midst of difficult problems.

The expert teachers I observed for this project clearly have discovered meaningful ways of involving learners in problem solving; they allow learners to contribute to effecting change in their own performance without overwhelming them. Through this approach learners participate in arriving at the solution of more complex problems that they may not solved on their own.

Directing attention

It is important to note the relatively few instances during which I observed learners establishing goals during the course of lessons. This is perhaps not unusual. In typical one-to-one instruction, learners receive very few opportunities to practice directing their own attention when in the presence of teachers; usually teachers determine which targets will be pursued in a given moment, obviating the need for learners to do so.

Teachers who carry out lessons by directing the attention of learners have few opportunities to observe learners directing their own attention to pertinent goals and to learn what proximal targets learners might pursue. The times I observed learners establishing goals were rare moments when learners did so on their own without teachers' prompting, and a few instances when teachers gave non-specific feedback, non-specific directives, or non-specific questions, without defining a particular goal. The first case, in which learners stopped themselves without teacher prompting, happened quite infrequently, most often with older students and those more assertive personalities. Students with less assertive personalities may be less inclined to direct their own attention unless prompted to do so, although this observation is highly speculative.

The instances I observed teachers able to prompt learners to direct their attention were those in which teachers established a need for the learners to direct their own attention. The most prominent examples of this involved the teachers giving non-specific negative feedback; that is, when teachers gave some indication that there was *something* wrong, but gave no information about *what* was wrong. Similarly, non-specific directives such as "Do that again" served the same function in prompting learners to establish goals. Learners were observed making positive changes in their performance following these directives, having been given no explicit information about what should be changed. Non-specific evaluation questions, such as, "What do you think about that?" also provided learners opportunities to decide what aspects of the performance they would comment on, thus establishing goals that they would then evaluate. Only in these situations were learners observed establishing a goal after teacher intervention.

Feedback and directives: When less is more

One of the most intriguing findings of this analysis is the observed variation in the specificity of feedback and directives, and learners' concomitant involvement in problem solving. I found that the degree of problem solving required of learners can be great or small, often depending on the specificity of teacher feedback or directives. Less specificity on the part of the teacher can actually yield greater learner involvement in problem solving, as evidenced by the high number of learner problem-solving components that followed non-specific feedback and directives.

In other words, I observed an inverse relationship between teacher specificity and student problem-solving opportunities. As teachers provide less specific feedback, students must evaluate, choose, create, and solve on their own. Generally, less specific feedback involves simply directing attention to a problem or a goal. It is what the teacher does *not* say or show that becomes the learner's opportunity to act.

This finding challenges commonly-held beliefs that teacher feedback and directives should always be specific and detailed. One may argue that the teachers I studied did not intend to provide less-specific feedback and directives. After extensive observation, however, I believe that there is little question as to these teachers' intent. They often deliberately refrained from providing further information when they made only an unspecified evaluative statement such as "No" or "Ouch." In contrast to novice teachers who may not say much because they simply do not know what to say, these experienced teachers demonstrated that they are certainly capable of being very specific. At times their feedback was very detailed, even in situations similar to those in which little detail was given. It is clear from the successful student performances observed following only a "No" or "Ouch" that giving more feedback is not always necessary or even helpful. The teachers in this investigation have developed a sense for teacher behaviors that promote change; appropriately providing less detailed feedback is part of their repertoire of successful teaching behaviors.

Knowledge is power

I also observed the great importance of a rich knowledge base for successful problem solving. This was indicative through several observations. First, I observed learners' difficulties when principles of action were not clear to them. For example, during some situations in which learners had difficulty with intonation or articulation, it became apparent that they did not understand the means of using the body to accomplish the desired precision (see QuestionP2-Clapp, QuestionP3-Clapp, Refrain3-Alessi).

Further, the extent to which the expert teachers made generalizations indicates that they recognized the importance of increasing learners' knowledge base. I observed numerous instances in which teachers intended to facilitate change not only in learners' behavior but also in their thinking, establishing organized principles of general knowledge. These instances found teachers and students generalizing principles, calling attention to similarities or differences between situations, thinking aloud, explaining why, analyzing how, and in other ways drawing connections. Teachers stated principles at a rate of once every 1 to 2 minutes during all 15 lessons that I observed in their entirety (see Table 11). These teachers frequently brought attention to generalizable knowledge, to be transferred and applied in solving future problems.

Such general principles facilitate transfer among situations, thus building the capacity for independence. Lessons during which teachers and learners devoted attention to a recurring principle throughout the lesson included multiple instances when learners solved problems with little assistance.

The experts in my sample frequently connected specific situations with knowledge that had applicability beyond the present contexts. Teachers who are less effective may observe changes in learners' performance but fail to extend the learning beyond the observed change. The five experts whose work I analyzed spent additional time ascertaining students' levels of *understanding* rather than only "getting the student to do it right." Performing correctly was insufficient. Teachers also discussed principles before and after changes in performance and invited learners to generalize principles themselves.

IMPLICATIONS FOR EDUCATION

I sought to understand the means by which teachers involve learners as active participants in problem solving. I conducted the analyses for this study within a naturalistic music learning setting, and the findings seem directly applicable to music teaching and learning.

In an effort to emulate the expert teachers described in this dissertation, teachers can involve learners in the problem-solving process by strategically doing less for their students. By performing some components of problem-solving but not others, teachers can systematically cede increasing responsibility to learners.

Learners successfully participated in the problem-solving process throughout the lessons I observed. When learners were involved, there were a number of identifiable teacher behaviors preceding their involvement. Assessments of teacher effectiveness may include not only measures of the changes teachers bring about in learners' playing, but also the extent to which they involve learners in problem solving to effect change in learners' thinking.

Teachers may be trained and assessed, in part, by considering each of the five components of problem-solving. Further, teachers may be evaluated on and trained in behaviors that promote learner problem solving, including the behaviors defined in this study: varying the specificity of directives and feedback, stating principles, demonstrating contrasting options, asking questions that invite learner problem solving, strategically refraining from answering exactly what learners may ask, acknowledging learners' agency and choices, and providing practice directives. Of course, some of these aspects of teaching are a part of many teacher evaluations, but emphasizing their role in the development of learner problem solving adds an important dimension to the assessment of teaching.

Teacher education and teacher evaluation

Teachers may become more successful problem-solvers through training on each of the problem-solving components that I have outlined. It is conceivable that teachers could be trained and coached through problem-solving by isolating one or more components in the problem solving process, just as the teachers I observed provided learners opportunities to practice problem-solving as they developed increasing capability to do so.

Similarly, teacher evaluations may include assessment of the problem solving components I identified. As Duke (1999) asserted, assessments of teacher effectiveness are most meaningful when they measure teachers' abilities to accomplish proximal goals. The components of problem solving provide evaluators a more systematic means for evaluating this process of achieving proximal performance goals, and provide insight as to why some teachers may be more or less effective in accomplishing these goals. One teacher may be excellent at evaluating but lack the knowledge of principles and options that lead to successful decision making; another teacher may struggle to choose appropriate rehearsal targets; and so forth.

Teaching learners to practice

Teachers may likewise evaluate learners' practicing in terms of problem-solving components. Learners' practice would be most meaningfully evaluated based on their ability to accomplish proximal practice goals, in the same way teachers' effectiveness may be evaluated based on accomplishing proximal targets. The description of problem solving that I developed in the present investigation may provide insight as to why learners struggle to progress in their practicing. Learners may be coached through a practice session in the same way teachers may be coached to rehearse: by isolating and developing each of the components of problem-solving.

Teachers may be trained to develop learners' problem solving skills by involving learners in the problem solving process. This would involve training teachers to give not only prescriptive directives, but also to strategically do less for their students at times, and allow students to take on a greater role as their own teachers.

This recommendation may seem to be at variance with a typical teacher training agenda. A high value is often placed on teachers' abilities to provide clear, specific feedback and directives, for example. Certainly these skills are important and serve as indications of teachers' capabilities to carry out components of problem solving. But it is important to emphasize that the expert teachers I observed strategically reduced the specificity of feedback and directives (Chapter 5), and learners were observed participating in problem solving to the greatest extent following less specific feedback and directives from the teacher (Chapter 4). This strategy is an effective means of giving learners opportunities to practice problem solving and is worthy of consideration by all teachers and teacher educators.

As a caveat, I acknowledge that further research is necessary to confirm the applicability of the observed teacher behaviors in lessons of all ages and ability levels. It could be argued that the teachers I observed are able to bring out learners' own successful problem solving simply because their students are all highly accomplished. It seems reasonable to suggest, however, that teachers can promote independent problem-solving in learners of any age and ability level, and the teachers whose work I analyzed for this investigation demonstrated strategies as to how this can be done.

In each lesson or rehearsal or class, teachers may ask, What might my students be able to do with little assistance? Instead of the teacher evaluating a given performance trial, could the student evaluate? Instead of the teacher making every decision, could the student make decisions guided by learned principles? Perhaps learners could be asked to determine the paramount goals or demonstrate possible options from which to choose. All of these opportunities have the potential to promote independent musical progress.

Learners who acquire these behavioral and perceptual skills increase their capacity to make musical progress independent of teachers' instructions. Time spent practicing outside the presence of the teacher can yield greater results as learners are prepared for independent practice.

Creative problem solving and expressive performance

The findings of the current study suggest ways to facilitate creative problem solving in music. As has been done in the field of mathematics (Haylock, 1987; Levav-Waynberg & Leikin, 2012), the field of music may consider ways to make music learning a more creative, open-ended experience for learners. Instead of only giving prescriptive directives, teachers may ask questions that lead to exploration, such as, "How many different sounds can you make with your bow? Let's make a scratchy sound, a heavy sound, a smooth sound, an airy sound…" These all may be considered viable options depending on the expressive goal sought. Music learning, in this way, may appear to learners as an expressive, creative art, rather than as a rigid, highly prescribed experience.

SUGGESTIONS FOR FURTHER RESEARCH

The framework describing problem solving and the results from analyses that applied the framework give rise to a plethora of questions and further research possibilities. These include application of the model and analyses within various developmental, instrumental, and multi-student contexts, application of the model to understand previous experimental studies of learners' practice behaviors, and exploration of questions raised in teacher education.

Apply this study within other contexts

The analyses applied within the present context may be applied in other musical contexts to determine the generalizability of the findings. I examined the work of five renowned expert teachers and their students engaged in one-to-one instrumental music instruction. Other instructional settings and other levels of teacher and learner experience should also be examined. Studies of learners' involvement in problem solving in lessons and classes taught by less experienced teachers would be enlightening.

Further, most of the students observed in the present study were highly advanced and highly motivated. Most were college-aged (including graduate students), although five were adolescents. Similar analyses should be conducted observing problem solving in the lessons of varied ages and ability levels.

The current study includes an analysis of two chamber music rehearsals. The similarities I found in problem solving between one-to-one instruction and chamber music instruction indicate that these findings may be independent of the number of students taught at one time; however, further study is necessary to confirm this possibility.

Experimental exploration of successful and unsuccessful problem solving

Many studies have attempted to reveal why some teachers and learners are successful in solving problems and others are not, or why some problems are successfully solved by the same learner or teacher, and others not. The current study is a step toward explaining the differences between successful and unsuccessful teachers and learners. It would be beneficial to compare the problem solving process as it occurs in teachers and learners who are attempting to solve specific problems. Some studies have examined the practice strategies of learners in a controlled, experimental environment (Duke et al., 2009; Rohwer & Polk, 2006). Duke et al. (2009) directed learners to practice a musical passage, which they later performed. Learners' performances were then ranked and correlations were observed between the practice behaviors and performance rankings. A similar format could be used to compare learners' practicing in terms of the problem-solving components I have described.

Questions related to teacher education

While the current findings certainly give rise to many recommendations for music education and music teacher education, these results also raise many questions related to teacher education. Can novice teachers successfully involve learners in problem solving in the ways that I observed? At what point in learners' training is it beneficial to invite learners to solve problems? What kinds of problems could teachers expect learners to solve at various phases of their development as musicians? Further, how and when should teachers be trained in involving learners in problem solving?

Related is the question, What factors affect learners' successful and unsuccessful attempts at problem solving? The most noticeable changes I observed in learners' problem-solving capabilities involved increasing the learners' knowledge base, awareness of options, and evaluative skills. Further research is needed to confirm this observation. I suspect that learners' difficulties in independent practice may also have a great deal to do with the targets they choose to pursue and where they direct their attention. This was not, however, observable during these lessons, as a large majority of instruction time was spent with teachers directing learners' attention rather than learners directing their own attention.

Questions remain as to learners' application of the problem solving skills they demonstrate during lessons in their independent practice. If a learner is observed accurately evaluating intonation within a lesson, for example, will she be equally accurate during practice? Certainly, the observation of learner behaviors during a lesson gives clues as to learners' readiness for independent practice; however, further research is necessary that connects learners' behaviors within and outside the presence of teachers. Further study should involve additional observation of successive lessons and practice sessions.

A framework for further research

The description of problem solving I developed for the analyses in this study need not be limited to the applications I have identified. This framework, and the understanding it provides, may enlighten further observational and experimental music learning research in multiple ways that have not yet been conceived. Further, because problem solving is a nearly universally-present human activity, this model may find application in fields beyond music study.

Teachers can provide opportunities for learners to bring about change in their own behavior during instruction time. Opportunities for learners to effect change occur when teachers withhold instruction and allow learners to instruct themselves. As a teacher's role decreases, a learner's role may increase. Learners become their own teachers.

Appendix:

Transcripts of Rehearsal Frames Illustrating Teacher Behaviors and Learner Problem Solving Behaviors

The following are transcripts of rehearsal frames providing further examples of the teacher behaviors identified in Chapter 4. Those that were included in the body of this paper are included first in each category.

ORGANIZATION: TEACHER BEHAVIORS

Rehearsal frames are organized according to the prominent teacher behavior illustrated by the rehearsal frame, in the following order:

Directives	Non-specific
	Outcome-specified
	Specific
Feedback	Non-specific
	Outcome-specified
	Specific
Options	
Principles	
Questions	Evaluation
	Principle
	Decision

Refraining from answering the learner

Acknowledging learners' choices or goals

Directives: Non-Specific

Transcript of Action	Teacher	Learner
The learner plays; he does not achieve a clear sound on a low note.		
Alessi: "You puffed out—you just collapsed.	GOAL EVALUATE	
I would rather have you keep working the corners, or working [points to his cheeks]. Collapsing is not a good idea."	OPTIONS PRINCIPLE	
Through several non-specific directives, Alessi provides the learner several opportunities to achieve this change with little further teacher intervention.		
"Just Practice that."		
The learner plays with a similar problem.		
"Try again."		
The learner plays.		EVALUATE OPTIONS DECISION
"There you go."	EVALUATE	
The learner plays.		DECISION
"That's it, that's it." (With approving shoulder slap)	EVALUATE	
(Later) *The learner plays the same passage with the same problem.*		
Learner: "Agh." *(shakes his head)*		GOAL EVALUATE
Alessi does not tell the learner why the note did not sound clearly. He only gives a non-specific directive to play again, allowing the learner to apply the principle previously taught.		
Alessi: "Do it again."		
The learner plays again, without the problem.		OPTIONS DECISION

Rehearsal Frame 26: Transcript of DirectiveNS1-Alessi.

<table>
<tr><th>Transcript of Action</th><th>Teacher</th><th>Learner</th></tr>
<tr><td>Alessi: “The last one’s a little dirty”

Alessi demonstrates.</td><td>GOAL
EVALUATE

GOAL</td><td></td></tr>
<tr><td colspan="3">Alessi gives a non-specific directive, allowing the learner to work with the passage on his own. The learner is initially unsuccessful solving the problem on his own, however.</td></tr>
<tr><td>“Practice that.”

The learner plays without improvement.

“You need to soften the tongue.”

The learner plays.

“No, not on the first attack
only when the tongue moves quickly

The first note is not moving quickly,
so you don’t need to worry about that.”

Alessi demonstrates.

“There – daduh – just at that moment.”
Alessi demonstrates.

The learner plays as directed.

“The first note will have [demos attack]”

The learner plays.</td><td>OPTION
DECISION

EVALUATE
OPTION
DECISION

EVALUATE
PRINCIPLE

DECISION

GOAL
OPTION
DECISION</td><td>DECISION</td></tr>
<tr><td colspan="3">Alessi gives a non-specific directive, allowing the learner to work with the passage without further teacher direction.</td></tr>
<tr><td>“Again”

The learner plays.

Alessi: “Better.”</td><td>EVALUATE</td><td>EVALUATE
DECISION</td></tr>
<tr><td colspan="3">Transcript of Action continues (Rehearsal Frame 27)</td></tr>
</table>

Transcript of Action, continued (RF 27)	Teacher	Learner
(Later) *The learner plays from the beginning of the passage, and the problem returns.*		
Alessi gives non-specific negative feedback and asks a non-specific evaluation question, alerting the learner's attention to the problem while allowing him to solve it.		
Alessi: "No. Did you hear that?" Learner: "Uh-huh" *The learner plays cleanly.* "That's better"	EVALUATE EVALUATE	 EVALUATE GOAL OPTION DECISION

Rehearsal Frame 27: Transcript of DirectiveNS2-Alessi.

Directives: Outcome-Specified

Transcript of Action	Teacher	Learner
The learner plays a passage with moving notes. Clapp: "Can you play any part of that from memory? Learner: "Yeah."		
Clapp directs the learner's gaze; he does not without give any evaluation or further information.		
Clapp: "I want you to look at your fingers." *The learner plays again and changes his finger height.* Clapp: "Good!	GOAL EVALUATE	 EVALUATE OPTION DECISION
To be certain the learner understands, Clapp invites the learner to verbalize the change.		
"Do you know what you're doing differently?" Learner: "They're staying close." Clapp: "They're not flying."	 Confirm EVALUATION	 EVALUATE

Rehearsal Frame 28: Transcript of DirectiveO1-Clapp.

<table>
<tr><th>Transcript of Action</th><th>Teacher</th><th>Learner</th></tr>
<tr><td>The learner plays.</td><td></td><td></td></tr>
<tr><td>McInnes: “Whoa, whoa…Gb.”</td><td>GOAL
EVALUATE</td><td></td></tr>
<tr><td>The learner explores a finger placement for Gb.</td><td></td><td>OPTION
DECISION</td></tr>
<tr><td>McInnes shakes his head and points down.</td><td>EVALUATE</td><td></td></tr>
<tr><td>The learner plays.</td><td></td><td>DECISION</td></tr>
<tr><td>McInnes nods his head.</td><td>EVALUATE</td><td></td></tr>
<tr><td colspan="3">McInnes gives an outcome directive, specifying a goal without particulars as to how to accomplish it.</td></tr>
<tr><td>“Now make something out of that phrase please.”</td><td>GOAL</td><td></td></tr>
<tr><td>The learner plays.</td><td></td><td>DECISION</td></tr>
<tr><td>McInnes: “Sharp, sharp.”</td><td>EVALUATE</td><td></td></tr>
<tr><td>The learner tries the interval again.</td><td></td><td>DECISION</td></tr>
<tr><td>McInnes: “Sharp.” To the pianist: “Play that chord.”</td><td>EVALUATE</td><td></td></tr>
<tr><td>The learner adjusts to match the piano. She nods her head.</td><td></td><td>EVALUATE
DECISION</td></tr>
<tr><td>McInnes sings. “It’s a major third. Then you have a minor third.”</td><td>PRINCPLE</td><td></td></tr>
</table>

Rehearsal Frame 29: Transcript of DirectiveO2.

Directives: Specific

Transcript of Action	Teacher	Learner
The learner plays. True: "That's getting better! Now pedal please." *The learner plays with pedal.* True: "Yeah. But of course you'll change the pedal when you get up to [plays top notes]." *The learner plays, as directed.*	 EVALUATE GOAL DECISION	 DECISION

Rehearsal Frame 30: Transcript of DirectiveS1-True.

Transcript of Action	Teacher	Learner
McInnes: "Don't stop your vibrato." *The learner plays.* *He mimics her sound. (Strident)* *He sings a round sound.* *The learner plays.* "Get your elbow up at the frog." *The learner plays, as directed.* "Yes!"	GOAL DECISION GOAL EVALUATE OPTIONS DECISION DECISION EVALUATE	

Rehearsal Frame 31: Transcript of DirectiveS2-McInnes.

Feedback: Non-Specific

Transcript of Action	Teacher	Learner
The learner plays a scale. One note is flat.		
Clapp communicates that something is wrong, without saying more.		
Clapp: "Ouch!"	EVALUATE	
The learner is required to evaluate what is wrong and decide on a change.		
The learner stops and explores a different finger placement.		GOAL EVALUATE OPTIONS
The learner extends her finger farther for a higher pitch.		DECISION

Rehearsal Frame 32: Transcript of FeedbackNS1-Clapp.

Transcript of Action	Teacher	Learner
The learner plays.		
Clapp: "Wait, wait…"	EVALUATE	
The learner stops, looks at the music, and plays a different rhythm.		EVALUATE GOAL OPTIONS DECISION
Clapp: "Yeah."	EVALUATE	

Rehearsal Frame 33: Transcript of FeedbackNS2-Clapp.

Feedback: Outcome-Specified

Transcript of Action	Teacher	Learner
The learner plays.		
Alessi gives feedback drawing attention to a general problem rather than specific notes.		
Alessi: “No.” *He pauses.* “We’re not getting all the notes.	EVALUATE GOAL	
You have to be [gestures] when you practice. Fill in the blank.”		
Learner: “More decisive?”		
Alessi: “No. Relentless.”	PRINCIPLE	
Alessi relates an experience involving relentlessness with his trombone choir.	PRINCIPLE	
Learner: “And that’s the way we should practice.”		PRINCIPLE
Alessi: “We came off pretty good in a small period of time. You gotta be that way.”		
Alessi plays the passage.		
The learner plays the first note several times, changing the sound.		EVALUATE OPTIONS
The learner plays the passage.		DECISION
Alessi stops him.	EVALUATE	
Alessi does not say why he stopped the learner; he only directs the learner to play again.		
“Once more.”		
The learner plays with improved sound.		GOAL EVALUATE OPTIONS DECISION

Rehearsal Frame 34: Transcript of FeedbackO1-Alessi.

Transcript of Action	Teacher	Learner
The learner plays.		
Killmer identifies a problem with the sound without directing how to fix it.		
Kilmer: "It sounds like there's cotton in your reed."	GOAL EVALUATE	
The learner is required to decide how to effect the desired change.		
The learner plays again with a different sound.		OPTIONS DECISION

Rehearsal Frame 35: Transcript of FeedbackO2-Killmer.

Feedback: Specific

Transcript of Action	Teacher	Learner
Killmer: "Try it without the tongue once."	OPTION DECISION	
The learner plays.		
"Without even the air sound ahead of time; just take a breath and play with your air."	OPTION DECISION	
The learner plays.		
"Now just put the tongue lightly there.	OPTION DECISION	
The learner plays.		
"There's still that sound in the air beforehand; that's what we're trying to avoid."	EVALUATE GOAL	
The learner plays successfully.		DECISION
"That's it."	EVALUATE	

Rehearsal Frame 36: Transcript of FeedbackS1-Killmer.

Demonstrating Options

Transcript of Action	Teacher	Learner
The student attempts a shift	GOAL	
Clapp: "K. Not quite there.	EVALUATE	
You're kind of rounding your finger and you end up a half step flat.	PRINCIPLE EVALUATE	
Keep the finger straight until you get there."	OPTIONS DECISION	
The student plays again, as directed		
"Perfect!"	EVALUATE	
"So that tells you that in motion your finger is going to go from kinda like this to kinda like this [*demonstrates*]."	PRINCIPLE OPTIONS	

Rehearsal Frame 37: Transcript of Options1-Clapp.

Transcript of Action	Teacher	Learner
True: “Now he says *violento*, which means…”	GOAL	
Student: “Violent.”		
True: “Violent. And you’re so nice.”	EVALUATE	
True demonstrates both “nice” and “violent” sound.	OPTION	
Student: “Do I need to be aware of the balance here?”		GOAL
True: “Yes, you always have to be aware of the balance.”	PRINCIPLE	
The student plays.		DECISION
“Now, Ok, you’re too good because what I’m not getting	EVALUATE	
is the dissonance.”	GOAL	
True demonstrates.	OPTIONS	
The student plays differently.		DECISION
“It seems to me that since he’s got 8th notes here [demonstrates] and then quarter notes,	PRINCIPLE	
that they’d have a different sound	DECISION	
so it isn’t just” [demonstrates]	OPTIONS	
The student plays differently.		DECISION

Rehearsal Frame 38: Transcript of Options2-True.

Transcript of Action	Teacher	Learner
"How are you grouping these chords? Are you going? *[True demonstrates]*	GOAL	
The learner nods.		DECISION
True demonstrates another option, and invites the learner to decide between the two options during her independent practice.		
"You could also do [demonstrates different option]. Fool around with that in your practicing."	OPTIONS	

Rehearsal Frame 39: Transcript of Options3-True.

Transcript of Action	Teacher	Learner
"I talked to you the other day about [*demonstrates*] that kind of pedaling or [*demonstrates with no pedal*]."	GOAL OPTIONS	
Learner: "Too dry?"		EVALUATE
"Well the thing is he says according to what I've read that this is supposed to be the insects of the night.	GOAL	
And this [*demonstrates without pedal*] does not sound as much like insects." [*demonstrates with pedal*]	OPTIONS EVALUATE	
Learner: "I think use some pedal maybe."		DECISION
"Yeah, but the thing that I was missing was this glaze of pedal. You find the spot on the pedal that just catches the sound. [*demonstrates*]	OPTION	
If I go all the way down to the bottom [*demonstrates*].	PRINCIPLE OPTIONS	
Learner nods: "It's too much."		EVALUATE
"Of course it's a mess. So… kind of creepy crawly. Try it see if you can find that spot on that pedal."	EVALUATE GOAL	
The student plays.		

Rehearsal Frame 40: Transcript of Options4-True.

Transcript of Action	Teacher	Learner
“Now let’s get the sound back though. ‘Cause I liked the sound you were doing in the etude, just a second ago. I’d like to get that richness back.”	GOAL EVALUATE OPTIONS	
The learner plays again, slower and more deliberately, with fuller sound.		OPTIONS EVALUATE DECISION
“Good.	EVALUATE	
(Later) “I’m looking for the most resonant sounds you can make. Almost the sounds you made in the beginning in the lesson; you’re not getting that sound.”	GOAL EVALUATE OPTIONS	
(Later) *The learner plays.*		
Alessi: “No.”	EVALUATE	
The learner stops.		
“Remember the low E you got in the Ostrander. You had a nice low E there. That’s what you want to shoot for.	GOAL OPTIONS EVALUATE DECISION	
The learner plays.		
“Right.”	EVALUATE	

Rehearsal Frame 41: Transcript of Options5-Alessi.

Transcript of Action	Teacher	Learner
The learner plays. Alessi: "Those notes sound accented.	 GOAL EVALUATE	
Alessi imitates the student's playing.		
Right here." [*Alessi demonstrates the passage with an exaggeratedly accented sound*.] Learner: "Oh." [*nods*.] *Alessi demonstrates unaccented, correctly* *The learner plays again, differently*.	OPTIONS OPTIONS DECISION	 EVALUATE

Rehearsal Frame 42: Transcript of Options6-Alessi.

Transcript of Action	Teacher	Learner
The learner plays octaves. She is out of tune.		
Clapp reconstructs the learner's problem. He plays the same passage, exaggeratedly imitating her intonation problem. He asks a question inviting her to evaluate.		
Clapp: "This is kind of what was happening. [*He demonstrates*.] Can you tell me how to fix it? I'm very exaggerated." Learner: "First finger is too low."	EVALUATE	 GOAL EVALUATE (attempted)
Clapp responds to her evaluation as if she were the teacher, allowing the learner to observe the inaccuracy of her evaluation.		
Clapp demonstrates again and brings the first finger higher in response to her evaluation. The intonation becomes worse. Clapp: "First finger actually is OK. Your shifts are going to the right place, but your third finger is closing down a little bit more than the first is." *Clapp demonstrates correctly.* *The learner plays correctly.*	DECISION EVALUATE DECISION	

Rehearsal Frame 43: Transcript of Options7-Clapp.

Transcript of Action	Teacher	Learner
True: “Now I’d like you to see what I’m doing with my body. See how my body is already over there? [*demonstrates*] Instead of [*demonstrates*].” Learner: “Uh huh.” *The learner plays and changes her approach.* (later) True: “Now, you and I approach that completely differently. You did [demonstrates] and I went [demonstrates].” Learner: “You drop.” True: “Exactly. And I didn’t cover the note first. And you may notice it sounds better when you do that, when you [*demonstrates*], for that ringing sound which is much more beautiful”	GOAL OPTIONS OPTIONS EVALUATE PRINCIPLE GOAL	 EVALUATE PRINCIPLE

Rehearsal Frame 44: Transcript of Options8-True.

Transcript of Action	Teacher	Learner
Killmer: “I think there’s a very good reason for keeping the staccato that way	GOAL	
because it really makes a nice line out of it.”	EVALUATION PRINCIPLE	
“If you try to make it too chirpy, it just doesn’t work.	EVALUATION	
Do it once, just chirpy.”	OPTION	
The learner plays “chirpy.”		OPTION
“Now put the bow back on the string.”	OPTION	
The learner plays longer.		OPTION
“I just like that.	EVALUATE	
And if someone says, ‘could you play it shorter?’ just play it more accented. And don’t tell ‘em what you did. Let’s try that.”	OPTION DECISION	
The learner plays.		
“It’s amazing how that sounds shorter.”	EVALUATE	

Rehearsal Frame 45: Transcript of Options9-Killmer.

Stating Principles

Transcript of Action	Teacher	Learner
"It's good except for one thing. The tone is too thin.	GOAL EVALUATE	
"You won't be heard… It's not just a matter of what you can do it's a matter of style."	PRINCIPLE	
McInnes plays, demonstrating big tone, then weak tone.	OPTIONS	
"Out there that would sound like…"	PRINCIPLE EVALUATE	
He demonstrates an even smaller sound.		
He demonstrates a longer passage with the big tone he has in mind.	OPTIONS	
"Mine sounds better. Right?"	EVALUATE	
"Why? … Because I have much more energy [in the bow], more weight, faster bow speeds, and I don't stop my vibrato. You start this all by yourself; the orchestra doesn't come in until here."	PRINCIPLE	
"You can't produce that type of sound. It sounds… You know the word we use, 'puny'?	EVALUATE	
You can't play with a puny tone. You can produce a beautiful sound."	GOAL	

Rehearsal Frame 46: Transcript of Principle1-McInnes.

Transcript of Action	Teacher	Learner
The learner plays.		
Killmer: "Get your money's worth out of that D.	GOAL	
The learner plays.		
Killmer sings it two ways.	OPTIONS	
"Absolutely connect."	GOAL	
The learner plays.		
"The staccato of the D before the last bar – you isolate it, and it doesn't go where it's supposed to go. It stops at the bar line.	EVALUATE PRINCIPLE	
"So, make sure the D goes to the C. There again, don't make it so short.	DECISION GOAL	
"I think incidental staccato, which is on your way, or isolated staccato, which is actually separate, and vertical…	OPTIONS PRINCIPLE	
…and this is definitely incidental, and not isolated.	DECISION	

Rehearsal Frame 47: Transcript of Principle2-Killmer.

Transcript of Action	Teacher	Learner
Alessi stops the student's playing.	EVALUATE	
Student: "Yeah, those first two notes…"		EVALUATE
Alessi: "Yeah, they lack any meat	GOAL EVALUATE	
because you're tight with the air stream.	PRINCIPLE	
So, [*Alessi plays*]."	OPTIONS	
The student plays.	DECISION	
"Yeah – that's the idea.	EVALUATE	
Try to get more of that.	DECISION GOAL	
If you practice with no tongue, you will get really good at that."	PRINCIPLE	

Rehearsal Frame 48: Transcript of Principle3-Alessi.

Transcript of Action	Teacher	Learner
The learner plays a piece and shifts incorrectly; he is flat.		
The learner stops himself		GOAL EVALUATE
He tries several times to hit the note correctly.		DECISION
Clapp: "So there's a little bit of a barrier there. The brick wall is stopping you."	PRINCIPLE	
Clapp demonstrates the shift correctly and incorrectly.	OPTIONS	
"So in addition to a lift, you've got to open the hand before you start moving."	PRINCIPLE	
The learner plays again, successfully hitting the shift by bringing the hand around.		OPTIONS DECISION
"Beautiful! It's so simple, isn't it?	EVALUATE	
But there are several re-education components. One is the pressure of the finger, one is the releasing of the hand from pressing in. And every time you come to those shifts you have to tell yourself that information."	PRINCIPLE GOAL for future situations	

Rehearsal Frame 49: Transcript of Principle4-Clapp.

Transcript of Action	Teacher	Learner
For the previous approximately 15 minutes, the goal and principle established during Principle4-Clapp is applied in multiple contexts. After these experiences, the learner detects the same problem and solves it on his own.		
The student plays a different passage with a shift. He shifts incorrectly and immediately stops himself. “Ah! Should have been up.” (Referring to his hand.)		GOAL EVALUATE PRINCIPLE
Clapp adds, “and too late!”	EVALUATE PRINCIPLE	
The learner plays again, shifting accurately on the second iteration.		OPTIONS DECISION

Rehearsal Frame 50: Transcript of Principle5-Clapp.

Transcript of Action	Teacher	Learner
McInnes: "This is the other thing that's very hard about this. You've done the Stravinsky *Elegy*, so you've experienced this.	PRINCIPLE	
You're putting the same amount of weight on both strings."	EVALUATE	
Learner: "And I should be putting the weight on the top string?"		OPTION DECISION
McInnes: "Wherever the melodic material is."	GOAL PRINCIPLE	
The learner plays.		DECISION
"Do it again. Be careful that 3rd note isn't longer; because, if you play it longer, it tells us it's going forward. That doesn't make any sense, does it?"	GOAL PRINCIPLE EVALUATE	
Learner: "It seems like when I try to play it shorter, it sounds too short compared to what it was before."		GOAL EVALUATE
McInnes: "But it's not a melodic note."	GOAL PRINCIPLE	
McInnes sings.	DECISION	
The learner plays.		
"Better, except your weight ratio isn't right."	EVALUATE GOAL EVALUATE	
The learner plays.		OPTION DECISION
"Now, you see how much more satisfying that cadence was?	EVALUATE	
Learner: "Yeah."		
"And it's not just what you did with the cadence, it's the way you prepared the cadence, by what you did leading up to the cadence. That's the secret to playing Bach."	PRINCIPLE	

Rehearsal Frame 51: Transcript of Principle6-McInnes.

Questions Prompting Evaluation

Transcript of Action	Teacher	Learner
Alessi and his student listen to an electronic recording of the student's audition. Alessi stops the recording after hearing the opening phrase and asks a series of questions prompting the learner to evaluate what he hears.		
Alessi: "How did you like the opening?"		
Learner: "I like the sound. Didn't like the D."		GOAL EVALUATE
Alessi: "What did you not like about it?"		
Learner: "It wasn't very stable, it was flat."		GOAL EVALUATE
Alessi: "What about that first interval, you happy with that?"	GOAL	
Learner: "The F's sharp."		EVALUATE
Alessi: "Can you sing that interval?"	GOAL	
The student sings.		OPTIONS
Alessi: "Play it again."		
The learner plays the recording of the interval.		
"Play it again." "Sing it again."		
The student sings.		OPTIONS
"Play it again." "What do you think about the Bb and the F? Happy with it?"		
Learner: "So so. I could have been a little more decisive."		GOAL EVALUATE
Alessi: "But I'm talking about the pitch."	GOAL	
Learner: "The F's flat."		EVALUATE
Alessi continues asking questions without further comment for over 2 minutes.		

Rehearsal Frame 52: Transcript of QuestionE1-Alessi.

Transcript of Action	Teacher	Learner
Alessi asks a non-specific evaluation question, inviting the learner to choose which goals to evaluate.		
Alessi: “What do you think about that?”		
Learner: “I think it’s really bumpy. The intonation’s not good, but it’s also so unstable. My natural slurs aren’t smooth at all.”		GOALS EVALUATE
Alessi: “How would you characterize the connections?”	GOAL	
Learner: “Very…constipated. It’s not smooth at all, I’m not using my air; it’s not a steady stream.”		EVALUATE
Alessi asks a question prompting to the learner to explain the cause of these evaluations by applying a principle.		
Alessi: “Yeah, causing what?”		
Learner: “Causing inconsistency…”		PRINCIPLE
Alessi: “So you’re not happy with the connections. If you were to sing what you sounded like, how would it sound?”		
The learner sings. “Instead of [*sings a positive example*].”		EVALUATE OPTIONS
Alessi: “To me it sounds like wa-wa. [sings]	EVALUATE OPTION	
I’ve heard you doing this before, when you’re up tight.	PRINCIPLE	
Constipation of the air is correct.	EVALUATE	
But you have to blow across, and you weren’t doing that.	PRINCIPLE EVALUATE	

Rehearsal Frame 53: Transcript of QuestionE2-Alessi.

Questions Prompting Principle Statements

Transcript of Action	Teacher	Learner
Alessi: "Do you know why the pitch is off?"		
"Is it because I'm not holding…?" *The student gestures the slide.*		PRINCIPLE
"Yes. It's because you're not holding the slide. You're not able to figure out where the pitches are because you're just bouncing around. I know exactly where the pitches are because I do this for everything." *Alessi gestures holding the slide.*	EVALUATE PRINCIPLE OPTIONS DECISION	

Rehearsal Frame 54: Transcript of QuestionP1-Alessi.

Transcript of Action	Teacher	Learner
The learner plays a scale.		
Clapp grimaces.	EVALUATE	
Clapp gives non-specific feedback; he does not vocalize the problem he sees.		
Clapp: “Hold on. Something happened up there around your second shift.”	EVALUATE GOAL	
The learner plays again, correctly.		EVALUATE OPTIONS DECISION
Clapp: “Ok, this was good.”	EVALUATE	
Though the learner has fixed the problem, Clapp asks a series of questions to ensure her understanding, inviting her first to evaluate, then to apply a principle.		
“Do you know *where* it happened the first time?”		
Learner: “I think it was right here.” The learner places her hand on the fingerboard to answer.		EVALUATE
Clapp: “It was there. That’s right.	EVALUATE	
And do you know *why* it happened?”		
Learner: “My half steps were too far?”		
Clapp: “Your half steps were beautiful.”	EVALUATE	
Learner: “Because of my shift.”		PRINCIPLE
Clapp: “Exactly. And where does the shift come from?”		
The learner demonstrates a lack of understanding of a principle guiding correct shifting.		
Learner: “The wrist?”		
Clapp gives the learner an opportunity to observe for herself and generalize the principle.		
Clapp: “Try it and see. Observe. Put your camera out here to look at yourself.”		
The learner plays.		
Clapp: “It’s actually coming from right here [*points to her elbow*].”	PRINCIPLE	
Clapp demonstrates the shift correctly and talks her through the process of shifting.	PRINCIPLE	

Rehearsal Frame 55: Transcript of QuestionP2-Clapp.

Transcript of Action	Teacher	Learner
The learner plays a passage that includes an inaccurate shift. Clapp: "Did you hear that the B didn't quite make it—the shift down to B?"	 GOAL EVALUATE	
Clapp asks a question to determine the learner's knowledge of the pertinent principle of shifting.		
"How do you get there? What takes your finger there?" *The learner answers incorrectly:* "The first finger." Clapp: "No ma'am. Ok, look."	 EVALUATE	
Clapp demonstrates the shift correctly so the learner can observe the source of the motion.		
Learner: "Oh, the elbow." Clapp: "Yes! So don't let your thumb get tied up in the transit. Release it." *The learner plays the passage again.* *Clapp nods approvingly.*	 PRINCIPLE OPTIONS DECISION EVALUATE	PRINCIPLE

Rehearsal Frame 56: Transcript of QuestionP3-Clapp.

Questions Prompting Decisions

Transcript of Action	Teacher	Learner
True and her student have considered several musical aspects related to creating the composer's intended sound, which True identified as "the insects of the night."		
True: "Frankly I can't think of any other spot in the repertoire that has exactly this kind of sound. I think this is a unique movement. So it's worth the time to figure out what you're going to do with both hands.	 GOAL	
True demonstrates options while asking the learner to choose between them.		
Is it going to be more the left hand [demos left hand heavier]? Or is it going to be [demos right hand heavier]?"	 OPTIONS	
The learner comes up with another possibility to choose from.		
Learner: "What about even?"		OPTION DECISION
True acknowledges the learner's conceived option. She reinforces the learner's decision by teaching a principle that explains the decision in relation to the goal.		
[True demos] "It's possible. But I definitely agree with you that it's not going to be the bass, because that's too heavy for insects crawling around in the night."	DECISION PRINCIPLE EVALUATE GOAL	

Rehearsal Frame 57: Transcript of QuestionD1-True.

Refraining from Answering the Learner

<table>
<tr><th>Transcript of Action</th><th>Teacher</th><th>Learner</th></tr>
<tr><td>“I think your tempo is a little too fast.”

“On viola the strings are a little farther apart than they are on fiddle…”
“…Start on measure 6”

Learner: “At the tempo I was doing, or…?”</td><td>GOAL
EVALUATE

PRINCIPLE</td><td></td></tr>
<tr><td colspan="3">Here McInnes refrains from answering the question directly; he does not provide a tempo. He answers instead with a goal and a principle to guide the learner’s decision.</td></tr>
<tr><td>“No, at what tempo you can comfortably break chords without disturbing the pulse.
The chords in Bach should enhance the beauty or direction of the phrase, rather than get in the way of it.”</td><td>OPTION
GOAL

PRINCIPLE</td><td></td></tr>
<tr><td colspan="3">The learner solves the problem of selecting a tempo by applying the principle.</td></tr>
<tr><td>The student plays slower.</td><td></td><td>DECISION</td></tr>
<tr><td colspan="3">McInnes reinforces the student’s decision and the effect the tempo choice had on other aspects of the student’s playing.</td></tr>
<tr><td>“That time you backed off enormously with your bow, tonally
“But it was much more comfortable for you, wasn’t it?”</td><td>GOAL
EVALUATE
GOAL
EVALUATE</td><td></td></tr>
<tr><td colspan="3">Following the teacher’s encouragement, the student elaborates on his evaluation of the last iteration.</td></tr>
<tr><td>Student: “I felt I could keep the pulse the same.”</td><td></td><td>GOAL
EVALUATE</td></tr>
</table>

Rehearsal Frame 58: Transcript of Refrain1-McInnes.

Transcript of Action	Teacher	Learner
"I have a way I like to do it. I'm not saying you have to do it that way… but let's look at it together. You took a breath here, and not here…? Let's go with that idea for now…" *The learner plays.* *The learner stops.* "I didn't take a breath there, did I?" "Should I breathe there?"	 GOAL	 DECISION EVALUATE GOAL OPTION
Alessi does not tell the learner where to breathe. He instead invites the learner to answer his own question.		
"You figure it out." *The learner breathes in a different place than the immediately previous performance. Alessi accepts this choice of breath.* *The learner takes an additional breath later in the passage.* Alessi: "No. Don't breathe there. Try breathing here." *Alessi marks it.* Alessi: "This is good. This will work."	 EVALUATE DECISION EVALUATE	 OPTION EVALUATE DECISION DECISION

Rehearsal Frame 59: Transcript of Refrain2-Alessi.

Transcript of Action	Teacher	Learner
Learner: “You always tell me that my air stops moving in the staccatos. How do you get the notes to be shorter? If the air keeps moving and the tongue is just interjecting, how do they speak?		GOAL PRINCIPLE
Alessi does not answer the question. He says nothing. Instead, he demonstrates the concept.		
Alessi demonstrates staccato air without the instrument. *The learner attempts imitating.*	OPTION	
Alessi gives non-specific negative feedback and demonstrates again, allowing the learner to discern what to do.		
Alessi: “No.” *Alessi demonstrates again.* *The learner watches and attempts again.*	EVALUATE	
Alessi: “I’m not tonguing.” *Alessi demonstrates again.*	PRINCIPLE	
Learner: “Ok, I see.” *The learner demonstrates correctly.*		EVALUATE DECISION
Alessi: “Yeah. So that’s what happens. I’m not saying you should never tongue like that. But that’s what happens in the background, when all this stuff is going on.	PRINCIPLE OPTION	
Alessi demonstrates on the trombone. “That’s no tongue.” He demonstrates again. “That’s the same thing, but with very little tongue.”	OPTIONS	
Learner: “Ok, I see.” *Alessi demonstrates a passage.*		EVALUATE
Alessi gives a practice directive.		
“That’s why I think you guys should practice with no tongue. On a daily basis. “Can you do that?” *He demonstrates.* *The learner plays.*		
Transcript of Action continues (Rehearsal Frame 60)		

Transcript of Action, continued (RF 60)	Teacher	Learner
Alessi: “Well that sounds like you haven’t practiced that very much. Is that true?” Learner: “Yeah.” Alessi: “I think you should. You need to figure out how to make a sound with no tongue. And an immediate sound.” *He demonstrates*. “So this is steady.” *The learner plays*. Alessi: “Right. Try to get good at that….You gotta practice that every day. “I’m always thinking about getting the air to do the job rather than the tongue. “So the answer is, how you get it—what did you say? Shorter—“ Learner: “Disconnected. Like, staccato.” Alessi: “Right. Kinda like you just did.”		 GOAL

Rehearsal Frame 60: Transcript of Refrain3-Alessi.

Acknowledging Learners' Choices or Goals

Transcript of Action	Teacher	Learner
The learner plays.		
True approaches a problem she hears from the standpoint of the learner's intention.		
True: "I'm trying to reconcile what you're really feeling here and how we can make it sound—not just hurrying the tempo.	GOAL EVALUATE	GOAL
She conceives an option that solves the problem while still accomplishing the learner's expressive objective.		
And I think the way you can get around it is to start the 16ths later." *True demonstrates.* "See what I'm hearing now is this [*demonstrates, hurrying*]. So it sounds—particularly the third beat sounds as if you're really pushing ahead." Learner: "Oh yes." *The learner plays differently with True's second option.*	OPTION DECISION OPTIONS EVALUATE	 EVALUATE

Rehearsal Frame 61: Transcript of LearnerChoice1-True.

Transcript of Action	Teacher	Learner
"Be careful of the quality of the sound on the two Bb's."	GOAL EVALUATE	
The learner plays.		
"Maybe it would help if you think [demos phrase]. And I'm not necessarily saying that that is the grouping; that just might help you."	OPTIONS	
Learner: "I'm trying not to play them too…So we don't want them too short, right?		GOAL EVALUATE DECISION
"It just suddenly changes the character I think there."	GOAL EVALUATE	
Learner: "Yeah. I changed the fingering, just to… I was trying to sweep…" [demos] "to make it so it's not so…[demos]		DECISION PRINCIPLE OPTIONS
True considers the learner's choice; she plays the passage as the learner has decided.		
True tries the fingering. "So you're doing…"	OPTIONS	
The learner demonstrates the fingering.		OPTIONS
"I always felt like I accented that last one."		EVALUATE
"But I'm thinking that you're doing, maybe too big a deal. I mean with the [demos sweeping motion] with this kind of thing."	EVALUATE	
Learner: "I want… so that there was no edge to the sound."		GOAL
"Well I appreciate that, needless to say,	EVALUATE	
but I think if you just… [demos] if you just stay close…"	OPTION DECISION	
The learner plays.		
"Good good."	EVALUATE	

Rehearsal Frame 62: Transcript of LearnerChoice2-True.

Transcript of Action	Teacher	Learner
McInnes: "What fingering are you doing?" Learner: [demos] "Stay on the G string; I just changed it. I was actually going [demos]."		 DECISION OPTIONS
McInnes accepts the learner's general decision but provides another option.		
"I think if you want to play it up on the C string you need to play the whole thing on the C string." Learner: "Yeah." *The learner attempts change in fingering.*	OPTION	 DECISION
McInnes provides a more successful means of accomplishing the learner's intention.		
McInnes: "Get to 5th position in the beginning of the measure." [sings] *The learner plays.* "Work it out; that's better.	DECISION OPTION EVALUATE	
McInnes provides the goals and principles as a rationale for adjusting the learner's choice.		
Because the change in the color if it's just the last 5 notes… Also it sounds too light weight." [he sings light sound, then full sound] "Because right now it sounds like [sings light sound with heavy ending] and that doesn't make any sense."	GOAL PRINCIPLE GOAL EVALUATE OPTIONS EVALUATE	

Rehearsal Frame 63: Transcript of LearnerChoice3-McInnes.

Transcript of Action	Teacher	Learner
True: “Do you hear how spread this is [demonstrates low notes]? Be close to the keys.”	GOAL EVALUATE OPTION DECISION	
The learner plays.		
True: “But I would change the pedal on [demonstrates the same low notes].”	OPTION DECISION	
The learner plays.		
True: “It still sounds like you’re catching the C in the pedal.”	EVALUATE	
The learner plays, slower and more deliberately.		EVALUATE DECISION
True: “Yeah!”	EVALUATE	
True recognizes the goal that may be in the student’s mind.		
“Now I imagine the reason you did that was a very good reason, and that was this:”	GOAL	
True demonstrates the chord before with the low notes in question. “Do you hear what that does?”	OPTION	
The learner hesitates and says nothing.		
“It’s just too much. It goes by so fast that I think it’s worth sacrificing that for that instant at the end.”	EVALUATE PRINCIPLE DECISION	

Rehearsal Frame 64: Transcript of LearnerChoice4-True.

Transcript of Action	Teacher	Learner
The learner plays the first note of a passage.		
Killmer: "Can you—instead of 'bah,' but 'wah.'	GOAL EVALUATE OPTIONS	
You have to speak French in this one. We're always saying 'Don't speak French, don't creep into the note.' But in this case I think 'wah' is appropriate."	PRINCIPLE DECISION	
The learner plays.		
Killmer: "Still kind of funny. Just easy."	EVALUATE	
The learner plays.		
"Can you take the vibrato away a little more?"	OPTION DECISION	
The learner plays.		
"Still sounds uncomfortable."	EVALUATE	
Killmer and the learner exchange playing the same note several times.		
The learner plays differently.		OPTION DECISION
Killmer acknowledges the learner's action that made the last iteration more successful.		
"You did the right thing; you let your body go, you let that tension go a little bit.	OPTION	
So you need to just really feel calm, because it's a calm note.	PRINCIPLE	
It's like taking a breath [*demonstrates tensely*] and then trying to go [*breathes out calmly*] you have all this tension going. We're trying to do the opposite.	OPTIONS EVALUATE	
Don't even take a breath. Just play on the air you happen to have."	OPTION DECISION	
The learner plays.		
"That's good!"	EVALUATE	
The learner continues playing.		

Rehearsal Frame 65: Transcript of LearnerChoice5-Killmer.

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