Journal of Elementary Science Education, Vol. 17, No. 1 (Spring 2005), pp. 55-68.

Student Teachers' Use of Learning Theories to Diagnose Children's Learning Difficulties

Andrea J. Madsen
Joanne K. Olson
Iowa State University

Understanding how people learn is the foundation of informed teaching, yet it is difficult for teachers to articulate and effectively use. This study investigated how two preservice teachers' conceptions of learning theories transferred to their decisionmaking during student teaching. This paired-sample case study examined Research-Based Framework papers, oral defenses, student teaching practices, and reflection on-action. Findings indicate that knowledge from a video case analysis assignment given in the science methods course can transfer to classroom decisions during student teaching; however, perceived institutional constraints can override such knowledge, resulting in decisions that meet district requirements yet are knowingly detrimental to students.

Introduction

Teaching is a profession that requires the effective practitioner to possess a sophisticated knowledge base (Schon, 1983, 1988) in content, pedagogy, and pedagogical content knowledge (Shulman, 1987), and to make constant decisions that rely on that knowledge base. Unlike technicians, "professionals are constantly being called on to make decisions in unique circumstances without certain knowledge. Past experience and a base of expert knowledge do not provide a set of fixed rules to follow but rather provide heuristics that will guide decisionmaking" (Loucks-Horsley, Hewson, Love, & Stiles, 1998, p. 31).

Critical to the decisionmaking process is the use of reflection, both in-action (current actions) and on-action (past actions). This reflection process should compare what is occurring in the classroom with the teacher's knowledge base, enabling the teacher to "apply knowledge about students, content, the curriculum, instruction, assessment, and the school and local communities" (Loucks-Horsley et al., 1998, p. 32). Such reflection on one's teaching is a cognitively demanding act (Johnson, 1993) and, not surprisingly, novice teachers tend to rely on fewer cues to make their decisions and then base those decisions on factors often disconnected from their knowledge base of effective teaching (Cleary & Groer, 1994; Englert & Semmel, 1983). Even more alarming is the frequent dependence on unreliable cues due to the absence of a theoretical knowledge base or a misunderstanding of how to apply it. The result of such an approach is trial and error in the classroom to develop a knowledge base of experience over time rather than a knowledge base of theory based on research.

This lack of a theoretical knowledge base is clearly illustrated by the following excerpt from a first-year teacher's journal: "Everyone tells us how our kids can't read, can't write, can't pass the SAT, etc. Nobody tells us how to teach or how to solve these problems. Why? Because I think nobody knows how. You just have to get in there and try and hope you're doing a better job than those before you" (Olson, 1992, p. 15). Despite completing a teacher education program, this teacher was learning how to teach through trial and error and perceived that no theoretical knowledge base exists. Unfortunately, many novice teachers perceive their teacher education programs as irrelevant to the realities of teaching, and this teacher's experience is not uncommon (Kagan, 1992). This example illustrates a substantial gap between theory and practice. If teacher education programs focus on theory and fail to address its classroom implications, preservice teachers fail to link theory with practice. Equally dangerous, however, is a teacher education program that focuses entirely on practical activities and strategies or school-based experiences while failing to address the theoretical underpinnings of such practices (Ohana, 1999; Olson, 2003a). Teachers from such activity-focused or experience-based programs are unlikely to be successful when circumstances inevitably change and they lack a knowledge base that can transfer to new situations. Critical to the development of decisionmaking skills is the development of a theoretical knowledge base tightly coupled with its application to the classroom.

Video Cases in Science Methods Courses

Because practicum teaching experiences vary widely in quality, lack the affordance of group reflection, and cannot be repeated, the use of video case analysis in methods courses is promoted in the literature as an important way to link theory and practice (Abell, Bryan, & Anderson, 1998; Bryan & Abell, 1999). Having students work together to view, discuss, and focus on various aspects of the lesson provides the instructor with a valuable tool to promote instructional decisionmaking. For instance, an instructor can stop the lesson and ask students how the teacher could respond to a student's comment, encouraging them to consider a number of learning theories, student goals, etc., as they frame potential alternatives. Such expert modeling is an important aspect of learning skills such as reflection in-action and on-action, and decisionmaking in general.

Purpose of Study

One of the purposes of the elementary science methods course at our institution is to promote the development of more informed decisionmaking among preservice elementary teachers. To assist students in making connections between their developing theoretical knowledge base and the realities of the classroom, we embedded a video case assignment within the methods course. Our goal was to provide a classroom-based context within which students could conceptualize the complexities of teaching and aid them in making classroom decisions. The case study was presented early in the course so that subsequent learning is framed in terms of the lesson on the tape and students' attempts to analyze it. One important aspect of the assignment is to help students better recognize the need to consider learning theories when they plan and teach lessons. This study was designed to look for transfer of this knowledge to student teaching. We sought to determine the extent to which student teachers diagnose children's learning successes and difficulties in terms of what they understand about how children learn.

We recognize that decisionmaking in the classroom is a complex process and relies upon more than a knowledge of learning theories. Indeed, teachers make decisions about their goals for students, specific behaviors and strategies they will use in a classroom, how the activities they use are promoting specific goals, to what extent individual students understand various aspects of the content, how to better engage students, what analogies might be appropriate to use, and so on. Further, a teacher's knowledge base includes his or her content understanding, pedagogical knowledge, and pedagogical content knowledge, to name a few. Understanding how people learn is just one aspect of this larger knowledge base; however, we selected learning theories for several reasons. First, knowing how people learn is the foundation of informed teaching. This is described by Loucks-Horsley et al. (1998) as follows:

> *The tasks of teaching need to express or embody the intended knowledge and need to be related to the current state of the learners in such a way that it is possible for the learners to learn the intended content (Fenstermacher, 1986; Hewson & Hewson, 1988; Hirst, 1971). What this means is that learning lies at the heart of any conception of teaching; the corollary is that a conception of teaching that does not include learning is a contradiction in terms. On the one hand, teachers need to match who the learners are and what they know with the intended curriculum in ways that make this a task that is reasonable for learners to be able to achieve. Assuming it is solely the learners' responsibility to make the necessary connections between where they are and where the teacher intends them to go cannot be a part of what it means to teach. (p. 31)*

Second, previous work indicates that despite its critical importance, understanding how students learn is rarely applied by teachers to their practice (Olson, 2003a; Skamp & Mueller, 2001). Finally, teachers without a strong knowledge base will establish poor practices of decisionmaking and automate these practices through time and experience, making these practices even more difficult to change (Gagne, Yekovich, & Yekovich, 1993). The constraints on a teacher's time are enormous; novices' concerns immediately switch to survival (Kagan, 1992); and in-service teacher education that is coherent, long term, and systemic is the exception rather than the norm. Therefore, if preservice teachers do not develop an understanding of how to apply theoretical knowledge to classroom decisions while in their teacher education program, it is unlikely they will develop this understanding once they begin teaching.

Methods

This study utilizes a comparative, paired-sample case study design (Yin, 2003). The two cases highlighted in this study were purposefully selected. Initially, four pairs of students were selected; one student from each pair took elementary science methods in Spring 2001 and completed a unit plan assignment, and the second from each pair took elementary science methods in Fall 2001 from the same instructor but completed a video case analysis instead of the unit plan. Students were matched by ACT scores, GPA, and course grade, and ranged from an "A" average GPA to a "C" average. Each student was observed and interviewed during student teaching. From this sample, we selected any pairs who were faced with a comparable circumstance that required a deliberate use of the student teachers' knowledge of learning theories to account for classroom events. We recognize that all teachers need to make decisions based on how children learn, but in this study, one pair was faced with an identical dilemma—the content they were teaching was developmentally inappropriate for their students. This pair was selected for this study to provide important insight into student teachers' decisionmaking when faced with such a situation. Taken together, these two cases represent an important contrast in student teachers' thinking.

Study Participants

Barb and Grace are Caucasian females from the Midwestern United States in their early twenties, who are classified as seniors at a large, land-grant university. Barb took elementary science methods from the second author in Spring 2001 and student taught in a school district close to the university the following fall semester. Grace took elementary science methods from the same instructor in Fall 2001 and student taught in a different school district close to the university the following spring semester. This pair of students was the second pair of the initial four, and both earned B+ grades in their science methods course.

The Elementary Science Methods Course

Great care was taken by the elementary methods instructor to keep the course content and expectations as equivalent as possible for the classes in both semesters. The primary difference between the two sections is that the Spring 2001 students (Barb's class) completed a traditional unit plan. Students worked in pairs to create a five-day unit for an elementary grade level and science content of their choosing, accompanied by a written rationale for their decisions that reflected their understanding of learning theories; their goals for students; the role of the teacher; and the role of activities, materials, and lesson planning models.

The Fall 2001 students (Grace's class) completed a video case study assignment in place of the traditional unit plan. Students were given a 40-minute videotape of an elementary science lesson and were given four weeks to analyze the lesson in groups of three. Individually, each student then created two lessons—one to replace the lesson on the tape, and one that would occur the following day. The expectations for this assignment were similar to those for the Spring 2001 students who completed the unit plan assignment—they had to demonstrate their understanding of learning theories; their goals for students; the role of the teacher; and the role of activities, materials, and lesson planning models in their analysis.

Both assignments were given the second week of the course and were due during week six. Extensive feedback was provided on all assignments. The key difference between Barb's class and Grace's class was the real classroom shown on the videotape. The lesson on the videotape provided the preservice teachers a context with which to critique and evaluate a science lesson using everything they had learned about teaching in their education program, and to determine what they did not yet understand.

Students in both sections also completed a self-analysis during their practicum teaching experience, audio-taping themselves and assessing their interaction patterns with elementary students. Additionally, students wrote a 20- to 30-page research-based framework (RBF) paper. This RBF paper outlined the goals they had for their elementary students and the characteristics of effective teacher behaviors, content, materials, strategies, and activities they would use to actively promote their goals in a manner consistent with how students learn. After writing the paper, each student met with the instructor for a 1.5 hour oral defense of their understanding of teaching and learning science. (For more information on an RBF-driven methods course, see Clough, 2003; Clough & Kauffman, 1999; Olson, 2003a, 2003b).

Three features of the course are important to understand the context of this study. First, this course is structured to invoke conceptual change in students regarding teaching and learning. It focuses on application of research findings to teaching situations rather than memorization of information. Second, the instructor of the course models instructional practices congruent with practices advocated in science education literature, and students are explicitly attended to the instructor's practices, including mistakes and the decisionmaking behind particular instructional decisions. Finally, assessment strategies employed in the course require students to synthesize information and apply their understanding of teaching and learning to multiple situations.

All preservice elementary teachers in this study have taken three courses in psychology—Introduction to Psychology, Educational Psychology, and Developmental Psychology—prior to their enrollment in elementary science methods. Within the science methods class, students work to accurately apply their understanding of four learning theories—Developmental, Constructivist, Social, and Behavioral Learning—to diagnose classroom situations and inform instructional decisions. This course posits that all four learning theories are useful, in appropriate circumstances, to support informed classroom decisionmaking. Instruction regarding developmental learning theory is based on the notion that children's thinking follows well-researched and predictable patterns, involving increased abilities to think abstractly over time (Piaget, 1964; Renner & Marek, 1990). Students are also attended to how children create ideas within their existing mental frameworks through assimilation and accommodation. Students are explicitly directed to the notion that children's thinking can be ill-formed and inconsistent with teaching that occurs in elementary classrooms. This makes the diagnosis of children's ideas critical for effective science teaching (Driver, Guesne, & Tiberghien, 1985; Posner, Strike, Hewson, & Gertzog, 1983). The role of peers and experts in learning is explored with students. Emphasis is placed on the importance of scaffolding questions to move children's thinking forward and to help them build important conceptual connections. Finally, the methods course does not deny the idea that people do change their behavior based on stimuli. Thus, behavioral learning theory can be used the inform the teaching of skills such as the use of scientific equipment, cooperative group skills, etc.

The application of learning theories is explicitly addressed throughout the course, using various strategies and activities. For instance, students' understanding of learning theories are articulated explicitly during week three. The rest of the course utilizes specific and explicit ways to untangle students' misconceptions of learning theories through discrepant events, the challenging of students' ideas, and the introduction of more accurate views of how students learn. Various videos are shown (Annenberg/CPB, 1997, 2003), while the instructor frequently stops the video to pose questions concerning the application of learning theories ("How is the learning cycle consistent with developmental learning theory?"; "For what reasons might this student misunderstand the content taught?"). Additionally, following hands-on activities in class, students are asked to discuss the student goals promoted by the activity and how the activity, strategies, materials, content, and teacher's role is consistent with how children learn. Furthermore, when students articulate vague phrases or vocabulary ("Students have to construct their own knowledge"; "I will be the facilitator"), they are frequently asked to clarify or elaborate on the idea in order to make the statement more accurate or useful ("What do you mean when you say students have to construct knowledge?"; "What is involved in facilitation?").

The Video Case

Mrs. S, a third-grade teacher, described a "show what you know" lesson, which took place approximately two thirds into her unit on physical and chemical changes. The teacher began the lesson by reading a book about monkeys baking a cake. Throughout the reading, she asked students if certain situations, such as mixing batter or baking, were a physical or chemical change. Students then worked in cooperative groups of four to mix combinations of three different powders with water or vinegar. Students observed and labeled the change that occurred. Mrs. S circulated through the room, utilized impeccable behavior management skills, and asked questions of students such as, "Is this a physical or chemical change?" When students gave an incorrect response, Mrs. S repeated the response of the student with voice inflection that conveyed to the student his or her choice was inappropriate. Then the student would respond with a different answer. At the end of the lesson, a student asked what would happen if all three powders were mixed together. The teacher said there wasn't time to try that combination.

The lesson contained many elements of effective teaching utilizing methods with which students are familiar. The students were well-behaved, the teacher had very good behavior management skills, and science content was being promoted through a hands-on cooperative activity. This lesson does illustrate the complexity of effective science teaching, however. For instance, the science content was too advanced for the elementary students involved. These 8-year-olds, as evidenced on the video, had difficulty understanding the concept of chemical and physical changes. Because of this they resorted to memorizing that if something changes color, bubbles, or fizzes it is a chemical change, and if it is not a chemical change, then it must be a physical change. Children of this age likely have misconceptions about the concept of the terms *chemical* and *physical*, making this topic even more difficult to understand. Furthermore, the teacher-student interactions were extremely teacher-directed. While the activity was hands-on, little or no thinking was required on the part of the students. Mrs. S made all decisions regarding what to mix, how to mix it, how to record the results on paper, and what conclusions were important. The interactions Mrs. S had with her students promoted direction following and memorization of correct answers rather than a deep understanding of science concepts. Mrs. S's questions did not give her important information about students' thinking, and students' frequent wrong answers and voice inflection indicates they do not understand the content.

This video case analysis required students to go past merely identifying strengths and weaknesses of the lesson. They had to demonstrate that they could identify what goals are promoted in the lesson, make informed judgments about multiple aspects of the lesson (e.g., content, materials, activities, strategies, teacher behaviors, etc.), support those judgments with learning theories and student goals, and generate solutions to the problems identified by designing a science lesson that would be better suited for the students observed on the videotape.

Data Collection

This study utilized four major data sources: (1) the RBF paper written in the elementary science methods course, (2) an audiotape of the oral defense conducted at the end of the methods course, (3) a classroom observation during student teaching, and (4) an audio-taped and transcribed interview following the observed lesson during student teaching. These four data sources make possible a comparison between science methods and student teaching and provide longitudinal data. Oral defense questions are provided in Appendix A, and interview questions are included in Appendix B.

Data Analysis

This study utilized qualitative research methodology, which includes thick description, inductive reasoning, and the researcher as the primary instrument for data collection and analysis (Merriam, 2002). Data analysis began with the student teaching observation and interview. Interpretations were made about the student teachers' ability to teach in a manner consistent with effective elementary science instruction. To aid in this analysis, a coding guide was used to categorize participants' statements based on the extent to which they successfully consider learning theories in their decisions regarding content, materials, activities, and teacher behaviors/strategies. The coding guide was taken from Olson (2003a). A longitudinal profile of each student was developed. This enabled the researchers to track students' thinking from a more theoretical preservice experience (RBF paper), to an application of that knowledge (oral defense), to the practical implementation of their knowledge (student teaching). The profile of each student based on the RBF and oral defense was compared with her profile during the student teaching semester. Strengths, weaknesses, and changes for each student were identified to determine how Grace, who had the video case study experience, compared to Barb, who had the unit plan experience.

Important to note is that the two parts of the data collection—(1) methods class and (2) student teaching—were conducted independently, involving two different researchers. The second author collected the RBF papers and conducted the oral defenses. The first author observed the student teachers' lessons and conducted the interviews before reading the students' RBF papers and listening to their oral defense tapes; therefore classroom observations could be made with a reduction in potential bias. This process adds credibility to the study and makes possible a more objective comparison between what students thought and articulated during science methods class and what they demonstrated, thought, and articulated during the student teaching experience. Due to this method of data collection and analysis and the fact the two semesters were taught by the same instructor using the similar instructional methods, comparisons between the two students could be made with increased confidence.

Findings

The two students selected for this study were both confronted with a similar situation in their student teaching experiences. They were asked to teach science content that was mismatched to their students from developmental and constructivist perspectives. The decisionmaking process of each student is explored further in the following profiles:

Barb: I don't know why my students do not understand what I am trying to teach.

Barb's third-grade students studied oceans. As part of the unit, students were to understand that ocean water had a different density than freshwater. To convey this to students, Barb had the students put eggs into containers of fresh- and saltwater. Barb thought this activity would demonstrate to students that fresh- and saltwater had different densities; however, the students perceived the activity was to demonstrate something important about eggs. At this point, Barb knew her students did not understand what she was trying to teach them.

To remedy this situation, she called her science methods professor from the previous semester. During this conversation, she indicated that her students did not understand the material and misperceived the activity, but she didn't know why. The next day, Barb asked the students, "Would we bring eggs to a lake? Would we bring eggs to an ocean? Why would I have you put eggs in water?" Through the teacher's questioning, students generated a list of things that would float and sink in lakes and oceans. She then had students think about what would happen when freshwater meets saltwater. After the term "estuary" was introduced, Barb asked her students to think about Iowa and what animals do to survive temperature differences. After this discussion, Barb related Iowa temperature differences to estuary salt differences. Students then shared ideas on how animals might be adapted for salt differences in estuaries.

At the end of this lesson, Barb conveyed to the first author the problems she faced during her lesson with water and eggs. She also articulated that she still did not understand why her students concentrated on eggs rather than the density of the water. While there are many ways to explain why Barb's third-grade students had trouble understanding that ocean water has a different density than freshwater, one valid explanation is that most third-grade students demonstrate logical reasoning patterns consistent with concrete thinking and, therefore, need to act upon concrete objects. Understanding density requires a learner to mentally act upon two ideas—(1) mass and (2) volume—and, consequently, is considered an abstract concept that these students will have difficulty conceptualizing (Karplus, 1977). A second explanation is that most of these Iowa children have not had experiences with an ocean or an estuary, thus limiting their ability to connect new information to experience.

Looking back at Barb's elementary science methods experience, she earned a B+ in the class and articulated several ideas regarding how she would make decisions in her classroom. In both her RBF paper and during her oral defense, she made deliberate attempts to use developmental learning theory in her decisionmaking. For instance, during her oral defense she said, "If they can't touch it, they won't be able to grasp it. So I wouldn't start to teach first or second graders an abstract concept that they can't even see. No matter how good of a teacher you are, developmentally, they won't understand it." Interestingly, in her RBF paper, Barb wrote, "Most elementary students are either at the concrete or formal levels. These levels suggest the type of manipulatives, if any, that need to be provided by the teacher. Students at the concrete level are unable to think in abstract terms. This means it is vital to their understanding that they are given hands-on manipulatives to experiment with and use. Older students are able to think in abstract terms. This means that they can picture a concept in their minds without having to actually see it performed in an experiment."

Barb demonstrated a beginning, yet problematic, understanding of developmental learning theory and could talk and write about how she would apply her ideas of developmental learning theory in her classroom, yet she failed to apply this knowledge when it mattered most—with children in a real classroom. In her post-lesson interview, Barb did not mention how children learn at all. In fact, she seemed genuinely bewildered by her students' lack of understanding. Unfortunately, Barb's story shows that even when a preservice teacher has been required to apply his or her educational psychology knowledge to potential classroom situations, this knowledge may be misinformed, incomplete, and may not transfer to teaching practice. Other studies demonstrate that preservice teachers rarely apply learning theories to their practice (Skamp & Mueller, 2001), so perhaps Barb's story is typical of preservice teachers.

Barb's partial and insufficient understanding of developmental learning theory at the end of science methods may have led to her inability to accurately diagnose why her students had difficulty understanding density. In Barb's mind, her students were working hands-on with manipulatives in order to understand the concept of density. Despite her best efforts, her students did not understand. It appears that Barb thought hands-on manipulatives would help concrete thinkers understand an abstract concept. Therefore, her bewilderment over her students' lack of understanding is expected. In one sense, Barb has been confronted with a discrepant event. She planned her science lesson the way she perceived students learned (hands-on), and they did not learn what she thought they would. She conveys dissatisfaction, yet has no new idea about how to move her thinking forward. She appears almost paralyzed by her own misconceptions and lack of understanding, which may explain why she sought help from her methods instructor.

Grace: I know why my students don't understand but I have to teach this content.

Grace's fourth-grade students studied electricity. As part of this unit, students were expected to understand the terms *attract, repel, positive and negative charges*, and *force*. Grace's students worked in small groups of three to four students. Students placed one piece of scotch tape on their desk and marked it with a "B" for bottom. Another piece of scotch tape would be placed directly on top of the B tape (labeled "T" for top). After ripping the B and T tapes apart, students were directed to answer the following questions: "How does a B tape affect another B tape?," "How does a T tape affect another T tape?," "How does a B tape affect a T tape?," "Use the words 'attract' and 'repel' to describe what happens to B and T tapes," "Does the distance seem to make a difference?," and "Try to use the word 'force' in your explanation."

Several students became frustrated with the tapes. Students had a difficult time working with the materials. Additionally, groups of students disagreed with each other's results and, unfortunately, were not given the time to test the competing ideas. Grace asked students, "Why do you think the tapes are repelling? Why do you think the tapes are coming together?" Students responded to these questions with silence or comments that conveyed they did not understand what Grace intended them to learn. Students used the words *attract* and *repel* correctly, but they did not know why the tapes behaved in that manner.

After the lesson, Grace articulated that her students struggled to explain what they observed because

> *There was something happening that they couldn't see and they couldn't quite understand. When we got into talking about positive and negative charges and all that stuff, they didn't understand quite how that was working. They understood that something was happening there, just like you can do with a chemical and physical change. You can see something happening, but you don't really understand why it is happening. So I think that was the biggest problem with teaching electricity.*

During her elementary science methods course, Grace analyzed the video case of a third-grade teacher teaching chemical and physical changes using a mystery powders activity. Grace explicitly connected the knowledge she developed during science methods to help her understand the difficulties she faced during her student teaching experience.

One discussion during the science methods course focused on the difference between memorized recall and deep conceptual understanding. Once the electricity unit was over, Grace admitted that "once we went over it four to five days in a row, they could repeat it back to me, but I don't think they understand." Grace knew her students would not understand the concept; therefore, she taught the unit in a manner that emphasized recall of key terminology so students could at least demonstrate declarative knowledge of terms such as *attract*, *repel,* and *force*. Even though this is contradictory to what is known about effective science instruction, this student teacher understands that the kind of learning her students did was mainly memorization of terminology. Because the concepts of electricity she tried to teach were too far removed from what her students were ready to understand, she understood that they did not gain the conceptual understanding she desired.

Why would Grace teach these particular electricity concepts when she knows that her students will not come to understand them at the level she desires? Grace believes that the electricity concepts she taught were "over their heads as far as I'm concerned, but if you have to teach it for the school district, then you have to teach it." Grace knowingly taught content that was inappropriate because she was not going to question the school district in which she was teaching. The school district's benchmarks for this unit were "Students will demonstrate static electricity, develop an open and closed circuit, identify parts of an atom, explain the difference between current and static electricity, identify the effects of electricity on everyday life, and compare and contrast parallel circuits and series circuits." While methods instructors, veteran teachers, and others in the field of science education may argue that some of these benchmarks are too advanced for fourth-grade students, Grace perceived that she was in no position to question the content that she felt she had to teach.

Looking back at Grace's elementary science methods experience, she earned a B+ in the class. She applied learning theories sparingly in her RBF paper and oral defense. During the oral defense, the instructor explicitly posed a series of questions to help Grace apply her knowledge of learning theories to a classroom situation. In response to a scenario the instructor presented, Grace stated that first-grade students "are still in a concrete world. Concrete objects they can feel, touch, and see are things they can relate to. Something they have to imagine isn't. I don't think they are ready for that. I think [using a microscope] would be more like a third-grade level." Interestingly, in her RBF paper, she wrote that "content should be developmentally appropriate *according to the standard given at the school*" (italics added). This line of thinking was also evident in her student teaching decisions and interview.

Like Barb, Grace demonstrated an incomplete understanding of developmental and constructivist learning theories and their applications at the end of science methods. Yet, when faced with the reality that her students were not learning what she intended, Grace diagnosed the problem based on her understanding of how children learn.

Even though Grace could accurately analyze her lesson and diagnose the learning problems her students had, ultimately she did not use this information to change her unit to help students learn. Grace felt that the school district's standards and benchmarks held more authority than her own understanding of teaching and learning, and the feedback she received from the students that they did not understand. This finding is not surprising, yet we wonder what she will do when she enters her own classroom. Will she assume that all school policies are unquestionable or will she use her knowledge of effective teaching and learning to effect positive changes for her students and her school? We certainly hope that she does the latter.

Discussion and Implications

Grace articulated a deeper understanding of learning theories and how they applied to her lesson while student teaching than she had in her RBF paper and oral defense. Interestingly, her understanding during student teaching was framed within the context of the video case assignment she watched during elementary science methods. Barb faced the same content dilemma, yet did not understand why her students were not learning what she intended. We suspect that the video case study helped Grace better understand the need to match content to the students' needs and abilities. Due to our small sample size, this link cannot be definitively made, but the fact that Grace can explicitly use the example from the video case study when reflecting on her own practice is encouraging.

Brickhouse and Bodner (1992) assert, "Teacher education should not only help teachers develop a rationale for teaching science, but also provide ways of actually accomplishing this in a classroom setting" (p. 483). Even though Grace had rudimentary knowledge of developmental and constructivist learning theories, she did not use them to make classroom decisions. As a student teacher, Grace had many constraints placed on her; she wanted to please her cooperating teacher, school district, and university supervisor. When she saw problems with the curriculum, she ignored what she knew to be good practice and did what the school district wanted. Grace did not think the school district's decision to place abstract concepts in fourth-grade curriculum was something she could challenge. Because this study took place in a state with locally controlled curricula and no statewide standards, this finding is particularly interesting. Her behavior may have helped her to survive her student teaching experience (Appleton & Kindt, 2002; Kagan, 1992), but perhaps she truly believes that she does not have the power to influence the situation in which she teaches. While some may argue that a beginning teacher is never in a position to influence curriculum, we assert that teachers must know how children learn and use this knowledge to advocate for appropriate content. Teachers who are not prepared to analyze appropriateness of curriculum will have difficulties understanding how to help individual students learn. In this case, district committees comprised of teachers make important decisions about what is to be taught, and this content is interpreted by each teacher regarding how deeply students should understand that content.

This situation exemplifies the complexities of learning to teach science. Even though the video case analysis seems to have aided the transfer of theoretical knowledge to classroom scenarios for one teacher, classroom constraints in the end had more influence than what this student teacher knew about how children learn. This leads us to think that outside "authority" may have more credibility or immediate consequences than educational research in the developing teacher's mind—a perception that needs to be confronted in both preservice education courses as well as in student teaching placements. The study reported here also underscores the need for better curriculum that takes into consideration the developmental needs and prior knowledge of students. Curriculum in the United States has been accused of being "a mile wide and an inch deep," and the curriculum in these student teachers' classrooms is no different. We caution, however, that better curriculum alone will not result in effective instruction. Teachers always have to make modifications to tailor the written curriculum into an enacted curriculum that helps students learn. This requires that teachers be professional decision makers, not simply implementers of curriculum materials.

A paired-sample case study, while providing insight into the actions and decisions of these student teachers, is limited in the extent to which generalizability is possible. Further longitudinal studies are necessary to determine the extent to which decisionmaking is affected by the use of video case analysis in elementary science methods, student teaching, and in professional practice. Further studies on the effect of such assignments on teacher decisionmaking could investigate teachers with three to five years of experience. Results of such studies may be more fruitful because those teachers have had the necessary time to address survival issues as well as to determine what school constraints can be adequately challenged.

Current reform efforts increase accountability of teachers, which, in turn, increases accountability on teacher education programs. If we are serious about educating teachers to teach in a manner consistent with current educational research, then synergy between teacher education programs, cooperating teachers, school administrators, and school districts becomes crucial so that preservice teachers can more successfully make the transition from student to student teacher to teacher. Ultimately, regardless of understanding or use of learning theories, both of these student teachers made the same decision—they taught inappropriate content to their elementary students. The challenge we continue to face as methods instructors is what will be required in teacher preparation programs to overcome the substantial gap between theory and practice so that new elementary teachers are better prepared to make informed decisions with their students rather than relying on trial and error or misguided authority.

References

Abell, S. K., Bryan, L. A., & Anderson, M. A. (1998). Investigating preservice elementary science teacher reflective thinking using integrated media case-based instruction in elementary science teacher preparation. *Science Education, 82*, 491-510.

Annenberg/CPB. (1997). *Minds of our own: Can we believe our eyes* (Math and Science Videotape Collection). P.O. Box 2345, South Burlington, VT 05407-2345.

Annenberg/CPB. (2003). *The learning classroom: Theory into practice.* P.O. Box 2345, South Burlington, VT 05407-2345.

Appleton, K., & Kindt, I. (2002). Beginning elementary teachers' development as teachers of science. *Journal of Science Teacher Education, 13,* 43-61.

Brickhouse, N., & Bodner, G. M. (1992). The beginning science teacher: Classroom narratives of convictions and constraints. *Journal of Research in Science Teaching, 29*, 471-485.

Bryan, L. A., & Abell, S. K. (1999). Development of professional knowledge in learning to teach elementary science. *Journal of Research in Science Teaching, 36*, 121-139.

Cleary, M. J., & Groer, S. (1994). Inflight decisions of expert and novice health teachers. *Journal of School Health, 64*, 110-114.

Clough, M. P. (2003, January). *Structure of a secondary science methods course reflecting a research based framework for teaching science.* Paper presented at the annual meeting of the Association for the Education of Teachers in Science, St. Louis, MO.

Clough, M. P., & Kauffman, K. J. (1999). Improving engineering education: A research-based framework for teaching. *Journal of Engineering Education, 88,* 527-534.

Driver, R., Guesne, E., & Tiberghien, A. (1985). Children's ideas and the learning of science. In R. Driver, E. Guesne, & A. Tiberghien (Eds.), *Children's ideas in science* (pp. 1-9). Philadelphia: Open University Press.

Englert, C. S., & Semmel, M. I. (1983). Spontaneous teacher decisionmaking in interactive instructional contexts. *Journal of Educational Research, 77*, 112-121.

Gagne, E. D., Yekovich, C. W., & Yekovich, F. R. (1993). *The cognitive psychology of school learning*. New York: HarperCollins.

Johnson, K. E. (1993). Learning to teach: Instructional actions and decisions of preservice ESL teachers. *TESOL Quarterly, 26*, 507-535.

Kagan, D. M. (1992). Professional growth among preservice and beginning teachers. *Review of Educational Research, 62*, 129-169.

Karplus, R. (1977). Science teaching and the development of reasoning. *Journal of Research in Science Teaching, 14(*2), 169-175.

Loucks-Horsley, S., Hewson, P. W., Love, N., & Stiles, K. E. (1998). *Designing professional development for teachers of science and mathematics.* Thousand Oaks, CA: Corwin Press.

Merriam, S. B. (2002). Introduction to qualitative research. In S. B. Merriam (Ed.), *Qualitative research in practice* (pp. 3-17). San Francisco: Jossey-Bass.

Ohana, C. (1999). *A tangled web: Interactions and structures in university-school collaborations*. Unpublished doctoral dissertation, Iowa State University, Ames, IA.
Olson, J. K. (1992). *In the trenches: My first year of teaching.* Unpublished manuscript, Claremont Graduate University, Claremont, CA.
Olson, J. K. (2003a, January). *Problem-based learning in context: The effects of embedding PBL within a research-based framework for teaching on preservice teachers' conceptions of teaching and learning.* Paper presented at the annual meeting of the Association for the Education of Teachers of Science, St. Louis, MO.
Olson, J. K. (2003b, January). *Structure of an elementary science methods course reflecting a research-based framework for teaching science.* Paper presented at the annual meeting of the Association for the Education of Teachers of Science, St. Louis, MO.
Piaget, J. (1964). Cognitive development in children: Piaget. *Journal of Research in Science Teaching*, *2*, 176-186.
Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education, 66*, 211-227.
Renner, J. W., & Marek, E. A. (1990). An educational theory base for science teaching. *Journal of Research in Science Teaching, 27*, 241-246.
Schon, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.
Schon, D. A. (1988). *Educating the reflective practitioner: Toward a new design for teaching and learning in the professions.* San Francisco: Jossey Bass.
Shulman, L. (1987). Knowledge in teaching: Foundations of the new reform. *Harvard Educational Review, 57*, 31.
Skamp, K., & Mueller, A. (2001). A longitudinal study of the influences of primary and secondary school, university and practicum on student teachers' images of effective primary science practice. *International Journal of Science Education, 23*, 227-245.
Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Correspondence regarding this article should be directed to

Joanne K. Olson
Iowa State University
Center for Excellence in Science and Mathematics Education
N157 Lagomarcino Hall
Ames, IA 50011-3190
(515) 0294-3315
Fax: (515) 294-6206
jkolson@iastate.edu

Manuscript accepted February 24, 2005.

Appendix A: Selected Oral Defense Questions

1. How will you promote the goal of ____________ in your classroom?

2. What is the value of having multiple strategies to reach your goal?

3. How would you decide what content to teach your students?

4. How would you respond if a parent complains about your use of cooperative groups?

5. How would you respond if a parent wants to know why you respond to his daughter′s questions with a question?

Appendix B: Student Teaching Interview Questions

1. What are your goals for your students?

2. What evidence do you have that the students are meeting your goals?

3. What do you feel is your role in helping your students meet these goals?

4. How comfortable are you at this point in teaching elementary science?

5. What have you found to be easiest for you with regards to teaching elementary science?

6. What have you found to be the most difficult for you with regards to teaching elementary science?

7. How has the RBF influenced your teaching? In what subtle or overt ways have you used the ideas from your RBF?

8. How closely did what you wrote in your RBF and stated in the oral defense match what you have experienced so far in student teaching? What example do you have of this?

9. What would you suggest to make the RBF and its oral defense more meaningful for preservice teachers?

10. How well do you feel your science methods class prepared you for teaching?

11. What recommendations do you have for methods instructors at ISU?