Implementing Contextual Teaching and Learning: Case Study of Sarah, a Middle School Science Novice Teacher

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Abstract

The purpose of the present study was to examine the beliefs and practices of Sarah, a new science teacher who participated in contextual teaching and learning (CTL) preservice teacher education and who has been implementing CTL for two years in large, diverse middle school life-science classrooms. Multiple sources of evidence led to four main findings. First, Sarah frequently bases her lessons on CTL and genuinely values it. Second, Sarah believes that lack of time is a barrier to using CTL, preventing her from using it more often than she does. Third, Sarah does not have a clear understanding of when CTL strategies are appropriate to use and, as a result, believes that some topics cannot be taught using CTL strategies. Fourth, Sarah's understanding of CTL is extensive enough that when she does use it, she uses it well, promoting engagement and mastery on the part of her students. The present findings support the view that Sarah's preservice education in CTL is accelerating her professional development as a science teacher and, at the same time, fostering her students' achievement and attitudes in the area of science.

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Introduction

Quality teaching fosters quality learning. One of the major goals of recent reform efforts in science has been to insure that preservice teacher education prepares teachers effectively for classroom practice. Beginning teachers often have difficulty relating various theories and methods taught in preservice courses to what actually happens in their daily teaching practice (Meijer, Zanting, & Verloop, 2002). In an effort to address this, a number of teacher education programs have reexamined their goals and reconceptualized their approach to preparing teachers. What has emerged is an approach that helps teachers relate knowledge to real-world situations. This approach, called *contextual teaching and learning* (CTL), "motivates students to make connections between knowledge and its applications to their lives as family members, citizens, and workers and to engage in the hard work that learning requires" (Sears & Hersh, 2000, p.4). The purpose of the present study was to examine the beliefs and practices of a science teacher who participated in CTL preservice teacher education and who has been implementing CTL for two years in large, diverse middle school life science classrooms.

Theoretical Framework

Contextual teaching and learning (CTL) is a new instructional approach rapidly being adopted by teachers, particularly science teachers, across the nation. It is a conception of teaching and learning in which teachers relate subject matter to real world

situations. It motivates students to apply what they learn to their lives as family members, citizens, and workers. By bringing knowledge to life for the students, CTL aims at increasing achievement throughout the nation. CTL is fully consistent with national reforms in science education (American Association for the Advancement of Science, 1990, 1993; National Research Council, 1996).

CTL is a *constructivist* approach to learning in that it focuses on knowledge which is highly contextualized and relevant to students (Glynn, 2000; Glynn & Duit, 1995). It unites disciplines rather than compartmentalizes them. CTL also encourages the development of higher-order thinking skills by offering students more incentive to engage in and govern their own learning. CTL helps students recognize that the material they are studying is beneficial to their lives outside of school. Because it uses authentic assessments based on real-life activities, students feel more positive about assessment, and because students are engaged, they feel more positive about their school work. The enhanced attitudes and motivation associated with CTL leads to higher academic achievement (Johnson, 2002).

CTL is not simple to implement, because it often requires learning to occur across the boundaries of disciplines. In other words, the integration of various disciplines, often necessitating the collaboration of several teachers, is required for learning to be connected to real-world situations. For example, if a science teacher asks students to design roller coasters and compete with one another to market their ideas to the CEO of a major amusement park, then principles of economics, language arts, and mathematics, as well as science, all need to be used by students. CTL assignments of this kind simulate the way marketing endeavors occur in the real world. Students recognize this type of

assignment as not only innovative and fun, but as potentially very useful in their future careers.

CTL, like any approach to instruction, is characterized by the use of some learning strategies more than others. When experienced teachers implement the CTL approach, they often use the following research-validated strategies, either singly or in combination:

1. *Problem-based inquiry learning*. Students are given either a real or simulated problem and must use critical thinking skills and inquiry to solve it. Ideally, they will need to draw information from other content areas. Problems that have some personal relevance to the students are the best choices to encourage maximum participation and learning.

2. *Cooperative learning*. Students work together in small groups and focus on achieving a common goal through collaboration. Each student within the group makes a significant contribution to the goal.

3. *Project-based learning*. Students work independently or collaboratively. There is an emphasis on constructing realistic work products.

4. *Service learning*. Students apply knowledge and skills to fulfill needs within their own community through projects and activities.

5. *Work-based learning*. Learning is accomplished through activities in the workplace or simulations of such activities. The relevance of learning to careers is emphasized.

6. *Authentic assessment*. Students are evaluated by means of their performance on tasks that are representative of activities actually done in out-of-school settings.

In order for the preceding strategies to be used effectively, they should be integrated with other commonly accepted good teaching practices. These other practices include promoting self-regulated learning, addressing student diversity when teaching, designing authentic assessment, and using questioning to develop higher order thinking skills (Berns & Erickson, 2001). The effective use of CTL strategies also requires that teachers assume a variety of roles such as facilitator, organizer, coach, referee, and knowledge resource.

The mastery of the CTL approach and its associated learning strategies is critically dependent upon teacher education (Lynch, 2000; Lynch & Harnish, 2002). Initially, research on the CTL approach focused mainly upon its use of component strategies by experienced science teachers who were introduced to the approach through inservice continuing education. These teachers have had success implementing it (Clifford & Wilson, 2000). The successful implementation of CTL by these teachers was explained in part by the fact that many of them were already using some of the CTL strategies as part of their normal instruction, as "good practice grounded in common sense" (Clifford & Wilson, 2000, p. 2).

The Present Study

The purpose of the present study was to gain some initial insight into how well a new science teacher, one who was introduced to CTL during preservice teacher education, implements CTL during the first two years of teaching. Accordingly, a case study was conducted to examine the implementation of CTL by a science teacher who received preservice training in CTL and subsequently implemented this approach in the first two years of teaching. This case study provides a detailed view of CTL instruction in

a middle school science classroom. The following four sets of research questions were particularly relevant to the goals of this case study:

1. How does the teaching practice of this CTL-trained first year teacher differ from more traditional approaches to teaching the subject matter?
2. Which CTL strategies does this first-year CTL-trained teacher use in classroom teaching contexts? Why? To what perceived or measured outcomes?
3. What are the facilitators and barriers to implementation of various CTL strategies in actual classroom practice in school settings?
4. Explain how each of the CTL strategies in #2 affects student engagement and their mastery of science content (as seen on measures of student achievement).

Method

The case study of Sarah Davis (a pseudonym) and her middle-school students (five classes, ranging from 19 to 31 students per class) was conducted by two university researchers involved in a large-scale federal study of CTL implementation across the disciplines. Our status in Sarah's school was that of "privileged observers" (Wolcott, 1988), in that, we were free to observe Sarah in her classes and around the school, and talk to her colleagues, including the school principal, and her students. We were particularly interested in their perceptions of Sarah and her teaching. These perceptions were helpful in verifying events recalled by Sarah, triangulating the perceptions, and providing leads for interviews (Merriam, 2001, 2002).

The case study was conducted during Sarah's first and second year teaching. The sources of data included Sarah, her students, her colleagues, and the administrators of her school. From these sources, data were collected by means of lesson observations, semi-

structured and structured interviews (reference), questionnaires, journal notes, audiotapes, photographs, teacher work products (e.g., unit and lesson plans, activity sheets, and grades) and student work products (e.g., lab reports, completed activity sheets, completed tests, models, drawings, and posters). These data collection techniques were used to shed light on the contextual conditions surrounding Sarah's use of CTL (Silverman, 2000, 2001).

In the semi-structured individual interviews conducted of Sarah and a random sample of her students, a *life history* approach (Woods, 1987) was adopted to shed light on what they thought about the process of schooling and what meaning it held for them. They were encouraged to talk about their lives and the role that schooling played in it. They also were encouraged to talk about their views of themselves, their responsibilities to others, their formative experiences, their present circumstances, and to speculate about their futures. These semi-structured interviews were later followed up with structured ones that focused on Sarah's perceptions of her teaching and her students' perceptions of their learning.

Case study methods do not produce generalizable findings (Stake, 1988), thereby limiting the value of this study. The value instead, as Erickson (1986, p. 153) explains, is to "examine the circumstances of the case to determine the ways in which the case fits the circumstances of the reader's own situation."

Setting

Hart Middle School (a pseudonym) was built in the late 50's as a high school, was converted to a junior high school for grades seven and eight in the early 70's, and was renovated and expanded in the early 90's to create a middle school for grades six, seven,

and eight. It currently has 50 classrooms and 800 students. There are approximately equal numbers of boys and girls. About 70% of the students are white (non-Hispanic/Latino), about 20% are Hispanic/Latino, about 7% are African American, and about 2% are Asian. Hart is a Title 1 school, with about 50% of its students coming from low-income families and qualifying for a free or reduced price lunch. The spending per student is about $6,000. The average income in the surrounding county is about $42,000. The school calendar year runs from mid-August to early June.

The school's mission statement is to offer all students the chance to reach their full potential; to grow academically, emotionally, socially, and physically in a positive, supportive environment. The school motto is: confidence, achievement, and success. The students usually score at or above the national average in all areas assessed by the *Iowa Test of Basic Skills*. The school's activities include a wide variety of sport teams, clubs, and organizations.

There are three administrators, a principal and two assistant principals, 58 teachers, and 26 other staff members, including teacher aids. The pupil-teacher ratio is 15 pupils to 2 teachers/teacher aids.

The Teacher

Sarah Davis has taught life science for two years, both of them at Hart Middle School. She is 23 years old, white, and single. She grew up in a rural county of the state and attended local elementary, middle, and high schools. School teaching is a tradition in her family and education is highly valued. Her father has been a high school industrial arts teacher and administrator for 31 years. Her mother has been a high school business education teacher for 29 years and her one sibling, a 29 year old sister, has been a teacher

for seven years. She is very attached to her family and often travels home to visit on weekends, a trip which takes about 1 _ hours.

Sarah attended a community college for two years, receiving an associate degree in biology. She then attended the state university where she received a B.S. degree in science education and was trained in CTL during her senior year. At the state university, she was trained to teach middle school science, consistent with the state curriculum standards and the *National Science Education Standards*.

She participates fully in Hart Middle School activities. She is the sponsor for the School Pep Club and for the Science Club. She also serves in an after-school tutoring program. She lives only a 10 minute drive from school, making it easier to participate in school activities.

Sarah's school day begins at 8:00 a.m. and she arrives at least a half hour early to prepare. Her day officially ends at 4:00 p.m., although she often remains later to participate in after-school activities. She teaches five classes each day, with student enrollments ranging from 19 to 31 in the classes. She has only 20 minutes per day for lunch and that is spent with the students; however, she has two planning periods, so she usually eats her own lunch during the planning periods.

Continuing education is important to Sarah, and she frequently attends professional development workshops and courses. In addition, she will soon begin a Master's program in science education at a nearby four-year college. Because of her interest in continuing education and enhancing her teaching skills, she was enthusiastic about participating in CTL training.

We observed Sarah to be a conscientious and dedicated teacher. In our opinion, she is committed to her students, her school, and the community at large. She participates extensively in school activities. She is interested in her students' well being, their home lives, and their lives in the community. She also is keenly interested in preparing them for continued education, their adult roles, and careers. She makes excellent use of community resources in teaching her students, often involving local businesses, organizations, and institutions in her activities.

Sarah's teaching style was enthusiastic and warm, but firm when students' behavior moved well off task. If several students were inattentive or disruptive, she would patiently, but firmly, remind them of the goals of the lesson and bring them back on task. Although she was firm when necessary, the classroom climate was quite positive. It impressed us as a safe, secure, relaxed environment for learning. She is committed to helping her students achieve in the area of life science, mastering ideas and skills, with positive attitudes toward the area.

Sarah was confident about her teaching skills. She appeared at ease when teaching, even though observers were seated at the back of her classroom. When interviewed after class about the decisions she made during lessons, she answered questions freely, providing sound rationales for her decisions. There was one area in which she appeared a bit defensive: discussing her students' individual differences. Many of the students were Hispanic. When asked if she thought she should address cultural differences in her lessons, she said that she did not need to do this because students tend to apply the lessons to their own cultures. Our impression was that she was uncomfortable with the diverse backgrounds of her students and wanted to avoid

inadvertently saying or doing something that might cause offense or misunderstanding. But, when this was suggested to her, she did not agree that this was the case. Instead, she maintained that it was unnecessary and difficult to address cultural differences in the lessons. Aside from these questions about culture, it was easy interviewing Sarah. She thought carefully about her responses, but spoke at length. We considered her responses to be authentic and valid; we did not sense that she was trying to script her responses in any way.

Sarah said she understood that the purpose of the study was to determine how CTL was being used by a CTL-trained teacher—and what effect CTL has on students' education in the area of science. Because the emphasis was on the implementation and effects of CTL training, rather than on her personal characteristics, Sarah was forthcoming in interviews and her observed behavior was likely representative of her typical behavior.

Findings

The findings are reported in the following sections under four categories which complement the research questions: approach to teaching, teaching strategies, facilitators and barriers, and student engagement and mastery of content. The findings are based on the multiple sources described in the Methodology section and the following lessons and laboratory activities taught by Sarah in her life sciences classes: *Dangers of Alcohol*, *You Are What You Eat*, *Reading Food Labels*, *Dissection of a Fetal Pig*, *Observing Yeast and Making Spores*, *Planning and Plotting a Garden*, and *Build a Model of a Cell*.

Approach to Teaching

Sarah's CTL approach to teaching differed considerably from the traditional approaches described in the introduction to this case. Her lessons were usually student centered. Rather than establishing herself as the primary source of knowledge for students, she acted instead as a facilitator of students' learning. In the observed lessons, she often treated her students as collaborators in the learning process. She shared decision making with them and respected the decisions they made. Sarah also ensured that her students learned in an active, hands-on fashion, and she encouraged them to discover knowledge through their own initiatives. Often, these initiatives were group initiatives because, she said, she valued social interaction during the learning process. She discouraged rote learning in her students and used Socratic questioning to stimulate higher-order thinking and problem solving.

A good example of Sarah's CTL approach to teaching was her interdisciplinary lesson on the *Dangers of Alcohol*. The task she posed to her students was: "You have been hired by the *Body Health Agency* to carry out an anti-drinking campaign." She arranged for students to work collaboratively in small groups and, at the same time, ensured that each student would be responsible for a meaningful share of the work products. The products were persuasive posters, radio announcements, TV advertisements, and brochures intended to change community attitudes. The products reflected authentic, creative, and collaborative problem solving. The products provided Sarah with reliable and valid performance-based assessments that documented the students' achievement. She scored and graded these projects, she explained, using the state curriculum standards and the *National Science Education Standards*. Sarah shared

these products with parents during parent-teacher conferences to facilitate discussion of the students' work and study habits. The products were not only displayed in the school, but also in community businesses so that the students' work would have a real-world impact.

Interviews we conducted with the students indicated that they enjoyed the lesson, were engaged by it, and understood the key concepts involved. The interviews also indicated that the lesson helped students to understand that knowledge is interdisciplinary and has important real-life implications. The knowledge and skills associated with the lesson were ones that students could easily transfer to other real-life contexts.

As the *Dangers-of-Alcohol* lesson illustrates, Sarah's teaching differs considerably from what is usually labeled "traditional." In this lesson, which is typical of those we observed, she effectively applied many of the CTL principles. Her application of the CTL principles was consistent with her expressed opinion of CTL and its effectiveness relative to traditional approaches to teaching. She said:

> "In my opinion, CTL teaching practices are far more interesting and helpful than traditional teaching practices. Students have the opportunity to learn concepts through hands-on methods that bring concrete understanding to them. Also, students are more engaged in their learning when they are taught through CTL methods. This is especially true in science, when hands-on experimentation is readily available …. It is much easier to learn about the steps of scientific method when one can perform an actual experiment… than learning through rote memorization."

Sarah believes all teachers should develop a philosophy of teaching to guide their classroom practices. She observed that her own philosophy of teaching continues to evolve after one year, and will presumably continue to do so. It was clear from her comments that CTL plays an important role in her philosophy:

> "I believe that students learn in a variety of contexts, and it is important as the teacher to facilitate, and often participate, in those various contexts. In my first year of teaching, I quickly learned that not all of my students learned in the same manner. Some are visual learners, some are auditory learners, and some learn when hands-on methods are used. Therefore, CTL plays a perfect role in my teaching philosophy because the CTL program itself suggests [that] various methods of teaching and learning be used….Because the CTL program utilizes teaching techniques such as problem solving, self-motivation, and cooperative learning, it is very easy to implement CTL into my philosophy of teaching."

We observed that Sarah exhibits a number of behaviors associated with the practice of CTL principles. For example, one such behavior is modeling the learning process for students. Sarah did this during the *Dangers of Alcohol* lesson by asking herself questions out loud and enthusiastically discussing issues with the students. According to Sarah, good teachers share a common mission with their students, and that mission is the enthusiastic discovery of knowledge:

> "I want to be a teacher that not only helps the students learn new things, but learn new things myself. This includes new concepts as well as techniques that motivate students to love science. CTL allows me to do this by helping my students and myself through the various principles."

We also observed that Sarah places emphasis on affective learning and the creation of a positive classroom climate. She said, "It is very important to me that my classroom be a friendly, inviting, and welcoming learning environment." In the *Dangers of Alcohol* lesson, some of the students volunteered comments about people in their lives who have alcohol problems. Sarah was considerate and supportive in her responses. In accordance with CTL principles, Sarah consistently made an effort to develop positive attitudes in her students, both toward the lesson content and the process of learning. Sarah's CTL training had an impact not only on her students, but on her fellow teachers as well. In interviews, her colleagues remarked that Sarah often brings up CTL principles during team planning. As a result, some of these teachers became interested in CTL. When we asked Sarah about this, she said:

> "I discussed CTL and its principles with my fellow teammates. It was extremely interesting to realize that almost every teacher, at one point or another, utilizes some CTL principles in their (sic) classroom. However, I don't think we actually realize it. CTL is a great addition to any classroom…but sometimes it fits better to one subject area rather than another."

Sarah's comment that CTL fits better to one subject area than another revealed her belief that CTL does not work equally well across the curriculum. She believes it is easier to implement CTL in social studies than in science which, in turn, is easier than mathematics. Despite this reservation, she gave a solid endorsement to CTL when we asked her for a frank evaluation of its value in teacher training:

> "I think that CTL is a great resource for current and future teachers to implement in their classrooms. I recommend that all college students preparing to enter a

classroom be introduced to at least a basic level of CTL principles. This would help them prepare their students to work in the real world once school is completed."

It was clear from her remarks and her behavior that Sarah genuinely valued her CTL training and believed that this training is useful for both pre-service and in-service teachers. We asked Sarah's principal for his opinion of her teaching effectiveness. His opinion was very positive. He attributed the quality of her teaching to her good training "at the university," but he was only generally familiar with CTL. He knew that it was an aspect of Sarah's training, and he knew that it involved connections to careers, but that was the extent of his knowledge.

Teaching Strategies

You Are What You Eat was typical of Sarah's CTL-based lessons. In it she applied several of the strategies that are associated with CTL. The lesson posed the following problem: "Does our school lunch menu provide a balanced diet?" In order to solve the problem, the students used actual school lunch menus, placed items in food groups, listed nutrients (carbohydrates, fats, and proteins), and distinguished between animal and plant products. Integrating science with mathematics, the students analyzed various combinations and proportions to solve the problem. The students worked in small groups. They were enthusiastic because the problem was relevant to them—they were examining their own lunches! The nutritional analysis tables the students produced served as a reliable and valid performance-based assessment for Sarah who evaluated her students' achievement as typically good to excellent, with only a few instances where students had

errors, and these were due to the mathematics involved. Interviews with the students indicated that they enjoyed the lesson and learned the concepts well.

In a related lesson, *Reading Food Labels*, Sarah asked students to solve science and mathematics problems using actual food labels as sources of data. In order to solve the problems, students had to apply knowledge about measures such as calories and grams to concepts such as fat, cholesterol, and proteins. Problems such as "Which cereal has the highest % Daily Values for fat?" have important real-life health implications for students. In this lesson, Sarah had the students work individually because she wanted to make sure that each fully understood the measures and computations involved. Like the previous lesson, Sarah found that most of her students achieved in the range of good to excellent.

We observed Sarah frequently applying CTL strategies in the food-related lessons. When we later asked her about them, she said, "Using CTL is central in my lesson planning and personal teaching methods." Without CTL training, it is possible that Sarah would have discovered many of the CTL strategies on her own because she actively pursues professional development through continuing coursework and reading. But our impression was that one reason she held such a high opinion of CTL training was that it pulled these strategies together for her in an efficient fashion. CTL saved her time because she did not have to discover these strategies on her own. In other words, Sarah values CTL training because it provides her with an integrated set of principles and strategies that are consistent with her teaching goals:

> "[To be successful] I must implement various teaching techniques that allow each student to excel in the classroom. CTL principles allow my students and myself

> to do just that. By using the various techniques that CTL provides, each student has the ability to excel in science and in school….I am not a believer in constant note taking and lecturing in the classroom. Although those two types of strategies are useful on occasion, I believe it is best for the teacher and student when a variety of strategies are used. CTL strategies, such as group learning, allow me to broaden horizons in my classroom."

Sarah used three CTL strategies (problem solving, cooperative learning, and authentic assessment) much more often than others. When we asked her about this, she admitted that she did not think that all CTL strategies are equally useful. According to her, their relative usefulness depended upon the subject matter. In her opinion, problem solving, cooperative learning, and authentic assessment were the most useful when teaching science. Other CTL strategies, such as anchoring teaching in diverse life contexts, she considered less useful. We found this peculiar and unconvincing since so many of her students were Hispanic and we, at least, could see relevance to diverse life contexts in lessons such as *You Are What You Eat*. When we later spoke with students about the lesson, many spoke about cultural foods.

Although she was sensitive to and supportive of her students' diverse backgrounds, Sarah did not see how or why she should publicly address diverse backgrounds in her science instruction. She half-heartedly argued that the students could do this themselves without her assistance. As a first-year teacher, she also wanted to avoid potentially sensitive topics such as ethnic background, realizing that students and parents might misunderstand the purpose of lessons that attempted to build on these

backgrounds. She maintained that the three strategies she found most useful were those that, in her opinion, prepared her students for their future roles in society. As she said:

> "I think that problem-solving, cooperative learning, and authentic assessment are the most important CTL strategies in a classroom. Because we are preparing students to work and become productive members of society one day, all of these strategies offer the most effective way to teach our students future expectations."

We then asked Sarah explicitly to share her specific opinions about what contributes to success in teaching her students lessons such as *You Are What You Eat* and *Reading Food Labels* lessons. We categorized her comments in the following ways:

Problem Solving and Inquiry

> "Science is a course where numerous problems can be solved on a daily basis. I try to teach my students to 'think outside of the box' so that they can devise more than one possible solution to any problem in life. When problem solving, students learn to work to achieve a goal and to think openly about a possible outcome. They also seem more interested when they have a "problem to figure out."

Teaching and Learning in a Variety of Contexts

> "I teach students from a variety of socio-economic backgrounds. Due to the various communities my students come from, I feel it is important to not only recognize but also implement teaching and learning in these various contexts. Almost 50% of our schools' population is Hispanic, and many of these students are from places other than Georgia. Due to the close family relationships that Hispanics have, many of my students take trips during the school year to visit other states and countries. During these trips, I ask my students to look at various

things in their hometowns and compare them to what we have in Georgia. This can especially be interesting when my classes are studying animal and plants due to the varieties of species across America."

Students Monitoring and Directing their Learning

"I believe it is important for students to learn to achieve their own goals. It creates responsibility. I, for one, do not want my students to grow up to think that things must always be handed to them when they don't feel like getting it themselves. Therefore, I encourage my students to be self-motivators and to achieve their own goals in science and in school in general… .When teaching a class of 30 students, it is extremely difficult to monitor each and every student's learning and comprehension. Therefore, it is extremely important that the students learn to direct their own learning in the classroom…if students do not understand a particular concept, it is very important that they recognize the difficulty and ask for help. The ability to recognize an area of difficulty is a requirement to be a self-regulated learner."

Anchoring Teaching in Students' Diverse Life-contexts

"Because I teach a majority of Hispanics, it is quite easy to bring in diverse life-contexts when using various scientific theories and concepts. This allows students to have concrete examples. However, there are times when this idea is not appropriate. I believe if the student has the ability to use concrete examples of their (sic) life to learn something, it makes learning not only more personal but also more interesting….New and old concepts can easily be applied to any life-context, especially as the student gets older."

Encouraging Students to Learn Cooperatively

"I have a lot of group work in my classroom. It teaches the students that they have to learn to work with other people. Interestingly enough, I have had several parents complain about the cooperative learning that takes place in my classroom. It is highly rare these days to obtain a job and not have to work on a team to accomplish a task. It is very important to me that my students learn this is coming and have experiences in the classroom dealing with this issue. Along the same lines, it is important that the students break up a task into portions so that each student is responsible for a part of the workload. This way, students are not only held accountable for their learning, but for others' learning also. Not only is this a great method of teaching, but also it is a great method of helping kids learn responsibility."

Employ Authentic Assessment

"CTL plays a vital role in implementing authentic assessment. Not only is it important that students learn and comprehend various concepts we teach in the classroom, but also it is even more important that they are able to apply it to real-life situations. Therefore, when appropriate, I try to have my students apply various concepts to everyday life."

Facilitators and Barriers

The laboratory activity that Sarah found most complicated and time consuming to plan was the *Dissection of a Fetal Pig*. As she explained in the overview to her lesson plan, this lab would count five times more than the typical lab because of the time

allocated and its importance, being a "wrap up lab for the human body." She strongly encouraged them to "do your best!"

Sarah's goal in this lab was for her students to examine the organs of a large mammal and, by extension, come to a better understanding of the organs of the human body. Sarah evaluated her students based on their dissection techniques and their lab reports. Although she found that most of her students achieved well and had positive attitudes about the lab, she found that a few did poorly, in part because of the complexity of the lab. The students said that they were confused by all of the techniques. In a lab as complicated as this, for a first year teacher at least, CTL was a double-edged sword. Sarah's application of the CTL strategies contributed to the lab's instructional value, but also contributed to the procedural complexity of an already very complicated lab. A positive feature of the CTL strategies, according to Sarah, was that they could be applied flexibly:

> "I think one of the great things about CTL is that one may call on the strategies when appropriate and necessary. This means that all don't have to be used all the time. One can pick and choose so that the classroom is an effective learning environment."

But that was easier said than done because the lab put great demands on Sarah's time management and lab preparations skills. She explained that a teacher must practice integrating the CTL strategies with these other critical skills:

> "I find that for each of the CTL strategies I implement…having time management and preparation skills help to facilitate these strategies. Some activities are readily available for CTL strategies while others require more planning and

preparation for such use. In being a first year teacher, it is sometimes difficult to use CTL strategies; however, I'm becoming accustomed to the required preparation….Some activities take weeks to prepare for and build prior knowledge for student learning. However, in [this state's] curriculum requirements for a school year, it is nearly impossible to put forth that much effort and time into one or two activities when you have 14 other chapters to cover."

In addition to time and planning demands, we observed another factor that hindered Sarah's use of CTL strategies. That was Sarah's belief that CTL strategies cannot be applied to some activities and topics in science:

"In science there are just some activities that have no CTL strategies to use. Sometimes students have to know scientific concepts so that they can use it later for testing or just because they need to know it. These particular concepts prevent the application of CTL strategies."

CTL strategies were absent in one of Sarah's labs, *Observing Yeast and Making Spores*. This lab reflected a traditional approach to teaching. There was little meaningful problem solving, no cooperative learning, and no authentic assessment—strategies that played such an important role in Sarah's other lessons. The only real factor hindering the use of CTL strategies in this lab, however, was Sarah's unfortunate belief that rote learning was the appropriate strategy to use here. Sarah said:

"I'm not sure that any of the CTL strategies are difficult to implement in the classroom; however, some may not always be appropriately used. For instance, in teaching a unit about Protists, it is quite difficult (if not impossible) to employ

authentic assessment and teach in diverse life-contexts. However, these strategies can be perfectly implemented in a different unit."

With respect to factors that facilitate the use of CTL strategies, we found that Sarah used them extensively during field trips and students' learned a great deal from these trips, far beyond what they would learn in an equivalent time spent in the classroom. Sarah explained how the fieldtrips place her students in real-world contexts:

> "We have field trips to the local nature center in which the students are able to use prior knowledge and skills in real situations. An example could be on a recent field trip to Elachee Nature Center, the students were able to look at various plants, insects, and water creatures that we have been studying."

Another factor that facilitated the use of CTL strategies in the lessons we observed was the availability of classroom technology. Sarah's classroom was well equipped and good use of the technology was made by her and her students. Sarah recognized the role that this technology played in her teaching by connecting lessons to real-life contexts: "Computers and other electronics are quite handy in the classroom…TVs and VCR also provide excellent opportunities for learning in context."

Student Engagement and Mastery of Content

Planning and Plotting a Garden: A Lesson on Plants was one of Sarah's best lessons in that she effectively used three CTL strategies (problem solving, cooperative learning, and authentic assessment), engaged her students' interest, and supported their mastery of content, as evidenced by performance-based assessments. Farming is common in Sarah's community, so planning a garden is relevant to the students' lives. She used this lesson as part of her unit on plants and flowers. She spoke to students about the

gardens that their families planted annually and encouraged the students to describe their own experiences with gardens. Like many of Sarah's lessons, this one was interdisciplinary, involving the integration of science with mathematics in a problem format. Sarah connected problem solving with authentic assessment:

> "Problem solving is often presented to my students as a form of assessment. One example of problem-solving assessment would be seen in test questions or lab questions that ask students to use various techniques and information and apply it to a real life situation. Often I ask informal questions during lectures or discussions that are in the form of 'what if…' situations so students can think in terms of: here's a possible problem, so what would happen if we…"

In *Planning and Plotting a Garden: A Lesson on Plants*, Sarah asked students to solve the problem of determining the maximum number of vegetables that could be effectively grown in a plot, taking into account both sunlight and the projected size of the vegetable plants. Sarah assessed the students' performance in two ways: first, by evaluating the plot matrices that students drew, assessing the accuracy of the scientific and mathematical information included in the matrices and, second, by evaluating the paragraphs students' wrote explaining the decisions they made when they solved the problem. Sarah used a scoring rubric to ensure reliability and validity. She found all of the students performed in a range of good to excellent. When mistakes were made by students, they were usually mathematical. This was the case in other lessons too. Strictly speaking, Sarah was not responsible for teaching mathematics; but because science often involves mathematics, she routinely incorporated it into her lessons and took it into account in her assessments. We noted that when Sarah incorporated CTL strategies into

her lessons, planned them well, and assessed learning with multiple performance-based measures, students' engagement and mastery of content was consistently and uniformly high. Sarah was aware of this:

> "Aside from standardized test scores, our student's science achievement is measured in different ways. I assess a student's achievement through traditional testing, but also through lab experiments, projects, journals, daily assignments, and other ways. I think that by using a variety of assessment methods, which is recommended by CTL, it is possible to see all students' weaknesses and strengths….Because CTL uses authentic assessment techniques, it allows me to identify different needs of students. Because I teach students at an age that they are just learning to think for themselves, they need reassurance of their abilities and capabilities. Therefore, through the use of CTL, my students know that they can and do excel…they have the ability to be an excellent student (sic) in science and in school in general."

It also was routine for Sarah to incorporate multiple measures of student achievement into her lessons to provide a more comprehensive evaluation of her students' achievement. For example, in her lesson to *Build a Model of a Cell*, students demonstrated their knowledge of the cell by first drawing, coloring, and labeling it, then by building a physical model of it, and finally by answering questions about it. Although Sarah used multiple measures in this lesson, she was not very effective in engaging students and helping them master content. The students found the instructional tasks too easy because they required few, if any, higher order thinking skills. The students' discussion during the lesson was off task and purely social. In this lesson, her use of

cooperative learning was unproductive and contributed to a lack of engagement. Furthermore, the students' mastery of content in this lesson was unimpressive because it was limited to learning cell parts and their structure. Later, Sarah expressed disappointment that the students did not realize that the lesson was relevant to their health since they were learning about the cells which makeup their own bodies. Yet, Sarah did not introduce content of this kind or promote its learning through CTL or other means.

Engagement and mastery were even less in a few lessons, such as *Observing Yeast and Making Spores*, where Sarah relied on rote learning, drew few connections to real life, and used only traditional "paper-and-pencil only" assessment. Some students said they were bored and confused. Lessons of the latter sort only occurred when the paperwork and extracurricular tasks that overwhelm first-year teachers prevented her from the additional planning that a CTL-based lesson usually requires. Sarah's principal and fellow teachers confirmed this observation, regretfully explaining that first-year teachers at their school are overworked. Ideally, given enough time to prepare, Sarah wanted to incorporate CTL into every lesson:

> "For my students, learning should be a fun and interesting process that requires both knowledge and skills….CTL allows the students to use knowledge they have obtained and apply it to real life situations to "test" themselves. If a concept/idea is mastered, an authentic assessment should be administered and taken to show knowledge. Skills learned through CTL methods can prove valuable throughout life….Authentic tasks motivate students to love science."

Most of the time, we found that Sarah used CTL strategies to effectively engage students and support their mastery of science content as seen on multiple measures of

performance-based achievement. In our view, Sarah is making significant progress toward achieving her major goal for her students and that CTL is helping her achieve that goal. In her words:

> "When students leave my classroom at the end of a year, I want them to recognize their abilities to handle various situations life may throw at them. Yes it is important that they know basic life science concepts, but it is even more important that they know they can think for themselves and solve problems. By working together with other people, solving problems, and applying things to real-life, my students have gained valuable skills that will help them in the future."

Discussion

The findings provide insight into how well Sarah, a new science teacher and one who was introduced to CTL during preservice teacher education, implemented CTL during her first two years of teaching in a middle school classroom. The findings are based on our observations and interviews of Sarah and her students, our reviews of Sarah's written lesson plans and her students' work products, and our discussions with Sarah's principal and fellow teachers. Taken together, these multiple sources of evidence led to four main findings that will be discussed.

First, we found that Sarah frequently bases her lessons on principles and instructional strategies identified with CTL. She genuinely values CTL and believes that it can motivate her students and help them to achieve at a high level. Seasoned teachers often use CTL strategies after discovering them on their own, but it may take a relatively long period of time in the classroom to do so. Sarah, on the other hand, despite her relative inexperience, is using CTL frequently during her first two years of teaching.

Furthermore, she views her instruction in CTL as an advantage she has over other new teachers who have not been trained in this method. As she sees it, she quickly learned the principles and strategies of CTL without having to experience years of trial-and-error learning.

Second, Sarah believes that lack of time is a barrier to using CTL. She is unable to use CTL as often as she would like. This is not surprising given that Sarah is a new teacher and is still learning to juggle the myriad responsibilities she is confronted with on a daily basis. Also, new teachers and veteran teachers alike must cope with current educational reforms that call for greater and greater amounts of content to be covered—this frequently forces teachers to resort to a traditional method of instruction that emphasizes lecture and rote learning. No matter how much Sarah wants to use CTL in her classroom, she can not do so if she feels too overwhelmed to do the thoughtful planning that CTL requires. Additional training in "time-management for teachers" might be helpful for Sarah. It also might be helpful to integrate such training in pre-service instruction in CTL.

Third, Sarah does not always have a clear understanding of when CTL strategies are appropriate to use in her lessons. She is very adamant in her belief that some science topics cannot be taught using CTL strategies. This is a considerable limitation to Sarah's implementation of CTL, and it indicates that her instruction in CTL did not prepare her for flexible and adaptive use of these strategies in her classroom. Sarah understands CTL, but is not able to implement it in some lessons. Unlike Sarah, we believe that CTL can be implemented significantly in all lessons and we noted many lost opportunities in the

lessons she taught. Perhaps, Sarah's preservice instruction in CTL should have included more practice in creatively applying CTL to a wide variety of lessons.

Fourth, we found that Sarah's use of CTL in her lessons promoted engagement and mastery on the part of her students. Sarah's understanding of CTL is extensive enough that when she does use it, she uses it well. Furthermore, she routinely uses the *National Science Education Standards* (NRC, 1996) and the *Georgia Quality Core Curriculum* (2003) to determine the content of her lessons and to ensure that her assessments of students' achievement are reliable and valid. During CTL-intensive lessons, her students were motivated and achieved well, as evidenced by our observations, the students' test performance and work products, and the observations of Sarah's principal and fellow teachers. These multiple sources of evidence support the view that Sarah is achieving her major goal of teaching science effectively and that CTL is helping her to achieve that goal.

Since our case study focused on one science teacher educated in CTL at the preservice level, care should be taken in applying findings with Sarah to the education of other preservice teachers in CTL. Despite this limitation, it is important to note that Sarah is in many ways representative of other new science teachers and, in Sarah's case, at least, preservice education in CTL proved to be quite valuable. In our opinion, Sarah's CTL-based knowledge has given her a sizeable advantage over many new teachers because it has increased her repertoire of teaching strategies and, more importantly, provided her with a framework on which to build her own philosophy of teaching. Her ability to implement CTL in her classroom will no doubt improve greatly with more experience, but already she seems to have more confidence in her teaching ability than is

typical of other science teachers early in their careers. The present findings support the view that Sarah's preservice education in CTL is accelerating her professional development as a science teacher and, at the same time, fostering her students' achievement and attitudes in the area of science.

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