Designing Teaching Dilemmas for Problem-Based Learning Professional Development

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Abstract

The purpose of this study is to examine 1) whether the use of teaching dilemmas helps teachers consider instructional strategies and move towards a more student-centered pedagogical orientation and 2) how the structure of the problem affects participants' thinking and performance in analyzing teaching dilemmas during a problem-based learning professional development seminar for K-12 science educators. In one case, we stated the teacher's problem of practice, or teaching dilemma, while the teachers in the other group had to identify the problem(s). We used a grounded theory approach to analyze teachers' responses to a pre- and post-assessment question and the charts constructed during each group's problem-based learning experience. Although teachers in both groups moved towards a more student-centered teaching approach, only those in the less structured group generated more ideas about instructional strategies after encountering the teaching dilemma.

Current science reforms (National Science Education Standards, 1996; American Association for the Advancement of Science, 1993) call for a pedagogical shift away from a teacher-centered approach and encourage a move towards student-centered instruction. In this reform-based vision of science education, the emphasis is on active science learning environments in which students are provided with opportunities to engage in both hands-on and minds-on learning experiences. Two key elements of student-centered instruction include engagement in inquiry, which involves interacting with objects and phenomena in the world and trying to make sense of these experiences through the development of patterns and explanations (Anderson, 2003), and social interactions with teachers and peers to develop students' scientific understanding. In these types of learner-centered environments, teachers pay close attention to students' prior conceptions and attend to their ideas both before and during instruction (National Research Council, 2005).

In this sense, students are positioned as "doing things and thinking about what they are doing" (Bonwell & Eison, 1991, p. 2). As active learners in this setting, students assume roles in which they "describe objects and events, ask questions, acquire knowledge, construct explanations of natural phenomena, test those explanations in many different ways, and communicate their ideas to others" (National Science Content Standards, 1996, p. 20). Students are no longer passive recipients of knowledge who memorize information, but are involved in higher order thinking tasks such as analysis, synthesis, and evaluation (Bonwell & Eison, 1991). Teachers' roles also change in this paradigm; they act as facilitators of students' interactions and engage students in activities and discussions instead of being the dispensers of knowledge. Certain instructional strategies, such as lecture, recitation and drill, are rarely used in this environment.

Although the incorporation of active, or student-centered, learning in the classroom involves potential risks and barriers, which might explain why some instructors are resistant to using this teaching approach (Felder & Brent, 1996), research has shown that the use of student-centered instructional methods has numerous benefits for students. These benefits include higher achievement overall on measures of higher-order thinking and understanding of discipline specific concepts, increased student motivation to learn, and development of problem solving and critical thinking skills (Von Secker & Lissitz, 1999; McCaffrey et al., 2001; Sivan et al., 2000).

Background

Problem-based learning (PBL) is a type of student-centered instruction in which participants are presented with an ill-structured problem and engage in a participant-driven process to solve the dilemma (Hmelo-Silver, 2004; Lundeberg, Levin, & Harrington, 1999). This instructional method has been used most often in medical schools to develop learners' clinical reasoning skills and deepen their content knowledge, although it has more recently been incorporated into the educational domain through teacher education courses, K-12 classrooms, and professional development (Levin, 2001; Sage, 2001; Oslund et al., 2006). In PBL, students encounter a problem; identify facts, learning issues, and hypotheses; engage in self-study; synthesize their ideas; come to a decision to resolve the controversy; and present evidence to defend their solution (Duch, 2001). This method has been used to develop learners' clinical reasoning skills, collaboration skills, deepen content knowledge and develop flexible, situated reflection on practice (Hmelo-Silver, 2004; Levin, 2001; Oslund et al., 2006; Sage, 2001). In the same way that PBL develops students' skills in each area, we hypothesized that this approach may develop teachers' skills in these areas as well. The development of these skills is essential in helping teachers plan and implement instruction that provides more learner self-direction and less direction from the teacher, corresponding with an inquiry, student-centered approach to instruction (National Science Content Standards, 1996).

Weiss (2003) recommended several important features of problems that promote higher-order thinking, including that they be appropriately challenging, ill-structured, grounded in students' experiences, require students to work collaboratively, and motivate students to become lifelong and self-directed learners. Others have recommended that problems be designed to promote students' engagement by stimulating interest, provoking controversy, and requiring students to justify decisions (Duch, 2001; Herreid, 1997; Kelson, 2004; Torp & Sage, 2002). These characteristics, however, are not empirically based. One unresolved question is how structured the problem should be.

Task structure can be defined as the level of explicitness and support specified in an activity that has been presented to a particular audience. This level of structure can vary depending on the context and the purpose of the task. Some examples of how the task can be structured differently include changes in the level of specification of the task's goals, the desired product, and the amount of direction given for how to complete the task. Research on the influence on task structure casts a large net, ranging from studies in language learning (Skehan & Foster, 1999) and in physical education (Silverman, Kulinna, & Crull, 1995) to those that explore its effect on interaction patterns and status hierarchies within groups (Chizhik, Alexander, Chizhik, & Goodman, 2003) as well as changes in students' achievement and self-efficacy (Lodewyk & Winne, 2005).

Findings in these studies have been mixed in terms of how much task structure is useful; specifically researchers have found that different levels of task structure have certain advantages and disadvantages, depending on the outcomes that are the focus of the study. For example, when investigating pre-service teachers' learning in a literacy methods course, Yadav (2006) found that teachers using the less structured task generated significantly more advance organizer concepts than those in the more structured group. However, when investigating teachers' perceptions of these tasks, teachers in the more structured group reported that they learned and understood more while teachers in the less structured group reported feelings of frustration more often. Currently, there has been little empirical research on the influence of the structure of a PBL teaching dilemma on participants' thinking. In this study we explore whether the structure of a PBL teaching dilemma matters in terms of influencing teachers' thinking in a professional development context.

Research Questions

This area of inquiry focuses on determining if the PBL approach is an effective method for helping teachers analyze problems of practice and whether the level of problem structure affects teachers' thinking and performance in analyzing teaching dilemmas. In a real classroom situation, teachers are responsible for defining, understanding, and researching problems of practice on their own. Altering the structure of the problem might positively or negatively influence how helpful it is in assisting teachers to develop their clinical reasoning skills. More structured problems have the possibility of narrowing the teachers' conversational topics and, thus, limiting what they learn. On the other hand, less structured problems could lead to conversations that wander aimlessly and never address key learning issues. We hypothesized that the more structured problem in which the teacher's dilemma is already identified is less authentic and will narrow the teachers' conversational topics and lead to less learning regarding reform-based instructional strategies.

Specifically, in the research study we address the following questions:

1. Does using the problem-based learning approach to analyze teaching dilemmas help teachers consider more instructional teaching strategies?
2. Does using the problem-based learning approach to analyze teaching dilemmas affect teachers' orientation towards teacher- or student-centered pedagogy?
3. Does the structure of the problem affect teachers' consideration of instructional teaching strategies or teachers' orientation towards teacher- or student-centered pedagogy, and if so, how?

Methods

Participants and Context

This study followed eighteen elementary teachers, 6 male and 12 female (mean age, 37; mean years teaching experience, 6.5), who participated in a two-week long professional development seminar during the summer. The seminar included two main parts that used problem-based learning to engage teachers in professional development; each part had a specific objective. During the first part, we used content dilemmas to assist teachers in building a more accurate and connected base of knowledge around a particular science content area, such as weather, the rock cycle, or force and motion. During the second part, which lasted three-and-a-half days, of this professional development experience, we used teaching dilemmas, or authentic problems of practice, to develop teachers' abilities to critically reflect on and reason about their own and others' teaching difficulties and decisions. We anticipated a variety of potential outcomes from this professional development, such as increased scientific knowledge, improved clinical reasoning skills and improved decision-making knowledge for teaching (Weizman et al., 2007). The second component of this professional development, in which teachers engaged in analyzing teaching dilemmas, is the setting for this research study. Before examining the results of our study, we will describe this setting in more detail.

Each teacher encountered three teaching dilemmas during this time. For this session, we divided teachers into four separate groups, two elementary and two secondary groups, based on grade level position and prior decisions regarding meeting groups for the school year. Facilitators wanted teachers who would be collaborating in the school year meetings to work with one another during this session in order to begin the development of a learning community within each group.

To introduce teachers to this new context, within each of the two small groups we engaged teachers in an analysis of the same teaching dilemma on the first half-day, although they did not complete the self-study and synthesis portion of the PBL process for this dilemma. The goal was to give the teachers a sense of how a teaching dilemma compared to a content dilemma. During the following two days, the teachers encountered two other teaching dilemmas, each with a separate focus and structure. In table 1, we show the teaching dilemma schedule for these two days for each group of teachers. Each pair of facilitators engaged two groups of teachers separately in one of the dilemmas. The circuits teaching dilemma, which centered on instructional decision making, was the focus of this study.

<Insert Table 1 about here>

Procedure and Materials

Before the circuits teaching dilemma, teachers wrote pre-test responses to the following question: "What is an effective way to respond to incorrect or conflicting student ideas and/or widely variable data?" Regardless of group, facilitators then introduced the teaching dilemma through a written sheet that provided information about the teaching context, the teacher's instructional objectives, and the teacher's viewpoint (see Appendix). For teachers in the more structured group (elementary group B), we clearly articulated the focus problem to solve and explicitly stated the specified product on this written sheet: "**Focus Question**: How might a teacher move his/her students from vague ideas to a more scientific understanding?; **Product**: A recommendation for how this teacher might move her students to a more scientific understanding of electricity." Teachers in the less structured group (elementary group A) did not receive this question and product on the informational sheet, and thus were required to collectively decide on what the problem(s) was and how it should be addressed.

Regardless of the group, the remaining steps were the same. Teachers then viewed a ten-minute video segment from an educator's classroom to better illustrate the teaching dilemma. In the circuits teaching dilemma, the video clip showed students building parallel and series circuits, observing the difference in brightness between bulbs in these types of circuits, and discussing their ideas to explain this observed phenomena. Both groups of teachers worked to solve the dilemma using a problem-based learning approach. As the teachers in each group engaged with the circuits teaching dilemma, the PBL facilitators documented the ideas generated in each group on various charts displayed around the room. They sorted the teachers' ideas on the charts according to the parts of the PBL process, which included: 1) identifying problems; 2) identifying facts; 3) identifying learning issues; 4) suggesting hypotheses; 5) documenting research findings; and 6) stating possible recommendations. Teachers presented their solutions to the problem(s) for the teacher depicted in the dilemma and ended by completing a post-test with a written response to the same pre-test question. Note that both groups of teachers solved this problem on different days, but with the same pair of faculty facilitators.

Data Sources and Data Analysis

We used multiple data sources to assess teachers' thinking and performance when analyzing the circuits teaching dilemma, including teachers' responses to the pre- and post-assessment question; written charts of the problems, facts, hypotheses, learning issues, research findings, and recommendations generated by each group; and facilitators' written reflections comparing the enacted teaching dilemma.

We used a grounded theory approach (Strauss & Corbin, 1990) to analyze teachers' responses to the pre- and post-assessment question in two ways. First, we began with all of the ideas teachers mentioned about instructional strategies, and then categorized these responses into larger thematic groups. In table 2, we present a description of each of these categories and one or more examples from teachers' responses for each category. Two members of the research team, who were blind to condition and teacher identity, coded the teachers' responses to the pre- and post-assessment. Coders agreed on the category 87% of the time, and when disagreements occurred, they settled these by coming to consensus.

<Insert Table 2 about here>

Next, we used a rubric to score each response based on the teaching approach that was emphasized, specifically examining the extent to which teachers advocated a teacher-centered or a student-centered pedagogical approach. Coders were blind to teachers' condition or group. In a similar manner, multiple coders used this rubric to evaluate each teacher's response. We reached an interrater reliability of 94% and resolved any disagreements with consensus coding. In Table 3, we illustrate our coding scheme and give an example of one teacher's response for each rating.

<Insert Table 3 about here>

We statistically analyzed pre-post scores from both rubrics using directional matched-pair t-tests (because only growth was expected, not regress) to evaluate the effectiveness of the overall approach (regardless of the structure of the problem). In addition, we analyzed the impact of condition using one-way ANCOVA, with the structure of the problem as the dependent variable, and the pre-test score as a covariate.

We also analyzed the charts from each group by using the first coding scheme, the categories for descriptive coding (see Table 2). We examined the charts from each group for patterns related to these coding categories and made comparisons across the two groups. To do this, we took each statement written on the charts and identified what category topic ideas were represented in that statement. Statements could have either one or more ideas related to the different categories. For example, the learning issue, “When do you give an answer versus let the students explore to find an answer?” was coded as including an idea from category one, which focused on directing students to the correct answer or explanation, and an idea from category two, which focused on providing opportunities for students to engage in more exploration or experimentation. Other times we coded a statement as being representative of only one category, such as the learning issue, “What is a good probing question?” This statement was coded as category three because it related to uncovering students’ ideas through questioning. We also used the facilitators’ comments to provide first-hand perceptions of the similarities and differences across groups.

Results and Discussion

Analysis of Teachers’ Responses to the Pre- and Post-Assessment

By using each of the rubrics to analyze the teachers’ responses, we found significant differences in the pre-post growth in terms of quantity of instructional strategy ideas for teachers in the less structured group, but not for teachers in the more structured group. However, teachers in both groups gained significantly in terms of their pedagogical orientation, regardless of problem structure, moving towards a more student-centered instructional approach. .

Quantity of Instructional Strategies Ideas

Overall, the problem-based learning approach did not help teachers uniformly develop new instructional strategies, as evidenced by pre-post changes on the instructional strategy rubric [$t(17)=1.70$, $p=0.054$, Cohen's $d=0.39$]. In table 4, we present the means and standard deviation for the number of instructional ideas in each category by type of problem design. When group is considered, however, teachers in the more structured group showed no pre-post change in the number of ideas while the teachers in the less structured group generated statistically significant more ideas after engaging in the problem-based learning session [$t(8)=2.68$, $p=0.014$, Cohen's $d=0.74$]. Furthermore, the teachers who received a less structured problem generated more overall ideas (3.78) when compared to their more structured counterparts (2.22) [$F(1,15)=6.70$, $p=0.02$, eta squared=0.31]. Even though the number of overall ideas showed a difference by group, this difference cannot be attributed to any single coding category (C1-C6), as individual contrasts did not indicate a statistically significant difference by group.

<Insert Table 4 about here>

This pattern, an increase in the number of instructional ideas in the less structured group after engaging in this teaching dilemma, is evident in Maria's response. Prior to this teaching dilemma, Maria, who engaged in the less structured task, described two instructional strategies for how one could effectively respond to incorrect or conflicting student ideas and/or widely variable data. One idea, which was coded as category two, was to "repeat data gathering as a whole class group and see what results we get" and the other idea, which was coded as category three, was a list of questions the teacher could use to probe the students' thinking, such as "Why do you think that? What is your evidence? Why do we have such a broad range of data?" However, her post-assessment response included three ideas, two which were similar to those on the pre-assessment as well as the addition of one more instructional idea, coded as category four, which stated that "sometimes more research or information may be necessary (go back to reading)."

Teachers' Pedagogical Orientation

We further analyzed the teachers' responses using the teaching-approach rubric to evaluate their responses on a continuum from teacher to student-centered. Teachers were significantly more student-centered (on average) after encountering this teaching dilemma [$t(17)=3.43$, $p<.01$, Cohen's $d=1.14$]. In table 5, we illustrate the scores to evaluate the teaching approach evident on the pre-post test by problem design. There does not seem to be any evidence that one form of the problem was more helpful to teachers than the other format in moving teachers towards a more student-centered teaching approach. Using the problem-based learning approach to analyze teaching dilemmas affected teachers' pedagogical orientation, regardless of problem structure. This pattern is more clearly shown by examining the individual teachers' responses.

<Insert Table 5 about here>

As stated above, teachers in both the more structured and the less structured groups showed a move towards a more student-centered pedagogical orientation. The pre- and post-assessment responses from two teachers, one from the more structured group, Josh, and one from the less structured group, Julie, demonstrate this pattern.

Josh's responses before and after encountering the circuits teaching dilemma illustrates this transition from a primarily teacher-centered approach to one in which the students' ideas and thinking are considered. In his pre-assessment response, which received a score of 0, he stated that

> "…This is a great time for the teacher to model, possibly in an experiment, the dilemma that they are faced with. The teacher needs to remind the students that nobody has a bad idea, they may have just received some information that may be false. "

This response reveals a didactic teaching orientation that portrays the teacher as the one who holds the knowledge and takes full responsibility for modeling what the students do. In this role, the teacher directs the process, acknowledging that the students have ideas but not providing them with opportunities to share their thinking.

His response on the post-assessment, which received a score of 1, showed that he was beginning to think about how he might have students share responsibility for their own learning and facilitate discussion among the students regarding their ideas. He wrote,

> "… list several ideas on the board and then have the students find a way to model the problem … share their results and compare them to see if there are any misconceptions. Once the misconceptions are listed then the teacher needs to draw all of the correct information out of the students and make them think critically and come up with the correct answer …"

His thinking shows growth in that he is now thinking of how to provide opportunities for students to articulate their own ideas and response to each other, commensurate with the recommendations of the National Science standards (1996). Compared with Josh's earlier response, the students are more active learners who are encouraged to share their thinking with one another and generate explanations. However, he still shows a desire to lead them to the correct answer.

Likewise, Julie, a teacher in the less structured group, made a similar shift evident in her response on the pre- and post-assessment. Before encountering this teaching dilemma, Julie stated that "it might be hard – difficult for the teacher to not just jump in and give the right, pat answer." However, she went on to say that the "teacher needs to hold themselves to the same, standards as the students in the scientific classroom community" and this means that "the teacher would need to also provide the facts and data as evidence of the 'right' answer." Nowhere in her response does she mention the students' ideas and attending to their thinking in this situation. As well, she provides no evidence that any responsibility is given to the students; in fact, the majority of her response focuses on the teacher and her role in the classroom.

> However, on her post-assessment response, which received a score of 2, Julie stated how "It would be effective to help the students develop an awareness of ideas that conflict or differ by student led discussion to determine the discrepant event. Then assist. Direct students to research the event and come to an 'agreeable' to all answer that will satisfy all the students."

In her response most of the responsibility is placed on the students' shoulders. As well, careful attention is paid to the students' ideas. Students are provided with opportunities to share their thinking with one another, consider one another's ideas, research the event, and try to establish consensus on the topic of their disagreement. The role of the teacher in this scenario is as a person who facilitates this consensus-making process, by helping them conduct some type of research to be able to reach an agreement.

Analysis of Facilitator Comments and PBL Discussion Charts Generated During the Teaching Dilemma

The charts provide a summary of the ideas generated during the group discussions. We used them to learn more about what happened during the professional development experience in each group. Specifically, we looked to see if there were any differences between the groups and whether the charts can provide some explanation for the results found from pre-post tests. The analysis shows there were some differences in the nature of the discussion, but not in the overall number of ideas generated.

The written reflections of the facilitator and observer differed in the way they compared the two groups, in that the facilitator thought the less structured discussed generated deeper discussion that pushed participants in using research to a greater extent than the more structured session, however the observer thought that the more structured discussion was more coherent and concise. The facilitator wrote: "the ideas generated in dilemma II (less structured group) seemed deeper, more thoughtful. Participants interacted more with each other, adding to ideas. The research collected from dilemma II was used to a greater extent when solving the problems (generated from the group prior to the video and post video). Many of the same learning issues were presented/ suggested in both groups." While the observer wrote: "Having a stated problem brought a great deal more focus to a tighter area of consideration. Participants dismissed their own comments at times, stating that an observation that engaged them is not the subject of focus. I thought the guided pieces were more coherent, intense, concise, etc."

In order to investigate the origin for these statements when analyzing the charts we examined the number of ideas in each of the categories generated earlier from the teachers' writing. In table 6 we show examples for coding chart ideas according to the different categories. Each idea, represented by a bulleted sentence on the chart, was sorted to one of the categories and sentences that had more than one idea were divided to the relevant categories.

<Insert Table 6 about here>

When we compared the charts created by the two groups for the overall number of ideas we found these were indeed similar in the more structured (84 ideas) and the less structured (86 ideas) group (Table 7). Looking more closely, we found that the emphasis in each group's discussion was on different parts of the PBL process. Specifically, the group with the more structured teaching dilemma reported more ideas related to their research findings and recommendations while the teachers in the less structured group generated more ideas regarding the problems and facts of this teaching dilemma. This result relates to issues regarding the difference between experts and novices. Experts are reported to discuss the problem presented to them in more detail before beginning the research, while novices often jump into research without enough discussion of the problems and facts. (Lundeberg, 1987) Specifically, teachers are used to very structured discussions, and when presented with a less structured task they might feel less comfortable (Yadav, 2006).

<Insert Table 7 about here>

When analyzing differences in the nature of the discussion between the two groups we found that the less structured group had a more open ended discussion, and raised ideas related to epistemology (or "deeper and more thoughtful" as the facilitator said) - about scientific knowledge which is not a fixed body of facts, and scientists who may have disagreements about their results.

Teacher one: You know scientists often disagree with one another and they've gone back and checked other people's theories that everybody thought yes, that's absolutely the way it is and other scientists have checked it out and they've come up with a different explanation for it.

Teacher two: That's good, it said, you know, scientists disagree too. And I also I think the thing was important was it said teachers need to realize that um subject matter knowledge is not a fixed body of facts…So that, you know you can tell them things, but things change.

Teacher one: But then, but then use that, use that as a springboard, present the, this is one explanation, let's go see if that's true or not…So then that way they, you're, you're getting it to them, you know you're getting that information to them, but yet they're, instead of just taking it and saying ok that's what the teacher said so that must be something, the way it is. They're taking it, now they're going to investigate what you said to see if it's actually true or not.

In this discussion, they raised important issues related to both the nature of science conversations, that scientists do not always agree, and the nature of science content, that science knowledge is not a fixed body of facts. Scientists investigate phenomena and change their thinking over time. However, when we examined the discussion in the more structured group, we noticed that the discussion became a reporting out of findings and recommendations, with little interaction between teachers about relevant ideas or issues.

In this study, project staff presented a teacher’s problem of practice, or teaching dilemma, as the task; we modified the task to provide for different levels of support. In the more structured teaching dilemma, the teacher’s dilemma and the product were explicitly stated and identified for the group. However, in the less structured teaching dilemma, the teachers had to determine the problem(s) and the product.

We found in both groups that the teachers' ideas from the pre-post assessment were significantly more student-centered after examining this teaching dilemma. Specifically, these differences can be linked to the change in the number of ideas in two categories: category two, which focused on providing students with opportunities for more experimentation, exploration, or replication of the same activity, and category three, which aimed to probe students' thinking by providing opportunities for students to discuss or share their ideas related to the content, the experimental procedures or variables. In both groups, the number of ideas in each of these categories increased. In fact, seven out of the eight new instructional ideas were from these two categories for the teachers in the less structured group. When considering a student-centered teaching approach, one would expect that teachers with this orientation would suggest strategies where the focus was on uncovering or understanding the students' thinking and on engaging students in activities; this is consistent with the ideas of doing and thinking that are hallmarks of a more student-centered pedagogical orientation (Bonwell & Eison, 1991). This finding seems to support the claim that using a PBL approach to investigating a teacher's problem of practice affects teachers' orientation towards a more student-centered teaching approach. This approach is one where students' ideas are fore grounded and most of the responsibility is given to the learner to direct the learning process (National Science Standards, 1990) to produce active, engaged learners who share responsibility for their own learning.

Of course, we must note that one of the limitations of this study is related to the design of the intervention. During the planning of the teaching dilemmas, the design team decided that it would be beneficial for each group to engage in a more structured problem followed by a less structured problem. They felt that this strategy would serve as a much needed scaffold for teachers in this process. One possible explanation for the finding that the teachers who received a less structured task generated statistically significant more overall ideas when compared to their more structured counterparts could be due to the fact that they had already engaged in one of these teaching dilemmas the day before and therefore had more experience with this process. Further research is needed to determine how the amount of experience engaging in problem-based learning teaching dilemmas affects teachers' ability to generate instructional strategies.

Conclusion

Teachers face multiple issues and challenges on a daily basis in their instructional practice. Helping teachers learn how to respond to problems they encounter in their classrooms has been a focus of professional development efforts. Results from this study suggest that PBL is an effective instructional approach that helps teachers consider student-centered instructional approaches advocated by reform-based models of science teaching (National Science Standards, 1996; American Association for the Advancement of Science, 1993). In addition, this study suggests that either format for structuring the problem is conducive in helping teachers move towards a more student-centered pedagogical approach, although a less structured problem seems more effective for helping teachers generate a greater number of instructional strategies.

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Appendix

PBL Focus On Practice Teaching Dilemma: Instructional Decision Making

Topic: Circuits and Pathways

Context:

The principles of electricity were the focus for my group of 30 fourth grade students in a public elementary school in Castro Valley, California during the month of March. I began the unit with a questionnaire asking students, "Where in your house do you find electricity? How do you use it? What might happen if your flashlight stops working?" I started by having the students learn about things that were more familiar to them and then moved to more complex ideas. First, the students made posters of ways that they use electricity in their lives. Then, students experimented with a variety of materials and focused on one challenge: lighting a bulb using a battery, bulb, and wire. They also used a battery, wires, and motor to make the drive shaft on the motor turn in a clockwise and counterclockwise fashion. After that, they moved to learning about and constructing series and parallel circuits. My goal was for students to come away with an understanding of some of the basic principles of electricity, including how circuits work, how circuits do not work, and something about the flow of current. I also wanted them to have the experience of designing and carrying out their own experiments.

Objective: Students will be able to construct a simple electric circuit that provides a pathway so that current can move between a source (battery) and an object (bulb and/or bell). Students will be able to identify and describe how various types of electrical circuits (i.e. series and parallel) provide a means of transferring and using electrical energy to produce light.

Teaching Dilemma:

I think that it's important for students to take responsibility for their own learning and to learn to think critically, to learn to question and to become excited about learning and excited about what they see happening in the world. When they're able to have their hands on the materials and when they're able to speak with one another, they're in control. After the students had an opportunity to create parallel and series circuits, they noticed that the bulbs in the parallel circuit were brighter than the bulbs in the series circuit. Asking the students to explain their thinking led to a variety of ideas for this observation.

Focus Question: How might a teacher move his/her students from vague ideas to a more scientific understanding?

Product: A recommendation for how this teacher might move her students to a more scientific understanding of electricity.

Table 1

Teaching Dilemma Schedule

	Day One	**Day Two**
Elementary Group A	Falling Objects (more structured) Focus: Student Interactions *Facilitators: Anne and Cathy*	Circuits (less structured) Focus: Instructional Decision Making *Facilitators: Marie and Tracy*
Elementary Group B	Circuits (more structured) Focus: Instructional Decision Making *Facilitators: Marie and Tracy*	Falling Objects (less structured) Focus: Student Interactions *Facilitators: Anne and Cathy*

Table 2

Categories of Pre-Post Instructional Strategy Ideas that Teachers Generated

Categories	Description	Examples
C1	Teacher provides or purposefully directs the students to the correct answer or explanation	"…so the teacher would need to also provide the facts and data as evidence of the 'right' answer…" "Find/explain the correct answer." "With younger students where the concept is really advanced I would just do as simple an explanation as possible."
C2	Teacher has students complete or engage in some type of activity to resolve the dilemma	"…the students need more data. This may mean repeating the experiments more times for a better sample – often students don't repeat tests enough times to be able to collect a sample to show a pattern or results." "Do another experiment to find proof and evidence."
C3	Teacher probes students' thinking by asking questions, facilitates student discussion, and/or assesses students' thinking and ideas	"A class discussion of the results would now follow. I usually ask many (leading-type) questions attempting to allow the students to look at their perspectives on the knowledge or data." "Ask students to prove, or for the evidence of their answer."
C4	Teacher provides an opportunity for students to conduct research on the computer or with books to find relevant information	"I would take my class to the computer lab and we would research the idea(s) or data as a class." "I would tell the student that we could all research the question together and gather more information."
C5	Teacher uses particular strategies or tools to create a positive learning environment	"Reassure the student that their answer is appreciated…First build an atmosphere where incorrect answers are just as valuable as correct ones. Pull as many positives from a student's incorrect answer as is possible." "Give the student positive feedback for attempting to answer the question."
C6	Addresses another way to respond to this dilemmas but idea does not fit into the other categories	"If a large amount of students have incorrect ideas, I would look at what I taught. Is there an issue that could be confusing or am I leaving a piece of the puzzle out."

Table 3

Rubric to Evaluate the Teaching Approach Evident on Responses to the Pre-Post Assessment Question

Score	Teaching Approach	Description	Examples
0	Teacher-centered teaching approach	No consideration of students' ideas or thinking **AND/OR** No responsibility given to students	"Whenever you have a classroom full of students there will be conflicting or incorrect ideas and thoughts. This is a great time for the teacher to model, possibly in an experiment, the dilemma that they are faced with. The teacher needs to remind the students that nobody has a bad idea, they may have just received some information that may be false. By modeling this topic to the whole class hopefully this clears up any misconceptions and brings out the truth."
1	Combination of teacher-centered and student-centered teaching approach	Some consideration of students' ideas or thinking **AND** Some responsibility given to students	"I would allow the students to discuss and explain their results without validating or not validating their responses. Based on the specific situation I would set up another inquiry for the students to research/test/explain their findings further. I may give the students an explanation and give the students an opportunity to prove or disprove my explanation."
2	Student-centered teaching approach	Major consideration of students' ideas or thinking **AND** Most or all responsibility given to students	"There are a variety of ways to respond to students who have incorrect or conflicting ideas. You can use questioning so that students delve deeper into their answers/findings. You can have students experiment and explore to find a new/correct answer (devise a different experiment/opportunity). You can have children/students attempt to answer each others' questions. I don't think there is one effective way to deal with this type of situation and you may have to play around and try different ones out before you find an effective one suitable for your classroom."

Table 4

Means Scores (and Standard Deviations) for the Number of Instructional Ideas in Each Category by Type of Problem Design

	C1	C2	C3	C4	C5	C6	Total
More Structured Pre	0.33 (0.50)	0.22 (0.44)	0.89 (0.93)	0.22 (0.44)	0.22 (0.44)	0.33 (1.00)	2.22 (1.20)
Post	0.11 (0.33)	0.56 (0.53)	1.11 (0.60)	0.11 (0.33)	0.33 (0.71)	0.00 (0.00)	2.22 (0.67)
Less Structured Pre	0.33 (0.50)	0.89 (0.93)	1.11 (0.60)	0.11 (0.33)	0.22 (0.67)	0.11 (0.33)	2.78 (1.20)
Post	0.44 (0.53)	1.22 (0.67)	1.44 (0.88)	0.33 (0.50)	0.22 (0.67)	0.11 (0.33)	3.78 (1.48)

Table 5

Scores to Evaluate the Teaching Approach Evident on the Responses to the Pre-Post Assessment Question

	Number of Participants			**Overall**
	Score 0	**Score 1**	**Score 2**	**Avg Score (Std Dev)**
More Structured Pre	2	7	0	0.78 (0.44)
Post	0	6	3	1.33 (0.50)
Less Structured Pre	1	8	0	0.89 (0.33)
Post	0	6	3	1.33 (0.50)

Table 6

Examples from the Coding of Chart Ideas

Categories	Description	Idea
C1	Direct to correct answer or explanation	When does the teacher "pull back" from the "teaching as telling" model of instruction?
C2	Opportunity for more exploration or experimentation	If students have not yet found the concepts then they are not yet done with this investigation, therefore they need to go further and design the next step in inquiry.
C3	Probe student thinking	How do teachers develop the ability to generate meaningful probing questions?
C4	Conduct research	STA – use a variety of sources to find information they are interested in.
C5	Positive learning environment	Children felt safe in the environment – safe to take risks
C6	Other	Science knowledge is not a fixed body of facts

Table 7

Number of Ideas Generated by the Teachers in Each Part of the PBL Process (from charts)

Group	Problems and facts	Learning Issues and Hypotheses	Finding and recommendations	Total number of Ideas
More Structured	19 (23%)	26 (31%)	39 (46%)	84
Less Structured	33 (38%)	25 (29%)	28 (33%)	86