You Learning Cycled Us! Teaching the Learning Cycle Through the Learning Cycle

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Abstract

Frustrated by how much difficulty my preservice secondary science teachers were having understanding the essence of the learning cycle and crafting learning cycle lessons, I changed both the language of the learning cycle and the way I taught it. Using *Concept* "*Discovery*," *Concept Clarification*, and *Concept Application* (DCA) as the names of the stages, I began to teach the learning cycle *through* a learning cycle. In my series of lessons to help them build understanding of the DCA learning cycle, I first have students analyze vignettes of learning cycle lessons in order to "discover" the critical elements of each stage. To "clarify" the concept of the DCA cycle, I spend several class sessions leading model lessons and engaging my pre-service teachers in discussions about each stage. To help them "apply" their understanding to teaching, I scaffold them through writing their own learning cycle lesson with help from a categorization scheme I developed for types of discovery learning experiences. Finally, in a short additional learning cycle, I have my pre-service students compare and contrast this model with others learning cycle models as a way to become knowledgeable about the history of the learning cycle and competent in the dominant discourse around it.

Introduction

When I started teaching high school biology, I figured out early on that my students were motivated by puzzles. I made it my challenge, then, to devise lessons in which the learning experiences were structured as puzzles for my students to solve. My early attempts included the extremely popular—though cognitively questionable—"Word-Scramble Treasure Hunts." In teams, students answered fill-in-the-blank questions from the text, then rearranged the circled letters of each answer to reveal the location of their next set of questions. The treasure hunts—and the bag of donut holes for the winning team—were a huge hit with lecture-weary students. For me, though, the logistics of the seven separate treasure hunt paths on seven different colors of paper for five different periods was overwhelming. Plus, I had to be honest: it was simply a worksheet cut into strips. Surely, I could do better.

Over my next few years teaching, the clues of my puzzles shifted from being words to being data. I developed a habit of beginning instruction on a new topic by providing students with a puzzle in the form of an experimental question or a set of data—numbers, graphs, images, observations—that they collected or that I provided to them. Their challenge was to analyze the data and draw a conclusion. The conclusion they drew was—by my design—the concept that I wanted them to learn that day.

When I began taking courses in my doctoral program, I learned that what I was doing with my students was, in the main, a form of constructivist and inquiry teaching. More specifically, this approach (and the learning experiences that followed) closely paralleled what was known in the field as a *learning cycle*. Briefly, a basic learning cycle involves students 1) beginning their learning about a concept usually through a hands-on investigation of a phenomenon or materials; 2) getting a clearer understanding of the concept through a variety of instructional approaches including additional labs, readings, lecture, videos, demonstrations, and others; and 3) applying the learning in a new context (e.g., Bybee, 1997; Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook, & Landes, 2006; Bybee, Powell, & Trowbridge, 2007; Karplus & Thier, 1967; Lawson, Abraham, & Renner, 1989).

As I looked to move from my career as a high school science teacher to the one ahead as a science teacher educator, I was thrilled to learn that what I had been doing had a name, theory, research (e.g., Bybee et al., 2006; National Research Council 2006), and even curriculum behind it. Because my own teaching had become so much more powerful for my high school students—and so much more enjoyable for me—I was driven to teach the learning cycle to the new science teacher candidates so that they could use it to support learning and thinking in their own classrooms. I was pleased that I would have more legitimacy behind my aspirations for my pre-service teachers' instructional designs than simply, "Hey, this really worked for me and my students!" The published and researched versions of the learning cycle were so well developed, so well articulated, and so integrated into the world of science education, that I felt that helping new teachers learn to plan using that model would be fairly easy—certainly easier than the fumbling around that I had done for a few years.

Naming Rights—or Naming Wrongs?

I was caught entirely by surprise, then, when the preservice science teachers whom I mentored and supervised in my doctoral program struggled so much to learn and adopt the learning cycle in their planning. What seemed to be such a straightforward concept to me perplexed and befuddled them. For all the time they spent learning and writing using the *Engage, Explore, Explain, Elaborate, Evaluate* (5E) model (e.g., Bybee 1997, 2002, 2006; Bybee et al. 2007)—two four-credit secondary science methods courses over two terms—they struggled enormously to write lesson plans using the model.

A troublesome aspect of the 5E model seemed—ironically—to be the clever, alliterative 5E naming system itself: the preservice secondary science teachers struggled to remember what each of the Es of the 5E model stood for. Worse, tripping up over what the Es stood for made them lose track completely of the overarching idea of the progression of thinking and learning that make up the pedagogical foundation of the learning cycle. The typical response to being asked about the 5E Learning Cycle was a variation on a theme: “The five Es? Um, I think explore, and expand, . . . explain, and . . . and . . . oh yeah, evaluate, and . . . shoot. How many is that?” The few students who could come up with all five names could not name them in order. It seemed that while “5E” was catchy, the real meat of the learning cycle was not. The students were—I really cannot resist this—missing the forest for the Es.

When I graduated from my doctoral program and began teaching science methods courses myself, I tried both the 5E model because of its power, presence, and ubiquity in science education and the three-part *Exploration, Term/Concept Introduction, Concept Application* model (Karplus, 1979; Karplus & Butts, 1977; Karplus & Thier, 1967; Lawson et al., 1989) because of its simplicity, permanence, and historical importance. But the *Explore*/*Exploration* name in both models was too loose for my students. What did it mean to “explore”? “Exploration” could be a lot of interesting but aimless wandering. My students could come up with all sorts of cool hands-on “explorations”—opportunities for students to put their hands on materials and play around with them—but to what end? That was the problem with “exploring;” there was no promise or expectation that one would actually *find* anything.

The implication set by the words “exploration” and “explore” was setting the bar too low for both teacher and students. With the publication of both *A Framework for K-12 Science Education* (NRC, 2012) and the *Next Generation Science Standards* (NGSS) (NGSS Lead States, 2013), the importance of using planning schema that emphasize scientific and engineering practices—especially, in this step, *making hypotheses*, *planning and carrying out investigations*, *analyzing and interpreting data*, *constructing explanations*, and *engaging in argument from evidence* (NRC, 2012)—cannot be underestimated. Bybee et al. (2006) articulated about the Explore stage that, as “a result of their mental and physical involvement in the activity, the students establish relationships, observe patterns, identify variables” (p. 9). The language of “exploration,” however, allows the novice teacher-planner to underestimate the possibility for real conceptual learning and for engagement in scientific practices.

Re-Branding the Stages

Based on the difficulties with the stage names that I saw my preservice science students experiencing, I devised a new naming system to use as I introduced the learning cycle to them. I stuck with the original core three stages—or, put another way, I lopped off the first and last of the 5Es that had been added to the older models (Bybee et al., 2006). My reasoning for the lopping was not that engagement and assessment (“evaluation” in the 5E) were in some way insignificant; to the contrary, I lopped them out of the learning cycle *because they are critical components that should frame—and be seamlessly woven throughout—all lesson plans*, not just those using a learning cycle approach. Our licensure program uses a lesson plan template that requires our preservice teachers to articulate their assessment plans (prior knowledge, formative, and future summative) as well as their plans to motivationally, physically, and cognitively engage their students in the learning. Because of that requirement, and because of the months that we have already spent in class building skills in engaging students and designing assessments, including the “Engage” and “Evaluate” portions of the learning cycle were unnecessary—and, in fact, a bit awkward—in instruction about the learning cycle as a *distinct* approach to teaching and learning.

For the first stage, I decided on the name *Concept Discovery.* In this stage, students are provided with a phenomenon, a structured or guided inquiry lab opportunity (Bell, Smetana, & Binns, 2005), or a set of data to examine. Often, they are provided an investigable question for which they propose a hypothesis, then design and carry out a test of that hypothesis. Using inductive reasoning, they examine the data and draw a conclusion—often the noticing of a pattern, relationship, or cause and effect—which they then justify with evidence and share out with peers. As they work, the teacher supports learning by watching, listening, asking probing questions, and providing scaffolding as needed.

I am intentional about using the word “Concept” in the name: I want it to be exceptionally clear to the teacher-planners that students are discovering *a particular concept* in this stage; they are not simply being tossed into a murky sea of data or materials with the hope that they may discover something. The quotation marks are also intentional. The “Discovery” going on is akin to Columbus “discovering” America: students are not really discovering anything new to the world, they are discovering something new to themselves. Too, the discovery is contrived: they are participating in a learning experience specifically engineered to allow them—through the processes of interpreting data and making and defending claims (and, quite often, brainstorming variables, making predictions, designing tests, and engaging in scientific debate)—to come to the intended meaning.

The second step I named *Concept Clarification*. The focus in this step is the teacher making sure that, regardless of—but built through discussion of—individual or group findings, the whole class comes to a common understanding of the main idea arising from the discovery experience. The teacher makes sure that appropriate terms are introduced and defined, preferably with definitions crafted as a class based on their experiences of the concept during the Concept Discovery stage. The teacher also uses discussion, notes, video clips, images, modeling, readings, additional laboratory experiences, and other instructional strategies to help students refine the understanding they built in the Concept Discovery stage.

The third step I left intact as *Concept Application*, the step in which students apply their new learning—often in conjunction with their understanding of previous concepts—in order to solve a new problem.

The naming and structure of the *Concept Discovery, Concept Clarification, Concept Application* (DCA) learning cycle is intended to help my preservice secondary science teachers plan single lessons or multi-day instructional sequences that allow their students to discover one concept, achieve clarity on that same concept, and then apply it to a new situation before moving on to learn the next concept.

Practicing What I Teach

The naming systems were, of course, not the only thing—and likely not the major thing—holding back mastery of the learning cycle. I realized as I began to teach science methods courses myself that the very thing that had made learning science so difficult for me in high school—traditional instruction that started with terms, notes, and readings—was keeping the preservice science teachers from learning the learning cycle. If leading with new terminology and following with notes and examples did not work for teaching meiosis or the rock cycle, why would it work for teaching the learning cycle? I realized that if I wanted my own preservice teachers to learn to teach using the learning cycle, I would need to help them learn it *through* a learning cycle. Over the past decade, then, I have worked to develop and refine a way of helping preservice teachers master the learning cycle in a way that honors the pedagogy of the approach itself.

I begin my lessons on the learning cycle with an assessment of prior knowledge that also serves to pique my preservice students' interest. I ask my students to write out or diagram what they regard to be a good general structure for the teaching of their content, be it life science, chemistry, or physics. I have my students share their representations with their content-area partners to see if they find any similarities. With little variation, they include lecture and lab—always in that order—as central to science teaching. I then let them know that we will be learning a lesson structure called the "learning cycle" over the next several class periods. In my efforts to model good instructional technique, I post the following objectives on the board:

- Name and describe the stages of a learning cycle;
- Create an instructional sequence using the learning cycle.

Concept Discovery

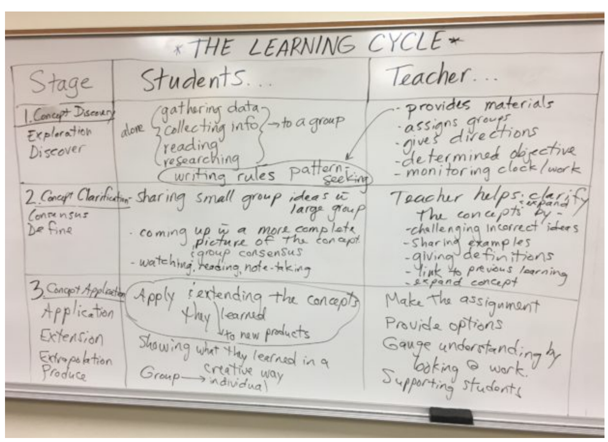
To begin the Concept Discovery stage for my students to learn the DCA learning cycle, I pass out vignettes of four lessons, one each for class sessions in Language Arts, World Language, Mathematics, and Health (see Appendix A for these vignettes). I use examples from non-science classes because I want my students to focus on the type of thinking and tasks happening, not on the content or if they think there is a "better" way to teach that content. Each vignette is divided into three short paragraphs, each paragraph describing what the teacher and students are doing in that stage of the learning cycle. Importantly, I do not label the names of the stages at this point as that would undermine my preservice students' opportunity to "discover" the heart of each stage.

I ask my students to read through the vignettes—the “data,” though I do not call it that—first without making any notes. Then, I ask them to read through them looking at just the first stage in all four, then just the second stage, then just the third stage. I then ask them to make notes about what the students and the teachers are doing in each stage and try to come up with a name for each stage. Once they have completed that individual work, I put my students into groups of three to four to share out their ideas. I spend my time roaming the room, informally checking in on their ideas as they talk and write.

Concept Clarification

Once my student groups are ready to share out, I put a chart on the board with “Stage 1,” “Stage 2,” and “Stage 3” down the left side and “Teacher does” and “Students does” on the top. I ask them to tell me which stage they feel most confident about and want to start with (it is *always* the third stage). I get them to fill in the boxes in the chart for that row and suggest a name (it is almost always “application,” lending support to the appropriateness of this name). We then move on to the other rows and do the same. Once we have the table filled in and I have circled the things they contributed that are central to the learning cycle and not simply to good teaching (for example, “students looking for patterns” is central to the first stage of the learning cycle but “students working as individuals and then small groups” is not), I unveil my “real” names for the stages and we craft short definitions of each from what we have recorded on the board (Figure 1).

Figure 1 (Click on image to enlarge). Sample chart on board.



I then have students read a handout I wrote that summarizes each stage of the DCA learning cycle (see Appendix B). For the next several class sessions, I model learning cycle lessons in science for them, with them as my mock middle and high school students. The examples I use (see Appendix C for summaries of the example lessons) involve an array of concepts (both declarative and procedural) from life science, chemistry, and physics; contain Concept Discovery experiences that use a wide variety of data types, data-gathering techniques, and data analysis approaches; and vary tremendously in the length and complexity of both Concept Clarification and Concept Application activities. My goal in using such a broad range of experiences is to help my methods students see a) that learning cycles can be used in all areas science, and b) that while the type of student cognitive work in each stage is consistent across different topics, there is great diversity in the types of learning tasks, instructional strategies, and assessment practices that a learning cycle can employ.

After each model lesson that I lead, I ask students to first write individually and then discuss with their partner where each stage began and ended in that lesson. Though I have shown for the reader how the three parts of each lesson are broken up, I do not reveal those transitions to my students while I am leading the lessons. I want them to have to puzzle through the boundaries of the stages as part of their cognitive work in learning the stages.

After informally keeping track of student ideas as they work, I lead a discussion of their perceptions and my intentions about the boundaries of the stages. I also help them see the fuzziness of those boundaries in transition: Is group share-out part of Concept Discovery or Concept Clarification? Is practice part of Concept Clarification or Concept Application? I remind my students that relative order of learning experiences is what is paramount, not how we divide up the sometimes fuzzy borders.

After the wrap-up discussion of the last lesson, I ask them to reflect on how I had helped them learn about the learning cycle: What did I have you do first? Then what did I have you do? Very quickly, someone cries out, “You learning cycled us!” I ask them why they think I “learning cycled” them instead of having them learn it in a different way. Someone is always quick to suggest—correctly—that I must think that using a learning cycle is the best way to help people learn something new.

Concept Application

I then ask my preservice teachers what stage we haven’t done yet (Concept Application) and what an effective application for the concept of the learning cycle might be. They gulp when they realize that, of course, I’ll be asking them to create a learning cycle lesson. I start their work on learning to write learning cycle lessons by assigning students concepts in their discipline and asking them to brainstorm things they might include in a DCA learning cycle lesson that would help students learn that concept. While I observe and scaffold with prompts as needed, students combine into groups to create and share a DCA lesson on their assigned topic.

Students then are asked to plan one learning cycle lesson on their own as part of a larger summative assessment for the course—a unit plan that they research and build over the term. I ask them first to submit to me—for points—the objective(s) for the lesson as well as a rough description (a few sentences) of their plan for each stage of the learning cycle. If the idea is viable, I allow them to move forward with their planning. If the idea is confusing or not viable, I ask them to resubmit it as many times as necessary. If they are unable to make a workable plan, I point them in a workable direction for the lesson with the understanding that they will not get credit for the draft. I then have the students lead the Concept Discovery portion of their lesson, and other stages if time allows, either in their clinical placement or with their peers in our class. They gather feedback from the students, reflect on what they learned from their experience teaching, and use that information to write the final draft of their lesson (see example student lesson plans in Appendices E and F). The learning cycle aspect of the lesson plan is then evaluated using a brief scoring guide that evaluates the degree to which each stage achieves its goal:

1. Concept Discovery section is appropriately designed so that students can “discover” a new-to-them concept (60%).
2. Concept Clarification section sticks to the exact same concept, not just same topic or benchmark, and fully clarifies it with examples, notes, definitions, and whatever else would be helpful and relevant for that concept (20%).
3. Concept Application asks students to use exactly the same concept in a new way, alone or in conjunction with previously learned concepts (20%).

I weight the Concept Discovery section three times as much as each of the other two stages because it is the lynchpin of the learning cycle. Excellent Concept Clarification and Concept Application plans are evidence of excellent learning cycle planning skills only if the Concept Discovery phase is workable. Without a workable Concept Discovery stage, I do not have evidence that my students can plan a learning cycle lesson.

Next Steps

Once my students have had the opportunity to complete their application of the learning cycle concept by writing a learning cycle lesson plan, I move to the next need: translating their understanding of the DCA learning cycle to the models used in the field of science education. It is critically important to me that my preservice students are able to engage in the discourse around the learning cycle in their professional networks, in their planning, and in their professional development. In the end, the DCA learning cycle is not meant to be an end in itself—I have no interest in seeing any of the other models ousted—it is only meant to serve as a clearer means to teach the underlying framework or philosophy of “the” learning cycle, whichever final model one chooses.

For this brief learning cycle, I set the objectives as, “Explain the evolutionary roots and development of ‘the’ learning cycle” and “Defend a lesson plan using published learning cycle theory.” For Concept Discovery, I ask my students to examine the 5E model and Keeley’s (2008) SAIL model, then craft text or a diagram that articulates the areas of alignment and divergence that they see (Figure 2, Figure 3, Figure 4). After students share those models with each other, for Concept Clarification, I diagram the areas of alignment on the board along with a branched evolutionary timeline showing the learning cycles by Karplus (Karplus, 1979; Karplus & Butts, 1977; Karplus & Thier, 1967), Lawson (Lawson et al., 1989; Lawson, 1995), Bybee (1997), and Keeley (2008) as a background for why the alignments are present. For application, my students need to rewrite the rationale for the pedagogy of their lesson plan using one of the published models of the learning cycle as the theoretical base in place of the DCA cycle.

Figure 2 (Click on image to enlarge). Student Comparison 1.

Figure 3 (Click on image to enlarge). Student Comparison 2.

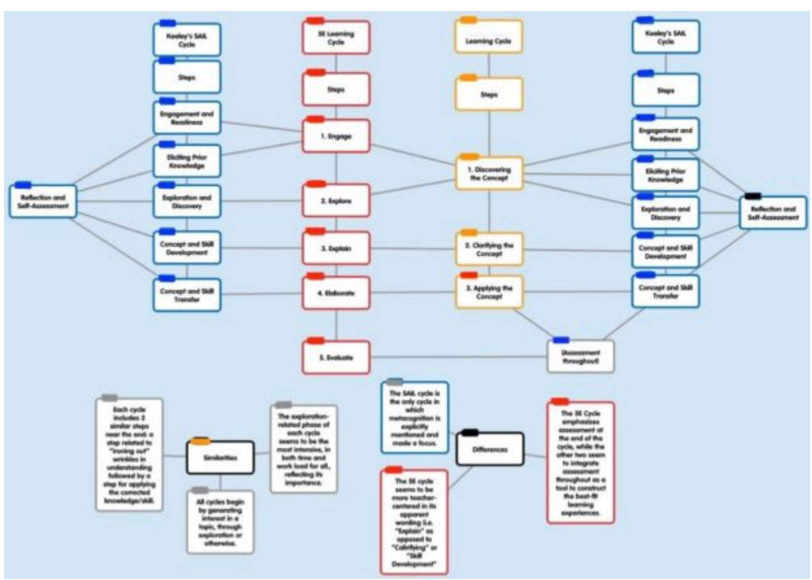
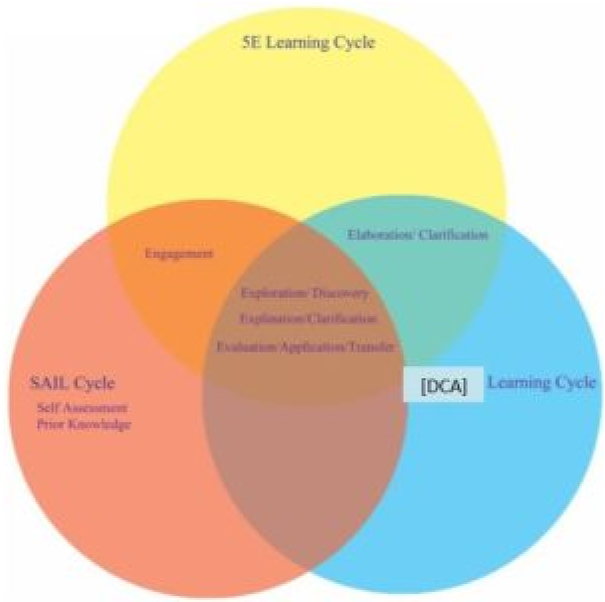


Figure 4 (Click on image to enlarge). Student Comparison 3.



Additional Support for Creating Concept “Discovery” Activities

I recognized a few years into my career as a science teacher educator that my preservice teachers struggled the most with creating discovery portions of the learning cycle. After a couple years of beating my head against a wall and wailing at the reading of some of my students’ derailed, tangled, or simply traditional confirmation labs (Bell et al., 2005) they were calling “discovery,” I realized that they needed more help in conceptualizing and building true, inductive, Concept Discovery experiences for their own secondary students. They also needed help moving beyond simply thinking about labs as ways of learning, especially for content that did not lend itself to laboratory investigations

As I analyzed my own learning cycle lessons trying to figure out how I was crafting them, I realized that there were some unwritten templates that I was employing. I first identified three main categories into which the Concept Discovery activities fit: drawing conclusions from data; inferring rules, definitions, or relationships from examples; and ordering or sorting based on observable characteristics. As I used those categories over the years and added examples, I found that all three categories—not just the first—really involved students in “drawing conclusions from data.” Additionally, I realized that I was subdividing the examples in the first category in ways that were more helpful than the larger category itself. I then arrived at six main—and, at times, overlapping—categories into which Concept Discovery learning experiences fall:

- investigating a hypothesis in a laboratory investigation;
- finding patterns in extant data sets;
- experiencing the phenomenon (live or through simulation);
- mimicking the way the relationship or phenomenon was discovered by scientists;
- ordering or sorting based on observable characteristics; and
- inferring rules, definitions, or relationships from examples.

Each approach involves students in using the science practices of “analyzing and interpreting data” and “constructing explanations” as well as one or more additional science practices (NRC, 2012). I provide my science methods students with a handout on these categories of Concept Discovery experiences (Appendix D) and ask them to identify which type each of my example learning cycle lessons employed. Providing my preservice science teachers with this categorization of Concept Discovery has helped them to expand their imagining of Concept Discovery experiences from just laboratory investigations to a myriad of data-driven inductive cognitive experiences. That freeing of their imagination has been especially helpful to students in chemistry and biology who frequently find themselves needing to address standards that do not seem to lend themselves to laboratory investigations.

Taking Stock, Moving Forward

Student Perspectives

My methods students and I have a tremendous amount of fun with the learning cycle in my courses. The amount of laughter and engaged conversation during the learning cycle experiences lets me know that they are enjoying themselves; the quality of their related assignments, lessons plans, and microteaching lets me know that learning and growth is happening. Responses to open-ended questions in on-line course evaluations, too, show that students really value the learning cycle experiences in shaping them as teachers. One student’s entry into the “best part of the course” section nicely captures the range of sentiments that students share:

I really enjoyed and got a lot out of all of the mini inquiry/discovery lessons we got to experience. They were fun, but they also gave me many concrete and easytoremember examples of how to get students involved in discovering concepts. Very good metateaching. I also enjoyed planning for and teaching the mini lessons. It was good, lowpressure practice.

The bulk of the comments each term focuses on the role of “modeling” of effective instruction. When students write about modeling, they are at times referring to the fact that I practice “what I preach” in the instruction of our class: I teach the learning cycle through a learning cycle. At other times, they are referring to my leading of demonstration science lessons with them as stand-ins for secondary students. Comment after comment makes clear that whether the student has never seen constructivism in action, learns best by doing, wants to see more practical examples of best practices or inquiry in science, or just appreciates the alignment of my expectations of their teaching and my teaching, they find the modeling to be powerful. One student, for example, wrote,

I liked seeing the activities from the point of view from the students. Moreover, I like the way you role played the teacher trying not to break character. This gave me more insight on how the flow of the classroom should be directed and how to use open questions.

Students also express relief in finally being able to put some meat on their skeleton ideas of what "constructivism," "inquiry," and "student-centered" really mean. One student wrote, "I liked having the opportunity to see lots of discovery and inquiry activities, instead of just hearing that I'm supposed to use inquiry." Another shared,

Before this class I had lots of vague ideas about the importance of student centered learning…I have been able to focus my ideas and see examples and practices to turn these ideas into great instruction. I feel much more confident as I proceed into teaching.

The comments also confirm for me that part of why these learning experiences are effective is that they are, after all, constructivist. Occasionally, a student recognizes the constructivist possibilities that the approach affords, like my student who wrote, "I learn sciecne [sic] best by hands on and that is exactly what this course was and by doing activites [sic], it was easy for me to see where students may stumble." Fortunately, the constructivism can be just as powerful for students who are traditional in both their own learning preference and their teaching philosophy. One student wrote that the modeling and micro-teaching "pushed me toward a more student centered teaching and away from my own way of learning."

Given that I see my two main professional challenges in science methods instruction as 1) changing the belief structures of my traditional learners towards a constructivist paradigm for teaching, and 2) supporting the motivated constructivists to develop constructivist practices, the comments from my students let me know that the learning cycle experiences are helping me make progress towards those goals.

The View from Here

After almost a decade teaching the DCA learning cycle in a learning cycle format and six years providing examples of the types of discovery experiences teachers can design, I have gotten to a place of more comfort with what my preservice science teachers are able to do. Sure, I still have a few students who cannot create a coherent discovery experience as part of a meaningful learning cycle, but they are now the exception rather than the rule. They are students whose content knowledge, focus, beliefs, or academic skills are simply not aligned with those needed for the immense cognitive task of creating Concept Discovery experience. But my other students, *most* of my students—including many with in-coming traditional beliefs about teaching and learning—are able to successfully craft excellent learning cycle experiences and are able to articulate the theory supporting that lesson model. They are thus, I believe, well-positioned to enter the field of science teaching ready to build their planning, instructional, and assessment skills in ways that align with what we know in science education about effective teaching. My next big task? To help them do just that in their first few years in the classroom.

Supplemental Files

Appendix-A-Vignettes.docx
Appendix-B-DCA-Summary.doc
Appendix-C-DCA-Models.docx
Appendix-D-Discovey-Types.docx
Appendix-E-Student-Lesson-1.docx
Appendix-F-Student-Lesson-2.docx

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