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Discrepant Teaching Events: Using an Inquiry Stance to Address Students' Misconceptions

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Science instructors have long known that the use of discrepant events with unexpected outcomes is a powerful method of activating thinking. A discrepant *teaching* event is similar to a discrepant *science* event in that it vividly portrays what is often an abstract construct or concept and has an unexpected outcome. The unexpected outcome creates what Piaget (1971) refers to as disequilibrium, thereby uncovering students' naïve conceptions and tacit beliefs about the concept being studied. This article defines what a discrepant teaching event is and compares and contrasts discrepant *science* events and discrepant *teaching* events. Examples of discrepant teaching events useful in mathematics and social studies are also provided. The article concludes with a discussion of the utilization of an "inquiry stance" to teaching as a way to address students' misconceptions of discipline specific concepts.

Discrepant events—demonstrations that produce unexpected outcomes—are used in science to capture students' attention and to confront their beliefs about a "phenomenon by producing an outcome which is contrary to what their previous experiences would lead them to believe is true" (Misiti, 2000, p. 34). Science teachers have long known that the use of this teaching strategy, which Sokoloff and Thornton (1997) call an interactive lecture demonstration, can be a powerful means of uncovering students' preconceptions about science phenomena at the same time that it activates the thinking and learning process. A discrepant science event can be as simple as floating two identical cans of soda, one regular and one diet, and observing that one floats while the other sinks. Discrepant science events (Limón, 2001) are designed to puzzle students and cause them to wonder why the event occurred as it did. Freeman (2000) defines a discrepant science event as a "teacher-centered performance in front of an audience of students to be used as a motivator or a direct teaching strategy" (p. 52). Discrepant events work because, as Piaget (1971) notes, puzzling situations create cognitive disequilibrium resulting in the need for students to *assimilate* (use existing knowledge to deal with new experiences) and *accommodate* (alter or replace existing concepts) their prior conceptions in order to adapt to these unexpected and puzzling experiences. Cognitive disequilibrium, also known as cognitive conflict, "is to student learning what the internal combustion engine is to the automobile. . . . Just as the fuel and the air are inert without the spark, so, ideas in the classroom are inert without the spark of [cognitive] conflict" (Johnson & Johnson, 2009, p.37).

Learning theory tells us that prior experiences and preconceptions play an important role in learning (Britzman, 1986; Holt-Reynolds, 1992; Schunk, 1996), while cognitive research demonstrates that students' prior knowledge affects all aspects of their information processing (Ausubel, Novak, & Hanesian, 1978; Bransford, Brown, & Cocking, 2000; Pintrich, Marx, & Boyle, 1993). According to Strike and Posner (1992), students "do not alter concepts that play a central role in their thinking unless and until they see them as having become dysfunctional" (p. 148). Conceptual change models hypothesize that once students are dissatisfied with their current thinking, new understanding can be formed if the new idea provides a better explanation than the previously held idea and is intelligible (understandable), plausible, and believable (Posner, Strike, Hewson & Gertzog, 1982). To be effective, discrepant events must be vivid enough to help students see the dysfunctionality of their current concepts in order to stimulate their desire to explain the unexpected outcome. Once the "need to know" is created and thinking is activated, instructors must also help students find intelligible, plausible, and believable explanations of the unexpected outcome. This allows students to properly assimilate and accommodate their ideas and overcome inaccurate conceptions in order to formulate new, more accurate ones.

What Is a Discrepant Teaching Event?

A discrepant *teaching* event is similar to a discrepant *science* event in that both vividly portray what is often an abstract construct or concept. They are similar in purpose as both are designed to confront students' naïve conceptions and tacit beliefs and to create cognitive disequilibrium (i.e., help students see the dysfunctionality of their current ideas), thereby motivating students to reexamine their thinking about previously held ideas and beliefs. The major difference between the two ideas is that a discrepant *science* event typically involves students observing a teacher's demonstration of a science phenomenon with a known outcome at the beginning of a class or lab, whereas a discrepant *teaching* event can be used in any discipline at any time and need not be a teacher-centered performance. Additionally, a discrepant *teaching* event requires students to be active participants in their own learning and to create new knowledge for themselves. When outcomes are different from what is expected, tacit beliefs become visible and students are motivated to reconcile previous beliefs with what actually happened, resulting in a deeper understanding of the concepts being studied. When this teaching strategy is used to confront students' naïve conceptions of course content, the planned "unexpected outcome" can be referred to as a *discrepant teaching event*.

Confronting the Nature of Science Misconception: The Apple of Understanding

I am a teacher educator and work with preservice teachers. This means I must not only teach students how to teach concepts in a discipline specific context, I must also uncover and attempt to overcome students' misconceptions about teaching and learning. When I was asked to pilot an integrated math and science methods course, I was reconnected to the idea of using discrepant events to confront students' science misconceptions. As I reviewed my students' lesson plans, it became clear that they believed the best way to begin a science lesson was by defining scientific terms. In other words, they thought of science as vocabulary and facts. When asked to explain the best strategy for introducing science lessons, they responded appropriately with "the Learning Cycle begins with exploration," but their lesson plans clearly demonstrated a lack of understanding of inquiry-based science teaching and learning principles.

Upon realizing my students were modeling the inadequate science teaching strategies they had experienced as P-12 students, I planned an activity (Author Unknown, National Science Teachers Association Conference, Louisville KY, 2002) designed to help them re-examine their thinking. Focusing the next class on how to teach a science concept, I handed out apples and explained that the apples were a metaphor representing the various science concepts students planned to teach. I asked each group to explore their apples and to generate a list of apple attributes by observing the apples, smelling them, weighing them, predicting what they might see inside, and then cutting the apples open and drawing what they saw. After removing the dissected apples, I revisited the use of models in science teaching by distributing wooden apples. I asked students to remove apple attributes from their lists that were no longer observable and to add any new observations. Next I put a black outline of an apple on the overhead and asked students to remove attributes from their lists which were no longer observable. I then replaced the black outline with the letters A-P-P-L-E and asked, "How many attributes would you have on your observation list if this is how I introduced the concept of appleness?"

The silence and puzzled expressions on students' faces which greeted this question told me I had achieved my objective. In the ensuing discussion of "appleness" attributes, students began to recognize that differences in mass, texture, and smell between real apples and models could result in the formation of misconceptions, and that there would be little or no understanding of "appleness" if only diagrams or words were used. As students saw the dysfunctionality of their ideas that science is vocabulary and that science teaching begins with words, about half of them asked if they could revise their lesson plans even though their plans had already been graded. More importantly, the new lessons began with hands-on exploration activities, evidence that their ideas about the nature of science teaching had changed. That's when it occurred to me that discrepant *teaching* events are as useful in confronting students' teaching misconceptions as discrepant science ones are in overcoming science misconceptions.

Overcoming a Mathematical Misconception: Numbers Are Impartial

Since this eye-opening experience, I have begun to create and use a variety of discrepant teaching events in my methods courses and to work with instructors in a variety of disciplines to create discrepant teaching events for their courses. For example, mathematics students often believe that the mathematical analysis of a set of numbers provides infallible *right* answers which can be used to make *fair* and *impartial* decisions; in other words, numbers don't "lie." Thanks to my earlier science teaching experience, I was able to create a discrepant teaching event using grades to address students' naïve conception related to the infallibility of mathematical analysis. Early in the semester I professed confusion regarding grades on the first assignment. I explained that the grade span was not typical of past semesters and asked students to help me decide the "best way to curve grades." I put the range of scores on the board and gave each student her/his raw score. I then asked students to work in groups to decide whether or not I should use mean, median, or mode to determine letter grades.

Students were unaware the scores were fictitious and that individual scores were distributed in such a way that some groups could get better grades using the mean, while other groups could improve their grades using the median or mode. It didn't take long for most groups to discover that one method had advantages over the others. Once the stage was set, we came together as a class "to make a fair and impartial decision using mathematical analysis." The ensuing discussion was engaging, often passionate, as each group lobbied for the method which gave them the best grade. As the discussion became impassioned, I ended it. Students reacted with stunned silence when I explained they had just experienced the realities of how the use of different methods of mathematical analyses can result in different outcomes, which some may see as unfair. As the mathematical implications became clear, the idea that numbers are not always impartial and fair became more understandable, plausible and believable, fulfilling Posner *et al.*'s (1982) conditions for conceptual change. Throughout the remainder of the semester, students made numerous references to this activity and its effectiveness in causing them to see the inadequacies of their previous thinking about the nature of mathematical analysis.

Cognitive Disequilibrium and Multiple Perspectives

A third example of a discrepant teaching event is from a history course where the instructor confronted students' beliefs that historical "facts" are indeed "facts" and *impartially* determined. In this instance, the instructor was interested in introducing students to multiple perspectives and interpretations of historical data related to American history, specifically the "discovery" and exploration of the "New World." For this discrepant teaching event it was necessary to enlist the cooperation of one of the students in order to plan what appeared to be a spontaneous argument between the student and the instructor. On the pretext of introducing students' to the use of primary and secondary sources in analyzing historical events, the instructor came to class dressed as a Native American. She began class by explaining that the lesson involved the use of primary and secondary sources to determine if Disney's *Pocahontas* was based on historical evidence or was purely fictional. While distributing materials, she began to talk about the phenomenon of perspectives in historical research and the need to understand both the perspectives of the participants in a historical event (i.e., first person narratives which are primary sources) and of a historian writing about the event (i.e., a book about an historical event written by someone who spoke to participants but who did not witness the event; in other words, a secondary source).

As previously planned, the instructor then proceeded to assume the role of Pocahontas and began to narrate documented events in Pocahontas's life, explaining that she was telling the story of Pocahontas and John Smith from the Indian perspective. At this point, the student who was part of the discrepant teaching event stood up and said loudly, "You're not an Indian; I'm an Indian!" The student was dressed in traditional East Indian attire, which made the "spontaneous" debate appear more authentic. The ensuing argument between the instructor and the student revolved around the naming/misnaming of Native Americans and proceeded to other issues related to the "discovery" of the "New World." After several minutes, the instructor enlisted her students' assistance in settling the dispute by asking them whether or not she should refer to herself as Pocahontas, or to the people who inhabited the Northern Hemisphere before the arrival of Europeans as "Indian," and a lively class debate followed. Students were asked to write an account of what had happened in class and to bring it to the next class. Students were also assigned the task of telling their roommates, or someone else, about what had happened, waiting a day or so, and then asking this person to write a brief account of the event. Both the first person accounts and the second person accounts were compared, and students were able to see that not only did their first person accounts vary somewhat, but that there was an even greater variance in the second person accounts.

Students subsequently completed their analysis of the Pocahontas-John Smith "affair" and were able to better see problems inherent in using secondary sources, especially sources written long after historical events by persons who did not witness the event. Having experienced ways in which historical events can be colored and even biased by the preconceived ideas of those who record and report historical events, students also went on to study the "discovery" of the "New World" from both the European and Native American perspectives. The American Indian vs. East Indian activity was effective in that it actively engaged students in thinking about historical perspective and allowed them to participate in the process of historical analysis—the retelling of an event which they had witnessed and shared with a "secondary source." It helped them find an intelligible, plausible, and believable explanation (Posner *et al*., 1982) of why descriptions and explanations of historical events differ. It enabled them to assimilate and accommodate (Piaget, 1971) their naïve idea that history is a compilation of impartially determined "facts" and to formulate a more accurate conception of history as an interpretation of events based upon the perspective of the tellers.

Designing Discrepant Teaching Events: Make the Invisible Visible

Discrepant teaching events enable instructors to confront students' misconceptions of concepts by creating cognitive disequilibrium. The disequilibrium activates the students' "need to know" and actively engages them in thinking about key concepts, resulting in a more meaningful discourse. As students are motivated to begin the processes of accommodation and assimilation, difficult concepts become more intelligible (understandable), plausible, and believable (Posner *et al.*, 1982). Although closely related to discrepant science events, the idea of discrepant teaching events can also be applied to any discipline as both the mathematics and history examples illustrate. It should be noted however that discrepant teaching events are different from discrepant science events in that discrepant teaching events need not be "a teacher-centered performance." In fact, student-centered, hands-on/minds-on activities are central to the success of discrepant teaching events. Although the history instructor did serve as a performer, her performance was dependent up the cooperation of a student co-conspirator, and the critical ingredient in the success of the activity involved the entire class deciding whether the term "Indian" was appropriate in documenting the event and collecting secondary sources.

When designing discrepant teaching events, there are two factors to consider. First, the instructor should design discipline appropriate activities which serve multiple purposes so that course content *and* its application to the discipline are made more visible. Second, targeting and timing are critical. Blend the discrepant teaching event into the course in such a way that it appears to be spontaneous and makes connections to what and how students are learning. Although discrepant science events *precede* the concept to be taught (science teachers know what misconceptions are typically associated with specific concepts), discrepant teaching events can be introduced *after* the instructor identifies students' inaccurate conceptions in order to better target the specific belief or concept. The students' misconceptions may differ from section to section and from semester to semester, which makes the timing of a discrepant teaching event especially critical to its success.

I've learned that although I can use the "appleness" metaphor every semester, where it is taught must be different from semester to semester. Only by waiting until my students are ripe for the picking can I ensure that they are ready to actively engage in meaningful pedagogical discourse. In other words, I either need to see the teachable moment or to design an activity that creates within students the "need to know." It is the desire to understand that activates the thinking and learning process and "hooks" students' interest on the thing they don't yet know they need to learn. It should also be noted that the use of a discrepant teaching event by itself, without appropriate follow-up (i.e., debriefing, discussion, assignment or activity), is not as effective in promoting the necessary accommodation or assimilation to overcome inaccurate preconceptions. Follow-up is critical to the success of this teaching technique.

Assessing Conceptual Change

Interest in the quality of student learning is currently high (Driscoll & Wood, 2007; Nicol, 2006), and many states have consequently mandated various forms of assessment in higher education (Angelo & Cross, 1993). Given the political climate regarding the importance of assessing what students learn, it is therefore surprising that the literature on how to assess conceptual change is so limited (Jonassen, 2006). There is, however, a growing body of literature on the scholarship of teaching and learning, or SoTL, a term first used by Boyer in his seminal book *Scholarship Reconsidered: Priorities of the Professoriate* (1990). McKinney (2007) enumerates various research strategies and methodologies that can be used to assess SoTL questions, including the effectiveness of teaching strategies such as the use of discrepant teaching events to promote conceptual change. The approaches she lists are from a variety of disciplines and include: (1) course portfolios and other forms of reflection and analysis which are qualitative and interpretative in nature; (2) student interviews and focus groups; (3) observational research which can include quantitative and qualitative coding schemes; (4) questionnaires; (5) content analysis using students papers, products and a variety of classroom assessment techniques such as background knowledge probes, concepts maps and one-minutes papers; (6) secondary analysis of data collected for other purposes such as data from the National Survey of Student Engagement (NSSE); (7) quasi-experiments including longitudinal studies; (8) case studies; and (9) multimethod studies. Depending on the discipline and the nature of the students' misconceptions, any of these methods can be adapted to provide the instructor with useful information on students learning. The specific methodology used will depend on "the research question, practical and ethical considerations, your disciplinary conventions, and your expertise" (McKinney, 2007, p. 73).

Conclusion: An Inquiry Stance Transforms Teaching and Learning

I have come to think of the use of discrepant teaching events as an "inquiry stance" to teaching. Cochran-Smith (2003) advocates an inquiry stance to teaching as a way to enable all members of a learning community to be "learners and inquirers" and as a way to disassemble the teaching model where an "expert transmits information to others with lesser knowledge" (p. 11). Cross (1990) argues that "education, properly understood, is not so much additive as transformational. New learning transforms the old into new interpretations. . . . *How* something is taught is every bit as important as *what* is taught" (pg.16). The use of discrepant teaching events allows instructors to "disassemble the teaching model" in a way that encourages students to become "learners and inquirers" and permits them to create accurate meanings of discipline specific concepts for themselves. Information is not transferred to those with "less knowledge," but rather students' understanding is transformed. Although carefully designed by the instructor, discrepant teaching events allow the learners' ideas to take center stage. By being in the spotlight, inaccurate conceptions can be addressed and transformed, and how the concept is taught becomes as important as what is taught.

The advantage of a teaching-as-inquiry stance is that, unlike the traditional didactic teaching model, the focus is on students' *understanding* of concepts rather than their ability to recall specific bits of content. For several decades research has demonstrated that students do not easily give up their deeply held beliefs (Guzzetti, 2000; Lipson, 1984; Strike & Posner, 1992). Typical teaching strategies like lectures, readings, and labs are ineffective in changing students' naïve conceptions. Although educational research cannot supply instructors with specific formulas that guarantee student learning, it can provide "repertoires that may help [them] recognize patterns in particular situations and to select tools that may prove more suitable than others" (Caravita, 2001, p. 428). Researchers such as Cross (1990), Pintrich, Marx and Boyle (1993), and Cochran-Smith (2003) have shown me the importance of focusing on my students' learning rather than on coverage of course content.

Because I now systematically observe and analyze my students' learning in the context of what happens in the classroom using a variety of classroom assessment techniques (Angelo & Cross, 1993), I am better able to see their perceptions of particular discipline-specific concepts and confront their misconceptions. Perhaps the most significant outcome of my inquiry stance to teaching is that, as I learn to use discrepant teaching events to confront students' misconceptions, my own teaching-learning assumptions are challenged. I no longer assume that what I say to my students is heard accurately or retained. The next time you're in your classroom, observe your students carefully. Listen to their ideas about critical concepts in your discipline and design active, student-centered, hands-on/minds-on activities to confront their naïve conceptions. Let your passion for your discipline welcome you to the exciting and transformative world of discrepant teaching events.

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