

Professional Development Case Study

Project: Renaissance in Science Education (RISE)

Location: Riverview Gardens Schools, St. Louis, MO

Author: Ann P. McMahon, Co-PI, RISE

The Instructional Unit

This report will focus on a fourth grade STC unit called Electric Circuits. The unit begins by having students construct a simple circuit using a battery, bulb and wire. Students determine what constitutes a circuit, define conductors and insulators, learn to troubleshoot circuits, explore series and parallel circuits, construct a switch, and work with a diode. The culminating experience in this unit is the wiring of a model house. In Riverview Gardens Schools' LSC, this unit is used at grades three through six for a minimum of sixteen hours of classroom instruction. (Note that units are cycled through the district every three years so a student will not experience this unit a second time in another grade level).

Challenges for the Teacher

The unit presupposes that teachers understand the meaning of the following words: energy, electricity, circuit, electrical current, voltage, conductor, insulator, semiconductor, and diode. In addition, it presupposes that teachers themselves have an accurate mental model of what happens inside an electric circuit that enables them to lead discussions and field questions during classroom instruction and to draw effective analogies for themselves and their students. Most teachers do not have this preparation. The challenge for teachers is to confront their own mental models and misconceptions about electricity and replace them with models and information that provide the pedagogical content knowledge necessary to provide quality classroom instruction.

Challenges for the Professional Developers

Few teachers perceive the aforementioned challenge until they encounter students who present thought-provoking questions in response to a particular lesson, so professional development must elicit in teachers a need to reflect on their own understandings prior to teaching the unit. Because teachers are pragmatic, they come to professional development with two major questions: 1) What must I teach? and 2) What support will I receive when teaching it? In order to address the teachers' questions and produce the desired reflections, we structured the professional development around two content questions central to this unit: 1) What constitutes an electric circuit? and 2) In a simple circuit that contains a battery, bulb and connecting wires, why does the bulb light but not the connecting wires? Not only must teachers perform the lessons in the unit in order to answer both questions, they must construct an accurate mental model in order to answer the second question. Professional Development Prior to Teaching the Unit Each teacher received twelve hours of professional development prior to teaching this unit. The professional development is designed to help teachers become conversant with the instructional materials they will use in their classroom, deepen their pedagogical content knowledge of the unit, and deepen their content knowledge. The professional development also makes it clear what support they will receive from the curator, materials manager, in their building.

The framework for each professional development session is a document we call a handbook. The handbook is a week-by-week implementation plan written by teacher leaders and based on the unit's teacher's guide. Each week in the handbook contains a pre-lab lesson, a lab lesson (when the curator stays to help the teacher) and a post-lab lesson as well as vocabulary words and a list of pages teachers can read for background information. For each lesson, the handbook contains the following sections 1) designation of the lesson as a pre-lab, lab, or post-lab; 2) advance preparation of materials with teacher-provided materials and curator-provided materials listed; 3) lesson objectives; 4) procedure notes that include any modifications to the lesson as written in the teacher's guide; 5) a list of assessments appropriate for that lesson; and 6) connections to the district's math and literacy programs. The handbook is meant to be used with the teacher's guide for the unit. A packet of activity sheets, assessments and writing prompts that support the district's literacy program accompanies the handbook and teacher's guide.

The teachers worked through the activities in the order in which they would teach it in the classroom and with the same materials they would receive from the building's curator. Teacher leaders modeled instructional strategies for the group. Content experts support the teacher leaders as they train their peers. At this time, teacher leaders do not express enough confidence in their science content and pedagogical content knowledge to train their colleagues without the experts' presence. For the Electric Circuits unit, I, a mechanical engineer by degree, provided content expertise. We hope to recruit scientists from Washington University and Riverview Gardens High School science teachers as content experts in the future.

Toward the beginning of professional development, I introduced common ideas children have about electricity as presented in the educational research. Subsequent content discussions addressed observations teachers made as they conducted the lessons and how each observation supported or discredited one or more of the common ideas children hold about electricity. We encouraged teachers to discuss their own ideas about electricity and how they reconciled the observations they made during the lessons with their mental models. In this way, teachers could think carefully about the meaning of the words associated with electricity.

I introduced an analogy for explaining what goes on inside an electric circuit in terms of racecars traveling on a closed oval track. In this analogy, we constructed operational definitions for all the vocabulary words mentioned in the unit. I offered this analogy as an addition to their own content knowledge as well as something they might use with their students if the class discussion warranted it. The racecar analogy provided a common language with which we could arrive at an answer to the second content question.

*It should be noted that the STC Electric Circuits unit is the basis for a graduate course in science education at Washington University in St. Louis. Dr. Pat Gibbons, (a RISE Co-PI and a physicist at Washington University) Jack Wieggers (RISE Senior Staff and Adjunct Faculty at Washington University) and Ann McMahon (RISE Co-PI and Riverview Gardens Science Coordinator) teach this course to K-8 teachers from districts throughout the St. Louis area. The professional development described above condenses a semester of exploration and discussion into twelve hours.*

### Support for Teachers during Implementation of the Unit

In Riverview Gardens Schools, each science unit is implemented simultaneously throughout the district. Each elementary school building has a curator, materials manager, who prepares and delivers materials for the activities to each teacher on a weekly schedule and stays to help with the most materials-intensive lesson. The curators meet for two hours each week with Ann McMahon and Jack Wiegiers to discuss the materials preparation for the upcoming week and the observations that students should make during each lesson. Although the curator is a teacher assistant, she can also advise the teacher on materials protocols and remind him or her about the focus of a lesson.

The weekly curator meetings and occasional classroom observations provide a feedback loop between teachers and project staff. If teachers have content questions, they call project staff and discuss their concerns. The previous week's challenges and successes are discussed during weekly curator meetings, so adjustments to the implementation process are noted at that time. Curators provide an additional six hours of support in the classroom over the course of the unit. Teachers may seek additional support from the curator or project staff as they need it. Total contact hours with teachers totaled 18 hours for this unit (twelve hours of initial professional development plus six hours of curator support.)

### Transfer of Professional Development to Classroom Instruction

I chose to observe three teachers with different attitudes toward professional development. I have changed the names of the teachers. Beau is a fourth grade teacher whose principal required him to attend professional development. Lily is a fifth grade teacher who attended professional development in order to take advantage of all resources available to her to improve classroom instruction. Constance is a sixth grade teacher leader for the project who has a strong science background and a willingness to examine her knowledge and add to it. All are caring and conscientious teachers, respected by their peers and principals. I observed a lesson on series and parallel circuits. This lesson provided me with the opportunity to informally assess students' prior understandings and teachers' comfort level with content and pedagogy that is of the most demanding in the unit.

### Beau's Story

During the first few hours of professional development, Beau told me that he was insulted by having to perform the activities in the unit. He claimed that, because he is a professional, he can read the teacher's guide and figure out what to do in the classroom. I explained that the observations made during the activities were part of a large conceptual picture that would unfold during subsequent discussions, and that an original analogy for an electrical circuit was to be presented. He insisted that he had already experienced elsewhere everything we could offer. I told him that we were always looking for teachers with strong science backgrounds who could help to improve the program, and I invited him to join our teacher leader cadre. He declined my invitation to become a teacher leader. Then I asked him how he would answer the question "In a simple circuit, why does the bulb light and not the connecting wires?" He informed me that the question was not relevant to the unit and that answering it was a waste of his time. He chose not to participate in many activities during professional development, and he was not attentive during group discussions. He was absent for the last four hours of formal professional development.

During the class I observed, students worked in pairs with curator-provided materials. Beau had his students follow the unit's instructions for constructing the different circuits. Beau, the curator, and I circulated among the pairs of students as they worked. As I talked with students, it was clear that they had performed previous activities and could report the necessary components and arrangements for a complete circuit (content question #1). Two students asked Beau questions about how the circuits worked. Beau chose not to respond to the questions. He focused on helping students build circuits, make observations and record them. Beau did not question students, call attention to the special properties of series and parallel circuits or connect this lesson with previous ones. Beau ended the lesson after students built the circuits and recorded their observations. He did not conduct the sense-making discussion recommended in the teacher's guide, citing lack of time. I gave the lesson an HRI capsule rating of two.

#### Lily's Story

Lily came to professional development eager to participate. She asked questions of the session leaders and took notes throughout training. She left professional development satisfied that she received strategies to improve instruction in her classroom. Lily's lesson on series and parallel circuits began with a brief review of what students had done before and how it led up to what students would do now. As in Beau's classroom, students worked in pairs with curator-provided materials. Lily drew the circuit diagrams on the board, gave verbal instructions, and proceeded to circulate among students and question them about what they were doing. After students made the required circuits and observations, Lily conducted the discussion comparing the two circuits. Her confidence level during questioning and the discussion was low, but she displayed many elements of quality instruction. I gave the lesson an HRI capsule rating of three solid.

#### Constance's Story

Constance has advanced degrees in science and wanted to provide professional development to her peers. She spent many hours in teacher leader training learning how to teach colleagues who did not have her background and who might be uncomfortable teaching science. She entered the experience with an open mind, but skeptical that other teachers were not as comfortable with science as she was. She is still learning how to transform her content knowledge to pedagogical content knowledge and impart that to her colleagues. She provided professional development in this unit.

Constance began her lesson in series and parallel circuits by challenging her students to construct circuits that would yield specific observations (for example, a two-bulb, one-battery circuit in which you could remove one bulb and the other would remain lit). Students worked in pairs with curator-provided materials. Students produced series and parallel circuits that looked different than the pictures in the teacher's guide but allowed them to make the appropriate observations. She then had groups show the closed paths in each circuit and compare series to parallel circuits.

Constance asked questions that led students to explain their observations using the racecar analogy presented in professional development. Students discussed the uses of each type of circuit in everyday life. The class discussion was conceptually rich and built upon prior experiences. Constance brought appropriate closure to the lesson. I gave the lesson an HRI capsule rating of four.

### Quality of Instruction and the Project's Vision

The project's vision is to provide all students with a common set of experiences that leads to major understandings in science. Consistent with that vision, all three teachers worked with the same instructional materials, were provided with the same hands-on, curator-provided materials and the same level of administrative support. They attended the same professional development. One might expect that the quality of classroom instruction would be consistent from classroom to classroom. Clearly, that is not the case.

In assessing the effect of professional development on classroom instruction, it is apparent that the attitude the participant brings to professional development makes a difference, as does the structure of the professional development. In the group of three teachers described here, the learners ranged in ability from novice to expert. Of the two novices (Beau and Lily), Beau did not perceive himself as a novice and, therefore, closed himself off from gaining new content and pedagogical content knowledge during professional development. This made a difference in his classroom instruction. While he could follow the instructions in the teacher's guide competently, he could not help students process their observations and questions in a way that would allow them to connect the experiences with meaning. Lily's classroom instruction, by contrast, showed as much attention to performing the activities, but added the sense-making component consistent with what she learned in professional development. Both novices still need to work on improving their background and instructional practices, but Lily is far closer to achieving the project's vision of effective instruction than is Beau. Constance is an expert learner whose teaching reflects her rich science background. Her instructional strategies revealed experience with observing nature and marshaling evidence to arrive at a conclusion. Constance embodies the project's vision of effective instruction.

### Challenges for Next Time

The structure of professional development must take into account the range of learners. Novices who do not perceive themselves as novices are a special group. We have had success in raising some teachers' awareness of their own weaknesses if we can convince the bright and vocal ones to join the leadership team and work on providing professional development to their peers. In preparing professional development, they must attend to the overarching content questions that underpin the lessons in each unit. They learn that professional development is carefully planned to balance content, pedagogy and attention to materials and classroom support. After experiencing the planning and delivery process, some vocal resisters have returned to their schools as vocal supporters of the program. Even the resisters who chose not to work on the leadership team for subsequent units reported a positive experience to their principals and displayed less resistance in their schools.

Expert learners require special attention as well. Teachers like Constance excel in the classroom, but believe that everyone thinks as they do. They must be trained to understand the difference in the thought processes of novices and experts before they provide professional development. If they teach their peers before they gain this understanding, they presuppose a familiarity with concepts and pedagogy that does not exist in their audience. They want to inject creativity into lessons that confuses beginning teachers and frustrates veteran teachers who are just learning the basics of inquiry instruction.

As we continue to help teachers determine their position along the continuum from novice to expert learner for each unit, we need to provide opportunities during professional development (of leaders and of the general teacher population) for differentiated instruction that produces greater buy-in. That can lead to consistent classroom instruction. The challenge is to match the structure of professional development to teachers' real and perceived needs. In doing so, we have a chance to improve attitudes toward professional development as well as the quality of classroom instruction.