HOW TO DEVELOP

Inquiring minds

BY KAREN M. BEERER AND ALEC M. BODZIN

Designing and implementing effective professional development is a continuous challenge to district staff developers. The challenge is doubly difficult when a district focuses on an area such as science—a subject not in many elementary teachers’ comfort zone. Most elementary teachers do not have a strong science knowledge base and have not been trained to use reform-based science pedagogical approaches (American Association for the Advancement of Science, 1993).

Science education reform requires a substantive change in how science is taught. However, individual teachers' professional development too often is a random combination of courses, conferences, research experiences, and workshops. Teachers need opportunities to reflect on their teaching practice with colleagues, to collaboratively plan curriculum, and to actively participate in professional teaching and scientific networks (Loucks-Horsley, 1987). The standards (National Research Council, 1996) recommend a student-centered instructional envi-

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Science Teacher Inquiry Rubric

Professional developers can use this tool to observe classroom instruction and help teachers reflect. This tool also can be given to teachers directly for self-reflection.

**LEARNER-CENTERED**

**CATEGORY 1: Learners are engaged by scientifically oriented questions.**

1. Teacher provides an opportunity for learners to engage with a scientifically oriented question.

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<tr>
<th>LEARNER-CENTERED</th>
<th>TEACHER-CENTERED</th>
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<tbody>
<tr>
<td>Learner is prompted to formulate own questions or hypothesis to be tested.</td>
<td>Teacher suggests topic areas or provides samples to help learners formulate own questions or hypothesis.</td>
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<tr>
<td>Teacher offers learners lists of questions or hypotheses from which to select.</td>
<td>Teacher provides learners with specific stated (or implied) questions or hypotheses to be investigated.</td>
</tr>
<tr>
<td>No evidence observed.</td>
<td>No evidence observed.</td>
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**CATEGORY 2: Learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions.**

2. Teacher engages learners in planning investigations to gather evidence in response to questions.

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<tr>
<td>Learners develop procedures and protocols to independently plan and conduct a full investigation.</td>
<td>Teacher encourages learners to plan and conduct a full investigation, providing support and scaffolding with making decisions.</td>
</tr>
<tr>
<td>Teacher provides guidelines for learners to plan and conduct part of an investigation. Some choices are made by the learners.</td>
<td>Teacher provides the procedures and protocols for the students to conduct the investigation.</td>
</tr>
<tr>
<td>No evidence observed.</td>
<td>No evidence observed.</td>
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3. Teacher helps learners give priority to evidence, which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions.

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<tr>
<td>Learners determine what constitutes evidence and develop procedures and protocols for gathering and analyzing relevant data (as appropriate).</td>
<td>Teacher directs learners to collect certain data or provides only a portion of needed data. Teacher often provides protocols for data collection.</td>
</tr>
<tr>
<td>Teacher advises learners to analyze given data and gives specific direction on how data is to be analyzed.</td>
<td>Teacher provides data and asks learners to analyze.</td>
</tr>
<tr>
<td>No evidence observed.</td>
<td>No evidence observed.</td>
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</tbody>
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**CURRICULUM: THE FIRST STEP**

To help teachers teach standards-based content through inquiry, the district decided to use units from the Science and Technology for Children (STC) program and the Full Options Science System (FOSS) program. A representative group of elementary science teachers and the senior high school science teachers reviewed several science programs supported by the National Science Foundation. They first rated the content and scientific process skills of the units according to how well they matched state standards and then checked that the essential features of inquiry were embedded in the curriculum. They decided to combine units from both programs to create a spiraled curriculum which included life, physical, earth, and space sciences. Because of the complexity of inquiry-based instruction as well as the addition of new science content, district leaders decided to implement only one new unit per year for three years.

All elementary teachers in the district participated in a three-hour introduction to the content of the first science unit, as well as learning the basics of inquiry instruction. Teachers at each grade level explored the unit's content and practiced inquiry-based activities with help from a teacher trainer from another district.

District leaders believed teachers would...
would be more likely to use the new materials and change classroom practice to be more inquiry-based only if there was follow-up and peer collaboration. Leaders next organized 3rd-, 4th-, and 5th-grade teachers into study groups.

Although Carlene Murphy and Dale Lick's model (1998) recommends small groups of faculty, the teachers felt strongly that they wanted to work as grade-level groups even if the group size exceeded the recommended half-dozen. Each group met once or twice each month for an hour each time over six months. At the outset, each group set a goal for its work:

**Grade 3:** "We will develop an awareness of what constitutes inquiry and how we can embed it into our science instruction using our new curriculum materials. We will read articles on inquiry, develop a skeleton outline for inquiry experiments and review assessment options for inquiry-based learning."

**Grade 4:** "We will develop a common base of knowledge supporting inquiry and its value and structure. We will develop a strategy to help implement inquiry in the classroom."

**Grade 5:** "We will read articles and study our new unit to find a way to combine ‘inquiry’ with the curriculum and district requirements. Specifically, we want to teach students how to formulate questions, develop hypotheses, gather evidence, analyze data, formulate conclusions, examine resources to make connections, and justify and communicate conclusions and explanations."

Each group studied articles as groundwork for discussion and viewed videos from the Annenberg Professional Development (Thirteen/WNET New York, 2000) series, “Learning Science Through Inquiry,” to provide additional information and a visual model of inquiry-
based instruction. Teachers discussed how they would structure their classrooms to incorporate the essential features of inquiry they saw on the videos. They talked about how to structure their lessons to ensure that each unit's content was aligned to state standards and inquiry-based teaching was occurring. They also discussed what they perceived as barriers to inquiry instruction, including the lack of time and classroom management issues, and strategized ways to overcome these barriers. At the end of each study group session, the groups completed a log to document their progress and their next steps.

RESULTS

To measure teachers' understanding and implementation of inquiry-based science instruction into their classrooms, we developed a Science Teacher Inquiry Rubric (STIR) (see tool on pages 44 and 45). We wanted to use it as an observation tool to show how well study group teachers implemented the essential features of inquiry in their classroom instruction. The STIR incorporates what the standards define as the essential features of inquiry.

Each essential feature lies on a continuum — a range of classroom learning from teacher-centered to student-centered instruction on one end to student-centered learning on the other end. While teachers may not fully implement each essential feature, to have science instruction that makes full use of inquiry requires use of all five features. Although the rubric does not include a complete and thorough explanation of each essential feature, it gave teachers a springboard definition to begin the inquiry process.

OBSERVATION RESULTS

Using the STIR, we observed 12 randomly selected study group teachers both before the study groups met and at the end of six professional development sessions to see whether teachers changed their instruction. We rated the teachers on each essential feature of inquiry and calculated a total score for each by assigning a numeric value to each cell. We scored the “not observed” cell at 0, while the adjacent cell was assigned a 1, continuing to the last cell, which was assigned a 4. The highest possible score on the rubric was 24 and the lowest was 0, meaning we observed no inquiry-based practices.

All 12 study group teachers who originally placed in several “no evidence observed” areas on the STIR during the pre-observation included most essential features of inquiry in the post-observation lesson six months later. Certainly, the newly implemented curriculum impacted the inquiry practices incorporated into the post-observation science classrooms, especially since both the STC and FOSS curricula are designed to be inquiry-based. However, the shift out of the “no evidence observed” area was more dramatic in some essential features than others.

Teachers incorporated the last three essential features of inquiry (statements 3, 4, and 5 on the STIR tool) more often in the post-observations than the pre-observations. In some cases, half the teachers moved from the “no evidence observed” STIR placement to an observed placement on the STIR. While this improvement may have been due to the newly implemented curriculum, we observed that study group teachers often customized the curriculum to allow for more student-centered practices. For example, instead of giving students a question to investigate as the curricular materials prescribed, several study group teachers prompted students to form their own questions or provided examples to help students formulate their own. This practice correlated to the study groups’ readings and discussions, which included sections from Inquiry and the National Science Education Standards (National Research Council, 2000) and Doris Ash and Barry Kluger-Bell’s Identifying Inquiry in the K-5 Classroom (2000) about formulating scientifically oriented questions to begin inquiry lessons.

Overall, all 12 of the observed study group teachers included student-centered essential features of inquiry in their classrooms during the post-obser-
vations. And two teachers reached the level of full inquiries in their classrooms, using each essential feature.

Based on these observations, it appeared that the study groups gave teachers a level of comfort not only in teaching a curriculum aligned to standards, but also in modifying curricular materials to include more student-centered features of inquiry. These modifications appeared to result from study group discussions.

Study group teachers focused on using new science curriculum and discovering what inquiry means in their classroom. Using well-developed curricular science materials in conjunction with a study group model of professional development focused on inquiry not only resulted in teachers implementing more essential inquiry features, but also in more student-centered classroom practices. This implies that study groups need to focus on both content and instructional practice.

STUDENT ACHIEVEMENT RESULTS

The ultimate goal of professional development is to get results — improved student achievement. We measured students' science achievement with pre- and posttest assessments from each unit of the new science curriculum.

Third- and 5th-grade students of study group members made significant gains on the posttest. The study group model of professional development combined with the 3rd- and 5th-grade focus on life science, a content area that elementary teachers are often comfortable teaching, likely added to students' achievement gains. Both the study groups and teachers' familiarity with life science probably contributed to the gains. Both content knowledge and pedagogical knowledge are necessary to help students understand scientific concepts.

Fourth graders did not raise their achievement significantly. One major difference at this grade level was the unit. Fourth-grade teachers taught magnetism and electricity, a physical science unit that many elementary teachers are uncomfortable teaching. The 4th-grade results may suggest that teacher's content knowledge played a significant role in how effective study groups were and, subsequently, on student achievement. The standards call for teachers to have strong content knowledge to be effective teachers of science (NRC, 1996). This implies that if teachers do not have deep content knowledge, study groups may not be the most appropriate model of professional development to affect student achievement.

CONCLUSION

Standards-based inquiry instruction demands a significant shift in what teachers typically do. To make this shift, teachers need support, and particularly so in the challenging areas of elementary science and mathematics. Teachers must think about what it means to learn different kinds of science material for different purposes and be able to use different teaching strategies, particularly inquiry-based instruction, as the context requires. Study groups, strong curricular materials, and tools like the STIR can positively affect teacher's implementation of standards-based science and, ultimately, develop in students the necessary skills to achieve scientific literacy.

REFERENCES


