The difficulty that experienced teachers often face when making fundamental changes in their teaching practices highlights the need for novice teachers to establish productive patterns early in their career. It is well established that, "left on their own, beginning teachers will focus on whatever works.... [A]ttitudes tend to become more negative and behavior becomes more inflexible" (Brock & Grady, 1997, p. 10). The literature
makes it clear that professional development of new teachers must begin as soon as possible in their careers (e.g., Brock & Grady, 1997; Lambert, Collay, Dietz, Kent, & Richert, 1996). In particular, novice teachers need induction experiences that are subject-specific, rather than generic first-year teacher strategies, so that they can explore pedagogical strategies that will work in their specific contexts (Darling-Hammond, Berry, Haselkorn, & Fideler, 1999).

Schools that are committed to implementing the NCTM Standards (1989, 1991, 1995, 2000) face additional challenges when inducting new teachers. Being asked to teach mathematics in a manner that most have not directly experienced as learners often creates a tension between novice teachers' perceptions of and the school's expectations for how mathematics should be taught. One way to address this tension is to carefully craft induction programs that offer novice teachers the opportunity to reflect on teaching in light of the needed reforms. Doing so requires a conscious effort by experienced department members to teach the tenets of teacher collaboration, collective inquiry, and experimentation, and to develop habits of continuous improvement (DuFour & Eaker, 1998).

Very few schools, however, have developed teacher induction programs that do this. One possibility that our school has explored is involving new teachers in an induction program that uses Lesson Study as a means of professional development. We wanted to explore the potential of Lesson Study to help novice teachers learn to work together as they make sense of the requirements of the mathematics department with regard to lesson design and implementation. In this chapter we describe how we used the Lesson Study component of a larger induction program to focus novice teachers' attention on meeting the goals of the mathematics department early in their teaching career.

LESSON STUDY

Lesson study is a professional development experience in which a group of teachers works collaboratively to: formulate a goal for student learning; plan and teach a lesson focused on the goal; devise and implement a strategy for assessing progress toward the goal; and revise and re-teach the lesson. As a part of the lesson study cycle, one member of the group teaches the lesson while all other participants observe and collect data. After the teachers meet to discuss the lesson and make revisions, a member of the group teaches the revised lesson while all members observe and collect data for subsequent collaborative analysis. This process is summarized in Figure 7.1.
Lesson Study provides the context for needed reflection, dialogue, and an interactive professional culture. This type of professional development affords teachers the opportunity "to fashion new knowledge and beliefs about content, pedagogy, and learners" (Darling-Hammond & McLaughlin, 1995, p. 597). Through intense collaborative sessions the participants study every component of the focus lesson. The professional exchanges between group members help each participant to articulate ideas, opinions, and perceptions. The group's data collection and debriefing sessions allow the teachers to compare what transpired in the classroom with their anticipated sequence of events. The process of Lesson Study engages teachers in research through reading other's research, integrating what was learned into their lesson, and investigating the results.

**BACKGROUND**

**The Context**

Stevenson High School is a large comprehensive public high school in a suburban setting. The mathematics department consists of 44 mathematics teachers. More than 95% of the 4,500 students continue their formal education after high school. Stevenson High School is guided by the tenets of a Professional Learning Community (DuFour & Eaker, 1998). The school culture is guided by a commitment to the district vision for education that includes teacher collaboration, a results-orientation, and a focus on continuous improvement. The curriculum at Stevenson is a set of departmental learning expectations for each course coupled with a departmental vision of instruction. The teachers of each course come to a consensus on how
that will be achieved on a course-by-course basis and work together to implement their plan. Within the mathematics department, the professional development of teachers is focused on the vision of mathematics education as outlined in the Principles and Standards for School Mathematics (NCTM, 2000). The entire department meets five times per year to engage in discussions regarding current research in mathematics education and its applicability to our department.

In addition to the departmental professional development, since the 2001–2002 school year mathematics teachers in their first and second year of teaching at Stevenson High School have met monthly for half of a school day to read and discuss current publications in mathematics education. As a part of each of two required iterations of the year-long induction program, the group of teachers engaged in a Lesson Study, as described above, with the goal of implementing the reforms called for in their readings. That is, each teacher completed two cycles of the Lesson Study process outlined in Figure 1.

Hiebert et al.’s (1997) work on classrooms that promote understanding (see Table 1) provided a framework for our professional development program. Reading excerpts from this text before meeting provided focus for our discussions. We concentrated on making sense of the dimensions and core features of classrooms that promote understanding in relation to our own situations and consistently referenced the summary in Table 7.1 throughout our Lesson Study process.

The Participants

During the 2001–2002 school year, two of the authors, Robert and Michelle, participated in our department’s first Lesson Study with five other mathematics colleagues. The participants were all first-year teachers at Stevenson High School with teaching experience ranging from 0 to 5 years. Three of the participants had graduated from teacher preparation programs specifically focused on the NCTM’s Standards. The other participants graduated from programs in which the NCTM Standards were presented, but were not the identified focus. The Lesson Study was facilitated by the third author, John, the director of mathematics and an experienced member of the department. The Lesson Study served as the final phase of the new teacher induction program for the mathematics department. The remainder of this paper is the story of our Lesson Study experience told through the eyes of Robert and Michelle, with input from John.
Table 7.1. Summary of Dimensions and Core Features of Classrooms that Promote Understanding

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Core Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of Classroom Tasks</td>
<td>Make mathematics problematic</td>
</tr>
<tr>
<td></td>
<td>Connect with where students are</td>
</tr>
<tr>
<td></td>
<td>Leave behind something of mathematical value</td>
</tr>
<tr>
<td>Role of the Teacher</td>
<td>Select tasks with goals in mind</td>
</tr>
<tr>
<td></td>
<td>Share essential information</td>
</tr>
<tr>
<td></td>
<td>Establish classroom culture</td>
</tr>
<tr>
<td>Social Culture of the</td>
<td>Ideas and methods are valued</td>
</tr>
<tr>
<td>Classroom</td>
<td>Students choose and share their methods</td>
</tr>
<tr>
<td></td>
<td>Mistakes are learning sites for everyone</td>
</tr>
<tr>
<td></td>
<td>Correctness resides in mathematical argument</td>
</tr>
<tr>
<td>Mathematical Tools as</td>
<td>Meaning for tools must be constructed by each user</td>
</tr>
<tr>
<td>Learning Supports</td>
<td>Used with purpose – to solve problems</td>
</tr>
<tr>
<td></td>
<td>Used for recording, communicating, and thinking</td>
</tr>
<tr>
<td>Equity and Accessibility</td>
<td>Tasks are accessible to all students</td>
</tr>
<tr>
<td></td>
<td>Every student is heard</td>
</tr>
<tr>
<td></td>
<td>Every student contributes</td>
</tr>
</tbody>
</table>

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**PARTICIPATING IN THE PROCESS**

As a part of the departmental induction program, we had five monthly sessions where we were provided substitutes to allow us to meet for half of our work day to work on our Lesson Study. These monthly sessions augmented the regularly-scheduled departmental professional development meetings and allowed us, the 7 teachers new to the department, to focus on making sense of the departmental expectations and culture. In the following
sections we first address preparing for the Lesson Study and then
describe our participation in each part of the six-step Lesson Study pro-
cess in more detail.

Preparing for the Lesson Study

As teachers who were novices to the school’s collaborative environment, we
needed to learn more about how to function well as a collaborative group
of professionals. An important part of this was discussing our expectations
of each other. For example, we felt it was important for everyone to pro-
vide input and for everyone to listen when input was being given. Most of
our group norms emerged as we learned to work with one another. In sub-
sequent Lesson Study Cycles, group norms have been discussed and
recorded from the start. These norms generally state the group’s expecta-
tion regarding honoring commitments to the group, active listening, equi-
table participation, acknowledging experiences of peers, and remaining
supportive of each other during this time of growth.

Another critical component was time spent discussing the preparatory
readings at length. We challenged each other’s understanding of the
research by asking for clarification or examples of how the speaker envi-
visioned these ideas in his or her classroom. These discussions gave us
insight into each other’s past experiences and the way in which we con-
ducted our various classes. They allowed our group to become familiar
with each other’s strengths, weaknesses, beliefs, and personalities, and to
appreciate the unique characteristics each person brought to the group.
The time taken to establish our norms for participation and to share com-
mon experiences enabled us to build a level of trust that served us well
during the Lesson Study process.

Setting the Goal

Using what we had read about the Lesson Study process, we began with set-
ting a goal for our work together. At the group’s first session, we decided to
focus our efforts on promoting learning for understanding as described in
the preparatory readings. With Heibert et al.’s (1997) dimensions and
core features of classrooms that promote understanding (see Table 7.1) as
our framework, we were able to discuss and analyze our current beliefs and
practices. A common theme was changes that would have to be made in
our teaching behaviors in order to reach our goal of teaching for under-
standing. For example, we discussed the need to provide students with more
wait time as we shifted to a task-based classroom. In another conversation,
members of the group expressed concern that teaching via tasks would limit the amount of time they could dedicate to working out examples for students. This was a concern because of the requirement that teachers cover the entire curriculum and the belief that providing worked examples was an efficient way to do that.

As a part of our early discussions we struggled with what learning for understanding meant and entailed. Initially, when our students were able to reproduce something taught in class, we thought that meant they understood the concept. Reading research about best practices challenged our beliefs about student learning. We took from the readings that learning for understanding involved making connections to things already known. The problem we encountered was how to help students make those connections.

Our goal was to develop a lesson that incorporated the type of student engagement, reflection, articulation, and communication emphasized in the readings we had completed on teaching for understanding. We wanted to choose a topic that would allow us to make progress toward that goal. Given our varied experiences, some members felt certain topics would be too difficult to tackle in our first attempt. Other members felt that some topics were too easy and our group would not be appropriately challenged to meet our goal. Our selection was also strongly influenced by the topics scheduled to be taught in the spring. In the end, we decided that writing a lesson to introduce exponential growth and decay would meet all our criteria.

**Researching and Creating the Lesson**

The second meeting focused on refining the content goals of the lesson and identifying what we felt was the important mathematical content that the students should understand. We wanted to create a lesson that would contribute to meeting our instructional goals, allow students to make connections to prior knowledge, and be mathematically problematic and interesting to students. We realized that trying to incorporate these ideas into one lesson could be daunting. For many of us, this was our first experience applying the research-based framework that we had discussed. As the research indicated, we needed to design tasks that would pique student interest and "leave behind something of mathematical value" (Hiebert et al., 1997, p. 12). As we worked to create the tasks that we would use in our lesson, we were mindful of the fact that part of the framework from which we were working required that a social culture be created in the classroom that would allow students to share ideas and methods and learn from each other.

Based upon our goal, we identified a need to create tasks that would help students build an understanding of exponential functions. We also
wanted the mathematics in the lesson to be problematic and engaging. In order to create these tasks, we realized that we first had to identify what was important about exponential functions and when in the unit the lesson would be taught. We decided to create a task that would allow students to consider the differences between exponential growth and linear growth by building on their prior knowledge of linear functions. We wanted to create a situation that allowed students to build the growth pattern by repeatedly multiplying by the growth factor. At the time, we anticipated students would generalize this process and recognize the need for exponents. As we designed the tasks and lesson, we continually referred back to the readings, particularly concentrating on the five dimensions outlined by Hiebert et al. (1997) (see Table 1), and revised the tasks accordingly. For example, when considering the role of the teacher and the social culture of the classroom, we decided to leave the correctness of the opening activity to be discovered in the mathematics of a later task. The readings provided a filter for how we came to analyze our work. We regularly revisited the dimensions and core features of a classroom that promotes understanding and, as a group, discussed our own progress in each area.

After several hours of discussing, brainstorming, and completing potential tasks in our notes and on the board, we started to assemble a lesson plan. We chose to begin the lesson by asking our groups of students to determine the amount of money they would have after 365 days if they accepted a contract to work for $0.05 on the first day and, after each day worked, they exchanged their previous earnings for 106% of what they had earned since the beginning of the contract. We agreed on this question because we felt it would allow us to elicit student thinking about exponential growth.

Much time was spent framing the questions we wanted to ask and anticipating student responses. As we became more aware of each other's thinking, we found ourselves generating multiple hypotheses as to what the students would do in response to the task. For example, some members of the group hypothesized that students would calculate 6% of $0.05, multiply it by 364 and add it to the original. Others felt that students would multiply $0.05 by 1.06, 364 times. Still others predicted students would multiply by 6% and add the result to $0.05 and repeat the process as often as needed. Due to the comfort level of the group and the focus on student thinking, no one expressed fear about contributing what may have been incorrect mathematical approaches and we were able to work through our own incomplete understandings. This type of discussion about potential strategies provided us with the opportunity to think about how we would respond to the groups of students who produced this kind of work. We
agreed that one of our responses would be to ask students to explain their reasoning.

During the next four meetings, we continued to develop the lesson. As the participants shared their ideas, these ideas would often trigger a new idea for someone else. By the conclusion of the second session, we had written a warm-up activity and had begun to create a framework for the task that would serve as the foundation for the lesson. We knew we wanted a task-based lesson and had to agree on how we would implement this approach that was new for all of us as novice teachers.

In creating the lesson, it became apparent that we had different views of how to implement the research-based practices. As facilitator, John encouraged us to work through these issues and come to consensus about how to proceed. When these differences were encountered, we listened to each other’s ideas and determined what we thought would best help us to implement Hiebert’s framework. We discussed the extent to which we would provide information to students and how we would respond to their questions and work. We discussed various proposals about how students would respond to the questions that were posed. Ideas and beliefs regarding calculator usage and how to implement it in our lesson helped to further shape our plans. Concerns arose regarding answering student’s questions. We found ourselves challenged by the analysis of the locus of control and sources of mathematical authority. We talked about our own classroom habits and referred back to Hiebert et al. (1997) as a way to examine what we were currently doing in our own classrooms versus what we wanted to do in the lesson study. These conversations caused us to reflect upon and often begin to modify our own teaching and practices.

In order to better understand possible student thinking, we concentrated on predicting student responses as a basis for developing our task questions. How would they write their expressions? Would they use words to describe their calculator methods? Would they write numeric expressions? Would someone see the pattern right away and show their group members before they had a chance to discover it for themselves? We tried to think of every possible student response and then decide how to structure the questions based on these responses. For example, we decided to ask a question that required students to think about and write out what they would enter into their calculator to solve a problem instead of actually using their calculator. We developed a sequence of instructions and questions that followed this idea of thinking and writing before typing into a calculator in the hope that students would begin to see a pattern within their work.
potential to create inequities in our classrooms. Thus, we decided that whenever we would ask a question that we felt merited a reflective response, we would direct students to think about the question for a period of 30 seconds in absolute silence. After the established “think time” had expired, we would direct students to share their thinking with the other students in their group. After the think time and social processing, we would then ask for responses from the groups of students. For us, this sent a message that thinking was valued and that we recognized the need to process information in a small group before sharing it with the entire class.

Our thoughtful discussions in the Lesson Study started to impact our classrooms in additional ways throughout the process. We thought about the framework established by Hiebert when developing tasks for our daily lessons. We created environments that fostered the sharing and exploring of students’ ideas and methods. All participants reported these types of changes in their own teaching behavior through the reflective journals that they wrote. John also noticed these changes as he observed lessons throughout the year in his role as the director of mathematics. In comparison with novice teachers in the past, novice teachers who had participated in Lesson Study designed more student-centered lessons and were better able to analyze their own lessons with respect to fostering student discourse.

Reflecting on Practice

Reflecting on the lessons in the context of our Lesson Study group helped us all learn to critique each other and ourselves in light of our stated goals. We learned we had to challenge each other to support any and all observational claims. The relationships we had developed during the year helped us all to feel more comfortable critiquing our own performance. In retrospect, we attribute this largely to the norms we established at the beginning of the experience. We had agreed to be active listeners, withhold judgment on new ideas, respect each other’s strengths and needs, and not allow any one person to dominate the discussion. While the actual group norms are not surprising, our stake in their creation and articulation allowed us to hold each other to them.

A facet of Lesson Study that was difficult to appreciate while immersed in it, but became clear through our reflection, is the fact that the collaborative process mirrors our own expectations for student learning. As we worked to design a lesson in which students were actively engaged, sharing ideas, listening carefully, making conjectures, and collecting data to inform decisions, we were doing exactly that ourselves—as a group of teachers we were engaged in our own professional learning.
Benefits Outweigh Difficulties

Integrating Lesson Study into the teacher induction process is intense. Our district has now repeated the Lesson Study with several groups of novice teachers. Throughout the process each year, participants report a variety of feelings. Journal entries over the years have included statements of fear, excitement, anger, elation, weariness, frustration, and success. The professional interaction and high level of focus can make for a long day if it occurs after school. For that reason, we chose to meet for half school days throughout the year. One of the difficulties with this approach was that it required teachers to miss time with their students. While this is always difficult, we have seen evidence that the resulting professional growth outweighs the time missed.

Although a common misunderstanding about Lesson Study is that the time invested is limited to improving one lesson, we have seen evidence that the effects of the process reach far beyond a single lesson and potentially far into the fabric of a novice teacher’s career. Based on John’s observations and those of the other school administrator who evaluates the new mathematics teachers, immersion in the Lesson Study process has helped each teacher make progress that is usually not witnessed until later in the typical teacher’s career. Very important to the goals of our department, these teachers demonstrated more confidence and skill in implementing student-centered lessons focused on student discourse.

CONCLUSION

The purpose of the Lesson Study component of our department’s induction program is to help novice teachers learn to work together as they make sense of the requirements of the mathematics department with regard to lesson design and implementation. Since experienced teachers often have difficulty making fundamental changes in teaching practices, it is important that novice teachers do not establish unproductive patterns early in their career that may later be difficult to change. Intervening early to help novice teachers develop a shared understanding of the departmental expectations can help to sharpen the focus of their teaching and promote the development of healthy instructional patterns. Providing novice teachers the opportunity to construct an early understanding of lesson characteristics that promote student understanding (Carpenter & Lehrer, 1999; Hiebert et al., 1997) through collaboration with their peers holds promise for accelerating their own learning along an otherwise steep learning curve.
Bringing a group of novice mathematics teachers together to collaboratively plan a lesson proved to have multiple benefits that we feel are generalizable. The group became a team and learned to work together toward their common goal. The camaraderie that developed helped each novice teacher develop the confidence needed to implement new pedagogical techniques in his or her classroom. In addition, the collaborative atmosphere helped counteract the feelings of isolation that often contribute to teachers leaving the field within the first three years of teaching (Gordon & Maxey, 2000). The detailed lesson planning process helped all members of the group to deepen their content knowledge as they faced common misconceptions or difficulties together. It also resulted in the novice teachers learning more about the department’s curriculum and culture. The discussions that ensued about students’ prior knowledge helped to broaden the perspective of all the participants with respect to the work of the department.

Based on our experience, we believe that this kind of induction program has the potential to challenge and modify beliefs that interfere with the goal of teaching mathematics for understanding. We encourage others to use Lesson Study as a way to engage teachers in research-based learning communities at their school. The collaborative nature of Lesson Study and focus on student thinking can accelerate the development of novice teachers by providing them with the learning experiences they need to construct an understanding of reform-based mathematics teaching and to implement it in their classrooms.

REFERENCES


