# Using Lesson Study to Develop an Appreciation of and Competence in Task Design

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This chapter focuses on how lesson study can be used to assist teachers in the design of meaningful mathematical tasks for their students. It describes strategies in designing the lesson study process of "outline, teach, analyze, critically design" that support teachers' development of task design. The chapter explains how specifically using critical design after observing the original lesson and having teachers' focus on making student thinking visible can impact teachers approach to designing tasks. Participating in lesson study enables mathematics teachers to return to their original service ethic, and provides them with structures to focus on their students and students' thinking. Examples of specific tasks that were developed using this method are discussed, and how the method and prompts enabled teachers to challenge their students to think on their own, rather than simply following their teacher's thinking. The chapter is based on data collected from lesson study work with hundreds of teachers over a 6-year period.

Lesson study, a form of teacher professional development that is widely used in Japan, has been cited as a crucial element in the improvement of mathematics and science education in that country (Stigler & Hiebert, 1999). In recent years, lesson study has become increasingly popular in the United States with the hope that it can drastically improve the US educational system (Fernandez, 2002; Wang-Iverson & Yoshida, 2005). During the lesson study process teachers work in groups to develop a lesson plan that one of the teachers will teach and have others observe. After the teaching and observations, the group meets and analyzes the lesson's success in reaching its goals, and then makes revisions accordingly. Thus, a central element of lesson study is task design. The lesson study process can enable teachers to share and learn from each other ways to modify curriculum to engage students in meaningful mathematics.

Lesson study by its very nature has teachers actively making decisions about the curriculum and redesigning it. In the process, teachers first develop and adapt

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curriculum based on their goals. They then collect data during the lesson to see if indeed their decisions resulted in the intended student learning. Lesson study can provide a structure for teachers to learn how to critically design – to critically assess and alter existing curricular materials.

Research has not been conducted to demonstrate lesson study's efficacy overall in improving mathematics instruction or student learning in the United States. At this stage, such general research would not be fruitful, given the variation in the way lesson study is conducted throughout the country (Lewis, Perry, & Murata, 2006). Even within one project trying to draw a causal link between teacher's participation in lesson study and improved student achievement would be difficult given that teachers often engage in other professional development as well and because non-participating teachers often gain some knowledge generated from lesson study by interacting with participating teachers. The purpose of this chapter is to contribute to needed lesson study research as described by Lewis et al. (2006) that provides "explication of the innovation mechanism" (p. 5). This chapter provides evidence that specific aspects of lesson study can change teachers' beliefs, goals, and strategies in designing meaningful tasks for students.

California State University Monterey Bay professors have been working with local teachers on lesson study for the past 7 years. Each year the number of participants has varied, with the most recent number being $\sim$150 teachers from ten different school districts. While the logistics of team meetings varied from school to school, typically teams of teachers met for several days during the summer and a few times after school to plan their lesson, and were paid a stipend for their participation. Most teams took a day out of their classrooms to analyze and revise their lesson. This chapter is based on data collected over the 7-year period from lesson study planning meetings and debriefing sessions as well as from teacher interviews and focus groups of participating teachers. Draft and final lesson plans were analyzed to highlight types of changes made after teaching the lesson, and also to see how lessons changed as instructions to teachers changed in developing lessons over the years.

This chapter focuses on how my colleagues and I have designed tasks to assist teachers participating in our lesson study project in their design of meaningful mathematical tasks for their students. By *meaningful* we mean that it helps students makes sense of mathematics, connecting to, and building on prior knowledge (Ausubel, 1963; Novak, 2002). Students make sense of mathematics, seeing how and why it works, through their internal cognitive connections as well as through social interactions (Carpenter et al., 1997). When mathematics makes sense to students, they do not need to have the teacher judge the validity of their solutions, they convince themselves and others of it (Carpenter, Franke, & Levi 2003). I have summarized our approach as: *outline, teach, analyze, critically design* with an emphasis on making student thinking visible. This cycle is similar to the design cycle discussed by Gravemeijer and Cobb (2001) and Jaworski (2003). Gravemeijer (2004) describes the process as having a research team develop a preliminary design of instructional activities that are carried out in a classroom, then the process of students' mental activities are analyzed, and the activities are revised. I first describe our specific process and then discuss the focus on making student thinking visible, and how that emphasis has effected how teachers approach designing tasks. I describe examples of specific lessons that were developed using this method, and how the method and prompts enabled teacher learning.

# 1 Designing a Lesson Study Cycle to Assist Teachers in Critically Designing Tasks to Make Mathematics Meaningful for Students

Curriculum development and task design traditionally have not been part of American mathematics teachers' responsibilities and thus, pose challenges for them (Fernandez, Cannon, & Chokshi, 2003). Teachers typically are given a text and are required (or expected) to follow it. My colleagues and I originally asked teachers to fill out a detailed lesson plan template that asked for short and long term goals as well as predicting student responses to teachers' questions. These are standard prompts commonly used in lesson study (Wang-Iverson & Yoshida, 2005) and are consistent with a preliminary design phase in design research (Gravemeijer, 2004). Most of the teachers in our project struggled with this prediction. They were adept at recognizing lesson flaws when observing lessons or videos of the lessons, but could not predict those flaws in advance. Our lesson study cycle has thus evolved to shorten the original planning phase and lengthen the analysis and revision (critical design) phase. Our current lesson study cycle includes: outline, teach, analyze, critically design.

## *1.1 Description of the Process*

### 1.1.1 Outline a Unit and Lesson

The lesson study process begins by having teams agree upon some shared beliefs about Mathematics instruction. Teams are provided a list of statements regarding specific classroom practices and about how students learn that the teachers rank from "strongly agree" to "strongly disagree". A few sample statements are: "Big, organizing ideas and inquiry questions are used when teaching content"; "Students spend more time involved in activities than listening to a teacher"; "Students have opportunities to teach and learn from each other".

From their individual responses, the team agrees upon two or three that they share and can modify to serve as their overarching goals. The purpose of the overarching goals is to have teachers think about, and focus on, broader goals they have for students. Instead of having them focus only on the content goals for the day, these overarching goals can redirect teachers to their original goals as professionals. When teachers enter the profession, they maintain a service ethic to serve their students (Yee, 1990). The technical culture of teaching mathematics to *cover topics* can overshadow teachers' original service ethic (Grossman & Stodolosky, 1994).

Professionals pledge their "first concern to the welfare of the clients" (Darling-Hammond, 1990, p. 25). This intention to serve all students is continually reaffirmed in lesson study as the primary purpose of teaching. By discussing their values and beliefs and incorporating these into their lessons, teachers reaffirm their professional purpose. They develop lessons that support this purpose to serve students, not just cover curriculum.

Grouped by grade level, teachers then choose an important problematic mathematics topic to research. They read through the California Mathematics Standards for their grade, and discuss topics that they believe are both important mathematically and are problematic for their students. Participants should not choose a topic just because they already know a *fun* activity for it. If the topic can be taught easily and does not relate to other areas in the curriculum or if students typically do not have trouble with it, then there is no reason to study that topic.

Teachers then develop a general unit plan and choose a lesson from the unit that they believe is key for the unit. Because these lessons usually require teachers to spend more time on the topic than usual, it is important for teams to choose a lesson topic that is at the core of the unit and will enable teachers to spend less time on other lessons because students will have a deeper conceptual knowledge that will assist them in making other mathematical connections. Teams use as a theoretical framework for designing their unit the five interwoven strands of mathematical proficiency described in the National Research Council's report (2001), *Adding It Up*. The strands are: conceptual understanding; procedural fluency; strategic competence; adaptive reasoning; and productive disposition. Teams may not be able to address each of the five in the single lesson, but they plan how the lesson fits into the development of the strands. The team then outlines a lesson plan that includes a description of the primary task in which students will engage. Teams respond to the questions found in Table 1 while writing their lesson plans.

### 1.1.2 Teach the Lesson

During this phase of the process at least one teacher from the team teaches the lesson in order for the team to analyze how the students interacted with the task. Other team members either watch it live as it is taught or watch it on videotape. In some cases, multiple teachers teach the lesson and the team compares students' responses. While teachers are observing, they are taking notes to provide evidence of student thinking.

### 1.1.3 Analyze the Lesson and Student Thinking

In this phase, teachers collaboratively observe and analyze the lesson or video, discussing student thinking during the lesson and how the lesson met its goals. University professors participate in these discussions as well, asking the team critical questions as the lesson progresses. The entire group discusses how well their goals and methods served students.

**Table 1** Questions teachers address while planning their lesson

1. Goals of this lesson
   - What student actions and thinking is the lesson trying to foster (e.g. independent mathematical thinking, group cooperation)?
   - What are the mathematical goals for this lesson? What do you want students to come out of this lesson being able to know or do?
2. Assessment and evaluation
   - How will you determine by the end of the lesson if the lesson met each of its goals? (What problems or questions would you ask students?)
   - What evidence of learning will be observed or collected during the lesson to make student thinking visible? Examples of ways to make student thinking visible:
     - Many students explaining their reasoning in a class discussion;
     - Many students showing and explaining work at the board;
     - Students using hand-held white boards to show their work, not just answers;
     - Students explaining their thinking in small groups (with the teacher checking in frequently with groups and asking questions).
     - Students handing in a *quick write* (answering a conceptual question or showing their work/thinking for one or two problems)
3. Progression of lesson highlighting students' learning activities
   - Lesson Introduction: What will hook students into thinking about this lesson and connect to prior lessons?
   - Main activities for the lesson: What rich problem or activities will the lesson use to engage students, keeping them mentally active and thinking originally, whereby they develop their own strategies, not passively follow procedures? How does the lesson design make students' thinking visible to the teacher and observers? What strategies will make*mathematics meaningful* for all students? (Some examples include: using multiple representations, connecting to students' lives and prior knowledge, providing structures for communication).
   - Lesson Closure: How will you debrief the lesson, explicitly pulling out the important mathematical ideas of the lesson?
   - Short assessment if evidence has not been collected earlier in the lesson (e.g. a quick write or solving one problem).

### 1.1.4 Critically Design

After the lesson or video has been analyzed, teachers reflect on the discussion. The team is now prepared to carefully design the learning task. Design does not have to mean developing teaching materials from scratch. In fact, a crucial element of design is the ability to critically assess and alter existing curricular materials or lessons. I will, therefore, use the term critical design to refer to this active and critical role of planning. Teachers' original lessons can be designed from existing materials, and their revised lessons are designed from the original. They critically analyze existing plans to design their new lesson. By seeing how students interact with the original task, teachers now have insight into students' thinking about the concept. For the "Main Activities" section of the lesson plan, teachers add columns "anticipated

**Table 2** Main activities of the lesson plan

| Learning activities | Expected student responses | Points of evaluation |
|---|---|---|
| | | |

student responses" and "evaluation points". The teams re-write the main activities with more detail and with responses in the new columns (Table 2).

In addition, during the original planning phase, teachers often have difficulty uncovering the important mathematical concept underlying the mathematical goals they have set for their class. During the critical design phase, the team can now anticipate student responses to each part of the lesson, and when needed, redesign the lesson and its goals to focus more on the important underlying mathematical concept.

## *1.2 Examples of Insights Gained During Lesson Analyses*

Below are specific examples of insights teachers gained when analyzing their lessons or videotapes, and how those insights influenced the final, more detailed lesson plan during the critical design phase of the process.

### 1.2.1 Surface Area of Cylinders

The purpose of this lesson was for 6th-grade students to learn how to find the surface area of a cylinder. The students used rulers to measure dimensions of a cylindrical can that was placed on their desk. The teachers expected the students to be able to see that the height of the can was the same as the width of a rectangle wrapped around the can, and that the circumference of the can was the same as the length of that rectangle. They expected the lesson to go smoothly, with students having little difficulty. Instead, students struggled to figure out what to measure. After teaching the lesson (and reviewing the video), teachers realized that the important and challenging aspect of this lesson was not having students simply develop a formula for surface area; it was having them visualize the 3-D lateral surface area in two dimensions and make the connection between height in 3-D and width in 2-D, as well as circumference in 3-D with length in 2-D. The planning phase of this lesson study cycle was not as fruitful as the analysis phase. During the analysis, the team discussed how they needed to spend more time with their class transforming 3-D objects to 2-D drawings. They needed to spend more time having their students deconstruct 3-D objects into flat objects. Activities such as breaking down a cereal box to see the 2-D figures from which it is composed or peeling off a rectangular label from a cylinder would help students visualize drawing nets from 3-D objects. Students had had some experience with these types of activities, but it was clear from the lesson that they needed a firmer grasp of this type of visualization. Without this background, students cannot successfully complete the task they were given.

### 1.2.2 Sum of Angles of Any Triangle Is 180 Degrees

In another lesson, the teachers' goal was for 5th grade students to understand that the sum of the angles of any triangle is 180 degrees. Students used protractors to measure the angles of several differently shaped and sized triangles. Students' data were often not accurate, and thus, incorrectly came to the conclusion that the sum of the angles of any triangle is not always 180 degrees. The team needed to revise the lesson, taking this into account. More importantly, though, the teachers learned that students do not understand the concept of angle measurement generally. The pre-knowledge necessary for this lesson was much greater than what teachers had expected. Teachers learned that the concept of angle measurement is much more complex than they had thought. Some students thought large triangles would have larger angles. They were sure they could make a very small triangle with the measure of each angle being 10 degrees. The teachers had not realized that the important mathematics necessary for this lesson was to understand what angles and their measurement mean. The teachers could not make this realization until they observed and listened to students.

### 1.2.3 Justifying Reasoning

The following task was designed by another group of teachers to have 4th and 5th grade students justify their reasoning while exploring the fractions in a novel way. The class had been working with fractions, but only looking at them as parts of a whole. The class was a 4th/5th grade combination, so they needed to use a problem that would be accessible for the 4th graders while also being challenging for the 5th graders.

> Mr. Smith's brownie pan holds 20 brownies. Last night he baked three batches. He and his wife ate 3 brownies each for dessert. Mr. Smith ate an extra half a brownie as a midnight snack and another one for breakfast.
>
> How many brownies did Mr. Smith bake?
> How many does he have left to share with the thirty kids in his class?
> How can you make sure that every person gets an equal share?
> How much will each person get?
>
> Be prepared to prove, present and explain your answer to the class using drawings, pictures, numbers, or words. You may create your own brownies out of construction paper to help you solve this problem.

Teachers did not know how students would go about solving the problem. They were surprised to find that most groups tried to solve the problem the same way, but had difficulty. When analyzing the video and student work teachers found the following issues. First, the wording was a little ambiguous. The last phrase of the last sentence says "and another one for breakfast". Some students interpreted the "one" as a whole brownie (as it was intended) and others interpreted it as another one half. That wording can be an easy change for the next version of the lesson.

More interestingly, the teachers were surprised that most students solved the problem by dividing up brownies, and then halves. Most students correctly multiplied 20 by 3 to get 60 original brownies. They then subtracted $7\frac{1}{2}$ brownies from 60 and got $52\frac{1}{2}$. At this point, students realized that each student in the class could have one whole brownie, so they subtracted 30 from $52\frac{1}{2}$ and got $22\frac{1}{2}$. This is where the problem became quite challenging for most students. Before teaching the lesson, the teachers were not able to anticipate student responses, and certainly did not expect so many groups to use the same method. Groups often doubled their numbers to see how many students they could feed if each ate a half. This allowed them to give an equal share to each of the 30 students. The groups kept track, that these shares were $\frac{1}{2}$ brownies, not full brownies. They doubled the $22\frac{1}{2}$ and got 45 shares. The 30 students each got a share (that was now a $\frac{1}{2}$ brownie), and they were left with 15 shares (halves). Some of the groups realized that when they doubled 15 they reached 30 again, and that each of these shares was now $\frac{1}{4}$ of brownie, so each student got $1 + \frac{1}{2} + \frac{1}{4}$ brownie, or $1\frac{3}{4}$ brownie. Some groups subtracted incorrectly at the beginning of the problem and ended up with $6\frac{1}{2}$ brownies. They then divided the 6 brownies into fifths so that they could have 30 pieces, and simply dropped the $\frac{1}{2}$. Those groups gave an answer of $1 + \frac{1}{2} + 1/5 = 17/10$.

This lesson showed how the analysis phase provided the richest opportunity for the teachers' learning experience. At first students focused on finding an answer and wanted approval from the teacher. The teacher reminded them that the task was to prove their answer with drawings, pictures, numbers or words, at which time students re-engaged in order to justify their reasoning. The teachers learned how powerful this type of task can be for developing students' capacity for justification by generalization versus "appealing to authority" as described by Carpenter, Franke, & Levi (2003), and for developing the capacity of adaptive reasoning generally (National Research Council, NRC, 2001). The analysis phase of the lesson provided the teachers with information about how students approached the problem and justified their reasoning without instruction, and thus, what knowledge they brought to the situation and what they can learn that will help them.

## 2 Designing Key Prompts that Assist Teachers in Critically Designing Tasks to Make Mathematics Meaningful for Students

My colleagues and I have found that another key for enabling teachers to develop challenging tasks that provoke student thinking is to focus teachers on making students' thinking visible during the lesson study process. The Cognitively Guided Instruction (CGI) project has provided evidence that when students develop and communicate new mathematical understandings based on their own knowledge, they learn mathematics better (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989;

Villasenor & Kepner, 1993). CGI recognizes that children have intuitive mathematical knowledge and that teachers can develop instruction that has students build on this knowledge without being told or shown how to do mathematics (Carpenter, Fennema, Franke, Empson, & Levi., 1999). Similarly, recent international studies have shown that a key feature of successful mathematics instruction is providing students with challenging tasks that provoke student thinking (Stigler & Hiebert, 1997; American Institutes for Research, 2005). The challenge is to assist American teachers in making that their priority and then assisting them in designing tasks that support the goal. Based on our work with hundreds of teachers in multiple school districts, a key for making this work is to focus teachers on making student's thinking visible during the Lesson Study process. As teachers develop lessons with the goal of making students' thinking visible, by definition, the lesson must make students think. Examples of strategies that are provided to teachers for making thinking visible are: having students show/discuss their methods in groups, having students show/discuss their method with the whole class, having students write out in words what they did and why they did it that way. When I use the term *visible* I also mean audible. The purpose is for the teacher and observers to be able to understand how the students are thinking about the mathematics during the lesson.

Lesson study provides permission to take risks. The purpose of developing, teaching, and analyzing the lesson is to learn about student learning. The lesson study team learns a great deal from both failure and successes; the purpose is not to develop a perfect lesson, it is for the team members to investigate how students think about the mathematics of the lesson. During the process teachers design lessons that often take them out of their comfort zone in order to produce evidence of student thinking that can be analyzed. Team members then have the opportunity to observe students learning math in ways that take some control away from the teacher. They are provided with a new vision for mathematics instruction and student learning. I will provide specific examples of teachers' shift in their design of tasks by describing some of their earlier and more recent tasks, and what caused them to make those shifts.

When my colleagues and I began our lesson study work, teachers tried to develop *the perfect lesson*. As one teacher says, she and her colleagues tried to make the lessons *student proof*. In other words, students could follow the task step by step and end up discovering what the teacher intended. Even at this school that has been diligently trying to improve mathematics instruction, teachers had not developed a need for pushing students' thinking. Teachers wanted to lead students to a discovery, but not have students do original thinking. They wanted students to understand why mathematics works the way it does, but they wanted to do so by having students follow the teacher's thinking. With the goal this year on making student thinking visible, their lesson did, indeed, require student to do original thinking. These teachers are now challenging themselves by working towards having students develop ideas themselves – think deeply about the ideas (not just *understand*). One of the teachers describes this transformation,

> The thing that I've really noticed the progression at Lincoln; when we first started doing Lesson Study we tried to make these lesson plans that were like student-proof, where we

> just walked the kids right through; and I don't think we really had the understanding that we could get kids to do the stuff successfully but it didn't mean they were thinking about it at all. It could just be that they were following a recipe. It's almost like getting a MapQuest[1] to go to somewhere and you follow the MapQuest exactly, it doesn't mean you really know how to get there next time.... So this year, I think we really got the point of, we just want to see evidence of student thinking... let's think about student thinking.

An example of the transformation this team has gone through can be seen in two of the lesson study lessons. Two years ago, their lesson was about the sum of interior angles of a polygon. The team wanted their students to "discover" the formula that the sum is 180 times the quantity $n = 2$, where $n$ is the number of sides of the polygon, and wanted them to understand where the formula came from. Students filled out a chart (Table 3) that had a column name of polygon, $n$-sides, number of triangles, number of degrees. At the bottom of the table there was a row for an $n$-gon. When filling out the chart, students could easily follow the pattern and get the correct answer without understanding why it worked the way it did (Table 3).

The teacher showed the class how to draw lines from one vertex to the other vertices, to create triangles within the polygon. The team realized later that students could go through this lesson, come up with the correct answer, and still not be able to re-create the formula. The students were able to fill out the table correctly, but did not do the thinking necessary to set up the table and develop the formula, and thus, would probably not be able to re-create the formula later.

This year, when teachers were given the prompt teachers to "make student thinking visible", the team developed a very different type of lesson. They developed their lesson with the goal of having students make connections between various representations of the same linear situation. They had students match cards with a *real life* situation (word problem), linear equation, t-table, graph, and ordered pairs. Students had to do the thinking in order to match the correct representations to each problem

**Table 3** Sample template for "discovering" formula for sum of interior angles of a polygon

| Name of polygon | Sketch | Number of sides ($n$) | Number of triangles formed | Number of degrees |
|---|---|---|---|---|
| Triangle | | | | |
| Quadrilateral | | | | |
| Pentagon | | | | |
| Hexagon | | | | |
| Heptagon | | | | |
| $n$-gon | | | | |

[1] Electronic system that provides street-level detail and/or driving directions for a variety of countries (Wikipedia, http://en.wikipedia.org/wiki/MapQuest, accessed May 28, 2008).

situation. In addition, students had to justify their answers (in words, through work, or both). Below is an example of one of their situations:

| |
|---|
| Fred and Ethel have been saving for many months in order to pay for their parents' 50th wedding anniversary. They have a total of US $5,000. Fred and Ethel now need to start paying for all of the food, music, flowers, hall rental and so forth. The bills work out to be a total of US $300 each month. |

This team did not do a lot of revision after analyzing their lesson, but had a rich discussion based on their observations. They discussed questions students were asking each other in groups as they worked on the task, and which representations were causing the students the most difficulty. For example, they noticed that students had the most difficulty with the ordered pairs and they were not used to fitting an ordered pair with a situation. They also discussed the difficulty students had with one of the problems due to ambiguity in the wording. In contrast, with the polygon lesson, there was little evidence of student thinking to discuss. Teachers quickly came to the conclusion that the students *got it* – they got the correct formula.

Another example of how the instructions to "make students' thinking visible" for study lessons had the effect of teachers planning lessons that make students do original thinking was the "brownie problem" lesson described earlier. The teachers in this group have shifted their focus to having students develop concepts themselves, rather than be shown them. A key feature of the "brownie problem" lesson was that students had to convince each other (using their model) that they had the correct answer. This lesson was rich with evidence of student thinking. Students calculated answers and wanted to share them with the teacher. The teacher's response was that they must use a model to convince each other. Students went back to their groups realizing that they had a great deal more to do for the lesson. Developing the models forced more conversations and deeper conversations amongst group members.

A teacher in another lesson study group described how his experience of designing lessons for lesson study has changed the way he designs all mathematical tasks for his class. He gave the example of teaching 5th grade students to compare the relative size of fractions. He used to teach students the rule of multiplying the numerator of one by the denominator of the other. This method is a shortcut to finding an equivalent fraction with a common denominator. The result gives new numerators (with the same denominator), allowing the student to compare whole numerators only. When he taught this method, he taught it as a rule, without providing justification for why it works (or having students figure out why it works). This year he approached the same topic in a very different way. He put some unit fractions on the board and asked students to draw them. He then asked them what they noticed about the size of them. Students quickly noticed that fractions with a larger denominator were smaller pieces of the same whole. He then put up some fractions with the same denominator and different numerators and asked students to draw them. Students noticed that the larger numerators resulted in a larger fractional portion. This teacher provided these explorations as a foundation for comparing fractions. This example illustrates how a teacher thinks differently about designing lessons due to his experience of developing tasks for his involvement in lesson study.

## 3 Conclusions

While a central purpose of lesson study is for teachers to learn from engaging in the process, an additional benefit is that teachers can acquire a collection of key lessons that have been studied carefully. Teachers do not have time to conduct a lesson study cycle for every lesson, but this collection can build students' foundational conceptual knowledge for many of their curricular units enabling teachers to spend less time on other related lessons.

The lessons that teachers collect, though, are still not perfect. A crucial element of designing tasks is to critically assess existing curricular materials or lessons, and then adapt them to better meet the teacher's students' needs. As such, teachers continually adapt lessons based on their learning from the process of analyzing and discussing students' thinking about a topic, and based on their knowledge of the particular students they are teaching. In our project, teachers have been better able to critically design after they have seen a lesson taught, even if the revised lesson is going to be taught to a different group of students. After teachers have seen any group of students respond to the lesson, they are better able to predict what other groups of students, even different types, will do because they have a basis from which to predict and compare.

When they first teach the lesson, teachers often expect it to go as planned, and for students to think about the task the way the teachers think about it. After they have observed students interact with the lesson, they are better able to understand the important mathematical concepts underlying the lesson, as well as how students will think about the concept and task. Furthermore, the tasks teachers design are more mathematically meaningful if the teacher focuses on making student thinking visible. Because teachers typically do not see critical design as a part of their job – their job is to implement the curriculum laid out in textbooks – strategies need to be studied and shared about how to assist teachers in developing this skill. Similarly, US teachers are used to focusing lesson planning and observations on the teacher, rather than on the students (Fernandez, Cannon, & Chokshi, 2003). This chapter provided descriptions of the tasks my colleagues and I have used to assist teachers in learning how to design meaningful tasks that highlight student thinking.

Due to their participation in lesson study, teachers are now challenging their students to think on their own; not just follow the teacher's path to a particular discovery. This, in itself, requires more risk-taking by the teachers. They do not know where their students' thinking will go. In the past, most of the teachers in our project either showed students how to use skills or procedures to find an answer, or they guided students to discover a particular concept or formula, without having students do any of the thinking. Many of the teachers now see the value of developing tasks that will allow students to do original thinking. By having us ask teachers to make thinking *visible*, teachers have embedded formative assessment into their tasks. They (and other observers) are gaining knowledge about students' understandings and misconceptions while the lesson is being taught.

The tasks and processes described in this chapter demonstrate how lesson study can assist teachers in developing more meaningful mathematical tasks for their students, and how, they in turn, reaffirm their professional purpose – to serve students. US mathematics teachers maintain a specialized culture that is comprised of shared practices and beliefs about students, and mathematics teaching and learning. This technical culture is often strong and inhibits serving all students well due to the belief that mathematics is a sequential series of skills that teachers must cover, even if students are not learning them (Talbert & Perry, 1994). This technical culture for many teachers is given and signals, implicitly or explicitly, a tension between caring about students and maintaining the integrity of their subject or adhering to systemic requirements to cover material (Talbert & Perry, 1994). Lesson study gives teachers permission to return to their original service ethic, and assists them by providing structures to help them focus on their students and students' thinking.

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