Designing a Discussion: Teacher as Designer

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For whole-class discussions, teachers need methods for orchestrating them with their students. This may require the design of tools to meet specific needs for a whole-class discussion. As teachers design tools for their practice, they can evaluate the effectiveness of those tools. As the tools are designed, documentation of teacher development is generated. So, tool design in a design experiment can meet teacher needs for useful tools and researcher needs for knowledge about teacher development.

Currently, there exist gaps between educational research findings and the teaching questions encountered by practicing teachers (Collins, 1999). There is need to both build teaching and learning theory while providing practical recommendations and innovations for teachers (Design-Based Research Collective, 2003; Lesh, 2002). "Design experiments" are emerging as a means for developing practical innovations while developing theory about teaching and learning (Brown, 1992; Collins, 1999; Kelly, 2003; Lesh, 2002). As teachers develop tools they can use in their practice, the tools and changes in the tools, can be used as evidence of knowledge development. The question for the researcher then becomes: What is a context where participants reveal their thinking and that thinking can develop? The context needs to allow for documentation of knowledge development, and encourage the design of tools that teachers find useful. The tools may solve some problem or resolve an issue a teacher sees in the classroom. For this study, the participants are teachers faced with the question of how to organize a whole-class discussion of student solutions to complex mathematical activities. Their design of tools that could be used to carry out whole-class discussion provides evidence of their knowledge development.

Whole-class discussion of solutions to complex mathematical activities is difficult to carry out for a classroom teacher. The teacher has to take into account a variety of factors and consider carefully the goals for the discussion. The discussion may be an opportunity for the teacher to evaluate or assess student understanding of mathematical ideas. It may also be an opportunity for students to elaborate on their problem-solving process. The discussion could emphasize the comparison of different solutions or methods. Given the previous considerations, orchestrating a whole class discussion represents an important point of decision-making for the teacher. The design experiment used in this study examines how teachers develop tangible products that can be shared with other teachers attempting similar discussions.

Method

Model-Eliciting Activities

The model-eliciting activities implemented in this study require students to work in a small group to develop a description, explanation, or prediction that solves an immediate problem for a client as well as serving as a template for the solution of future problems. For example, in the *Million Book Challenge*, students are asked to determine how many

standard copier-paper boxes it would take to ship one million books to schools in Indianapolis. They have to explain the method they used to determine a number of boxes in order to explain how to pack the boxes for shipping. They also have to explain their method for packing because different kinds of books are being collected and shipped (e.g., primary picture books, dictionaries, novels) to schools with students of different ages. Since they do not have one million books available, they have to consider aspects of statistical sampling in order to find an answer by packing sample boxes and considering different sizes of books. They also have to consider area and volume computations as they pack the boxes. Since there is a degree of estimation involved in all of their answers, when each group of students presents their method, there are a wide variety of answers (about 6,000 to 17,000 boxes) and a variety of methods.

Design Experiments

Design experiments in various venues have focused on the learner as designer (e.g., Erickson & Lehrer, 1998) or the design of learning and teaching innovations by researchers (e.g., Brown & Campione, 1994; Linn, Bell & Hsi, 1998; Verschaffel et al., 1999). The present study adds to that literature by situating the teacher as a learner. An important characteristic of this study is that the teachers developed the tools on their own to fill needs they identified in their own practice. The teachers in the present study have different purposes and goals for the discussion for themselves and for their students. These purposes impact the development of the tools. As tools are designed, the teacher learns about practice, improves practice, and designs sharable products. The discussions improve and the tools improve over time. Tools were revised based on implementation considerations the teachers saw after testing them with their own students. So, the design of the tools serves as an on-the-job professional development opportunity. In addition, it is important to note that I did not determine what tools the teachers should design. I went into the study not knowing what tools might be useful. I also wanted to encourage as much diversity in tools as possible and encourage the development of sustainable tools by giving them greater autonomy in terms of tool selection.

A common characteristic of design experiments is their cyclic and iterative nature (Collins, 1999; Design-Based Research Collective, 2003; Edelson, 2002). Namely, innovations (in this case, tools) are expressed, tested, and revised based on implementation. These revisions produce documentation and evidence of teacher development as well as improved innovations. For this study, the teachers developed a tool, implemented it, and revised it based on implementations. The nature of the implementations and subsequent revisions gives insight into their purposes for the tool and improvements they can make in their teaching.

The power of the design experiment is that it asks the teachers to produce an externalized product that they can examine for effectiveness at meeting their goals while also giving insight to researchers about their teaching practice. This is similar to model-eliciting or thought-revealing activities for students (Lesh, Hoover, Hole, Kelly & Post, 2000) that promote the cyclic development of models that can be self-assessed by the students for their effectiveness at meeting a client's needs. So, rather than a teacher telling a student their answer is not quite right, the student can tell when something is missing in

their solution. Similarly for teachers taking on the role of designer in a design experiment, the researcher does not have to say to the teacher whether or not the tool was effective or not. The teachers can tell for themselves because they knew what they wanted from their students when they developed it and they implemented it with their students as a test of its effectiveness. After testing the tool, it can be made more effective and tested again.

Participants

Three middle school teachers in an urban school participated in the study. Two are sixth grade teachers and one is an eighth grade teacher. Each teacher agreed to implement at least three model-eliciting activities over the course of one school year. All three had been implementing activities for at least two years and had participated in summer institutes and/or professional development workshops. I asked them to participate in the study because they had gradually been using the model-eliciting activities more regularly as part of their curriculum, which indicated a stronger commitment to the activities. Additionally, I was interested in the types of needs and strategies for filling them that had emerged as they become more experienced at using the activities.

To document teacher development, the data collection followed an express-test-revise cycle. The teachers expressed (developed) a tool. Then, the tool was tested in the classroom during a whole-class discussion following a model-eliciting activity completed by the students. Then, the tool was revised before the next activity. This process is illustrated in Figure 1.

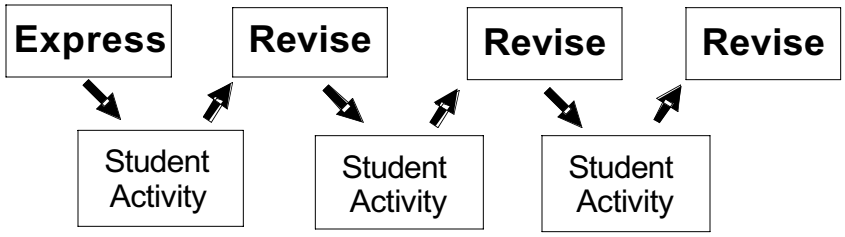

Figure 1. Tool design and revision cycles.

I was a participant-observer in each classroom during the activity implementation. In addition, each teacher participated in follow-up discussions with me after school about each activity and in an interview about their teaching practice in general. I also collected copies of tools as they were designed in order to document their development and to generate a shareable set of resources that could be used by other teachers implementing model-eliciting activities. Design cases (Edelson, 2002) were generated for each teacher in order to document their revision and implementation of the tools and the contexts surrounding the implementation of the tools in their classrooms.

Results

Whole-Class Discussion: Three Perspectives

The teachers followed a similar structure for discussion after the students had completed the model-eliciting activity. Groups went to the front of the room to present their method for solving the model-eliciting activity. The group frequently read their letter as part of the presentation. Depending on the teacher, the presentation was then followed by questions from the teacher, other students, or both. Although the general structure was similar between classrooms, there were differences across classrooms in the types of questions asked to the group presenting and to the roles of the students listening to the presentation. In addition, the teachers had different methods for assessing the students' work. Assessment might include some combination of final letter, presentation, and participation in the solution process. All three viewed the presentations as a valuable opportunity for assessment and evaluation as the students described their process. However, the evaluation varied across teachers. Two teachers developed specific tools for this purpose. Some of the differences in implementation led to different types of tools.

An important aspect of the tools for evaluating their effectiveness was their purpose. In two cases particular tools are modified from activity to activity according to how well the tool met a specific purpose. The third teacher developed a wider variety of tools depending on the model-eliciting activity. However, each teacher had a specific purpose for the discussion of solutions by their students. Table 1 describes the purpose of the presentation according to the teachers, the purpose of the tool they developed (or the need it filled) and the type of tool that was developed to fill that need. In general, the tools were very simple. Ease-of-use emerged as an important criterion given the time constraints teachers work under and the need for tools that could be communicated easily to students and used effectively by the teachers. For example, useful assessment tools could be completed in class as each group gave their presentation.

Table 1
Teacher Designed Tools

Teacher	Katy Stagle (8th grade)	Amy Green (6th grade)	Abby Robbins (6th grade)
Presentation Purpose	Explain method to other people	Explain problem solving process and product	Real-world experience explaining product
Tool Purpose	Clarify explanation Encourage quality of solutions and evaluate work	Understand problem solving process	Clarify explanation.
Type of tool	Presentation questions from the teacher	Presentation Outline	Presentation questions primarily from students and

	Scoring rubric	some questions from teacher

Design Case: Presentation Outline

In order to illustrate the design process and the relationship between purpose for the tool and revisions, I will describe the development of a presentation outline given to students that began to fill Amy's need for more information about the events that led up to their final solutions. The presentation outline was developed over a series of four activities. She implemented one model-eliciting activity approximately every six weeks. The outline consisted of a series of questions that she wrote on the board before the presentations started. For example, the mini-golf presentation outline in Figure 2 was the first outline she developed as part of this study. "Getting started struggles" were the things that the students felt were difficult about the problem at first. The "Aha! Moment" was when they figured out what they needed to do. "Who did what?" indicated the division of tasks among group members. The final three categories were the letter they wrote to the client (in this case, a principal), their golf course layout, and questions from other students in the class.

Mini-Golf Presentation Outline

1. Getting started struggles
2. Aha! Moment
3. Who did what?
4. Letter to the principal
5. Your layout
6. Questions

Figure 2. Amy's presentation outline.

In an interview with Amy, she stated the need that outlines such as this filled for her. She wanted to know more about what the students were thinking as they solved the problem. She wanted to know about the series of decisions, events, or insights that resulted in their final product.

> Amy: The reason that I started doing the questions is I just didn't feel I was gettin' enough out of 'em. They would get up and either present their letter or if it was a poster board, they'd get up … introduce themselves, present their poster board, and I just felt like "Ok, but how did you get there?" I wasn't finding how they were getting there to be able to make that presentation. That wasn't gettin' shared. And that's what I was more interested in than anything. Especially since so often the results are not always correct. So, I was more interested in their thinking.

In addition, Amy also has particular reasons for making modifications to the outline. Some of these depend on the case study. For example, in the mini-golf activity, the students constructed a mini-golf course layout on poster board so they needed to describe the layout as part of the presentation. A question she continues to work on relates to their process. She wanted to know more about how they started the problem and then changed

their thinking. From a metacognitive standpoint, she is very interested in their reflection about their process.

> Amy: Cause some case studies lend itself more to talking about struggles they had getting started. What I would like them to hear them do more and this is another question I haven't figured out exactly how to word is paths that they started to follow like they thought "Oh, this'll work" and then what caused them to realize that it didn't. And, so then what did they start thinking next or move to next. Cause they jump from … they jump ... in their presentation, they jump from struggles that they had being something like "We couldn't figure out how to do it".

So, she added or changed some of the presentation questions to ask about first thoughts or early struggles they had with the problem. In addition, for the second activity, they did the introductory parts of the model-eliciting activity individually and she gave them time in class to think about it individually. As a result, when the students gave their presentation, they could talk about their first thoughts as individuals before describing what happened when they started to work as a group. The questions about process continue to emerge in the outlines and there may be other methods for asking students about their solution process that she has not explored yet. She could also ask them to reflect about their initial thoughts in writing or just before they start working on the problem as a group.

Another type of revision occurred when Amy implemented the problem with different classes of students. Amy implemented the *Million-Book Challenge* with her advanced classes and then tried it with the rest of her classes a week later. When the advanced classes solved the problem, they had a wide range of answers from about 6,000 to about 17,000 boxes to hold one million books. A question she began to ask groups after the presentation was how confident they felt about their answers. After seeing other presentations, some groups or individuals felt more or less confident about their answers. In answering this question, the students need to consider the method they had used to develop their method and the factors they had considered in order to arrive at a number of boxes. Since Amy found the question about confidence an effective way to understand more about her student's thinking, it was added to the presentation outline she used with the next set of classes (see Figure 3).

Million Book Presentation Outline

1. First thoughts
2. How you chose your group
3. Troubles
4. Plan to solve
5. How confident are you about your answer?
6. Read your letter.
7. Questions

Figure 3. Amy's revised presentation outline.

Dimensions of change for the Million-Book Presentation Outline and the Mini-Golf Presentation Outline included a focus toward individual thinking and improved questions to encourage students to reflect on their process by evaluating confidence in their answer. In addition, Amy noticed other questions that were no longer interesting to her. She mentioned

that their responses to how their group was formed or what group members did were not particularly interesting or did not change from problem to problem. Namely, students said they picked their friends or people who were sitting close to them. Tasks the group members did included writing the letter, getting supplies, and any construction tasks that came up. Occasionally, the students could describe a particular insight from a group member, but this was not typical. So, questions that do not give her information about their solution process might be changed or deleted from the outline.

A point for design experiments and teacher development about the express-test-revise cycle employed for data collection is that revision to the tool occurred not as a result of suggestions by a researcher, but rather because of implementation problems that Amy observed herself. When the students were not telling her everything she wanted to hear about their solution process, she developed a presentation outline. When the student's responses to the outline were still not completely answering her questions about their process, she revised the outline. This type of self-assessment of the product (in this case the presentation outline) is possible because Amy developed it out of a self-defined need and implements it with her own students. In addition, the tool is such that it can be shared with other teachers and easily modified for different model-eliciting activities.

Conclusion

Amy Green developed more effective tools to help her understand her student's solution process. The development and modification of the tools occurred over multiple model-eliciting activities. The presentation outline was changed in response to implementation in the classroom and her learning about questions that were or were not meeting her goals. Her self-identified goal was to learn more about the cycles of development of their solution. This parallels the researcher goal to learn more about her development as a teacher. The design of a tool also gives insight into what aspects of the activity are more important to the teacher. In Amy's case, she is interested in their solution process and her student's thinking. Revisions to questions are made with this end goal in mind. In other cases, the teacher is more interested in having the students clarify and explain their final product.

In this study where the teacher is the tool designer, teacher learning and development can be documented as they design tools for their own practice. The tools improve as they are tested in the classroom and teachers themselves can assess whether or not the tool is working. The express-test-revise design process allows researchers to document development. In addition, practical tools are designed that can be shared with other teachers; so potentially there are benefits for the research community and for teaching practice.

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