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**MAC-CPTM Situations Project**

***Chapter 6***

**Summary of Uses**

***by***

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Throughout the tenure of this project, we have attended to the *practice* of teaching mathematics. The prompts in each Situation came from our observations of real mathematics classroom events. Ultimately we want our work to have impact on that *practice* by leading to better mathematics understanding for secondary teaching. There is a basic assumption that the improved practice of mathematics teaching is derived from a deep understanding of the mathematics in the curriculum and the connections to the wider body of mathematics. Our Situations are connections to the mathematics identified by examining the prompts and the MUST Framework represents a synthesis of this work across more than 60 Situations that we produced.

**USERS CONFERENCE**

As we refined the process of creating the Situations and the MUST Framework we directed the project toward a national conference of potential users. Thus, our third Situations Project conference was a *Users Conference*, held at the University of Georgia in March 2o1o with more than 60 participants from across the country. We invited participants with a variety of interests in mathematics teacher education, postsecondary mathematics teaching, mathematics professional development, secondary school mathematics teaching, research in mathematics education, and mathematics curriculum development. This chapter will attempt to synthesize the ideas from the Users Conference. An appendix lists the participants, since sometimes the input of particular participants is indicated without any reference document other than “conference participant.”

It became clear early on that “Uses” meant not only uses of the products—the Framework and the Situations—but also uses of the processes. The conference was organized so that individuals and groups produced proposals for using either the materials or something from our approach. Many at the conference proposed direct uses of the materials with prospective teachers. Others concentrated on use of particular sets of the materials as stimulus for mathematics professional development with in-service teachers. Several proposals addressed using the materials in postsecondary mathematics courses. These uses included not only the Situations as mathematics explorations but also use of the Framework as a guide for analysis and discussion. Almost every proposal had some element of research or assessment included. Finally, many proposals cited uses of our materials and processes as a step to create materials (e.g., videos) for other work in mathematics education.

Some proposed uses were more orientated to incorporating the process of generating situations from classroom prompts into course or workshop syllabi. Certainly, the experience of producing the Situations and the Framework had been a stimulating journey for many graduate students and faculty who worked on the project. These processes can enable analysis and discussion about the various connections among mathematics topics.

The Users Conference also was a venue for discussing the value of our approach and also for thinking deeply about alternatives. Some users cautioned that the situations did not focus on the “best” way to present some mathematics topics. Rather, the building of connections seemed to give weight to some mathematics presentations that were not as good as others.

Many of the conference participants had some prior experience with the Situations Project, either as participants in one of the previous conferences for mathematicians and mathematics teacher educators or in using situations or the framework from the project within their own teaching or professional development activities. Therefore, their discussion documents generated at the conference communicated not only proposed uses but also some of their experiences.

On the other hand, the faculty and graduate students who worked on this project were active participants in mathematics teacher education, both in-service and preservice. There were many opportunities to informally try out ideas for the use of materials as they evolved. This chapter will summarize some of those experiences.

The discussion that follows will have sections on proposed uses of the Situations Project materials in several interrelated categories:

Research in Mathematics Education

Professional Development – Preservice Teacher Preparation

Professional Development – In-service

Teaching Postsecondary Mathematics Content Courses

Graduate Mathematics Education

Assessment in Mathematics Education

We also have made some use of Situation Project materials in our research and in our Mathematics Education undergraduate and graduate courses and some mathematics courses at the University of Georgia and The Pennsylvania State University. Some of these were reported at the users conference but some are included here as accounts of our experiences and ideas for use.

**USES**

In the presentation that follows, a large number of potential uses will be discussed. These tend to be brief summaries of the potential uses and they require elaboration and adaptation to particular contexts. Proposals at the conference tended to be two or more pages rather than a paragraph as presented here.

***Research in Mathematics Education***

The Situations Project is a long-term project of scholarly inquiry. It is a research enterprise and taken collectively, the MUST Framework and the Situations represent innovations for exploring mathematical understanding for secondary teaching. All of this work begins with observations of practice and emphasizes the exploration of mathematics that may be relevant to those observations of practice.

The Users Conference generated several suggestions for research based on the MUST Framework and the Situations.

***Study of results of professional development***

When the Situations are used as the basis for professional development with any elementary school, middle school, or high school teachers, corresponding research questions such as the following might be addressed:

1. What mathematics do teachers learn from this professional development?

2. What impact does the professional development have on teachers’ planning and preparation?

3. What impact does the professional development have on teachers’ instructional practice?

4. What impact does the professional development have on student achievement?

Almost every proposal at the Users Conference had comments about potential research or assessment questions.

***Study of the mathematical disposition of subgroups of master’s degree students***

In master’s-level programs, there are often up to four groups of students, all holding undergraduate degrees in mathematics: Non-mathematics education students who now want to teach high school and working for initial certification, current high school teachers who seek a higher degree and want to continue to teach high school, mathematics students who want to teach at the community college level, and mathematics students who do not plan to teach. Looking at how these four groups might respond to the mathematics in one or more situations could shed light on the mathematical dispositions of each group. Understanding those dispositions could lead to improved programs most appropriate to the groups.

***Study of mentoring practices with student teachers***

The mentoring of student teachers by an experienced critic teacher is essential, yet we know very little about structuring the discourse between student teachers and the critic teachers to engage mathematical thinking. The MUST Framework is proposed as a research tool to characterize the types of feedback mentor teachers give to their student teachers or to develop awareness of mathematical understanding to be observed and discussed in mentoring settings.

***Study of Situations for generating mathematical discussions***

A study by Conner, Wilson, and Kim (2011) reported on the use of a small set of situations with preservice and in-service mathematics teachers in a professional-development context. Their research found that the Situations led these prospective and in-service teachers to in-depth discussion and understanding of the mathematics relevant to the prompts. Students reported that the process often extended the range of their mathematical knowledge and understanding, sometimes recalling material they had not considered before or sometimes bringing them to explore new ideas. The material provoked increased levels of mathematical understanding.

***Empirical validation studies***

The MUST Framework represents an extensive set of hypotheses about the nature of mathematics understanding and its connection to practice. There were several conference participants who called for validation studies of the MUST framework with experienced mathematics teachers. Data are needed to verify or clarify the ideas of *mathematical proficiency*, *mathematical activities*, and *mathematical work of teaching*.

***Further development of the MUST Framework***

The MUST Framework is the key conceptual product of the Situations Project! In many ways, the particular Situations are not as central, and not necessarily unique. Many additional Situations might be possible, and the particular Focal discussions that have been produced are not unique. The MUST Framework was produced out of the Situations (such mathematical issues being found in classrooms)—thus, it is a type of “reverse engineering” result.

Now, it may be important to use the framework as a structure to generate Situations linked to teaching practices but which are now designed to give specific manifestations of the elements of the MUST Framework. Is there yet another level of analysis to consider? What are the connections across Foci within a Situation? What are the connections across Situations that link to the Framework?

***Research on preservice and induction-year(s) teacher education***

One proposal from the conference was to use the MUST Framework to identify the development of mathematical understanding across a preparation program and the induction years for prospective middle grades teachers. This program included a new organization that was not developed using the MUST Framework. Rather, the MUST Framework was to be a lens for examining the paths these teachers take in becoming mathematics teachers. The program incorporated several problem-based preservice mathematics courses and pedagogy that included mathematical “play.”

***Investigating the MUST Framework and Situations in action: An investigation of mathematics teaching***

Hatfield proposed this use with dual purpose—first as an implementation of a professional development in a school or as a capstone course in teacher preparation, and second as a research project tied to that implementation. The proposal was designed with the following stages:

Stage 1. Help practicing secondary mathematics teachers to use the MUST Framework as a conceptual backdrop for studying a variety of Situations with the aim of strengthening participants’ pedagogical content knowledge.

Stage 2. Engage the participants in their identification of new Situations, directly connected to what they are teaching. They would write and refine Focal analyses.

Stage 3. Each would conduct one or more lessons in which they would enact their usages of one or more approaches based on the mathematical ideas in the given, or constructed, Situation/Foci discussions.

Stage 4. Using video snippets, they would come together to engage in collaborative analyses of lesson events and student thinking. These could lead to further refinements, or extensions of their lessons.

Stage 5. After the professional-development project has ended, follow up with participants to see the extent to which they are continuing to use MUST Framework/Situations in support of their teaching and their professional work.

***Professional Development—Preservice Teacher Preparation***

Preservice secondary mathematics teacher education involves extensive study of mathematics content and mathematics education (i.e., mathematics teaching and learning). The Situations and Framework may find direct use as course materials for study and discussion. Quite often, however, a powerful strategy is to move from direct use of the materials for discussion to a mode of generating situations.

***Use of Situations in an undergraduate mathematics teacher education course***

At The Pennsylvania State University, Blume has used draft versions of the Situations in an elective course, Understanding Mathematics in Classroom Situations. He chose 23 draft situations selected for content not directly focused on algebra. These included trigonometry, geometry, number concepts, and statistics. The class met for 3 hours per session and usually examined 1 to 3 situations per class. Typical use was to pose some version of a prompt and then engage the students to react to the prompt with a focus on the mathematics ideas underlying the prompt rather than on pedagogical issues. This was followed by discussion of the students’ reactions to the prompt, developing or elaborating on the mathematical concepts underlying the situation. Next, there was opportunity for further development of some topics that arose from the discussion or development of ideas from Foci that were not addressed in the small groups and ensuing discussion. Homework assignments included explorations that constituted extensions of mathematical ideas encountered in class discussion, proofs of results that were conjectured to be true but not proved during class, and identification of additional mathematical ideas related to the Situation (e.g., a mathematical idea that might constitute the basis for an additional Focus for that Situation). Challenges faced included finding adequate time for following up on the mathematics topics that arose, making decisions about which mathematics content to pursue in depth, maintaining a focus on content rather than pedagogy, and difficulty in crafting the course into a coordinated sequence of topics.

***Developing a situation into an assessment instrument***

Situation 46: Division Involving Zero was used by Seaman in a Logic of Arithmetic class at the University of Iowa. Seaman adapted the Situation for an in-class writing assignment. Students were asked to decide what meant and how to address the student who thought should be 1. The mathematical Foci of Situation 46 provided a framework for examining student responses and follow-up to the lecture that had emphasized partitive and quotitive division. Seaman’s use provided a formative assessment for deciding further emphases to be incorporated in the lectures.



***Using Situations in an undergraduate mathematics methods course***

DuCloux and Lee also used situations to facilitate assessment and feedback within a secondary mathematics methods course. The prompts of Situation 1: Sin 32° and Situation 40: Powers were provided to the students in an online discussion. Students were asked (a) How would you respond to the student? and (b) What mathematical knowledge would a teacher need to know to provide a conceptually sound response? This assessment was near the end of the teacher education sequence just prior to student teaching. DuCloux and Lee were also examining research questions on mathematical proficiencies of preservice secondary mathematics teachers and on misconceptions that might be revealed. Such online uses require special attention to technical issues, establishing an online response/discussion format, and issues with lack of depth or superficial and imprecise explanations. Others at the conference had proposals for the online use of Situations with considerable warning about the special issues, both technical and motivational.

**U*se of the MUST Framework as a metacognitive tool***

Portnoy discussed this use in a course at the University of New Hampshire, Analysis for Secondary Teachers. It is a course designed to deepen prospective secondary teachers’ understanding of secondary school mathematics. Students are given context-based mathematical problems to investigate. These challenging problems require a deeper understanding of the secondary mathematics than future students in the secondary school will be expected to develop. Prospective student teachers are asked to find solutions to the problems and to find strategies that might be useful in explaining the solutions to secondary students. They are asked to keep a problem-solving journal that details their investigation and solution(s). The proposed use of the Framework as a metacognitive tool is to have the students code their journal according to the categories (mathematical proficiency, mathematical activities, and mathematical work of teaching) and subcategories of the MUST Framework.

***Use of the prompts from Situations in a first secondary mathematics methods course***

Jaqua proposed using discussion and analysis of the Prompts in the Situations to review the high school mathematics curriculum. Jaqua’s model for a first methods course proposes that the Situations would be a basis for prospective secondary teachers to explore their mathematics, discover what additional mathematics they need to know, solve problems and review curriculum at a deeper level, and determine connections to diverse mathematics content. Jacqua proposed giving the students the Prompt to a Situation and then requiring each to post online a discussion of the mathematics relevant to the Prompt. Students would read and respond substantially to the posts of at least two classmates. Face-to-face discussion of the submitted responses would be done in the next class meeting.

***Use in undergraduate mathematics methods and content courses***

We have received and granted requests for mathematics educators to try out and use the Situations Project materials in their courses. These have been liberally granted. We have not, however, systematically followed up and received feedback from these requests. The uses have included summer courses for in-service teachers, preservice methods and content courses for middle school teachers, mathematics content courses for elementary teachers, geometry courses for prospective secondary teachers, and others.

***Secondary methods course for the big picture***

McCrory, Winsor, TeCroney, and Edenfield proposed to use the MUST Framework to help students to see the “big picture,” including the complexity of knowledge and proficiency they are developing for teaching. They described their goal of using the Situations and Framework to help preservice mathematics teachers develop the inclination and ability to deconstruct and connect mathematics ideas. The emphases were on using the Situations to (a) provide a context for understanding ideas in the MUST Framework, (b) develop experience analyzing and deconstructing mathematical ideas (especially in conjunction with their work in Calculus 1), (c) develop a disposition to keep exploring mathematical ideas even when a single explanation is apparent, (d) develop and appreciate the benefits of collaborative work in mathematics, (e) learn to plan or prepare a lesson by attending to the mathematical ideas related to the lesson. Situation 24: Absolute Value was used to illustrate the proposal.

***Professional Development—In-service***

Discussion of in-service teacher professional development activities covered a wide range of activities, from the one-day professional development to activities that spanned an academic year. Some were targeted to particular school contexts, and others were more general.

***NCSM Facilitators’ Guides***

At the Users Conference in March 2010 Briars proposed development of Facilitators’ Guides for those who conduct professional development workshops. A facilitators’ guide would be built around the use of a particular Situation, giving background information and specific suggestions for professional-development session activities. The National Council of Supervisors of Mathematics followed up on this idea and proposed that a small number of Facilitators Guides be produced. Other participants of the Users Conference supported the ideas of this proposal.

In the spring of 2012 NCSM personnel and Situations Project participants developed a prototype Facilitators’ Guide for use with Situation 46: Division with Zero. This prototype was presented at the 2013 NCSM Annual Meeting in Denver. The discussions of the prototype were very positive and the decision was made by NCSM to work with the Situations Project to produce a total of six Facilitators’ Guides for the following Situations:

Situation 46: Division With Zero

Situation 01: Sin 32°

Situation 15: Graphing Quadratic Functions

Situation 27: Product of Two Negative Numbers

Situation 34: Mean and Median

Situation 43: Can You Circumscribe a Polygon?

Each of the guides contains specific information and resources to assist professional- development facilitators to conduct short-term professional development workshops around the content of one specific Situation. There are suggestions for time schedule, activities, and assessment. There are specific comments on the mathematical background required for each Focus in the Situation to assist facilitators to plan and conduct effective professional development workshops. Each Facilitators’ Guide is indexed to a set of pertinent Common Core standards. Suggestions for reflection and assessment are also included.

***Facilitators’ Guides for professional development***

Boone argued that well-designed facilitators’ guides and/or video demonstrations/models of the Situational Prompts (and/or various Foci) should be created to support both facilitators and teachers. Professional development opportunities will be necessary to help teachers think about the mathematics inherent in the posed Situations (as well as other situations that occur in a teacher’s classroom). Classroom teachers need to become more adept in determining the mathematics within a posed Situation, thinking deeply and comprehensively about the mathematics, and creating and implementing lessons that develop students’ mathematical thinking and understanding.

The importance of teacher professional development and the training of professional development facilitators should not be underestimated. Others at the Users Conference presented comments for assisting professional-development facilitators with using the MUST Framework and Situations as a means for mathematics explorations. Many of these ideas are implemented in the NCSM Facilitators’ Guides.

***Professional learning activities for in-service mathematics teachers***

Viktora and Jakucyn discussed using the MUST Framework and a Situation in a professional development day. They felt that such use as the basis of activities for a professional development day might be especially valuable for teachers who have been in the field for some time. One of the benefits of using these materials in this way for in-service teachers is to help them make connections across secondary mathematics and to give them a more complete understanding of the overall curriculum. These materials can be used as a springboard to encourage further teacher reflection and collaboration.

One approach would be to begin by presenting the Prompt of an appropriate Situation and encourage the teachers to think about the mathematics involved not just in the specific situation but also in a larger context. Thinking more generally about the mathematics that might be related to the prompt might be uncomfortable for teachers, but it can provide time for the participants to be prepared for discussion. The Foci of the Situation can be introduced and discussed, one at a time, followed by a conversation about how this activity can be helpful. The MUST Framework should be introduced, giving teachers time to read the document. (Given the constraints teachers face, it is probably not realistic to assume that teachers will have read the document ahead of time.) As part of the effort to encourage understanding of the MUST Framework, it is important to discuss how the Situations were used to develop the MUST Framework. Later in the day, several other Situations can be used. For instance, it might be valuable to group participants by course committees to analyze Situations appropriate to their courses. The day should end with an appropriate culminating activity that, hopefully, will encourage teachers to use these materials as a springboard to improving the mathematical quality of their lessons.

Viktora and Jakucyn also proposed that the same goals might be addressed in a capstone mathematics course organized with the MUST Framework and a set of the Situations.

***Planning a summer workshop and follow-up sessions for secondary mathematics teachers***

Gober discussed use of the MUST Framework as a guide in planning the activities for a summer workshop and follow-up sessions for secondary mathematics teachers. The MUST Framework helps a teacher to consider and plan learning experiences related to the different aspects of mathematics understanding for teaching: mathematical proficiency, mathematical activity, and mathematical work of teaching.The MUST Framework is also shared with the workshop participants as a guide for thinking about their own practice. As part of the workshop, teachers examine some of the Situations that relate to the mathematics they are exploring and delve deeper into the pertinent mathematics (mathematical proficiency and activity). During the school year, teachers meet regularly to plan units for the Georgia Mathematics III curriculum and discuss previously taught units. As teachers plan and share their reflections on lessons that have been taught, contexts for the development of new situations may arise. Teachers have opportunities to work together to generate new situations related to their own practice and/or apply knowledge and understanding of the situations and related mathematics discussed in the summer workshop (mathematical work of teaching). The MUST Framework is used to guide the design and implementation of workshop and follow-up activities. The workshops are tied to the interpretation and implementation of the new state mathematics standards.

***Developing mathematics teaching proficiency with middle school teachers***

Lappan, Borko, and Graysay emphasized the use of the MUST Framework to develop metacognitive awareness of middle school teachers as part of school-based, ongoing inservice to develop proficiency in mathematics teaching. The Situations Project materials, both Framework and Situations, would be used as a template for working with tasks focusing on mathematical areas of the curriculum. One example of a situation to use with middle school inservice is the Situation 07: Temperature Conversion, around which the professional development leaders would develop activities for teacher participation and discussion. In examining the Foci of the Situation, questions such as the following would be explored:

• How do your ideas compare to the set of ideas in the Foci?

• Where is the overlap? What ideas in this set are not present in ours? What ideas in our set are not present in theirs?

• What did you learn from this activity?

• What new mathematical ways of thinking did this activity stimulate for you?

• What new insights did this activity give you about the mathematics that would support your students’ thinking?

• What new insights did this activity give you about your students’ learning?

• What new insights did this activity give you about your teaching?

For homework, each teacher would identify a prompt from his or her classes that was mathematically problematic for the teacher or the students. Describe the setting and write the Prompt, Commentary, and Foci, using the Situations Template as a guide. The next inservice session should be built around sharing and discussing these teacher-produced situations. The cycle of homework and preparation of draft situations for discussion would continue. The final professional development session would focus on questions and discussion to assess the value of the program, such as:

• How have the MUST Framework and the development of Mathematical Foci been useful to my growth as a teacher?

• Share final reflections. How can we use the MUST Framework and Mathematical Foci, as a community, to continue enhancing our knowledge, dispositions, and practice?

***Bi-Weekly professional development group of 8 to 10 mathematics teachers***

The context would be an urban high school 2-hour after-school session, two sessions per month. Benson suggested the use of prompts from the Situations as mathematics stimuli to engage and focus mathematics teachers on a task of common interest. He was undecided whether to share the MUST Framework with teachers but would use it as a guide. Likewise, the initial session would be to get the group of mathematics teachers to suggest mathematics Foci for the Prompt. Eventually, a goal would be to have teachers create their own situations based on the discussions. Whether to use the project Situation Foci would be decided on a case-by-case basis.

***Bi-Weekly or monthly electronic dialogue for mathematics teachers***

Harrington also proposed mathematics teacher dialogues built from selected Situations but suggested the use of electronic discussion and a focus on the three broad areas from the MUST Framework: mathematical proficiency, mathematical activity, and mathematical work of teaching. The structure would have a teacher leader or participant observe an event in a classroom that was fertile enough for expanded conversation and post a description to the electronic discussion board. Facilitating questions would follow as needed to generate discussion about mathematics that might be helpful.

***Use of Situations and Framework with in-service elementary teachers in professional development settings***

Although our project collected Prompts primarily from secondary settings, there were several at the users conference who saw the use of selected situations and the process with elementary teachers. Seaman proposed a summer workshop setting for elementary teachers where selected Situations would be chosen that address particular issues (e.g., fractions) that assessments have indicated to be a need for elementary teachers. The summer workshops would have a format of 5 consecutive 8-hour days. The MUST Framework would be used to align discussions and solutions with mathematical proficiency, mathematical activity, and mathematical work of teaching.

The workshop would probably be built around a small number of Situations, perhaps adapted so that the content was within the grasp of elementary teachers. A selected Situation would be the initial focus for thinking about the mathematics in the Prompt. The sequence might follow a pattern of discussion of the problem, work on the problem, and then follow-up discussion. A postworkshop assignment of 2-days of work consisting of a mathematics inquiry or exploration based on ideas generated in the workshop would be completed with electronic reporting of that postworkshop work. Additional Situations from the project could be the source of the postworkshop work.

***Inservice teacher professional development***

Harrington proposed using the MUST Framework for inservice professional development and using the Situations as specific contexts for discussion of mathematical proficiency, mathematical activity, and mathematical work of teaching. His experience suggests that this needs to be a full-day teacher inservice. The format of the inservice using small-group and large-group work sessions, begins with an overview and discussion of the MUST Framework, followed by discussion of a Situation or multiple Situations. To avoid having teachers view this workshop as a make-it-take-it for their next lesson, he would select Situations and direct discussion toward more general proficiency.

***Looking across Situations through the MUST Framework***

This use proposed by Lannin and Kastberg selects a set of Situations that are related (for example, the use of *variable* or *domain*). Foci across Situations would be examined and discussed by teachers as a means of relating them to the MUST Framework. The goal is to have teachers explore mathematics ideas that bridge several Situations and the roles these more global ideas have in the mathematics curriculum. The ultimate goal is to ask, “How does the analysis of Situations impact practice?”

***Using the MUST Framework and Situations in a lesson study model of inservice***

This proposal came from Winking, using the Gwinnett County’s High School Mathematics Institute. The Institute is set up to meet for a week in the summer and explore tasks to be used in classrooms for the Georgia Performance Standards (GPS). That is followed by meetings twice per month throughout the following year. Teachers are given a potential GPS task and, using the MUST Framework as a guide, they are to use the strategies of Lesson Study to develop a teaching episode. The identification of an appropriate range of foci is essential to this process. Several examples were suggested from a web site at Phoenix High School.

***Lesson study with secondary mathematics teachers***

Hix proposed a synergy between the MUST Framework and Situations and the inservice process of lesson study. One challenge of implementing lesson study is that teachers in the United States often do not understand how to attend to the mathematics of a lesson. Attending to the mathematics of a lesson includes the development of mathematics necessary for the teacher to carry out the task of teaching. This mathematics goes beyond the mathematics of the lesson, and it is the facet that often eludes teachers. Considering the Situations and multiple Foci, the teachers may be able to more directly and deeply develop this mathematics. The teachers would begin their lesson study during the summer, studying the MUST Framework and using the Situations to begin their lesson-study activities.

***Personal reference documents in the MUST Framework and Situations***

Jakucyn and Viktora proposed that the MUST Framework and the total set of Situations might be viewed as a personal reference guide for mathematics teachers to use in personal planning for teaching episodes. Once a Situation is selected relevant to the teacher’s episode planning, the Foci will help to provide a better idea of the depth and breadth of the mathematics. This will enable the teacher to use the ideas of mathematical proficiency, mathematical activity, and the mathematical work of teaching. Part of the goal is to encourage teacher reflection and these materials provide a range of support for that reflection.

An extension of this reference guide or library concept is to make the collection one that grows as new situations might be developed locally or shared with others.

***Masters course in curriculum design for secondary mathematics teachers***

Burke observed his experiences with master’s degree students who often do curriculum redesign for the purpose of action research or a capstone project. He proposed using the MUST Framework and situations for a decision-making course on guiding the redesign of particular curriculum units. The course would present students with examples of Situations, each of which have five Foci—one elucidating each of the Mathematical Works of Teaching of the MUST Framework. Students would be asked to contribute more options within each Focus that went beyond the examples included in the Focus. This would give students the opportunity to illustrate or see how specific aspects of mathematical proficiency and mathematical activity can emerge as critical features of the mathematics their own students might do. Collectively, the Situations should give multiple focused expositions of the type of proficiency that would be helpful in a variety of topics and contexts for curriculum decision making.

With this grounding in the MUST Framework and Situations as pointers to the multifaceted nature of understanding and doing mathematics, the students would design their own situations both using prompts provided to them and in situations for which they must provide the prompts. Once students have gained insight into the rich possibilities revealed by the MUST Framework and have addressed other issues related to curriculum design (students with special needs, cultural relevance, methods for engaging students, use of technology and other instruments, pedagogical decision making, etc.), they would be asked to redesign a unit of mathematics in their curriculum. They would be asked to teach the unit and use daily journals to note student learning, wondering, and questioning. They would be asked to produce two or three pivotal situations that capture the highlights of the mathematical thinking that was achieved in the unit. They would be asked to pay particular attention to the foci on assessing and accessing student thinking in the write-up of these situations while still reflecting on and producing foci related to the other components of MUST Framework. These situations would be submitted as part of their overall evaluation and analysis of the unit and its effect on student learning.

***Using the MUST Framework to guide teachers in their analysis of current curricular materials***

This proposal from Sheehy takes the use of the MUST Framework and Situations into the schools were teachers deal daily with the implementations of mandated standards. In this case, the curriculum standards to be implemented were the Georgia Performance Standards, but the ideas here would apply to Common Core standards as well. The setting was envisioned as a small group of teachers in the same school meeting to select materials and plan lessons. The role of the Situations might be that of a curriculum-materials resource as they are coordinated with standards and resources the teachers have available.

The MUST Framework would be used to guide discussions teachers might have in identifying the need to use a particular task with students. Then, that task would be used for developing sets of foci related to the task, rather than a prompt. The MUST Framework would help teachers attend to mathematical proficiency, mathematical activities, and the mathematical work of teaching. By generating a list of mathematical foci related to each task, teachers will be able to reflect on their own mathematical knowledge as well as that of their colleagues. Teachers take the time to study mathematics together, discuss multiple means of representation, identify any misconceptions or gaps in their own understanding of a given topic, offer predictions about the concepts that will be difficult for students to grasp, and connect this planning to their teaching practice.

***Building from mathematical foci toward statistical foci***

In this proposal, there is a plea to use and extend the MUST Framework for teachers to think specifically about how mathematical proficiency, mathematical activities, and the mathematical work of teaching can be drawn for the practice of teaching statistics. It would include having teachers augment the MUST Framework to involve more statistics ideas. Situation 34: Mean and Median was used to illustrate how that Situation could help direct teacher discussions of things both mathematical and statistical. There is a dual purpose here: One is for teachers to know the mathematical structures that are useful in understanding statistical concepts and the other is for developing better understanding of the statistics concepts and ways of thinking that should be used when engaged in data analysis and probability tasks.

***Use of Situations and the MUST Framework with inservice elementary teachers in professional development settings***

Even though most of the materials from the Situation Project are oriented to the middle school or secondary school level, many participants saw adaptations that were appropriate for use with the teaching of elementary-level mathematics. Seaman developed this proposal, with several options, for use in professional development activities in mathematics summer-workshop settings for elementary teachers. Workshops have generally consisted of 5 consecutive 8-hour days. In this proposal, emphasis would be on getting teachers to discuss and understand mathematical proficiency, mathematical activities, and the mathematics work of teaching from the MUST Framework. The Prompts would form the launch point for student inquiry and engagement. This would be followed by engaging teachers in thinking about and discussing multiple/alternative solution strategies to a given mathematics problem such as are exhibited in the Mathematical Foci. This would expose teachers to a variety of problems arising in school mathematics contexts that generate sophisticated mathematics questions and require precise definitions and arguments to resolve. Hopefully, this would foster a feeling of mathematical empowerment in teachers that they are not alone in being unfamiliar with certain mathematics they may have encountered in learning and teaching settings. Additionally they will see that simple-sounding mathematics questions may require sophisticated mathematics to resolve. Even for teachers who may not have the mathematics background to produce complete solutions to prompts, we hope to encourage them to contribute as much as they can and then use the Mathematical Foci to help fill in gaps in solutions or explanations.

***Teaching Mathematics Content Courses***

Many of the proposed uses of the Situation Project materials dealt with instruction in mathematics courses. Most of these were upper-division courses for teachers.

***Use of the MUST Framework as an organizational guide for content courses for middle school or high school***

Beckmann discussed ways to use the Situation Project Materials in content courses for middle school or high school students. The MUST Framework was viewed as a guide for engaging students to think deeply about the mathematics in which they engaged. The Framework provides not only a guide for the instructor in organizing courses but also, as Situations are examined, the Framework provides a structure for students to identify elements of mathematical proficiency, mathematical activities, and the mathematical work of teaching in the content and contexts. These uses envisioned adapting the Situations for various courses but also creating Situations to provide a coherent whole to each course.

***Using the MUST Framework in teaching advanced graduate mathematics courses***

Smith discussed his experiences of using the MUST Framework in teaching a range of advanced graduate mathematics courses. The framework succeeds, with a clear and convincing argument, that mathematical teaching and learning must involve three aspects: internalizing procedures and facts, creative use of knowledge in problem solving, and facilitating learning through understanding how we think about mathematics, (i.e., knowing, doing, and teaching). The MUST Framework was viewed as useful to an individual teacher as a guide to planning a course, as a guide for conducting an individual class, and a guide for assessing the success of the class. Smith assigns the MUST Framework for students to read and absorb. The use envisioned here would give the students a prompt and challenge them to develop their own path, or collective path, to a set of foci. Smith’s experience includes teaching college courses for mathematics majors, mathematics courses for teacher candidates, and high school courses for honors mathematics students.

***The MUST Framework as a guide for teaching an abstract algebra course for teachers***

Cofer proposed uses of the Situation Project materials in an abstract algebra course for prospective teachers. The MUST framework would serve as a background document for the instructor to use in organizing and assessing course activities. Situations would be selected and adapted for relevant abstract algebra topics. The mathematical goal woud be to scaffold students’ understanding of advanced and theoretical algebra concepts by connecting the key ideas to familiar mathematics relevant to the school curriculum.

***Using the MUST Framework and the Situations to organize capstone courses for teacher preparation***

Capstone courses are a key point in mathematics teacher preparation at many institutions. The use of Situations in such courses was proposed by several Users Conference participants. Lee proposed using the MUST Framework and engaging students in explicit discussions of mathematical proficiency, mathematical activities, and the mathematical work of teaching as various topics were explored from an advanced perspective. This capstone course would coordinate the use of various Situations with the presentation of material in a textbook that might be used.

***Transition to higher mathematics course: A course emphasizing mathematics proof and problem solving***

Benson proposed using the processes from the Situations Project in the development of a course for secondary teachers in a transition to higher mathematics course or for a course on mathematics proof and problem solving. A set of situations would be developed for this course using the Situations Project model. In other words, the syllabus would be built around a set of situation-like episodes developed explicitly for each course.

***Organizing a calculus course***

McCrory and Winsor proposed using Situations within a calculus course to show different representations of key concepts. They would select or create specific Situations but not explicitly use the MUST Framework.

***Algebra for elementary and middle school mathematics teachers: Functions***

Senk proposed incorporating the use of the MUST Framework and selected Situations into two existing courses at Michigan State University. These were upper-division mathematics courses for preservice elementary and middle school mathematics teachers majoring in mathematics: MTH 304, Algebra for Elementary and Middle School Mathematics Teachers and MTH 305, Functions and Calculus for Elementary and Middle School Mathematics Teachers. The MUST Framework would be to focus the students on the mathematical activities, mathematical proficiency and the mathematical work of teaching. These courses are to broaden and deepen the mathematics understanding of future teachers and attention to the MUST Framework is a way of doing that. Typical use of the Situations would present the Prompt followed by individual or group exploration and discussion followed by class discussions of the mathematics relevant to the Prompt. Examination of the set of Foci in the Situation might then be pursued. Also, homework could be developed from some situations. Homework might involve assigning an entire Situation to study, it might involve presenting the prompt and having the students produce potential foci, or it might involve having the students develop a particular focus.

***A writing-in-mathematics course***

Bona described a course, Writing in Mathematics, required of all mathematics majors at the University of Illinois at Chicago. The Situations provide a rich source of ideas for mathematics essay topics.

***Material for exploring misconceptions about f(x + y) = f(x) + f(y)***

Royster proposed developing a situation-like episode to investigate the common misconceptions about *f*(*x* + *y*) = *f*(*x*) + *f*(*y*). Misconceptions include the assertion that it is never true and assertions that it is true for cases for which it is not true. The developed material would lead students to explorations of conditions when the equation is true for all arguments. The material would be appropriate for a capstone course.

***Graduate Mathematics Education***

Many of the proposals from the Users Conference could be adapted to elements of graduate study in mathematics education. In this section, however, some work at the University of Georgia is discussed. The first of these is a 3-semester-hour course, Mathematics Connections, for which the syllabus was built around use of the Situations Project materials. The second is a brief account, reported at the Users Conference, of using the development of a Situation as a class project in a master’s degree seminar. The third is an account of an applied project for a Specialist in Education degree student who was a high school mathematics teacher who used prompts drawn from his classes. In addition, doctoral students have used the MUST Framework to help build rationale for research questions.

***A course on mathematical connections***

The EMAT 6500 Mathematics Connections course at the University of Georgia is a mathematics teaching field course for graduate students—in-service teachers working toward the Master of Education degree or candidates pursuing initial certification at the master’s level in the Master of Arts in Teaching degree. All students would have mathematics background equivalent to an undergraduate major in mathematics.

The author developed a syllabus and taught this course built around four components:

1. The Common Core State Standards in Mathematics (CCSSM),
2. The CCSSM Standards for Mathematical Practice,
3. The MUST Framework and Situations,
   1. Situation 01: Sin 32˚
   2. Situation 03: Inverse Trigonometric Functions
   3. Situation 08: Point on a Moving Segment
   4. Situation 09: Perfect Square Trinomials
   5. Situation 10: Simultaneous Equations
   6. Situation 20: Area of Plane Figures
   7. Situation 21: Exponential Rules
   8. Situation 28: Adding Square Roots
   9. Situation 27: Product of Two Negative Numbers
   10. Situation 39: Summing the Natural Numbers
   11. Situation 40: Powers
   12. Situation 43: Can You Circumscribe a Circle about this Polygon?
   13. Situation 46: Division by Zero and Situation 46 Facilitators’ Guide From NCSM, and
4. The creation of new situations.

The course objectives were:

1. To learn about and develop and understanding of the CCSSM grade-level standards;

2. To become aware of and implement the CCSSM Standards for Mathematical Practice;

3. To explore Mathematical Understanding for Secondary Teaching (MUST) via the components of Mathematical proficiency, Mathematical activity, and the Mathematical work of teaching

4. To explore MUST principles via examination of Situations prompted from classroom episodes;

5. To create MUST Situations from possible classroom episodes;

6. To engage in independent investigations of mathematics topics using the MUST framework; and

7. To examine correspondence among the MUST Framework, CCSSM standards, and the NCTM *Principles and Standards for School Mathematics* (2000).

The first few meetings of the course were devoted to discussions of the MUST Framework, the Situation Project generally, the CCSSM *Standards for Mathematical Content* , and the CCSSM Standards for Mathematical Practice. These meetings accomplished a general orientation to processes and products of the Situation project.

Throughout the course, the typical format of the class sessions was developed around discussions. In using the Situations from the project, the students preferred to explore the Prompt, collectively or individually generate some ideas for mathematical foci, engage in discussion, and then examine the Foci from the project. Usually the first examination of a Prompt from a project Situation was in a homework assignment. All materials were available on the class web site.

After discussion of about six of the Situations, we moved to a mode of creating drafts of new situations. This was a critical phase of the course that required direction of the instructor and willingness to discuss the process as well as potential products. Students were given a template for the Situation format with Heading, Prompt, Commentary, Foci, and Postcommentary. They were encouraged to generate prompts from their own experience, but they were also given a list of Prompts from the project that had not been developed into final Situations.

The creation of situations involved the basic ideas described in Chapter 5. The completion, discussion, review, and revision of situations in final form were significant activities for the course. After examining and discussing the first five Situations in the preceding list, the course included a group project to respond to the following prompt:

An Algebra II class has been examining the product of two linear expressions:

(*ax + b*)(*cx + d*).

Well into the class, a student asks, “What would happen if we DIVIDED one linear expression by another?”

Two groups worked independently on developing a set of topics that would eventually be developed into foci. There were discussion sessions within and across the groups. Actually writing of the foci demanded much more than the students anticipated, but they came to believe that the writing and revision process contributed greatly to their understanding of the topics. The two teams came up with slightly different final products—different in terms of the foci and different in the discussion of the foci. Regardless, they all agreed that the process of creating a completed situation, using the template to standardize the process, contributed to a more thorough understanding of the topic. In each of the two groups’ products, essential points of asymptotes, undefined values, division of polynomials, and roots were addressed.

During the second half of the course, each student was expected to complete three situations in final form. Students presented their drafts and engaged the class in discussions. Every student-generated situation went through multiple discussions and revisions. All drafts and final write-ups were posted on the course web page. The topics for the final situation write-ups were:

Quadrilaterals

Pythagorean theorem

What is π?

Limit and sum of a series

Solving logarithmic equations

Parentheses and brackets

180 degrees in a Euclidean triangle

Adding fractions

Increasing or decreasing functions

Infinity + infinity

Zero vs. nothing

Slopes of perpendicular lines

Complex roots

Line of best fit

Exponential bases

Translating functions

False identity

Multiplying binomials

Exponential rules

Irrational lengths

Numbers raised to the zero power

Congruent triangles vs. similar triangles

Zero slope; undefined slope

Simultaneous equations

This use of the Situation materials and the Situation Project strategies fit nicely for this particular course with a small cadre of well-prepared graduate students. The free-flowing and creative student discussions introduced some unanticipated topics and required some additional preparation by the instructor. From the perspective of the instructor, these course activities demanded more depth and breadth of mathematical knowledge than had other approaches to this course.

*Looking back*

The following are some observations about use of the Situation Project processes and materials in this course.

1. There was demand on the instructor to respond to a wide range of mathematics content knowledge, make suggestions to students, and work to redirect some of the issues that grew out of the discussions.

2. There was a strong tendency for students to connect course content to their knowledge of existing school curricula. Suggestions from the instructor or from the discussions were often needed to broaden the perspective.

3. Connecting discussions to the CCSSM content standards was hampered by the views these students held of the CCSSM standards. Basically, the CCSSM content standards were thought to represent all that was to be included in the school mathematics curriculum rather than a minimum level. If a Situations topic was not explicitly mentioned in the Common Core materials, there was resistance to considering it.

4. We found, via discussions, much agreement between the CCSSM Standards for Mathematical Practice and the MUST Framework of Mathematical Proficiency, Mathematical Activity, and the Mathematical Work of Teaching.

5. Students expressed a desire to revise the Situations from the Project. This may have been an artifact of our organization of the course, in that they reviewed the Prompt, and then generated their own list of topics that might be considered for Foci. When they examined the project-produced Foci, they often found topics they thought to be important that were not present or were stated in a different way. On the other hand, they usually found additional topics in the project-produced Foci that they had not uncovered. Regardless, this process was helpful for getting students to think critically about the mathematics content represented in the Prompt.

***Master’s seminar on mathematical knowledge for teaching***

The goal was to understand the process of specifying mathematics knowledge for teaching. The seminar chose to pursue this goal by looking at a particular mathematical entity (a real-valued function that is the quotient of two first degree polynomials) and using a much earlier draft of the MUST Framework as background for examining this topic.No Situations were used directly. Students in the seminar had studied and discussed several of the Situations. We felt the process of developing a Situation write-up for a new topic would be instructive in the seminar format.

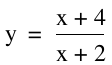
This was a master’s level graduate seminar in which all participants were either experienced teachers or master’s degree candidates who had completed a mathematics teaching internship or student teaching in mathematics at the secondary level. Three of them were graduate students with teaching experience outside the United States. Class met once per week.

The following prompt was proposed:

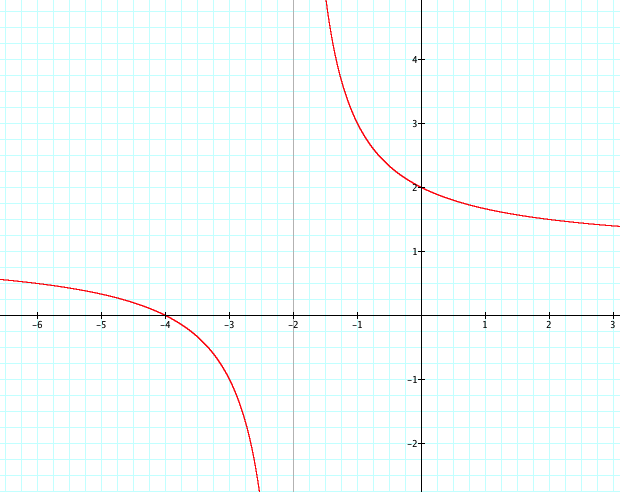
A high school algebra class was studying multiplication of binomials (factoring and roots) *ax* + *b* and *cx* + d. A student asks, “What if we divide instead of multiply?”

The students organized into small groups and worked on developing the situation write-up over a period of 3 weeks. There were extensive revisions.

A significant activity, individually as well as in the group, was to produce a graph of an example and play with changing the parameters *a*, *b*, *c*, or *d*. This helped the seminar participants to identify special cases and general patterns. For instance, using Graphing Calculator 3.6 students produced the graph of (see Figure 1.)



In other words, the parameters were *a* = 1, *b* = 4, *c* = 1, and *d* = 2.



*Figure 1*. Graph of .

Then, by substituting *n* for one of the parameters and animating the graph, a family of graphs could be examined. This eventually led to algebraic characterizations of various observations about the curves, asymptotes, domain, roots, and the like.

The word *play* was chosen intentionally. In no case did these students want to argue that the graphs were proving anything.

By the third week, the class had produced the following Commentary and Foci:

Commentary

In our foci, we are assuming that we have a new function *f*(*x*) = (*ax* + *b*)/(*cx* + *d*). We prove that this is a function within Mathematical Focus 3 (asymptotes). With this new function, we find that there are restrictions on the domain and range, unlike the function *f*(*x*) = (*ax* + *b*)(*cx* +*d*). In this situation, we do not consider complex numbers. We see that the graph of this function is always a hyperbola, with the exception of the degenerative (or undefined) cases. To completely discuss hyperbolas, we found it important to discuss how to represent the roots and intercepts, graphically and symbolically. It is also necessary to show how the coefficients a, b, c, and d affect the graph. In the last two foci, we explain the limits and the inverse of the function.

Mathematical Foci

Mathematical Focus 1: Roots and intercepts

Mathematical Focus 2: How the parameters *a*, *b*, *c*, and *d* affect the graph

Mathematical Focus 3: Asymptotes

Mathematical Focus 4: Limits

Mathematical Focus 5: Inverse of *f*(*x*)

Mathematical Focus 6: The function is always a hyperbola, with the exception of degenerative or undefined cases.

As the instructor, the author found several recurring issues in this course. These included (a) struggle with precision of language; (b) constant pressure to change focus to pedagogy rather than mathematical knowledge; (c) lack of knowledge of, or interest in, applications or historical perspective; (d) pressure to be guided by (even satisfied with) what is in some particular syllabus or textbook; (e) redundancy; (f) difficulty with being explicit about their perceived connections to the MUST Framework; and (g) unwillingness to relate this work to the mathematics of more general functions that are the ratio of two polynomials, one or both of which may be of degree greater than 1. On the other hand, there was strong evidence that the seminar participants engaged in challenging reflection about this task.

***Specialist in Education applied project***

The Specialist in Education Degree at the University of Georgia is a degree program for 1 year of study beyond the master’s degree. In mathematics education, a very significant component of the degree is an applied project that is developed with some connection to the student’s teaching assignment. One such project at the University of Georgia was developed by a teacher at the local high school who held an undergraduate degree in mathematics from the University of Tennessee and the Master of Education degree from the University of Georgia. The applied project developed from interest in our Situation Project but not as a graduate student working on the project. Using the Project guidelines for Situation development from prompts observed from classroom episodes, the teacher developed 10 prompts from his classes. Then he developed the following 10 situations building on those prompts:

PN1. Dividing an Inequality by a Negative Number

PN2. Slopes of Perpendicular Lines

PN3. Absolute Value in the Complex Plane

PN4. Simplifying Rational Expressions

PN5. Finding the Mean of a Set

PN6. Modular Arithmetic

PN7. Complex Numbers

PN8. Functional Representation

PN9. Constructing a Tangent

PN10. Area of Intersection of Two Circles

This turned out to be a very challenging Applied Project. This teacher did not have the benefit of a team of people working with him to share ideas for foci. Each Situation required several revisions. On the other hand, three of his Situations were eventually adopted by the Situations Project.

***Assessment***

Assessment activities making use of the MUST Framework and the Situations were proposed at the Users Conference. Portnoy suggested creating an instrument to assess the MUST level of novice teachers upon graduating from various teacher education programs. For example, at the University of New Hampshire there are two paths to certification, an undergraduate path and another postgraduate path. The first requires the candidate to spend 1 semester (usually the final semester of the program) student teaching. The second places graduates in yearlong internships at cluster sites (similar to professional development schools). A question that arises is whether one could evaluate and compare these two programs using measures based on the MUST Framework.

At a different level, assessment activities are built into each of the NCSM facilitators’ guides. These assess the specific goals of a particular Situation and the professional development associated with it.

***Understanding how to assess statistical thinking and reasoning***

The MUST Framework and a Situation were proposed by Franklin to help high school teachers come to better understand how to assess statistical thinking and reasoning. Rather than tests of procedural fluency, the proposed assessment used the MUST Framework with a statistics Situation and a set of guided questions to evaluate the goals embedded in the situation. This particular proposal was geared either to in-service high school teachers in professional development workshops or to students in preservice mathematics education courses. The statistics example was Situation 34: Mean and Median. Some of the guided questions suggested were:

1. Is this student's approach the one you would have used?

2. If not, what approach would you present?

3. Discuss the strengths and weaknesses of the student’s write-up. How does the student's approach compare to the other approach(es) suggested within your group?

4. What type of thinking and/or reasoning was used by the student (mathematical or statistical)? Explain.

5. Of the approaches under consideration (student and group), how do these approaches connect with the Framework (MP, MA, and MWT)?

6. What are the intended mathematical and/or statistical goals that you see being assessed with the prompt?

7. How do these goals connect with the Framework?

8. What are goals missing from the Prompt you consider important to assess?

9. How would you improve the Prompt to meet these missing goals?

10. Develop a scoring rubric for the new and improved Prompt. Write a model solution for the Prompt. Also, note other possible acceptable solutions. Clearly outline what you would consider a complete solution, a substantial solution, a developing solution, and a minimal solution from the student.

11. After developing the rubric, revisit the Prompt. Do you believe the rubric allows you to adequately assess the intended goals?

12. How might you change your teaching to better meet these goals?

***Use of the Situation structure in a mathematics instruction examination***

Wilson implemented an assessment in a University of Georgia graduate mathematics education class based somewhat on Situation 27: Product of Two Negative Numbers. Situation 27 had not been explicitly studied by this class. In the assessment, a modified version of the Situation 27 Prompt was given and then the students were asked to provide two responses. The first was to list as many mathematics perspectives as they could determine. This was similar to making a topic list for a range of Foci. The second was to describe an instructional sequence they would use to help ninth-grade students understand why the product of two negative numbers is positive. It is assumed that ninth graders would “know the rule.”

The results were surprising. The lists of mathematics topics varied greatly from one to as many as eight. Only 3 of the 10 teachers listed some version of using the properties of number systems (e.g., inverses, distribution, identities) as suggested by Common Core. On the second part, however, the proposed instruction from 7 of the 10 experienced teachers attempted some version of using multiplication as repeated addition as a means to develop understanding. None of them saw any unjustified statements in the process. The Common Core objective of justifying that (-1)(-1) = 1 on the basis of the properties of number systems was cited by 7 of the students but none of them implemented that approach in their proposed instruction.

The assessment was successful, not in deciding progress, but rather in redirecting the class discussions to some useful and in-depth explorations. This led to several looks at the use of the number-system properties, geometric interpretations, and use of applications and models.

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**APPENDIX**

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