

MATHEMATICS TEACHERS' PERSPECTIVES ON FACTORS AFFECTING THE IMPLEMENTATION OF HIGH COGNITIVE DEMAND TASKS

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While there are instructional practices researchers claim teachers should be engaging in, (e.g., use of technology, implementing high cognitive demand tasks) often times teachers are either not engaging in these practices or not successful with implementation (Henningsen & Stein, 1997). I conducted a research study from the perspective of three middle school mathematics engaged in professional development around the implementation of high cognitive demand tasks (Smith & Stein, 2011) and whether or not they could identify when the demand of task was lowered and maintained and what factors contributed to either instance. This report details the teachers' perspectives and hopes to contribute to the body of knowledge around those providing professional development to teachers and how to use teachers' perspectives to shape the professional development to support teachers' use of instructional practices.

Keywords: Teacher Education –Inservice/Professional Development

Smith, Bill, and Hughes (2008) stated, “mathematical tasks that give students the opportunity to use reasoning skills while thinking are the most difficult for teachers to implement well” (p. 132). Teachers should be able to select tasks appropriately and implement those tasks while maintaining demand in order to support students' mathematical thinking (Henningsen & Stein, 1997). These assertions are based from research on teachers' implementation of high cognitive demand tasks that occurred from the researchers point of view (e.g., Henningsen & Stein, 1997; Stein, Grover, & Henningsen, 1996). My goal was to understand from the perspective of middle school mathematics teachers what they cited as impacting the demand when implementing high cognitive demand tasks. In doing so, I was hoping to break down the barrier between teacher and researcher by talking with the teacher and understanding what they claimed made the implementation of a high cognitive demand task difficult and they cited as supporting their efforts to maintain demand. Prior work has solely been from the point of view from the researcher and I wanted to see if teachers could identify the factors that either led to the decline of demand or helped maintain the demand of a task and do more than just provide the account of the lesson from my point of view. If teachers could identify those instances, I maintain that someone working with the teacher would then be able to help a teacher build upon their strengths in maintaining demand and support the teacher around what was lowering the demand of a task. By offering the teachers' perspectives, those working with teachers can anticipate possible roadblocks and provide the necessary support needed when implementing any new instructional practice being learned. The research questions that guided my study included: What are teachers' perspectives of their classroom practices as they implement high cognitive demand tasks? What factors do teachers identify as affecting the implementation of high cognitive demand tasks?

High Cognitive Demand Tasks

Cognitive demand refers to the amount of effort a student needs to expend to think about a problem, and mathematical tasks are categorized in two levels, low and high cognitive demand. Smith and Stein (2011) outlined and characterized four different sublevels of the demands of tasks: memorization tasks, procedures without connections tasks, procedures with connections tasks, and doing mathematics tasks. Memorization and procedures without connections are low cognitive demand tasks while procedures with connections and doing mathematics are high cognitive demand

tasks. This study focuses on teachers implementing high cognitive demand tasks. Research on high cognitive demand tasks to date has focused on whether teachers could identify high cognitive demand tasks and if teachers maintained the level of demand during implementation as determined from the researchers point of view (Henningsen & Stein, 1997; Stein et al., 1996). Stein and colleagues (1996) wanted to observe and portray the nature of the mathematical task as implemented by teachers and found the teachers had success selecting and setting up high cognitive demand tasks but were not as successful in maintaining the intended level of cognitive demand throughout the lesson. Stein and colleagues characterized factors related to the maintenance or decline of cognitive demand during task implementation, but these observations were entirely from the perspective of the researchers. In a follow-up study Henningsen and Stein (1997) looked more closely at the classroom factors associated with the implementation of high cognitive demand tasks, specifically tasks classified as *doing mathematics*. The researchers looked at how tasks at that level affected student engagement and found many factors associated with both the maintenance and decline of demand. Although the researchers described and characterized factors associated with the implementation of high cognitive demand tasks, they used archival data and therefore were unable to include the teachers' perspectives on what happened during task implementation. In these studies, the researchers were unable to converse with teachers to gain their perspectives on whether they realized they lowered demand and if so, their reasons for lowering demand.

Teachers' Perspectives

Research on teachers' perspectives seeks to give voice to teachers. Some research studies on gaining teachers' perspectives involved the researchers understanding topics that have been documented as being beneficial to student learning (eg. technology in the classroom, teaching thematic units) but lack the teachers' perspectives of the reality of implementing such structures in the classroom (Handal & Bobis, 2004; Wachira & Keengwe, 2010). Both Wachira and Keengwe (2010) and Handal and Bobis (2004) wanted to identify barriers that kept teachers from implementing different aspects of instructional practices that research has shown to positively influence students' learning of mathematics. Wachira and Keengwe wanted to gain urban teachers' perspectives on integrating technology in their mathematics classrooms to see if urban teachers' perspectives aligned with research on the benefits of using technology in the mathematics classroom, giving their purpose as follows:

While the use of technology has been found to be an effective means to produce growth in students' understanding of mathematics content, research findings indicate that few teachers integrate technology into their teaching to enhance student learning. This study sought to explore urban teachers' perspectives on barriers that hinder technology integration in their mathematics classroom. (p. 18)

Handal and Bobis (2004) wanted to capture teachers' perspectives on teaching mathematics around a central theme instead of content and understand what barriers were preventing teachers from teaching thematic units, even though a thematic approach can motivate students and deepen their conceptual understanding of mathematical topics. Barriers teachers cited as preventing them from implementing new instructional practices included no access to technology, unreliability of technology, lack of technology support, lack of time, lack of knowledge, lack of confidence, lack of curricular coherence, and a mismatch from the content being taught and the content on the end of year state test (Handal & Bobis, 2004; Wachira & Keengwe, 2010). Proposed actions to help teachers overcome perceived barriers included strengthening teacher support and building learning communities of teachers.

Theoretical Framework

The theoretical framework guiding my study was the task implementation framework, as shown in Figure 1, developed by Stein and colleagues (1996).

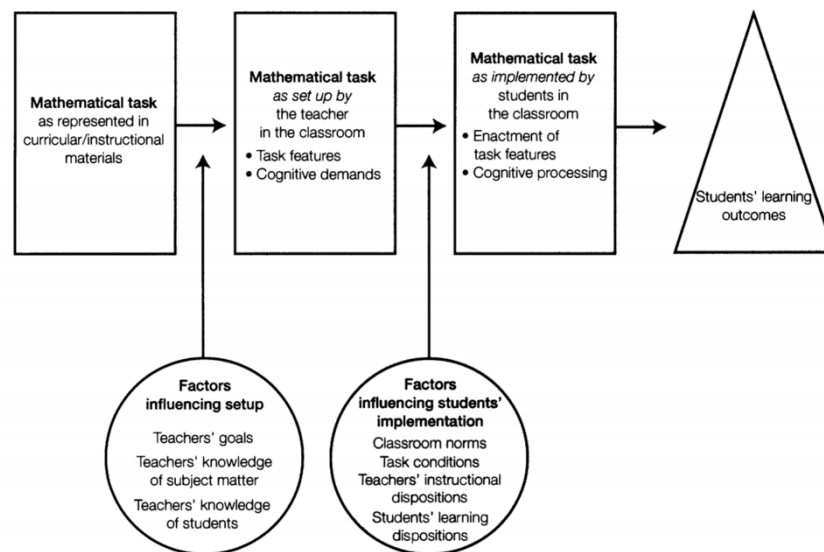


Figure 1. Task Implementation Framework (Stein et al, 1996, p. 459).

I chose to situate my study within this framework because it highlights factors that affect the implementation of high cognitive demand tasks. The task implementation framework “proposes a set of differentiated task-related variables as leading toward student learning and proposes sets of factors that may influence how the task variables relate to one another” (Stein et al, 1996, p. 458). The purpose was to identify factors that changed the task as it was implemented. While a task may start out at one level, during implementation the level may change due to the factors listed in the framework. The level of the task can change between successive phases of implementation: between the task as represented and the task as set up by the teacher or between the task as set up by the teacher and the task as implemented by students. I used the task implementation framework to identify factors affecting implementation when the participants in my study enacted high cognitive demand tasks.

Settings and Participants

I worked with the seventh grade mathematics team at a middle school in the Southeastern United States with approximately 700 students. The participants reported that 75% of the students were eligible to receive free and reduced lunch with 4% of the population being English language learners. The population of the school consisted of 60% African-American, 25% White, 7% Latina/o, 4% Asian, and 4% multi-racial. The three teachers in my study, Mr. Cone, Mrs. O’Neill, and Mr. Fielder all had less than five years experience. Mr. Cone in his 5th year of teaching and taught both mathematics and social studies. His bachelor’s degree was in history and decided to get a master’s in middle school education where he added a concentration in mathematics. Mrs. O’Neill was in her third year of teaching after being a stay at home mother for 25 years and only taught mathematics. Mrs. O’Neill went through a state certification program where she needed to pass the state certifying exam and be employed by a school. She was hired by the school and earned her certification in a year taking classes online and after school. Mr. Fielder taught mathematics and was in his first year of teaching after completing his bachelor’s in middle school education with concentrations in social studies and mathematics. Mr. Fielder was in his second year and he was a student teacher in Mr. Cone’s classroom the year before.

Data Collection and Analysis

I collected data through classroom observations and interviews. I provided professional development before school started on high cognitive demand tasks and then initially observed each teacher during one of their class periods for the first two and one-half weeks of school. I then observed each teacher multiple times throughout the semester. I planned with the teachers for the specific implementation of two high cognitive demand tasks, the Figure S Task and the Border Problem (see Figure 2) and made sure to observe and interview the teacher after each of those lessons.

“Figure S” Pattern Task

1 2 3

- Assume the pattern continues, and draw the next step in the pattern.
- How many squares will be in step 5?
- If the base is 10 squares long, how many squares will there be?
- Write a rule to find the number of squares in any step.

Border Problem

Find the border of this pool without counting all of the green squares.

Figure 2. Figure S Task, (adapted from Smith, Hillen, & Catania, 2007, p. 41) and Border Problem (adapted from Boaler & Humphreys, 2005).

During classrooms observations I took field notes and audio recorded and transcribed the interviews. I interviewed each teacher three times with a semi-structured (Patton, 2002) interview that lasted between 40 and 60 minutes. The interviews included questions on conceptions of high cognitive demand tasks, if they thought they maintained or lowered the demand of tasks, when they thought instances of maintaining or lowering demand occurred, and factors that affected the implementation of high cognitive demand tasks.

The goal for data analysis was to gain teachers’ perspectives of factors that affected the implementation of high cognitive demand task. The data I used included observations and individual interviews. I went through each teacher’s interview line-by-line and found instances where the teacher made a comment about a factor that affected the use or implementation of high cognitive demand tasks. I created narratives separating the data into instances where the teacher cited factors that led to the decline of demand and instances where the teacher cited factors that maintained the demand of the task. Once I had each teacher’s narrative, I went through and coded using the factors from the task implementation framework. I coded each teacher’s narrative individually first and then looked for common themes across all cases, making note of where the teachers had common factors.

Because I was comparing my perspectives to the teachers, I included a member check in my data analysis that involved checking back with participants to determine whether the analysis accurately represented their experiences. I wanted, to give the participants the opportunity to examine my work and offer advice if they saw a different interpretation (Lincoln & Guba, 1986). I provided each teacher with a copy of my analysis of his/her implementation of tasks in response to the first research question and my analysis of all the teachers in response to the second research question to get their input. Specifically, I wanted to find out if they agreed with the factors I identified as influencing the implementation of high cognitive demand tasks in their classrooms and whether I had omitted any important factors. I emailed each teacher the summary of my analysis telling each to read over the

analysis and then get back with me on a time so I could meet with each teacher separately. Mr. Fielder responded quickly to the email saying he agreed with my analysis and it was not necessary to meet. I met with both Mr. Cone and Mrs. O'Neill on separate occasions and after discussion the analysis was kept intact.

Teacher Identified Factors Influencing Implementation

Teachers' Instructional Dispositions

Each teacher's instructional disposition was a factor influencing implementation. Stein and colleague's (1996) defined teachers' instructional dispositions as the "features of [teachers] pedagogical ... behaviors that tend to influence how they approach classroom events" (p. 461). Examples of teachers' instructional dispositions include the extent to which a teacher is willing to let a student struggle with a difficult problem and the of assistance that teachers typically provide students during that struggle (Stein et al, 1996). All of the teachers said they often guided students to the right answer. They gave different reasons as to why they led students, but each had the tendency not to allow students to productively struggle with the task. Mr. Cone was not apt to let students struggle with the problem but was working on being able to question students instead of just giving them the answer. Mr. Fielder lowered the demand during the Border Problem when the students struggled with finding the border of any size square. He had not intended to lead, but when students could not come up with an expression for any size square, Mr. Fielder showed them how to take each of the numerical expressions and turn it into an algebraic expression rather than asking questions or offering hints to help them find the expression themselves. Mr. Fielder recognized this behavior saying:

The only struggles I had were in those classes where I had to give it away. It was frustrating because I know that theoretically we are supposed to allow students to develop these ideas themselves, just kind of point them in the right direction. To have to tell someone about this idea and them not get it, that is frustrating because they can't get it on their own and then you try to tell them about it and then they get more confused so then it's almost like you have no idea, and that's the frustrating part.

Mrs. O'Neill also acknowledged that she struggled with leading students too much. During the implementation of the Figure S task, she said she explicitly helped students who were stuck because she was afraid the students would shut down without her help. She said she led students too much during the Border Problem when they were getting an incorrect answer. She initially told a group of students they were getting the wrong answer because they were double counting the corners, but when she realized that she was being too directive, she adjusted her questioning to help the other groups of students arrive at that conclusion without her doing it for them. She said she initially was guiding her students through tasks because she wanted to make sure she had enough time to accomplish her goals. Thus, instead of letting students struggle, she gave them the information needed to solve the problem.

Teachers' instructional dispositions positively influenced students' implementation when the teachers held back and allowed students to productively struggle with the task. Examples of teachers holding back included using questioning techniques or referring students to work with each other instead of relying on the teacher for ideas. Both Mr. Cone and Mr. Fielder pointed to questioning students and not giving away answers as reason for maintaining the demand of tasks. The teachers recognized both instances of maintaining demand due to questioning but also lowering demand due to giving away the information too soon. Mr. Fielder said he had success with the Border Problem because he maintained demand with his on-level students by pulling back and not leading students to the answer. He said he realized the students were getting it on their own, and he could lead less and

watch the students come up with the ideas of generalizing any size square on their own. Mr. Fielder said he was becoming okay with allowing students to struggle with the mathematics and if they could not finish the task in one day, he would allow them to take two days to struggle with the task. By engaging with the task for two days, they may flail but not give up entirely. Mr. Cone said that he was getting better at using questions, and his goal was to focus students' attention on the mathematical concepts with questions rather than statements. He said he had to make a conscious effort not to give away pieces of information during implementation and he was getting better at letting students "carry more of the cognitive burden" because he tried to answer the students' questions less frequently and encouraged the students to engage with their peers more.

Task Conditions

The task condition related to class time affected the implementation of the task because often there was not enough time in class for students to grapple with the task, thus lowering demand. Mr. Cone attributed class time as a reason for not maintaining the demand saying he did not think the students discussed how to generalize for either problem. Mr. Cone described the implementation of the Figure S task by saying; "I am leaning towards failure because we didn't have a lot of time in class to do it. Students worked on it, but they weren't able to share their thinking. I didn't have a chance to continue that discussion." Mr. Cone claimed he altered tasks because he did not have the time for students to grapple with the mathematics so he would often make the connections for his students instead of letting them try to figure it out. Mrs. O'Neill identified lack of class time as a reason for lowering demand, saying she often gave the answer away because that would save her time in class to be able to get to each part of the lesson.

The task conditions helped the teachers maintain demand related to students abilities of building on prior knowledge. The teachers commented on the task conditions as a reason for the success of the lessons. Mr. Fielder said the Figure S task was successful because the students did not need a lot of prior knowledge to engage with that task. He had the same sentiment with the Border Problem and explained that the task was both easy to set up and implement because the students could engage with the task. He noted that the Figure S task built on itself in a way that students did not need much support from the teacher. He also said the Border Problem had an easy set up in that all he needed to do was give simple instructions, and the students were able to access the task. Mr. Fielder posed the tasks as challenges or problems for the students to solve because he said lessons were successful when he found tasks that he could set up as challenges and have students engage in without realizing they were doing mathematics. Mr. Cone attributed the success of the Border Problem to it having a low entry floor while also allowing students the option of being creative. Mrs. O'Neill spoke of the nature of the Border Problem and noted that all levels of students could access the task; saying, "The kids that were more advanced, they were looking for different, more complex strategies for solving it, so it was a puzzle for your weakest learner as opposed to the one that is more advanced." As an extension, she had her accelerated group create their own patterns to give other students to come up with the generalization for the pattern.

Students' Learning Dispositions

The teachers explained that high student engagement in the class as well as the ability to have a discussion around the task contributed to maintaining the cognitive demand during successful implementations. Mrs. O'Neill said she was successful with task implementation when she was able to have a discussion around the mathematics with the students sharing multiple solution methods because she enjoyed hearing multiple ways the students had solved the task which was different from the beginning of the year when the students just wanted to know how to get the answer. Mr. Cone said success with tasks implemented in his classroom was due to high student engagement. He said that through the implementation of tasks he had become more reflective about his practice of

interacting with students, thinking about how he can clarify, extend, or prompt students' thinking based on what the student says, which he had not thought of before. Mrs. O'Neill claimed students' learning dispositions lowered the demand of the task saying students relied on her or other adults in the room for the answer and would not productively struggle with the task. She wanted students to work by themselves or ask a neighbor if, but often they wanted her to give them the answer. She said that it just took time for the students to get to know each other to feel comfortable talking with their neighbor.

Discussion

The teachers recognized factors that affected the demand of tasks during implementation. Each of the teachers attributed giving away information to lowering the demand and not giving information away to maintaining the demand. According to the task implementation framework this relates to the teachers' instructional dispositions and their inclination as to when to allow students to struggle with the task. The teachers often did not allow students to grapple with the problem. Instead, they intervened to help students find the answer. The teachers realized they were lowering the demand and provided justification for leading students, claiming that if they did not give the information or help the student, the student would have disengaged with the problem out of frustration. From the perspective of the teachers, lowering the demand was acceptable if it kept a student engaged. The teachers attributed task conditions, students' learning dispositions, and teachers' instructional dispositions as relating to maintaining the demand of tasks. The teachers explained that the tasks having multiple solution methods and multiple entry points allowed students to engage successfully with the task. The teachers noted that students at all levels engaged with the high cognitive demand tasks, which was not always common in their classes. The teachers also attributed their instructional dispositions to helping maintain the demand of the task when they intentionally did not provide students with answers or lead them to solution methods.

The teachers were often able to identify the factors that helped to maintain or lead to the decline of demand. This was encouraging because in the future when they implement high cognitive demand tasks hopefully when there is an instance where they start to lower demand, such as giving a leading answer, they may be able to recognize and correct themselves to ask a question or not provide the student with the answer but still give support. The teachers being able to pinpoint when the demand was lowered can help those providing professional development to then provide support around those areas. Because the teachers all realized they lowered demand when giving students the answers when they struggled, I should have taken that information and then provided more targeted support on how to scaffold in such a way that supports student thinking, but does not explicitly give the student the answer.

Overall, there were many factors identified by Stein et al. (1996) that the teachers identified as contributing factors affecting the demand and illuminate the complexity around implementing high cognitive demand tasks. The teachers' ability to identify these factors illustrates teachers can identify when they maintain and lower demand. Each teacher was able to identify what led to the decline of demand and if I had a chance to continue working with the teachers, I would strive to help each with areas that needed improvement such as helping not give information away to students, or helping to plan a task that fit into the allotted class time. I argue those who work in a professional development capacity with teachers need to break down possible barriers between researcher and participant by listening to teachers' perspectives. Researchers can ascertain what interventions will benefit teachers and will fit within the confines of teachers' many responsibilities and abilities. Listening to teachers can help individualize professional development plans and provide targeted support for each teacher. While I initially implemented one professional development session with all three teachers, when analyzing the data from interviews and observations, it became apparent that each teacher needed different interventions and support to help him/her implement high cognitive demand tasks as related

to what each claimed lowered or maintained demand. Researchers can use teachers' perspectives to provide the support necessary to help teachers become successful when implementing new instructional practices in their classroom.

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