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The effects of argumentation on student motivation in mathematics

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THE EFFECTS OF ARGUMENTATION
ON STUDENT MOTIVATION IN MATHEMATICS

A Thesis Submitted
in Partial Fulfillment
of the Requirements for the Designation
University Honors

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This Study by Julie Kirkpatrick

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Date

Dr. Catherine Miller, Honors Thesis Advisor

Date

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Introduction

As a future educator, I am going to need to motivate my students to learn mathematics and be engaged deeply with the material. Because mathematics is a required subject for students, mathematics teachers must employ various strategies to motivate their students. Something that has motivated me in past mathematics courses has been the chance to form arguments and defend them in class. Argumentation in mathematics classrooms has been included in the Common Core Standards for Mathematical Practice as Practice Standard 3: “Construct viable arguments and critique the reasoning of others” (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). I would like to use argumentation extensively in my future classroom, because I enjoyed it as a student and it helped me learn and engage with mathematical concepts. However, I do not know if it will be a motivator for my students like it was for me, and I would like to see evidence before I use it extensively in my future classroom.

The purpose of this research is to inform my future practice by studying the effects of argumentation, specifically the implementation of the *Common Core Standard for Mathematical Practice*, related to constructing viable arguments and critiquing the reasoning of others (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010), on student motivation in secondary mathematics classrooms. I also hope that I can draw attention to this topic so that those who are interested can help contribute to the literature concerning a substantive connection between the two ideas of argumentation and motivation.

To focus my research, I have developed the following research question: Does meeting Common Core Standard for Mathematical Practice 3, “Construct viable arguments and critique the reasoning of others,” affect student motivation in mathematics classrooms?

Literature Review

As with any study, it is crucial to look at what is already known by the community. Due to there being two main ideas in my thesis, my literature review will be in two parts: student motivation and argumentation. While I do not claim to have found and read every piece of literature that has been published on these two topics I can say, even though I looked extensively, I found a lack of information that showed a clear connection between these two ideas.

Student Motivation

There is extensive research completed in regards to student motivation in mathematics classes. Motivation can be categorized into two types: extrinsic and intrinsic (Reiss, 2012). Extrinsic motivation in mathematics classrooms is powered through rewards, tangible or not, like grades, lessened homework, or treats in class (Middleton & Spanias, 1999). In contrast, intrinsic motivation in mathematics classrooms is powered through a desire to learn mathematics for the sake of learning (Middleton & Spanias, 1999). Extrinsic and intrinsic motivation are heavily tied to the goals students have, whether they be learning or performance goals. Learning goals are those related to mastery of the content, and students who have these goals tend to be intrinsically motivated. Students who are extrinsically motivated tend to have performance goals, such as being perceived as smarter than others or performing well on assessments. It has been shown through many studies that intrinsic motivation leads

to more understanding and higher achievement in mathematics than extrinsic motivation (Reiss, 2012). Therefore, it makes sense that mathematics teachers would like to instill a sense of intrinsic motivation in their students. This is an easier task for teachers of younger elementary students, as many young students feel eager to explore mathematics. However, this enjoyment and eagerness typically decreases over time (Middleton & Spanias, 1999).

There are many reasons why students have different levels of intrinsic and extrinsic motivation. Intrinsic motivation has been shown to correlate with students' perceived levels of competence in mathematics; this competence level is also related to how much students value mathematics (Middleton & Spanias, 1999). How students value mathematics also has a clear effect on motivation levels and the types of learning strategies that students are willing to use in mathematics classrooms (Berger & Karabenick, 2011). Perceived competence levels are constructed ideas instilled early on in mathematics classrooms mostly by teachers and the learning environments they create for their students (Middleton & Spanias, 1999). If students feel like they have little to no competence in mathematics early in their educational lives, they rarely feel competent in mathematics later in their educational careers. Because it can be very difficult to raise perceived competence over time, elementary teachers need to be cognizant about their mathematical teaching practices. For example, a student who has a negative experience in the elementary mathematics class will probably continue to have low perceived competence in mathematics throughout their secondary educational career, negatively influencing their ability to succeed. Additionally, students recognize the difference between being competent at varied depths of knowledge (Middleton &

Spanias, 1999). A student who has memorized a formula will feel less competent than a student who has deep conceptual understanding of the content. Deep conceptual understanding is the comprehension of the underlying reasoning of content that goes beyond simple recall and shallow application. The deeper the understanding the students have of mathematical content, the more competent students feel, and thus they are motivated to engage deeply with mathematics (Berger & Karabenick, 2011; Middleton & Spanias, 1999).

Beyond perceived competence, other factors that affect student motivation include but are not limited to: perceived value of mathematics, value of effort put toward academic pursuits (Berger & Karabenick, 2011), fixed or growth mindset (Murayama, Pekrun, Lichtenfeld, & vom Hofe, 2013), quality of feedback on work, self-efficacy (Pajares & Graham, 1999), and gender (Middleton & Spanias, 1999). We know that student motivation is a complex thing that is not solely controlled by one factor. Many of these factors can be addressed by the educator by conscientious actions in the classroom such as giving high quality feedback and instilling growth mindset practices.

Argumentation in Mathematics

There is a plethora of research about argumentation in regards to secondary mathematics classrooms. Argumentation in mathematics classrooms is the use of techniques by teachers to require and empower students to justify mathematical statements (Aberdein & Dove, 2013). It is usually in the form of “I think this (statement) because (justification and reasoning).” For example, a student learning about geometric translations could say “I think if you move the shape up 5 units, the points will look like $(x, y+5)$, because the x value is related to the side-to-side movement, and that shouldn't

change. The y value is related to the up and down movement, and that goes up by 5. So you take whatever value you have, and add 5 to it.” More formally, this is the process of proof-based instruction done to develop conceptual understanding of mathematics.

Most of the research covers argumentation effects on student learning. Increased use of argumentation has been linked to improved student understanding of mathematical topics and overall mathematical achievement (Kosko, Rougee, & Herbst, 2014). A majority of argumentation in elementary and secondary mathematics classrooms is in the form of a whole class discussion (Cross, 2009; Kosko et al., 2014). These discussions allow students to have a voice in the process of learning, rather than just absorbing information presented by the teacher. This could give students autonomy over their learning and could boost their self-confidence in mathematics.

There are many classrooms where there is a lack of argumentation and discussion among students. In some classrooms, students view mathematicians (their teacher in early grades, and those who study mathematics for a living in later grades) as the ones who make mathematical arguments, but rarely do they view themselves as mathematicians (Walter & Barros, 2011). This is often the result of classroom cultures that do not support these two pedagogical actions (Yackel & Cobb, 1996). If students are not in an environment where argumentation and discussion are encouraged, they rarely will prosper. Argumentation could be absent from mathematics classrooms due to classroom discussions are not the norm. This type of instruction can be quite difficult to perform (Conner, Singletary, Smith, Wagner, & Francisco, 2014). This could explain why classroom discussion is not a norm in schools.

Educators who choose to encourage argumentation during mathematics class must do so carefully, making sure that they build a classroom culture that does not look for “easy answers,” but instead relies on logical and understandable explanations for mathematical facts. Educators who act as facilitators of information and conversation rather than an all knowing source of information will encourage more students to engage in discussion. Some educators believe that students are not capable of mathematical argumentation, but it has been shown that children can start to use formal and abstract arguments starting as early as grade five (Stein, 2001).

Another reason keeping educators from using argumentation in their classrooms is because the classroom environment has to be carefully constructed for students to feel comfortable sharing their thinking (Yackel & Cobb, 1996). When students feel like they are wrong, their perceived competence decreases and they are less likely to engage with the material (Middleton & Spanias, 1999). This effect is magnified when students feel like they are wrong in the public eye, such as in front of their classmates (Kosko et al., 2014). Thus, if an educator has made a classroom environment where it is okay to be wrong and make mistakes, a student can feel safer in arguing their proof and argumentation can flourish.

Even if educators do not implement argumentation in their classrooms, it is still highly encouraged by large groups of mathematics educators. As stated in the introduction, the Common Core Practice Standards call for argumentation, as we can see in Practice Standard 3 which includes the statement “mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical

progression of statements to explore the truth of their conjectures” (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010).

Argumentation is also present in the National Council of Teachers of Mathematics Process Standards under the heading “Reasoning and Proof,” which we can see in the statement “Mathematical reasoning and proof offer powerful ways of developing and expressing insights about a wide range of phenomena” (National Council of Teachers of Mathematics, 2000). These organizations have endorsed the benefits of argumentation in mathematics classrooms as a tool for student learning, not for student motivation.

The link between the two ideas of motivation and argumentation is not made explicit in the literature. However, there are overlaps in the ideas of deep conceptual learning and perceived competence. Student motivation is higher when students have a conceptual understanding of the content, rather than a computational or procedural understanding. Students also feel more motivated when they feel they are competent with the material being studied. I think argumentation can provide a pathway to show competence to others and build perceived competence.

Methodology

Recall that the purpose of this study is to find out if using argumentation in secondary mathematics classes affects student motivation. I was a non-participant observer in a local secondary mathematics classroom for three weeks. I planned to observe classrooms where argumentation is present and well used. My advisors have a great familiarity with local secondary mathematics teachers and identified classrooms where argumentation is an instructional method used. Due to my schedule, I was only able to conduct observations in one classroom. It is important for a non-participant

observer to blend into classroom's surroundings and community in order to obtain accurate data (Kawulich, 2005). To make this happen, I was in the classroom before I started taking descriptive field notes. By doing this the students and classroom teacher were accustomed to my presence in the class.

While in the classroom, I mapped the physical space and used a seating chart provided by the classroom teacher to keep track of the students and their interactions. I assessed student motivation levels by observing student behaviors. I interviewed the classroom teacher about their use of argumentation and observations regarding motivation among the students. The interview questions addressed four categories: general teaching background, student motivation, use of argumentation, and the intersection of the two. I also surveyed students about extrinsic and intrinsic motivation, perceived competence, and argumentation.

To collect data, I first observed classroom events, using descriptive observation as defined by Kawulich (2005). I was mindful to only record events and not force meaning upon them. During this window of observation, I formulated teacher interview questions based on what was observed. At the end of my observation, I surveyed the students. I adapted the Motivated Strategies for Learning Questionnaire (Pintrich & de Groot, 1990), a 44 question, seven point Likert scale survey based on components of the interview and the observed actions in the classroom. This survey was anonymous. The survey was administered on paper.

I analyzed the field notes by coding the data for patterns of argumentation and evidence of motivation. In order to analyze all of my observations, I also examined the teacher interview by identifying connections between the teacher's intent and the

observed actions of both the teacher and students. When I analyzed the student surveys, I looked for the students' perceptions of argumentation and motivation. Due to having a small number of participants, I used a measure of center to summarize the data and look for interesting common themes or outliers to highlight.

Results

My participants were the classroom teacher, a student teacher, and the students of a seventh grade math classroom in a Midwestern city. The class had 25 students, 13 of whom got permission to participate in my study. Six of the 25 students were female, and the rest were male. Both the teacher and student teacher were females. The classroom was arranged into groups of three or four desks, with whiteboards in the front and back of the classroom. Materials used in the classroom often included Chromebooks, online math activities created by the classroom teacher, and a classroom set of whiteboards and markers. There were many posters hung around the room encouraging classroom norms. The posters included sayings like these: "Mistakes are Expected, Respected, Inspected, Corrected," "Give it your all, Redo if necessary, Ignore giving up, Take time to do it right," and "In this classroom: We don't do EASY! We make EASY happen through HARD WORK, We PERSEVERE through STRUGGLE, believe in ourselves and never give up. We think critically, analyze information, ask questions, make connections, and justify our reasoning. We do what is needed to LEARN."

Qualitative Data

I observed this class and took field notes twice a week for three weeks, for a total of six class periods of observation. In that time, the class completed a review unit on combining like terms and solving one-step equations, a unit on two-step equations and

inequalities, and started a unit on integers operations of addition, subtraction, multiplication, and division. Classes were 46 minutes long starting at 8:00 A.M. The students in the class were not identified as gifted and talented or remedial, so it can be assumed they represent an average level of performance in mathematics in comparison with that grade's population. The students were not assigned to their groups by mathematical ability. Thus, the tables groups were not intentionally homogeneously or heterogeneously grouped by ability; some table groups had all high ability students, others had a mix of abilities, and others were all lower ability students.

Findings from Field Notes

Most of the tasks in the classroom were differentiated online activities created by the classroom teacher where students were to work independently or with a partner. A common website used to create and execute these tasks was www.quizizz.com (Quizizz: Fun Multiplayer Classroom Quizzes). Students would be shown a question and would have to select the correct answer from a bank of four possible solutions. Students often found answers using scratch paper or personal whiteboards. The classroom teacher and the student teacher would circulate and answer student questions during this time.

I coded for high and low student motivation levels in my field notes, looking for signs of student engagement, completion of the task assigned, and amount of student-led extensions of the tasks. In my field notes, there were 16 instances of particularly high or low motivation shown by the students, nine being instances of high motivation, and seven being instances of low motivation. A typical high motivation observation would be "All students are working on the task, writing their process down on personal whiteboards before entering an answer on their school Chromebook and moving on." A

typical low motivation observation would be “Some students have their heads on their desk, not looking at the assigned task. A student is doodling in the margin on their otherwise blank worksheet. Another student has turned their worksheet over and is sitting with their arms crossed and leaning back in their seat, looking out the window.”

I also coded my field notes for instances of argumentation used by the teachers or students, by looking for explanation. Twelve instances of argumentation were observed. Typical student to student verbal argumentation observations noted follow, “Two students get different answers for the task. Student A says Student B’s answer is wrong, and explains the process of how they got their answer. Student B points out a flaw in Student A’s process, and the two conclude that Student B is correct.” A typical teacher to student argumentation observation could be something like, “Teacher announces to the class during class work time: ‘Be sure you write out all your steps so I can see where you got your answer. Answers without work are not sufficient; you need the work.’”

Across classes I observed, there was a common theme of student competition in the classroom. I decided to code for that as well by looking for when students would share their outcomes after playing mathematical games or taking quizzes, or when students compared themselves and their work to other classmates verbally. Typical observations of student competition were like this, “After some students finish the quiz activity, they start saying things like, ‘I missed 4.’ or ‘It took me so long, and I only got 60%.’ loud enough for others to hear,” and “3 students are working on a task. During this task, student A verbalizes ‘[Student B] is smart, so I thought they were right. I’m dumb, so I’m usually wrong,’ to the classroom teacher.” There were 13 instances of

observed student competition. These instances usually happened at the end of tasks, once students had answers.

The last theme I coded for in my field notes was building perceived competence and student self-esteem in mathematics. Signs of this included celebrating mathematical victories and seeing mistakes as things to grow from rather than failures. There were nine observed instances of this in my field notes, including the following “Teacher praises students’ hard work on task, says that they are doing better on even harder tasks, and they are asking good questions,” and “Poster hung on the wall reads: Mistakes are Expected, Respected, Inspected, Corrected.”

Findings from Teacher Interview

In my last week of observations, I took a half hour to interview the classroom teacher, henceforth referred to as Ms. X, about her background, her thoughts on motivation and argumentation, how she employs different teaching strategies in her classroom, and how her teaching has changed over time. Ms. X has taught for five years at the time of this study, and had taught this course for all of those years. In the beginning of her teaching career, Ms. X used a textbook for most of her instructional materials. She noted a purposeful transition to using argumentation rich tasks for students to complete in her second year of teaching. Ms. X defines argumentation as “Reasoning and conversation, being able to prove what you did makes sense. The ‘tell me why’ part of math.” In order to use argumentation properly, she ensures that her students work in groups, have freedom to talk and discuss, and have opportunities to dig deeper. She says she is very cognizant of making sure to pose right questions to her students. Ms. X also pointed out the importance of classroom norms in regards to using

argumentation. Since many students had not been expected to use arguments in their previous mathematics classes, she said she takes great care in setting expectations with the students at the beginning of the year. Some of those expectations include: everybody participates because everyone has an idea, a lack of agreement does not make the solution wrong, and everyone is an equal player in their table group and in the class.

She finds that students have been more engaged during class since she started using argumentation. When asked for evidence of this engagement, she noted that class discussions had more contributors and more ideas shared during classroom time than before. She finds that students are the least motivated when they cannot access a problem cognitively and do not know where to start. She stated that either she or another student usually helps the student in need and the motivation problem is resolved. Her reasoning for switching to a more argumentation heavy instruction style was that it helps students with number sense and knowing why and how mathematics works. Ms. X also has switched her assessments to include more informal proof and reasoning items. For example, if a student gets all the correct solutions on an assessment, but do not show any of their work and justification, they cannot earn a perfect score.

Quantitative Data

13 students completed a survey (found in Appendix A) on the sixth and last day of my observations. The survey used a seven point Likert scale with one meaning “does not describe me,” and seven meaning “very much like me.” to respond to the 30 prompts. There were five themes in the prompts, four of which were relevant to this study. The five themes were: Extrinsic Motivation, Intrinsic Motivation, Perceived Competence,

Enjoyment of Argumentation, and Testing Anxiety. Sample prompts from each of the five themes respectively are as follows: “Compared with other students in this class I expect to do well”, “I like what I am learning in this class”, “I think I will receive a good grade in this class”, “I enjoy asking and answering the question ‘Why?’ in this class”, and” I have an uneasy, upset feeling when I take a test.”

The Testing Anxiety theme was not relevant to my study, but was included to direct students’ attention away from the relevant items. Some of the prompts were negatively coded, which means the best score of 1 or 7 is applied at the other end of the Likert Scale.

Prompt Theme	Extrinsic Motivation	Intrinsic Motivation	Perceived Competence	Enjoyment of Argumentation
Mean Value <i>n</i> =13	5.62	5.49	6.01	4.13

The highest rated mean values were all in the theme of Perceived Competence. The next highest themes in order are Extrinsic Motivation and Intrinsic Motivation. The lowest rated relative theme was Enjoyment of Argumentation. All of the means were above the neutral response of 4, meaning that the students surveyed felt, on average, like they were competent in their mathematics class, had some level of both extrinsic and intrinsic motivation, and felt some degree of enjoyment of argumentation. Some responses to particular prompts were exceedingly high. For example, the prompt “I expect to do well in this class” had a response breakdown of nine 7’s, a 6, two 5’s and a 4.

Discussion

Three conjectures emerged from my data related to my research question. It is important to note that these conjectures are only applicable to the mathematics classroom where I observed and cannot be generalized to other settings. Nonetheless, the conjectures warrant attention and perhaps more study. My conjectures are as follows:

1. Students are motivated to complete tasks when they use argumentation, even if the student does not enjoy argumentation.
2. Students are motivated to complete tasks when they have some form of student competition.
3. Students are less motivated to complete tasks when their arguments about the content are dismissed in comparison to when their arguments are integrated into the instruction.

Rationales for each for each of these conjectures follow in the coming sections.

Conjecture 1: Students are motivated to complete tasks when they actively use argumentation, even if the student does not enjoy argumentation.

My evidence for this comes from the interactions I observed between students when argumentation was being actively used. For the purposes of this thesis, I define active use as a student sharing solutions and reasoning with peers or with the teacher, having to justify her solution out loud instead of simply on paper. In my observations, almost any time the students were asked to talk with their peers about a task, all groups were active and on task, at least until the group came to a consensus. Contrast this with observations of students being told to work through problems on a worksheet without

being instructed to justify their answers to anyone verbally. Some students would work diligently on the task, but others would use stalling actions, such as taking a superfluous amount of time to get out materials, staring out the window, or getting up to get a drink of water before starting the task.

Another piece of evidence I gathered that supports the first conjecture comes from the teacher interview. Ms. X stated that she has seen a change in student engagement and thus motivation after switching to argumentation based instruction. In my observations, there were no instances of students displaying negative behaviors or attitudes towards argumentation. (For example, I did not observe students complaining when Ms. X said that students needed to justify their answers.) However, survey results tell a slightly different story. The mean for the theme of enjoyment of argumentation, $M=4.13$, was the lowest out of all the relevant themes. While this mean is neutral and not negative, responses to prompts from the theme of enjoyment of argumentation were wide-ranging. For example, the response breakdown of the prompt “I enjoy asking the question ‘Why?’ in this class” resulted in two ratings of 7’s, a 6, three 5’s, a 4, three 3’s, and three 1’s. This tells me that some students really enjoy argumentation in this class, while others have a strong dislike for it.

Even though some students do not enjoy argumentation, as seen in the survey data shared above, it appeared to me that all students were more motivated when they were expected to justify their answers to their peers, in comparison to when they were not. It would make sense for students to be motivated to complete a task when they find that task enjoyable, so it comes as a surprise that students appeared to be motivated to complete the argumentation tasks even when many of them did not like argumentation.

I surmise that, even though argumentation might not be enjoyable for these students, it provides a deeper conceptual understanding of mathematics (Kosko, Rougee, & Herbst, 2014), therefore students are more likely to engage with the material. During one of my visits to the classroom, a student told me directly, “I understand it more if I have to show why I’m right.” This shows me that argumentation appears to be helping these students feel like they understand the content being studied which is one of the major factors of student motivation in mathematics classes.

Conjecture 2: Students are motivated to complete tasks when they have some form of student competition.

I did not expect to observe this during my time in this classroom, however it became apparent very quickly that this is something I would want track. Ms. X used a large number of immediate feedback activities in her class, such as online quizzes and games. Almost every time students were working individually, they were doing these kinds of activities, which were used for warm-ups, unit and daily reviews, but they were never used to introduce a concept. While student competition was not encouraged by the teacher (there were no instances of Ms. X telling her students to compare their answers), students would announce their own scores almost immediately after completion of the quiz or game every single time they did this type of activity. The only incentive provided for doing well on these quizzes and games was not having to come in for remediation later. In my observation notes, every instance of students knowing they would be getting immediate feedback was followed by all students starting the task immediately and working on it until they had finished. In instances where time allowed, students would often restart quizzes and games trying to get a higher score. Contrast

this with when students worked in small groups and were instructed to cooperatively to complete a task. When working together the students stopped working when the small group had an answer and justification.

There were some instances when students engaged in negative self-talk surrounding the quizzes and games. For example, a student said “He [another student] finished so quickly and got almost all of them right! I’m only on problem 5 and I’ve only gotten 2 right!” What was interesting about this instance was that the student continued working even after they had seen that they were not doing as well as their peers.

Further evidence of competition in this classroom can be seen in the survey responses to the prompt “Compared with others in this class, I think I’m a good student,” which had a mean score of $M=5.77$, and the prompt “Compared with other students in this class, I think I know a great deal about the subject,” which had a mean score of $M=5.54$. These scores are above the neutral response of 4, meaning the students, on average, felt that they could compete with their peers mathematically.

Conjecture 3: Students are less motivated to complete tasks when their arguments about the content are dismissed in comparison to when their arguments are integrated into the instruction.

Usually, argumentation was integrated into the instruction, but there was one instance where argumentation from the students was dismissed consistently. The student teacher, henceforth referred to as Ms. Z, taught one lesson on adding and subtracting integers. In this lesson, Ms. Z provided the rules of how to add and subtract both positive and negative numbers. For example, she had a slide that read “For adding mixed signs, subtract the smaller number from the bigger number and take the sign of

the bigger number. $-35+7 = -(35-7)$.” She did not give an explanation of why these rules worked before expecting students to work on practice problems. Students did try to interject with questions and posited justifications like “Can we just subtract if the positive number is bigger?” and “You can switch the order if you keep the signs with [the numbers].” However, Ms. Z did not acknowledge these responses from the students beyond telling them to look at the rules sheet she handed out at the beginning of class. After her presentation, she handed out a practice worksheet for them to complete using the rules she had talked about. Many students were disengaged at this point; some had their heads on the desk, others were doodling and not paying attention, and a couple students had turned over their papers and were not writing anything. This lesson was the only lesson where I consistently observed low motivation and engagement from a large majority of the students. Ms. X, the classroom teacher, continually reminded students that they would have more time with this content during this lesson. She knew her students were confused and disengaged.

In her interview, she talked about the importance of listening to the students’ ideas, both for her and to benefit other students in class. In the survey data, the prompt, “I always try to understand what the teacher is saying even if it doesn't make sense,” had a mean response of 6. This tells me that even though Ms. Z’s presentation might have been confusing to the students, they were still trying to make sense of the content through argumentation and justification. However, when Ms. Z would not listen to the students, many of them became frustrated and disengaged with the lesson. This result does not surprise me, as when students were trying to get confirmation on their thoughts and were unable to, they could have felt like their involvement was moot.

In the context of this particular classroom, all of these conjectures are reasonable, as they are supported by evidence from multiple sources. While these conjectures are not generalizable for academic purposes, I can take my experience and apply it to my future classroom practice. It was encouraging to see that argumentation, while not universally loved, was a motivator for this class. Student competition is an extrinsic motivator, which is not ideal for my future classroom, but still can be used. I also know that I should listen to student argumentation thoughtfully, and not just dismiss it in favor of unexplained procedures.

In conclusion, it stands that argumentation and the use of the practice standard “constructing viable arguments and critiquing the reasoning of others” does have some effect on student motivation in this particular classroom. However, student competition, an unforeseen variable, seemed to affect motivation to a greater extent. The other effects of student competition, like lowered self-esteem and detrimental social situations, would be a concern and would need to be further studied before I would feel comfortable with using this motivation technique with my future students. Because argumentation is shown to be incredibly beneficial for student learning, I am very likely to apply argumentation concepts in my lessons. The fact that it was a positive motivator in this class strengthens my reasoning to use it in the future. While I do not yet know if this work will inspire others to continue researching this topic, it is a good baseline to see what happened in this one particular classroom.

Suggestions for Future Research

I have been able to make some reasonable conjectures about motivation and argumentation specific to the class I observed. However, what I did is just a starting

point for this topic. In order to gain a clearer understanding of the effects of argumentation on student motivation, the mathematics education community should continue to study this topic. After doing a semester-long thesis, I have many suggestions I would like to give for those interested in this topic.

It is my recommendation going forward with this research that further studies gain access to more classrooms. I would have liked to observe classrooms that use a large amount of argumentation and classroom that use little to no argumentation. One would be able to compare motivation in these two groups and observe differences that might occur due to different levels of argumentation.

I would also recommend more observations. While six periods of observation was sufficient for my purposes of gathering information on one specific class, if one wants their study to be generalizable, it would be more beneficial to observe classrooms over a longer period of time. More time in the classrooms not only means more data, but also means that one could potentially see multiple units of study from introduction of the topic to assessment of knowledge. In my observations, argumentation was used most heavily at the beginning of a unit, so it would be interesting to see if this is a pattern throughout most classrooms and units of study.

Another study I would like to see for this topic is an intervention study. Finding a classroom that currently does not use argumentation and observing that classroom would give the investigator an idea of the student motivation levels in the class without any influence of argumentation. The investigator could then require the classroom teacher to use argumentation in the instruction and assessment of the classroom, and see how this affects the student motivation levels. There are many variables to control in

this situation. It is understandable that if a teacher is not trained to use argumentation in their classroom, the content could become inaccessible to students and thus lower their motivation levels. However, that should not be the focus of the intervention study. The investigator should take extreme care in ensuring the classroom teacher is well trained in using new and different instruction and assessment methods.

My final suggestion would be to conduct a comparative longitudinal study of two groups: students that are regularly required to use argumentation in their learning of mathematics, and those who do not. Using a longitudinal study would make trends over time more evident, and I think would that this could provide clearer evidence for using argumentation for motivation. Again, it would be beneficial to the investigator to have a control group of students who are not exposed to argumentation, however this could be detrimental to the students' learning, especially as argumentation has been shown to be of value to conceptual understanding of mathematics. An alternative would be to track one group of students, and for every class they have, track both argumentation and motivation levels. One could then see if there exists a correlation between the two, while keeping in mind the many variables such as age and content difficulty.

All of these recommendations would have made my study more impactful. Time and resources were both not as boisterous as I had initially hoped. However, even with these obstacles and constraints, I still feel like I met my goal of informing my future teaching practice and starting the conversation on how argumentation can affect student motivation.

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Appendix A

Motivated Strategies for Learning Questionnaire* (adapted)

Please rate the following items based on your behavior in this class. Your rating should be on a 7-point scale where 1= not at all true of me to 7=very true of me

1. I prefer class work that is challenging so I can learn new things.
2. Compared with other students in this class I expect to do well.
3. I learn best when the teacher does most of the talking in this class.
4. I am so nervous during a test that I cannot remember facts I have learned
5. It is important for me to learn what is being taught in this class.
6. I like what I am learning in this class.
7. I'm certain I can understand the ideas taught in this course
8. I think I will be able to use what I learn in this class in other classes
9. I expect to do very well in this class.
10. I enjoy asking and answering the question "Why?" in this class.
11. Compared with others in this class, I think I'm a good student
12. I am sure I can do an excellent job on the problems and tasks assigned for this class.
13. I have an uneasy, upset feeling when I take a test
14. I think I will receive a good grade in this class.
15. I don't like explaining my ideas in this class.
16. Even when I do poorly on a test I try to learn from my mistakes.
17. I think that what I am learning in this class is useful for me to know
18. I think that what we are learning in this class is interesting
19. Compared with other students in this class I think I know a great deal about the subject.
20. I feel nervous when I am asked questions in this class.
21. I know that I will be able to learn the material for this class.
22. I like proving a point in class.
23. I worry a great deal about tests in this class.
24. I think I ask useful questions in this class.
25. Understanding this subject is important to me.
26. I always try to understand what the teacher is saying even if it doesn't make sense.
27. I feel like it is ok to be wrong in this class, as long as I learn from my mistakes.
28. I work on practice exercises and answer end of chapter questions even when I don't have to.
29. Even when study materials are dull and uninteresting, I keep working until I finish.
30. I work hard to get a good grade even when I don't like a class.