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The Effects of Small-Group Collaboration on Student Attitudes Towards Mathematics

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Table of Contents

ABSTRACT 4

INTRODUCTION 5

LITERATURE REVIEW 7

The Benefit of Collaborative Work 7

Best Practices for Collaborative Work 8

Studies from Classrooms that have implemented Collaboration 11

Summary 12

METHODOLOGY 13

Research Questions 13

Design of Study 13

Sample 19

Setting 19

Instruments 22

Procedures 24

Limitations 26

RESULTS 27

Data 27

Interpretation 32

DISCUSSION 33

CONCLUSION 36

REFERENCES 37

List of Tables

Table 1: Pre-Survey Responses from Student Group A

Table 2: Post-Survey Responses from Student Group A

Table 3: Pre-Survey Responses from Student Group B

Table 4: Post-Survey Responses from Student Group B

Table 5: Individual Student Index Scores

List of Figures

Figure 1: Example of the First Part of the Statistics Project

Figure 2: Math Attitude Survey A as it Appeared to Students

Figure 3: Math Attitude Survey B as is Appeared to Students

Figure 4: Diagram of the Setup of the Classroom

Figure 5: Mean Student Responses

Figure 6: Student Index Scores

ABSTRACT

Collaborative group work has become a prevalent teaching strategy in high school mathematics classrooms, and for good reason. When implemented effectively, studies show that collaboration improves student learning outcomes. However, there are other factors to consider when deciding on best practices for teaching, one being student attitudes towards the content. In particular student attitudes towards mathematics (which are not generally positive) are important to consider. In this study, students in a high school mathematics classroom took a survey before and after a unit that implemented collaborative strategies. Results of the study indicate that student attitudes towards math improved after working collaboratively during the unit.

The Effects of Small-Group Collaboration on Student Attitudes Towards Mathematics

Educational pedagogy has undergone many changes in the past fifty years. One of the most profound has been in the way that students interact with each other. Student collaboration has come in and out of style over the past century but is now viewed as a best practice (Holt, 2018). Collaboration, when implemented effectively, has shown to improve student learning outcomes (Allen, 2012). Although there are no doubts that collaboration has its benefits, there are more questions to consider when thinking about its effectiveness. One such question is “what affect does collaboration have on student attitudes towards the content?” In this study, I examined specific attitudinal measures of students in a high school math classroom.

In my experience, many students do not have a productive disposition toward mathematics. As defined by the National Research Council (2001), a productive disposition is a “habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy” The common perception among students is that some people are just math people and others do not stand much of a chance when it comes to succeeding in math. This way of thinking is especially common among students whose guardian(s) have an unproductive disposition towards math (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). This destroys many student’s belief in diligence and self-efficacy. The reality is, however, that although some students have had a more positive experience in their mathematics education, every student has the ability to learn and succeed in a math class. The National Council of Teachers of Mathematics (NCTM) even goes so far as to state that “The question is not whether all students can succeed in mathematics but whether the adults organizing mathematics learning opportunities can alter traditional beliefs and practices to promote success for all.” (2014) These traditional beliefs and practices that NCTM is referencing include a very teacher-centric classroom model where students' interactions with each other are limited. What each student learns might be different, but that does not mean that every student's learning outcome is not legitimate. Many students will not need to remember the Pythagorean Formula after they graduate, so the problem solving, collaboration, and critical thinking skills they develop will last much longer (LeGere, 1991). Thus, student attitudes when it comes to math are very important.

The way I explored student attitudes towards mathematics included surveying students who I taught during my professional semester. My ultimate goal was to see whether or not student attitudes towards math were affected by their participation in collaborative learning activities. A very similar study was completed by Whicker, Bol, & Nunnery (1997). In this study, one class of students worked in groups, while the other class worked independently. This study found that students who worked in groups had better test scores. Most students enjoyed working in groups, since they could ask their peers for help. This not only helped students who needed help, but also the students that they asked, since they were able to reaffirm their knowledge (Allison, 2012). The survey they used for this study consisted of five open-response questions, and the researchers concluded from this qualitative evidence that student attitudes were better when collaborative small groups were implemented. Another study was completed by Vaughan and found that students of color specifically benefited from collaborative learning (2002). I used these qualitative studies as a basis for my quantitative study.

The purpose of this study was to investigate the ways are high school students' attitudes toward mathematics affected by learning in a collaborative, small group setting? This question is significant because it can validate much of the direction that teaching has been going and add to the existing body of literature concerning collaboration as a best practice in education pedagogy

(Holt, 2018). It can also guide my pedagogical approach in the coming years and hopefully provide insight into how students view both collaboration and mathematics.

LITERATURE REVIEW

THE BENEFIT OF COLLABORATIVE WORK

One of the earliest studies conducted that deals with collaboration also happens to cover the most comprehensive sets of benefits to collaboration. In "Collaboration in the Mathematical Community," Bagnato (1974) discusses the importance of collaboration in the community of mathematicians as a whole, not just in the classroom. Bagnato claims that mathematics is inherently a collaborative subject and that it should be taught as such. If collaboration is included in high school math classes, students who end up becoming a part of the larger mathematics community will already be accustomed to the collaboration present among mathematicians. Mathematicians often lean on each other in collaboration by helping each other make generalizations.

Ellis describes how student's interactions with each other can help create generalizations (2011). When students explain their ideas about math to each other, they give each other opportunities to hear concepts in different ways. When students combine these different ways and create their own understanding of a concept, students can then verbalize their own generalizations. Creating generalizations also helps develop critical thinking, another skill that is highly valued in the mathematics community and academia as a whole. Skills which support critical thinking, such as making generalizations, can be improved through collaborative work (LeGere, 1991). LeGere suggests that giving students time to process information by utilizing collaborative activities will help students develop critical thinking skills as well as a stronger grasp on content knowledge.

Both critical thinking skills and the ability to create generalizations have a positive effect on student's knowledge, self-efficacy, and disposition towards mathematics. According to the National Research Council, a positive disposition toward mathematics is a "Habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled. with a belief in diligence and one's own efficacy" (2001). This is the definition that will be driving how student "attitudes" towards math are measured.

Finally, collaboration has been shown to help create a more equitable learning environment for students of color. Stiff and Harvey identify student attitudes towards math as one of the key factors in the achievement gap between black and white students (1988). Vaughan found that cooperative learning had a positive impact on student attitudes and achievement in group of fifth-grade students of color (2002). Creating equitable learning communities is one of the main goals of the National Council of Teachers of Mathematics. This council, which is at the forefront of mathematics education research, published a book in 2014 entitled *Principles to Actions: Ensuring Mathematical Success for All*. This book lays the groundwork for the idea of access and equity in the mathematics classroom. It gives ways to best incorporate group work, open ended questions, and technology, which are identified as best practices.

BEST PRACTICES FOR COLLABORATIVE WORK

Most articles that describe best practices for collaborative work come from education practitioner journals and are more condensed than those that describe the different benefits of collaborative work. These articles also make up most of the articles referenced in this review. Two themes define the articles in this section, best practices for teachers to engage in, and ways that students can work collaboratively.

The efficiency and cooperation of student groups are two of the key aspects of collaboration. Therefore, teachers have to be intentional about the way that they structure collaborative work and the groups that students work in. Adodo and Agbayewa (2011) make the claim that homogenous ability groups are the best way to set up student groups . Although Adodo and Agbayewa recognize that heterogenous groupings can allow for peer instruction, homogenous groupings are better for differentiating instruction. In addition to grouping students, teachers also have the responsibility to nurture groups by including opportunities to get to know each other better, as well as work together (Allen, 2012). As students work with each other more, trust will form among the students, which will lead to a positive learning environment.

As for student collaborative activities, critical writing is a great way to end a collaborative activity, as it gives students an opportunity to reflect on their experience learning both as an individual and as a group (LeGere, 1991). Critical writing activities are often viewed as difficult for mathematics teachers to incorporate, due to mathematics reputation for not being expository. However, if students are able to put their thought processes into words, students are much more likely to secure a basic understanding of the concept. Writing activities can also provide teachers with valuable feedback, as they also highlight student achievement and expose student misunderstandings. Unless teachers are actively involved in groups, it can be easy to overlook students who are falling behind, since they can occasionally hide behind the work that their groupmates complete. This is another reason why homogenous grouping is an effective tool for teachers looking to implement collaboration.

Along with critical writing, inquiry-based assignments can be used effectively when paired with collaboration. Goos (2004) makes the claim that “All classrooms are communities of practice,” meaning that no matter the learning environment, certain norms and expectations are present. Goos goes on to say that classrooms must normalize mathematical inquiry and discussion. Having students verbalize their thoughts in meaningful discussion is somewhat lacking in most math classrooms, but it offers immense benefits. When a small group of students discuss a math concept, they must put it into a language that everyone involved in the discussion can understand.

Staples (2007) agrees with Goos in that discussion in the mathematics classroom is essential. Staples takes it a step further by giving a framework by which small-group discussions can transform into whole-class discussions. This scaffolded approach to discussion is effective in many ways, since it allows students who might be intimidated by a whole-class discussion to share ideas while in the small-group phase, and for all students to be able to hear those ideas when the entire class is discussing a topic.

The initial student-peer interaction in Staples’ scaffolded method is looked at more in depth by Lau, Singh, and Hwa in a 2009 article. This article looks at the different types of collaboration in the context of Vygotsky's zone of proximal development. The two types of collaboration it looked at were teacher-student and student-peer. This study finds that teacher-student collaboration is time-consuming (as there is a high ratio of students per teacher). A more effective method was found when the teacher created an interactive learning environment in which students were asked to expound on other's ideas and participated in student-peer collaboration. Teacher guidance was needed, but less one-on-one teacher-student collaboration took place.

Another way to encourage student interaction is to use peer instruction, where students help each other understand material. According to Allison (20120, using peer instruction can help improve student achievement and motivation. Peer instruction has also shown to increase student engagement for both students that are being instructed and those that are instructing. Specifically, peer instruction was shown to improve student's attention and feelings towards the relevance of mathematics in their lives. The other two aspects of student motivation that Allison looked at, confidence and satisfaction, did not see statistically significant improvements.

STUDIES FROM CLASSROOMS THAT HAVE IMPLEMENTED COLLABORATION

The study that has correlated the most with the theme of this thesis is "Cooperative Learning in the Secondary Mathematics Classroom (Whicker, Bol, Nunnery, 1997). In this study, the researchers looked at how student achievement and attitude towards math was affected by group work. This study had two separate math classes work through the same material for three chapters of their math curriculum. During this trial, one class would be instructed using group work strategies. Students were encouraged to ask each other questions, work in teams, and discuss what methods worked for them. The other class would be instructed to work independently. Students were instructed to work on their own, and to ask the teacher for help when they needed it. At the end of this trial, the students who were in the cooperative class showed better math test scores than those students who were in the independent class. After the students were tested, those in the cooperative class were also given a survey of five open-response questions. These questions were meant to gauge how student's attitude towards math ware influenced by being in a group setting. Questions covered what the students liked and disliked about working in groups, if it was easier to learn new concepts in these groups, and what they would change about the group setup. Although this survey provides a base for looking at math attitudes towards group work, it was not specified as collaborative and was a qualitative survey as opposed to being quantitative. The goal of this research thesis is to replicate the study completed by Whicker, Bol, and Nunnery, but address those two items.

In another qualitative article, Webel brings up two examples of students working in a group setting. In the first example, students do not work collaboratively, but rather, one student does most of the work while ignoring her teammates. She does not ask for input from her group because she does not think they are going to be able to offer anything to the discussion. The second story finds a collaborative group that does work together and offer input. Both students feel secure enough to offer input, even when that input might be wrong. This setup allowed both students to "think out loud," and actively contribute. This article provides a sort of definition by example to distinguish between collaboration and basic group work.

This research thesis will be looking at student attitudes towards math in a more quantitative scope. The survey that this thesis will utilize was built from items from the MAPS survey (Code, Merchant, Maciejewski, Thomas, and Lo, 2016) and a mathematics attitude survey from Oregon State University. These items have been used and validated in prior research studies.

SUMMARY

There is a dearth of research in opposition to the use of collaboration in the high school math classroom. Areas that can benefit from students working together in small groups include critical thinking, generalization making, self-efficacy, and equity in the classroom. Although none of these directly address student's attitudes towards the subject of math as a whole, they all play a part in positively shaping student's mathematical frame of reference.

As for the best practices and tips that are present to increase classroom collaboration, critical writing and inquiry-based assignments are efficient ways to encourage deeper understanding. The major theme that was present in the best practice articles was that students who practiced consistent discussions concerning math topics had a far better grasp on them than students who did not.

Finally, the concepts and ideas that are driving this thesis have been covered in previous studies. Although none have tried to quantify students' attitudes towards math due to collaboration, they have all shown that students tend to have a more positive disposition towards math when consistently exposed to small-group collaborative work.

METHODOLOGY

RESEARCH QUESTIONS

The research question for this study was:

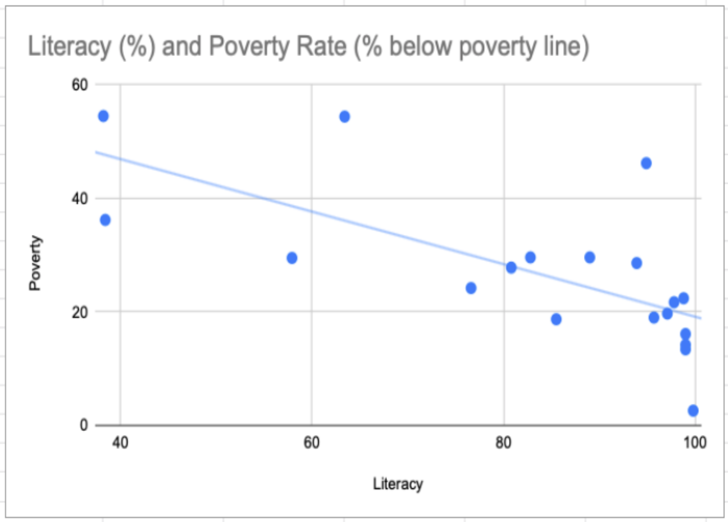
> Does learning mathematics in a collaborative group setting influence high school students' dispositions towards mathematics?

DESIGN OF STUDY

The design of this study was based on two units of Algebra 2 coursework. These units lasted approximately two weeks each and were about statistics and probability. During the first unit, students worked independently from each other on a statistics-based project. Students began the unit by collecting data in the form of a table, then graphing their data on a scatterplot. Students then began the process of analyzing the data by calculating statistics such as the mean, standard deviation, and correlation coefficient. Students were allowed to ask each other questions as it pertained to the project, but each student was required to complete their own project. In order to help model the different statistics, I completed an example project that students could reference. Figure 1 shows the model that I used for the first half of the statistics project.

Figure 1. Statistics project example

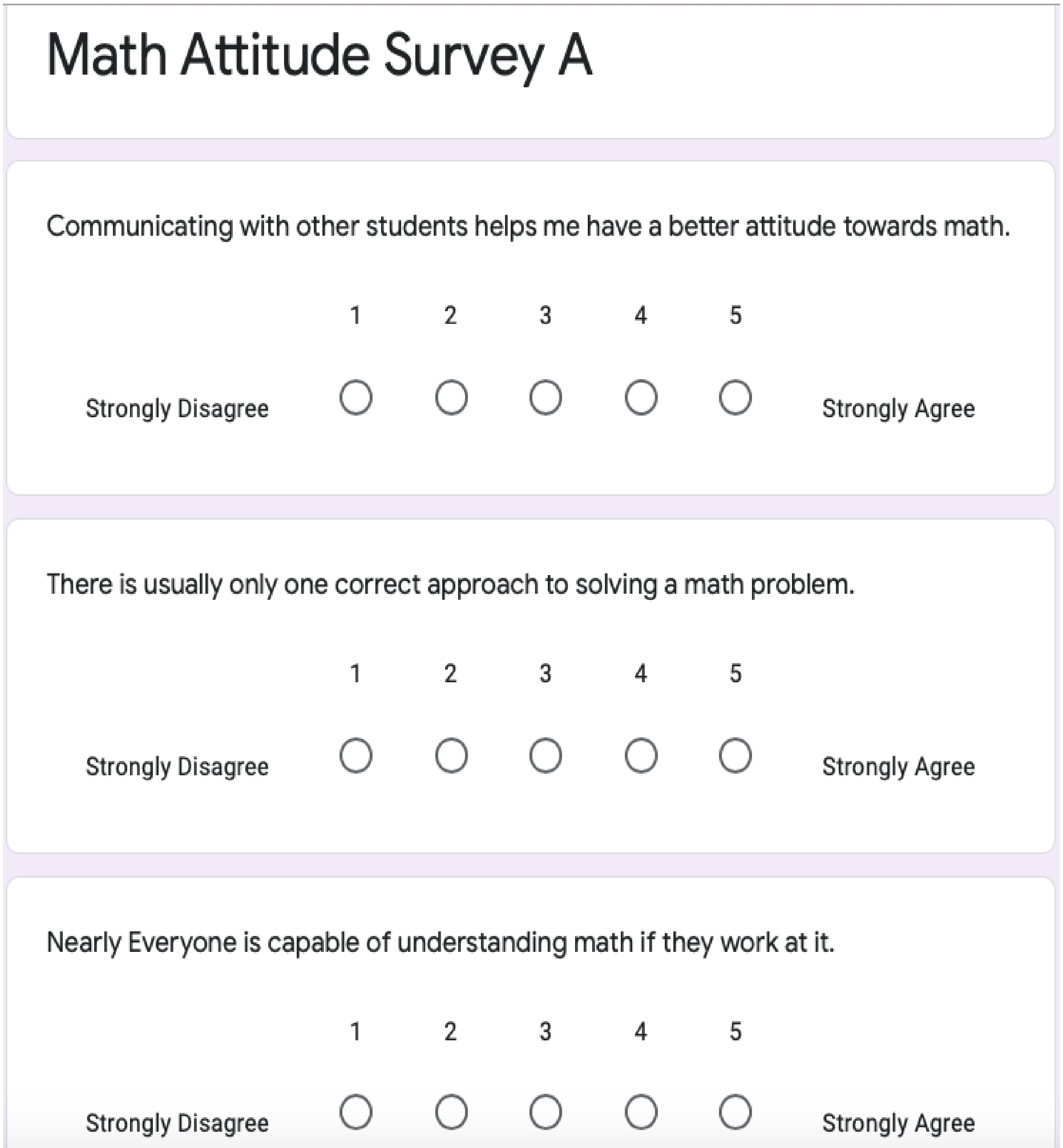
Country	Literacy (%)	Poverty Rate (% below poverty line)
Afghanistan	38.2	54.5
Benin	38.4	36.2
Costa Rica	97.8	21.7
Denmark	99	13.4
Egypt	80.8	27.8
France	99	14.2
Ghana	76.6	24.2
Honduras	89	29.6
Iran	85.5	18.7
Japan	99	16.1
Kazakhstan	99.8	2.6
Lebanon	93.9	28.6
Mexico	94.9	46.2
Nicaragua	82.8	29.6
Pakistan	57.9	29.5
Portugal	95.7	19
Romania	98.8	22.4
Venezuala	97.1	19.7
Zambia	63.4	54.4
	Avg: 83.6	AVG: 26.8
	Std dev: 19.5	Std dev: 13.2



During the second unit, students studied probability. During this unit, students completed multiple collaborative activities to discover how probability works. Activities were completed in small groups and included creating questions for other groups to solve, a group "Jeopardy" style review game, and many opportunities for math dialogue and discussion. One specific activity that students did during this unit was about counting large numbers. Students were asked to find how many phone numbers were possible using the guidelines that the United States follows. After I told students the guidelines for what made up a valid phone number, I also gave their table one big sheet of scratch paper, on which I asked them to do all of their work. I did this to encourage them to look at their teammates work and critique each other. During this time, I made sure to visit each table in order to take note of the different strategies that students were using. After ten minutes, I called the class back together and asked each group what number they found and how they found it. I then gave students time to go around to other groups to see the work they had done. Finally, if students hadn't already come up with the right answer, I showed them my way of getting the answer. We then spent the rest of class practicing this process in groups. After each of these units, students were given summative assessments. Once students had completed their assessments, they were given the opportunity to take a three-question survey in order to gauge their attitudes towards mathematics.

Parent permission forms were distributed a week before the first survey was released, in order to give students time to obtain parental consent. Students and parents were informed of their rights during the survey, including that the survey was optional and would not affect their standing in the class. 32 students completed at least one of the two surveys, and 18 (27% of the students) completed both surveys. For the first round of surveys, half of the students were given one subset of three questions, and half of the students were given the other subset of questions. For the second round of surveys, students were given the other subset of questions (the one that they did not take during the first round). The questions were split up by matching each question with a similar question. Each question was put in a different group from its match, so that both sets of surveys would contain similar questions. The reason that the questions were split up was so that students did not take the same survey twice. This was done to ensure that students would not be able to use the same responses to each survey. Surveys were created using a Google Form and posted on a Google Classroom page. Figure 1 and Figure 2 show what students saw when they opened the survey. Students were given access to the survey on the Friday that ended each unit and responses were accepted until the following Monday. After student responses had been recorded, student names were removed, and each response was given a numerical code number that corresponded to that student to allow for confidentiality and matching of pre- and post- responses. Student responses were compared as a whole from pre- to post- survey by finding the mean of each item. Student responses were also examined for each student who completed both the pre- and post- survey.

Figure 2. Survey A as it appeared to students.



Math Attitude Survey A

Communicating with other students helps me have a better attitude towards math.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

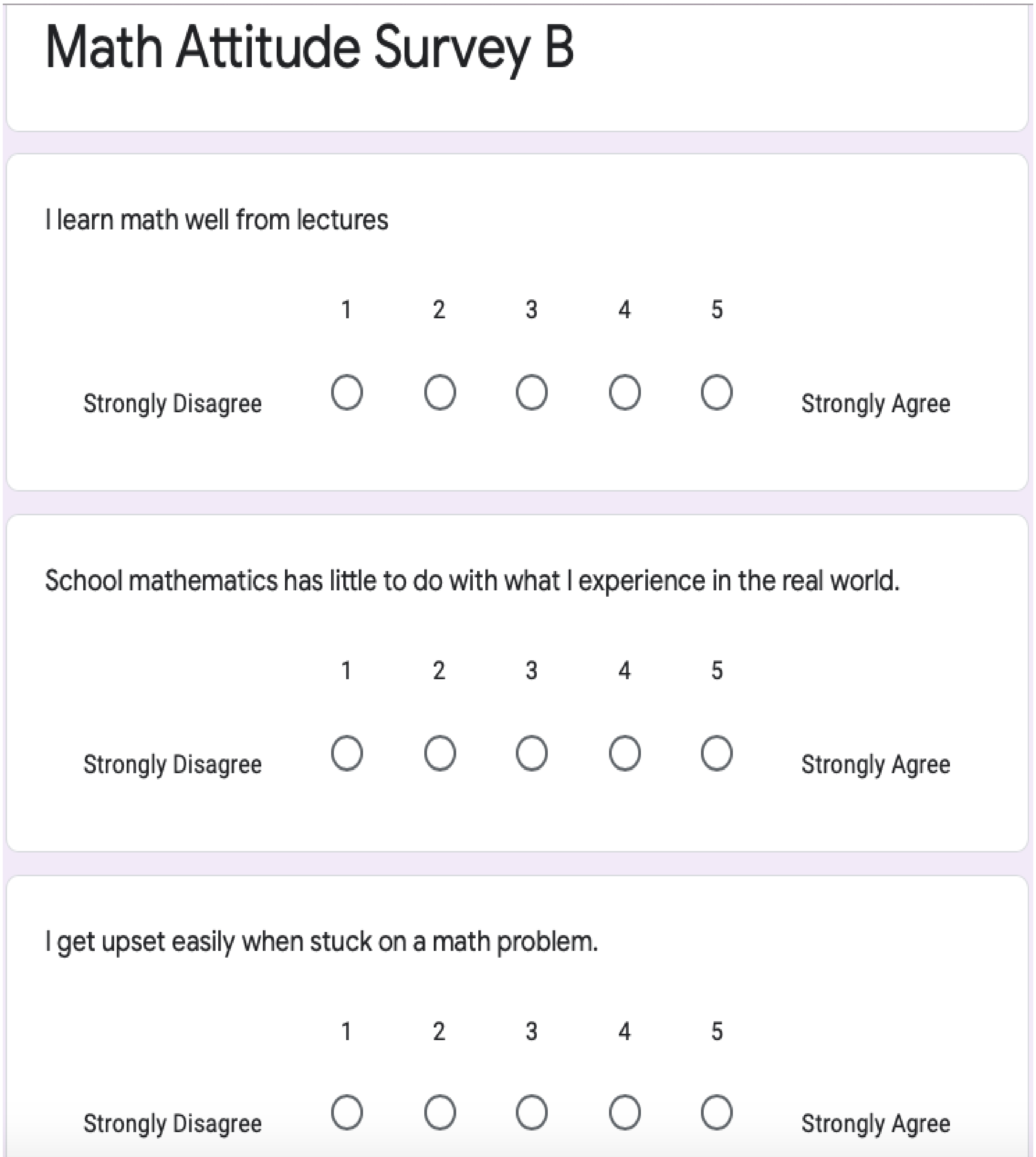
There is usually only one correct approach to solving a math problem.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Nearly Everyone is capable of understanding math if they work at it.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Figure 3. Survey B as it appeared to students.



Math Attitude Survey B

I learn math well from lectures

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

School mathematics has little to do with what I experience in the real world.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I get upset easily when stuck on a math problem.

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Sample

This study was completed in a mid-west urban high school. This high school had a graduation rate of about 90% and belongs to a district with graduation rate of about 80%. The school had over 1,200 students and is rated as One Star School (out of five stars) in the 2018-2019 star-level rating. Mathematics achievement for the school was below the district and state rates. The school had a 20% proficiency rate in the 2018-2019 mathematics test, compared to a 30% achievement rate for the district and a 35% rate for the state[1]. Students who were included in the study were sophomores in an Advanced Algebra 2 class, thus the cooperating teacher who I worked with described most students as above average in their mathematics comprehension and calculation abilities. Students came from a broad range of socioeconomic backgrounds as around 70% of the students were economically disadvantaged (including 49 students who were homeless). Although a little over 50% of the student population of the school was white, almost 67% of students in the advanced classes (and therefore included in this study) were white. Students were in the age range of 15-16 years old and in addition to being in the advanced math class, most were also in the advanced sections of their other classes. Among the three classes, 65 students were included in the study.

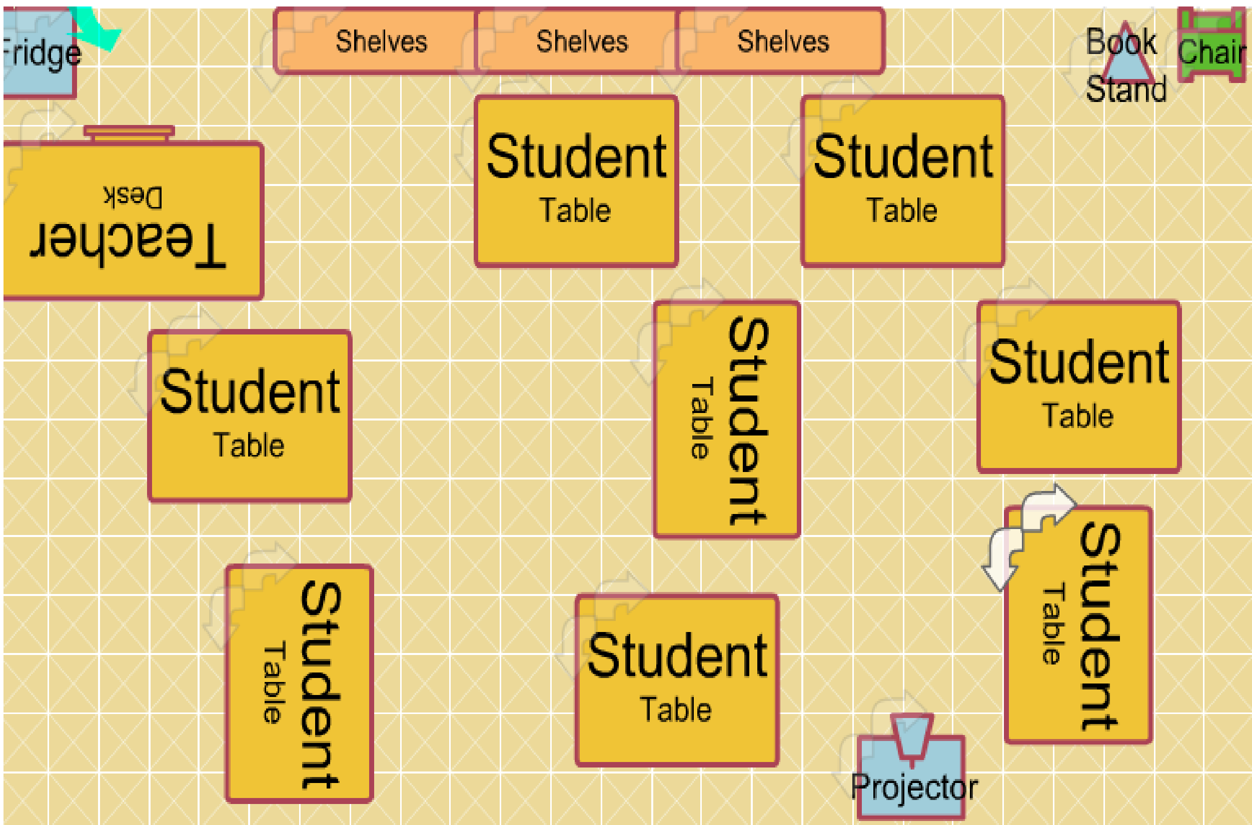
Setting

The classroom in which the study took place had eight tables with four students at each table (a diagram of the classroom is provided in figure 3). In addition to this, my cooperating teacher posted a list of group-work expectations. Both the classroom setup and the group-work expectations were present to encourage students to work together on their assignments, so

[1] The citation for the sample statistics has been omitted to protect student anonymity.

students were accustomed to working in groups before the study. There were three class periods that were included in the study. The first period had thirty students, the second had fifteen, and the third had sixteen. Each class was seventy-five minutes long, as the school ran on a trimester schedule.

Figure 4. A diagram of the setup of the classroom. Created using http://classroom.4teachers.org.



My cooperating teacher who allowed her classroom to be used for the study had been teaching at the school for ten years. This was her first-year teaching Algebra 2, as her first nine years had been spent teaching Algebra 1. My cooperating teacher and I worked collaboratively to create lesson plans starting three weeks into my student teaching semester. As the semester progressed, I began taking over teaching responsibilities one class period at a time. By the time that I was ready to start the trial for the study, I was in charge of teaching three out of the four class periods.

Even though class assignments were different every day, the class procedures stayed consistent. At the beginning of each week, students would pick up a "Daily Accountability" (DA) sheet on which they would record their warm-up, learning target, and closure for the week. Students would also pick up their homework packet that, in addition to their DA sheet, would be due at the end of the week. The warm-up problem would be posted on the board as students came into class, and students would be given five minutes to work on the warm-up problem. After the five minutes elapsed, the learning target would be posted on the board and I would go around to students and give students points if they had completed the warm-up. Since the warm-up was used as a pre-cursor to what we were going to discuss in that day's lesson, warm-ups were only graded on participation. After all students wrote down the day's learning target, we would go over the warm-up as a class. After the warm-up was reviewed, we would begin the main activity for the day. On most Fridays, the main activity was a summative assessment in the form of a quiz or test. If it was not a Friday, then students were taught using a variety of techniques and activities. With about ten minutes left in class, the activity would be wrapped up, and the closure prompt would be posted on the board. As students finished the closure, I would check their response for understanding and redirect them if their response did not align with what we had learned that day. After students were graded for their classwork and closure, they would begin packing up their belongings and get ready for the bell to ring.

INSTRUMENTS

The instruments that were used in this study consisted of two versions of a three-question survey to measure student attitudes towards math. The survey questions are based off a 5-point Likert scale so that the data that was collected could be represented numerically. For every survey item, students could choose “Strongly Disagree”, “Disagree”, “No Opinion/NA”, “Agree”, or “Strongly Agree”. As required by the school district IRB agreement, students could choose to not answer a question. I selected the survey items from two previously utilized and reviewed surveys.

The first item in Survey A was “Communicating with other students helps me have a better attitude towards math.” This item was selected in order to measure student attitudes towards group work in math assignments. This item was taken from a survey created by researchers at Oregon State University (n.d).

The second item in Survey A was “There is usually only one correct approach to solving a math problem.” Collaborative work encourages students to think of more than one approach to a problem, so this item was designed to measure how effectively collaborative work was in changing the perception that math problems only have one correct method. This item was originally in the Mathematics Attitudes and Perceptions Survey (MAPS) created by Code, Merchant, Maciejewski, Thomas, and Lo and was published in 2016.

The final item in Survey A was “Nearly everyone is capable of understanding math if they work at it.” This item measured student’s locus of control and whether that locus lay inside or outside of the individual. This item was also taken from MAPS (Code, Merchant, Maciejewski, Thomas, Lo, 2016).

The first item in Survey B was “I learn math well from lectures.” Generally, lectures do not allow for collaborative work, so this item was included to gather information on how students viewed their own learning process. This survey item corresponds to the first item in Survey A, as they both ask students about their preferences on how class activities are set up. This item was originally from the Oregon State University survey (n.d).

The second item in Survey B was “School mathematics has little to do with what I experience in the real world.” This item represented student attitudes towards the applicability of mathematics and the importance it would play in their lives. This item corresponds to the second item in Survey B as both have to do with the problem-solving aspect of collaborative work. If students are able to see the value of working in groups, they might link that to the value that mathematics plays in the “real-world.” This item is from MAPS (Code, Merchant, Maciejewski, Thomas, Lo, 2016).

The final item in Survey B was “I get upset easily when stuck on a math problem.” This item was designed to gauge how students felt about their own attitudes towards math. To respond to this item, students must be aware of their own reactions and tendencies when it comes to math class. This item corresponds to the final item of Survey A, as both items concern the resilience and willingness to work on challenging material. This item is also from MAPS (Code, Merchant, Maciejewski, Thomas, Lo, 2016).

The Oregon State Survey and the MAPS were used because they had both been validated and dealt with attitudes towards math. They both also used the Likert scale, which meant the items did not need to be restructured. Only six items were used because of the time-constraint, to minimize the threat of test fatigue, and the thought that students would need to put into each item. Students were asked to fill out the survey in the last five minutes of class, so a survey with a large number of questions would be impractical. The length of the survey also allowed students to read the items more carefully and put more thought into their responses.

PROCEDURES

At the beginning of the semester, I began the process of attaining Institutional Review Board (IRB) permission to conduct this study. Although I was surveying minors, the items in the study were only measuring attitudes and did not present a risk for any students involved. This being the case, I applied for an expedited IRB approval through Bellarmine University. Once I received Bellarmine IRB approval, I submitted an application through the school district IRB. As soon as I received IRB approval from the district IRB (on the condition that I submitted my data back to the IRB when completed) I began the first unit of the study.

Although students were permitted to talk to and seek help from their peers during the first unit, there were no learning activities that had them working together. Instead, students were to focus on their own project as they worked to calculate statistics on the data that they found. Students still sat in the groups that they were in prior to the unit. When one week was left in the unit, parent permission forms were passed out, and students were informed that they would have the opportunity to participate in this research study. Students were informed that the study was optional, and that it would have no impact (positive or negative) on their standing in the class. Students were asked to return the surveys by the end of the unit if they wished to participate in the survey. On the final day of the unit, students were given time in class to finish and submit their projects. Students were also given the opportunity to take the pre-survey during the last five minutes of class. Students were given Survey A or B based off of last name.

During the second unit, every lesson included at least one collaborative component. At the beginning of the unit, students were asked to discuss with their peers and come up with a definition for probability. Students also responded to prompts as a group that guided them towards theorems of probability. As the unit progressed, the collaborative work became more advanced as students were tasked with creating probability problems for other groups and discussing how to solve them to the class. The only part of the unit that was not collaborative was the summative assessment at the end of the unit. The summative assessment was a test that covered all of the material in the unit. After students took the test, they were given time to complete the post-survey. Students who had taken Survey A as the pre-survey were given Survey B for their post-survey and vice versa.

LIMITATIONS

This study was completed in a small window of time, as students took the second survey two weeks after the first survey. The short amount of time in between survey administrations might not have allowed for student's attitudes to demonstrate meaningful change. Since the survey was being administered in a public-school setting, I applied for IRB approval through the school district as well as through Bellarmine University. Although the Bellarmine IRB approval process was completed quickly, attaining IRB approval from the school district took longer than expected. In the end, the IRB documentation had to be resubmitted and was approved with six weeks remaining in my student teaching semester.

Students were not required to complete the pre- or post- survey, as stipulated in the IRB agreement. This limited the amount of data that was collected. Students were given the opportunity to complete the post-survey even if they did not complete the pre- survey. Although students were given time at the end of class to complete the survey, if they did not have a device (such as a smart phone) that could access Google Classroom, students were provided with the option of using one of the Chromebooks that were kept in class. This might have discouraged students who did not have access to Google Classroom on their phone for taking the survey.

A limitation that could have influenced the data collected was the wording of the questions. I made the corresponding survey items similar, but not identical so that students would be encouraged to read the question thoroughly and not just answer the exact way that they did during the pre-survey. Although this was necessary to ensure student responses were accurate, it did create the possibility that the index might be skewed one way or the other.

My sample size was also a limitation, since I only had 65 students who were in the same class section. This sample was selected based on the convenience of being the classes that I taught during my student teaching. Since I wanted to be able to keep coursework the same for all students involved in the study, I was unable to use the Comprehensive Algebra II class that my cooperating teacher and I taught in addition to the Advanced Algebra II classes. This would have given a larger sample size.

Another limitation that might influence the data collected is that the collaborative unit was completed on probability and the individual unit was on statistics. If a student had a preference of statistics or probability, this preference could have influenced their responses in the surveys. In addition, each survey was only three questions long, so although it was more accessible to students at the end of class, the data collected does not include any student work or any open-response questions.

RESULTS

DATA

Between both the pre- and the post-survey, I received 50 responses. 28 responses were from the pre-survey and 22 were from the post-survey. In addition, 18 students completed both the pre- and the post- survey (the other students only chose to fill out one or the other). Listed below are each student's responses. Each student was assigned a two-digit number. The letter beside their number refers to which survey that set of responses represented. Each question utilized the Likert Scale, with "Strongly Disagree" being 1 and "Strongly Agree" being 5.

The questions have been labeled as follows:

Q1: Communicating with other students helps me have a better attitude towards math.

Q2: There is usually only one correct approach to solving a math problem.

Q3: Nearly everyone is capable of understanding math if they work at it.

Q4: I learn math well from lectures.

Q5: School mathematics has little to do with what I experience in the real world.

Q6: I get upset easily when stuck on a math problem.

Table 1

Pre-Survey A	Q1	Q2	Q3
26A	4	2	3
25A	3	3	3
29A	2	1	5

32A	4	2	5
33A	2	2	3
30A	5	3	5
31A	4	1	4
34A	5	2	5
24A	5	1	5
27A	5	2	5

Table 2

Post-Survey A	Q1	Q2	Q3
17A	1	3	1
10A	5	2	4
16A	4	1	3
03A	4	2	3
15A	5	1	1
01A	5	2	5
22A	4	5	5
08A	4	2	3
11A	5	3	5
02A	5	2	5
13A	4	1	4
19A	4	3	4
09A	4	1	3

18A	3	3	4
14A	5	2	4
06A	5	3	4

Table 3

Pre-Survey B	Q4	Q5	Q6
05B	4	4	3
17B	3	4	5
10B	2	4	5
16B	1	4	4
03B	5	4	3
15B	3	3	5
01B	4	4	2
22B	2	3	5
04B	3	2	1
08B	2	3	3
11B	1	5	3
13B	3	2	2
19B	5	2	2
09B	4	2	3
18B	3	3	4
06B	4	4	3
20B	2	3	3

12B	4	5	4

Table 4

Post-Survey B	Q4	Q5	Q6
26B	4	4	2
23B	4	2	2
28B	3	4	3
29B	1	5	3
32B	2	5	3
33B	3	3	2

Figure 5. A bar graph showing the mean student responses for each question. Responses were sorted based on whether they were from a pre- or a post- survey

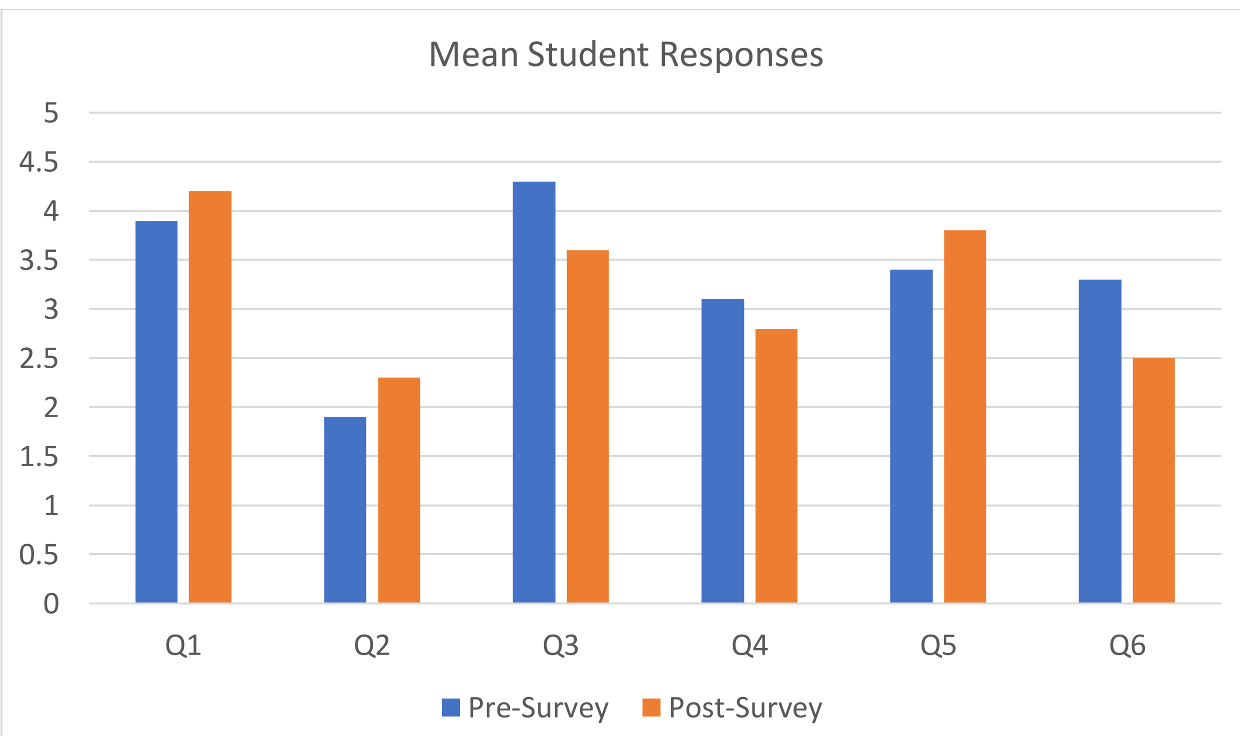
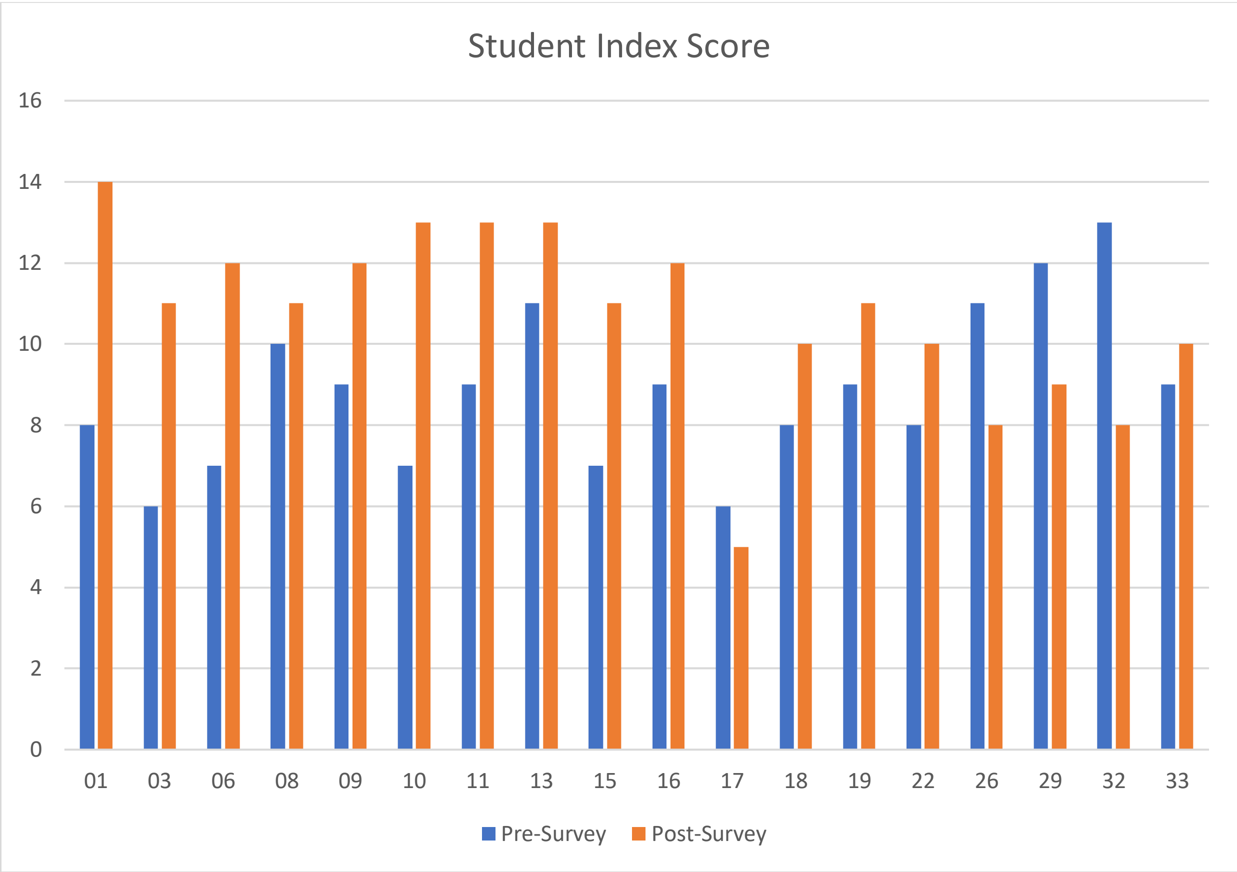


Table 5

	Pre-Survey	Post-Survey	Change
01	8	14	6
03	6	11	5
06	7	12	5
08	10	11	1
09	9	12	3
10	7	13	6
11	9	13	4
13	11	13	2
15	7	11	4
16	9	12	3
17	6	5	-1
18	8	10	2
19	9	11	2
22	8	10	2
26	11	8	-3
29	12	9	-3
32	13	8	-5
33	9	10	1
Average	8.83	10.72	1.89

Figure 6. A bar graph showing all student index scores for students who took both the pre- and post- survey.



INTERPRETATION

The results from this survey were somewhat mixed, as Q1 (Communicating with other students helps me have a better attitude towards math) improved by 0.3 points from the pre- to the post- survey, and Q6 (I get upset easily when stuck on a math problem) decreased by 0.8 points. Both of these results point to student attitudes towards math improving after working with their groups. Additionally, Q4 (I learn math well through lectures) declined by 0.3, which could point to preference for different teaching methods (such as problem-based learning or collaborative activities).

As for the other three survey items, the responses did not indicate a positive student reaction to collaborative work. Q2 (There is usually only one correct approach to solving a math problem) increased by 0.4 points, which means students were more likely to think that there was only one correct way to solve a problem. One of the goals of collaborative work is to value all voices and show students that there is often more than one way to work through a problem. Q3 (Nearly everyone is capable of understanding math if they work at it) decreased by 0.7 points. Q5 (School mathematics has little to do with what I experience in the real world) increased by 0.8 points.

To compare individual responses to the pre- and post-survey, I created an index based on the combined scores from each survey. For Q2, Q4, Q5, and Q6, I inverted the score so that a response of strongly disagree would correlate to a 5, disagree would be a 4, N/A would still be a 3, agree would be a 2, and strongly agree would be a 1. For Q1 and Q3, I used the original scoring method to assign a number to each response. I then summed each survey and recorded each student's pre- and post-survey. These are the scores that are reflected in Table 5 and Figure 6. Out of the eighteen students who completed both the pre- and post-survey, twelve saw their scores improve by more than one point. Three student's scores dropped by more than one point and the final three student's scores stayed within one point of the pre-survey. Student surveys improved by an average of 1.8 points (out of a total of 15 possible points).

DISCUSSION

Most prior research on collaborative work in the classroom has focused on the academic impact on students. Although improved learning outcomes are incredibly important, teachers must consider more than that when deciding what teaching techniques to utilize. One area that is often overlooked is student attitudes towards that content. Although previous studies have provided qualitative data for understanding student attitudes towards mathematics when it comes to collaborative work in the classroom, this study strove to quantify student attitudes towards mathematics. By using a Likert Scale, this study was able to place a numerical value on student responses to survey items designed to measure their attitudes towards mathematics before and after working in collaborative groups for two weeks.

The study that I referenced most while completing this study was “Cooperative Learning in the Secondary Mathematics Classroom” (Whicker, Bol, Nunnery, 1997). My study was very similar to this study, with a few differences so that the data would reflect student’s attitudes towards math instead of just their success in the class. Additionally, my survey had all students work in non-collaborative and collaborative work, while the study from Whicker, Bol, and Nunnery had one class of students who worked collaboratively the entire time and one class that worked independently. Although the results that Whicker, Bol, and Nunnery found concerning student attitudes towards math were qualitative (students were asked open-ended questions after their assessment), their results do agree with the results that I found from my quantitative survey, especially when it comes to Q1 from my survey. Most students in most studies responded that they

Although the students in this study were high school sophomores, another study on eighth grade students found similar results when it came to student motivation. Allison found that student motivation was positively impacted by incorporating a specific type of collaborative learning, peer instruction (2012). Allison found that the student motivation factors that increased were attention and relevance. The other two aspects of student motivation that Allison examined were confidence and satisfaction. All of these were aspects of attitude that were addressed in survey items Q3 (Nearly everyone is capable of understanding math if they work at it.), Q5 (School mathematics has little to do with what I experience in the real world), and Q6 (I get upset easily when stuck on a math problem). Student motivation is a key part of student attitudes towards mathematics.

In terms of creating an equitable classroom, a study by Vaughan states that collaboration can specifically help minority students improve their attitudes towards mathematics (Vaughan, 2002). In this study, students showed improvement in their attitudes towards mathematics no matter their race, gender, or background. Similarly, the few students whose attitude scores did not improve did not share any specific characteristics either. Students of color made up about 33% of each subgroup (improved, declined, and no change). One way to further explore this area of impact of collaboration would be to enact this study in a more diverse setting. During my student teaching, I was a part of a comprehensive Algebra II class in which students of color were the majority. If I attempt to repeat this study in the future, I would repeat it in multiple different levels of mathematics to ensure a diversity in ability level as well as ethnicity, socioeconomic background, etc.

Implementing collaboration in the math classroom takes practice, but once students are used to it, it can become a vehicle for improved learning opportunities. One way to encourage collaboration is to have students discuss ideas on the best way to solve a new problem. Let each group know that they have to find three unique ways to solve a problem before they can decide which they like best. Another way to increase collaboration in the classroom would be to split students into two groups and have each group learn how to do one part of a problem. Then, students would need to find a partner from the other group and teach each other how to complete the problem that they had just learned.

As a future high school math teacher, I look forward to using small-group collaboration in the classroom. I plan on using the same style that my cooperating teacher and I used in terms of classroom setup, with groups of three or four students and mixing up student groups in order to help students gain experience working with different types of people. I also want to use the direct collaboration strategies that I used during the probability unit during other units. Having all students in a small group work on the same problem on the same sheet of paper encouraged them to have discussions on what method they wanted to use and why. I also want to continue allowing student attitudes towards content to drive how I plan instruction. While small group collaboration is very beneficial, there is still a time and place for students to work individually, especially when they need to cement and demonstrate their own knowledge.The classroom should be a positive environment, and any instructional strategy that helps students' motivation or attitudes towards a subject is an instructional strategy that I want to incorporate in my future classroom. I hope to be able to continue contributing to existing literature around best classroom practices and become a life-long learner just like the ones I am trying to develop in my classroom.

Conclusion

Student collaboration in the classroom has recently seen a resurgence in popularity, especially in the world mathematics, due to multiple studies pointing to increased student achievement when collaboration is effectively utilized. Although achievement scores are important, student attitudes are also a vital piece of the puzzle that educators should consider when making pedagogical decisions. This study examined the question, "Does learning mathematics in a collaborative group setting influence high school student's dispositions towards mathematics?" Based on student responses from three different sections of the same Advanced

Algebra II course, student attitudes towards math seemed to improve after working in a collaborative group setting. More research is still needed to fully determine the extent of influence that collaborative work has on student attitudes, especially considering the other factors that influence attitudes. That being said, based on the results of this and other studies, collaboration should be considered best practices for teachers in the high school mathematics classroom.

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