Student Attitudes, Collaborative Group Work and Technology Use in Elementary Mathematics Classrooms: Examining Connections

Katie Kukulka

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Student Attitudes, Collaborative Group Work and Technology Use in Elementary Mathematics Classrooms: Examining Connections

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Participating Classroom Teacher: Maren Tillman
Faculty Advisor: Dr. Christine Browning

Western Michigan University
Introduction

Understanding how the structure of a group of students impacts how they work together has always been an interesting concept for me, as sometimes my teachers strategically placed certain students with other students, and sometimes we got to choose our seats in class. Recently, I began to focus on how my college peers worked together in groups in my mathematics classes. For example, I noticed how some students would start to lead and take ownership for a group, others would facilitate these group conversations, commenting on the lead students’ suggestions or perhaps recording answers to group work but not necessarily contributing to the discussion, and finally others would remain quiet throughout the group conversations and not participate much at all. These observations have been evident to me in both group tasks, as well as in whole-class discussions. Having some understanding of the roles each individual takes on in productive and less-productive group work, as well as how to alter a group structure to allow for more equitable participation within the group, would be important for me as a beginning teacher of mathematics and thus, helped to frame my research focus for this project.

There are many factors that may contribute to how one participates in a small group in a mathematics class such as their interest in the content (Hidi & Renninger 2006; Fung, Tan, Chen 2018), their knowledge of how they are being evaluated on the task (Azevedo, diSessa, & Sherin 2012), and their prior experiences, knowledge, and current curiosity in learning (Kovalainen & Kumpulainen, 2007). Additionally, a student’s attitude towards the subject has been found to impact the level of engagement that a student portrays (Qaisar, Dilshad, Butt 2015). Another factor that interested me was the use of technology in the mathematics classroom. Polly (2014) found that “technology provides learners with the ability to quickly generate and manipulate mathematical representations, thus allowing them to concentrate more on examining the mathematical concepts and making connections between the representations and the mathematics they explore”. Since research suggests attitudes about mathematics are not fixed (Qaisar, Dilshad, Butt 2015), I chose to focus on student attitudes, and incorporate technology, as I was interested to see if technology may play a role in the changing of attitudes.

Thus, I examined if there are any correlations between students’ attitudes towards mathematics and the collaborative practices that they exhibit in small group work in the classroom. Additionally, my research examined the incorporation of technology, and the impact technology may have on changing attitudes of the students, or the collaborative work of small groups.

Literature Review

The research project relates to three broad areas: children’s attitudes toward mathematics, students work in small groups, and the use of graphing calculator technology in the teaching and learning of mathematics.

In regard to children’s attitudes toward mathematics, research shows that students’ attitudes toward mathematics can have a significant impact on their ability to complete mathematical tasks. Middleton and Spanias (1999) found that if a student has decided they are
interested in mathematics, they will be more likely to engage in a mathematical activity than a student who has classified mathematics as “not an interest” and will likely not participate in the activity. They also indicate that feelings about mathematics and students’ interests regarding mathematics are often developed in the elementary grades. Because the study consists of upper elementary students, we will be able to examine attitudes about mathematics that are becoming more established. More recently, Orosco (2015) found that students with positive attitudes toward mathematics tend to engage in more challenging math activities. Mofield and Peters (2018) have also found that attitudes are not fixed, as long as the student has a growth mindset. From this section of my research, I was interested see what attitudes about mathematics the 5th grade students participating in the study had, and if their attitudes changed after participating in the brief unit I taught.

For student work in small groups, Boaler (2008) has found that students who work in effective groups in mathematics class find an improved ability to learn responsibility and respect for their peers and have commented on a greater positivity in the atmosphere of the class. She also found that students enjoy considering each other’s contributions, allowing them to find a solution to a problem together. When small groups are effectively used, students gain communication and problem-solving skills, in addition to completing the mathematical task. Students who are engaged in effective groups have learned to trust and respect each other, as well as have the ability to create and carry out a plan for how to complete the task (Baines, Blatchford, Chowe, 2007). In order to complete the tasks assigned, Esmonde (2009) found that high school students working in small groups “adopt a variety of positions within their groups, including expert, novice, in-between, and facilitator.” The positions that students place themselves within a group is an indication of their feelings about mathematics; if they feel they know more or less than a peer, this can affect their participation in the small group. I was interested to see how the children in the study work in collaborative groups. Do they engage in any features of effective group work as described above? Are any of the group positions as suggested by Esmonde (2009) exhibited in their group work?

Finally, for the use of graphing calculator technology in the teaching and learning of mathematics, research indicates that technology can positively impact students’ ability to learn mathematics: “It has been shown that experiences, in which students interact with tools to create phenomena, help them to understand the mathematics connected to those phenomena” (Ferrara 2014). Additionally, since students learn in various ways in a classroom, the traditional print medium may not be an effective learning tool for every student. Educators have integrated technology to provide a way for students to manage learning new information, as well as to help create an individualized learning environment, where students can take control of their learning (Shin, Sutherland, Norris, Soloway, 2012). Further, Kurtz and Yanik (2019) found that graphing calculators provide an opportunity for students to develop algebraic concepts with more meaning, because the calculators allow them to see graphical representations in order to connect graphically what is happening symbolically in an equation. In particular, concepts of distance, time, velocity, and acceleration are abstract and challenging for learners. They found that by
using graphs of motion created from using graphing calculators in conjunction with Calculator-Based Rangers (CBRs), students could explore these relationships, improving their understanding because they have the opportunity to visually see a model. The combination of this research led to my interest in observing the group dynamic as the students used the technology within their groups to solve problems involving distance and time relationships.

**Data Collection Methods**

To explore the collaborative practices of elementary students in small groups, I developed a unit focused on the two topics of patterns and relationships and graphing, reading, and interpreting data on a coordinate plane. All students completed an attitude survey before and after the completion of the unit. During the teaching of the unit, an observation protocol was used to examine student collaborative practices for just two groups. All students completed both individual and group-assigned exit tickets, various unit assignments, and a short unit test to provide formative and summative assessment of their content understanding. Both quantitative and qualitative data was collected to examine correlations and associations between attitude, collaborative practices, and the use of technology.

This research project was approved by the Western Michigan University Human Subjects Institutional Review Board (WMU HSIRB). Parental consent forms and student assent forms were completed by the parents and students for each student that participated in the study.

**Participants and setting**

The research took place at Comstock STEM Academy in Mrs. Tillman’s fifth grade mathematics classroom. Classroom observations, the teaching of the unit and data collection took place between September 2019 and November 2019. A brief timeline of the time spent in the classroom is provided below. All of the students in Mrs. Tillman’s class participated in the class work as the unit taught was part of the normal class routine, however data was only collected from students who assented to be in the study and whose parents had consented for them to participate. There were 17 students in the class, and 11 agreed to participate, from which 8 students were selected by the classroom teacher to participate in the small-group data collection in this study. Selection was chiefly based on student participation in class up to the beginning of the introduction of the study unit, with Mrs. Tillman choosing students who she thought would readily share their thinking in a small group discussion. Data analyzed for this study only came from these eight students.

<table>
<thead>
<tr>
<th>September 2019</th>
<th>Observing Mrs. Tillman’s class one to two times per week, creating and testing observational protocols.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>September 6, 2019: Students completed pre-attitude survey</td>
</tr>
<tr>
<td>October 2019</td>
<td>Observing Mrs. Tillman’s class two times per week, interacting and working with students</td>
</tr>
</tbody>
</table>
October 16, 2019: Katie taught part of Mrs. Tillman’s lesson to familiarize students with her. Finalized the observational protocol to be used during the study.

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 4, 2019</td>
<td>Lesson #1; small groups observed; exit ticket #1 completed individually</td>
</tr>
<tr>
<td>November 5, 2019</td>
<td>Lesson #2; small groups observed; exit ticket #2 completed individually</td>
</tr>
<tr>
<td>November 6, 2019</td>
<td>Lesson #3; small groups observed; exit ticket #3 completed in groups</td>
</tr>
<tr>
<td>November 7, 2019</td>
<td>Lesson #4; small groups observed; exit ticket #4 completed individually</td>
</tr>
<tr>
<td>November 8, 2019</td>
<td>Lesson #5; small groups observed; exit ticket #5 completed in groups, students completed unit test individually</td>
</tr>
<tr>
<td>November 11, 2019</td>
<td>Students completed post-attitude survey</td>
</tr>
</tbody>
</table>

**Design of the Unit**

A unit plan (See Appendix A) was developed collaboratively with Dr. Browning, with feedback from Mrs. Tillman. The unit plan consisted of five lessons, each one hour in length. Developing students’ abilities to analyze patterns and relationships and to graph, read, and interpret bivariate data on a coordinate plane was the focus of the unit. Additionally, technology was used for students to read, interpret, and construct graphs, using a graphing calculator and a CBR motion sensor, both introduced in lesson four. The lessons were centered around graphing points on the coordinate plane to solve real-world and mathematical problems, and the following related Common Core State Standards (CCSS):

- **5.G.1.** Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to gravel from the origin in the direction of one axis, and the second number indicates how far to travel from the origin in the direction of the second axis, with the convention that the names of the two axes and coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate).
- **5.G.2** Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane and interpret coordinate values of points in the context of the situation.

These two content standards and the unit we prepared aligned with the content from the 5th grade school curriculum. Student objectives that were met through each lesson are described below, and the individual lesson plans are in Appendix B.
<table>
<thead>
<tr>
<th>Lesson</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Students will understand the parts of a graph and how they are used to read the whole graph correctly, including the axes and coordinates, and labeling the axes and scale used correctly. Students will also be able to construct a line graph. Students can also plot points from a table onto a graph. In this activity, students can see the connection between the ordered pairs on the table being the actual points on the graph.</td>
</tr>
<tr>
<td>2</td>
<td>Students will continue working on how to read a line graph and will be able to connect a story describing a particular line graph. They will need to determine the key variables in the story, connect each one to an appropriate axis (setting the stage for independent and dependent variables), plot key points on the graph based upon the story/scenario and then connect the points with line segments to finish the line graph. Students will begin to make sense of slope as a measure of distance/time or speed.</td>
</tr>
<tr>
<td>3</td>
<td>Students will walk along a straight path of varying speeds to begin to develop a connection between the slope/steepness of a line with their speed. Students will create a graphical representation of their movement.</td>
</tr>
<tr>
<td>4</td>
<td>Students will begin to learn how to use the CBR and graphing calculator. Students will walk along a line marked with distance measurements so that their movement mirrors a given distance/time graph. From this, students will begin to understand how a distance/time graph can represent a person’s motion, focusing on a meaning for positive, negative and zero slope with respect to walking away from or towards the motion detector or not walking at all. Students will connect this lesson to previous lessons in which we saw that stories can be created from distance/time graphs.</td>
</tr>
<tr>
<td>5</td>
<td>Students will create a distance/time graph to match a given graph. Students will draw upon what they learned in the previous lessons to create a plan for their matching walk, carry out their plan, and then assess their performance by examining their path displayed on the calculator screen.</td>
</tr>
</tbody>
</table>

**Observational Protocol**

To develop the observation protocol (Appendix C) used in this research, we examined studies that had used existing or created new observation protocols. Esmonde’s (2009) research on the positions of members of a group and how they collaborate in a group, utilizing the labels “expert, novice, in-between, and facilitator”, created the basis for the first observation protocol we created for this research. After using the protocol to observe a group in Mrs. Tillman’s class for the entire class period, it proved to be difficult to keep up with the changing dynamics of a group, as well as not specific enough for the purposes of this research. Looking for a way to narrow down the focus of the elements on the observation protocol, Roschelle et al (2010) and Kern, Moore, and Akillioglu (2007) suggested the observation time be a shortened portion of the lesson, such as ten minutes. Roschelle et al (2010) created a protocol consisting of three parts; classroom observation overview, student behaviors, and teacher activity. Although his research focused mostly on the teacher activity, we used the structure in creating our observation protocol, which goes more in depth in regard to the observed elements, as well as including student
characteristics that Esmonde (2009) labeled. For example, we noticed which students took a lead in the activity, whether students asked and responded to mathematical questions of each other, and if students made use of any tool (paper or technology) when providing a mathematical explanation to their peers.

The goal of the design of the observational protocol was to attend to key features within a cooperative group and maintain high inter-rater reliability of gathered data, meaning the protocol had to be clear enough for two people to gather observational data from the same group and collect very similar, if not identical, data. After several iterations, a protocol was developed (Appendix C) that allowed us to observe components of group dynamics and had an inter-rater reliability of at least 85%. Two groups of four students were selected to be observed by the classroom teacher. Mrs. Tillman chose students she believed would collaborate in group work based upon how they had participated in class up to the beginning of the study unit.

At a pre-determined time during each lesson, Dr. Browning and Mrs. Tillman observed the two groups of four students. During the 60-minute lesson, they agreed upon a particular ten-minute segment to collect data using the observation protocol, where focus was given to the conversations, contributions, and work completed by each of the students in the group and tallies were collected on specific collaborative practices listed on the observation protocol. Completion of the protocol occurred at a time when students were actively working in their small group, and intervention from any adult in the room was minimized. At other points during the lessons, Dr. Browning and Mrs. Tillman could interject, as to ensure the essential content was covered and aid in questioning the students about the mathematical task they were engaged in.

**Attitude Survey**

Before the unit began, students completed the attitude survey (Appendix D). The survey was developed based upon items from existing attitude surveys. The goal of our survey was to gain a perspective of an overall attitude each student had about learning mathematics. Item stems for the majority of the survey questions were taken from the following two studies focused on designing attitude surveys. Orosco (2015) developed a survey for his research consisting of ten groups of two related broad statements that students chose one option for, such as “I like doing math and I do not like doing math.” Qaisar et al’s (2015) study focused on student beliefs about mathematics as a subject, as well as their beliefs about personally learning mathematics. This research inspired the inclusion of questions on our survey focusing on mathematics as a whole and the students’ vision of mathematics in their life. In addition to survey items adapted from these two studies, we included questions on the survey based upon other research related to student learning. For example, a question was focused on the confidence that students felt they had while engaging in mathematical tasks. This question was included because we believed confidence may have an impact on student participation in a small group. At the end of the unit, students completed the attitude survey again, with three additional questions about technology. The questions existing on both surveys were compared to learn of any changes in students’
attitudes after participating in the unit, working collaboratively in groups, and engaging with technology.

Responses to each of the questions were measured using a Likert scale of 5, allowing the students to show how they felt about a particular survey item as a scaled response, and were scored from 1 (low/weak) to 5 (high/strong). The response scores were then used to assign each student an attitude score. The post survey added one additional question with numerical response choices, and two additional free response questions regarding the use of the technology in the classroom. Data gathered from the additional questions included on the post-survey are provided in the results and discussion section below.

Formative and Summative Assessments

To provide a formative measure of student knowledge, this study used various exit tickets after each lesson (Appendix E). For example, students completed a graph in the first lesson, which focused on how to read a graph, plot points, and label axes correctly. Students focused on making a connection between ordered pairs on a table and the actual points on the graph during this lesson. For the first exit ticket, students were shown a correctly completed graph of a trip of a balloon and were asked if the graph told them anything about how fast the balloon was traveling. This exit ticket allowed insight into the understanding the students had after the lesson, as well as examining if students’ thinking went beyond the content focus for this lesson. The tickets were completed individually for 3 lessons and collaboratively within the student groups for 2 lessons. In addition, the test at the end of lesson 5 provided summative results from the individual students, allowing us to gain an idea of the effectiveness of the unit in helping the students reach the overall unit objectives.

Results and Discussion

The three main data-gathering instruments for this study were the pre- and post-attitude surveys, observation protocols completed for the two groups from each lesson, and the assessment tasks (formative and summative assessments) completed during the unit. In this section, I will provide results from each of these tools for the eight students from the two groups. Additionally, I will begin to discuss how these findings relate to my overall research focus of finding correlations between students’ attitudes towards mathematics and the collaborative practices they exhibited in small group work in the classroom. The impact technology may have had on changing attitudes of the students or the collaborative work of small groups will also begin to be discussed.

Attitude Survey
Table 1 shows student response scores for each of the attitude survey questions (blue), mean scores for each student for the entire survey (orange), total scores for each student (green), and mean scores for each survey question (yellow). Mean scores (orange) for each student provide an overall attitude score for the student, based on the five-point Likert scale. Total scores (green) for each student provide another look at an overall attitude score, with the highest survey score possible of 35 points. Mean scores (yellow) for each survey question provide a sense of the typical attitude that these eight students had for each question, based upon the five-point Likert scale. Scores in red text are those that decreased from the pre-to post-survey. Lighter and darker shades for each color category are used to help read the table.

Data collected shows that the majority (6) of students’ mean scores (orange) increased after participating, ranging from an increase of 0.2 to 1.0. The 2 mean scores that show decreases are small, ranging from a decrease of 0.1 to 0.3, indicating minimal change in attitude. Student mean attitudes ranged from a 2.5 to a 3.8 on the pre-survey, and from a 3.3 to a 4.4 on the post survey. When examining a change in the mean student item scores, we see an increase from 3.5 to a 4.0. This shows that before participating in the unit for this research, students had a
relatively high positive attitude regarding mathematics, however, the positive attitude still increased after participating in the unit.

Overall, five survey questions saw an increase in mean scores (yellow) from pre- to post-surveys, while the other two questions (5 and 7) remained constant. Question 2, that asked about using graphing calculators to learn mathematics, showed the largest mean score increase of 1.5. The absence of a decrease in any of the item mean scores, along with the increases in 5 mean item scores, shows that student participation in the unit helped to support student development of a more positive attitude towards mathematics.

Questions with the highest positive attitude score in the pre-survey included liking math (question 4), how easy or hard doing math is (question 5), and the importance of math (question 6), suggesting that, for these eight students, they believed in the importance of math, found it fairly easy to do and enjoyed doing it.

The data shows that only question 2, asking students the extent to which they thought graphing calculators helped them learn mathematics, had pre-survey responses of 1, indicating “they didn’t know”. For this question on the pre-survey, no students indicated that they felt graphing calculators were not helpful (a code number of 2), one student indicating they are somewhat helpful (a code number of 3), 3 students indicating they are helpful (a code number of 4) and one student indicating they are very helpful (a code number of 5). Each of the three students that chose “I don’t know” on the pre-survey then chose “helpful” or “very helpful” on the post survey. This shows that students had an open mind about the use of graphing calculators before using them in the unit, in addition to the positive responses received from students after they interacted with the technology.

Post-Survey Additional Questions

The post-survey included one additional question with numerical responses and two additional free-response questions. These questions were included in order to gain some insight into how students felt about the specific technology they engaged with during the last two lessons. These three questions were not included on the pre-survey because the researchers felt students would not have had the experience to accurately answer the questions. Student responses to question 2, regarding students’ use of graphing calculators, show that was the case, since three students chose “I don’t know” as an answer.

Question 8 asked students about the use of the graphing calculators and CBRs in helping them understand how graphs can show motion. Responses from students for this question are shown in table 2. The same 5-point Likert scale was used to measure student responses. Six out of eight students answered with a five and one answered with a three. One student did not answer the question\(^1\). All other student responses to this question show that the students believed technology helped them in understanding how graphs can show motion, one of the objectives of

\(^1\) Although the student did complete the two questions after this question on the survey, it is unclear why student P did not answer this question. It is possible they were unsure how to answer, skipped it to come back to and then forgot, or was confused and did not feel confident in choosing an answer.
the unit. This question suggests students were thinking positively about the incorporation of technology and how it can help them learn mathematics after participating in the unit.

Table 2 shows responses for the two additional free-response questions included on the post survey, asking students about their use of technology. It is evident that all students had not previously used a graphing calculator and felt positive about their use of it along with the CBR. Student responses show that most enjoyed using the technology, and some believed that it helped them in understanding the content covered in this unit. Although students in Mrs. Tillman’s class that participated in this research are in a technology rich environment, with access to laptops in the classroom daily, as well as regular usage of a robotics lab in the school, the students’ use of technology specific to mathematics learning in this research was new and they believed was beneficial for them.

<table>
<thead>
<tr>
<th>Student</th>
<th>Response for Q #8</th>
<th>Q #9: Was your use of graphing calculators in Miss Kukulka’s lessons the first time you have used them at school?</th>
<th>Q #10: Would you want to use technology, such as graphing calculators and CBRs (motion sensors), more often in your learning? Why or why not?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>It was not only the first time in school but my first time ever</td>
<td>Yes, because they help a lot to understand math</td>
</tr>
<tr>
<td>M</td>
<td>5</td>
<td>Yes</td>
<td>Yes, because it has a little fun in it and it’s cool how it could sense movement. It helps a lot, for example it shows the pace</td>
</tr>
<tr>
<td>O</td>
<td>5</td>
<td>Yes</td>
<td>Yes, because it is fun to learn the graphs and see the motion and it helps me concentrate</td>
</tr>
<tr>
<td>P</td>
<td>N/A</td>
<td>Yes</td>
<td>Yes, because they are fun to use</td>
</tr>
<tr>
<td>N</td>
<td>3</td>
<td>Yes</td>
<td>Yes, because kids can learn while having fun and if they use it in the future, they will know how to use it</td>
</tr>
<tr>
<td>H</td>
<td>5</td>
<td>Yes</td>
<td>Yes, because they can help us with understanding graphs</td>
</tr>
<tr>
<td>F</td>
<td>5</td>
<td>Yes</td>
<td>Yes, I would because it could come in use</td>
</tr>
<tr>
<td>D</td>
<td>5</td>
<td>Yes</td>
<td>Yes, because it is interactive, so you are not just sitting down in your chair</td>
</tr>
</tbody>
</table>

Table 2: Student responses for the three additional questions included on the post-survey.

Observational Protocol
The following two tables show the total count of observations from Dr. Browning and Mrs. Tillman for each student for each item on the observational protocol. The total counts shown in tables 3 and 4 below were collected in the students’ respective group for each of the five consecutive days that lessons took place. Data for both groups is separated into days 1-3, where no technology was used in the classroom, and days 4 and 5, when technology was introduced and used.

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Days 1-3</th>
<th>Days 4 &amp; 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O</td>
<td>A</td>
</tr>
<tr>
<td>Did a student take the lead?</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Did a student ask a math question of another student?</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Did a student give a math explanation to support their work?</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Did a student give a math explanation referencing a tool?</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Did a student display confusion where no other students responded?</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did a student interrupt another student?</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did a student disagree with another students’ response?</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Was a students’ response ignored?</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Were students excluded during a discussion or worked alone?</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3

<table>
<thead>
<tr>
<th>Group 2</th>
<th>Days 1-3</th>
<th>Days 4 &amp; 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P</td>
<td>D</td>
</tr>
<tr>
<td>Did a student take the lead?</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did a student ask a math question of another student?</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did a student give a math explanation to support their work?</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Did a student give a math explanation referencing a tool?</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Did a student display confusion where no other students responded?</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did a student interrupt another student?</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did a student disagree with another students’ response?</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 4

<table>
<thead>
<tr>
<th>Was a students’ response ignored?</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were students excluded during a discussion or worked alone?</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Looking at the data from all five days together, neither observer noted a student displaying confusion where no other students responded, and a students’ response to a mathematical question being ignored was observed only one time across both groups. Group 2 did not observe any students interrupting another student, ignoring students’ responses, or students being excluded or choosing to work alone over the course of the 5 days. The highest observations for both groups over the five days are seen in a student taking the lead, with student A in group 1 taking the lead 46% of the time (17/37), and student M in group 2 taking the lead 57% of the time (4/7). The lowest for this category in group 1 was student N, taking the lead 10.8% of the time (4/37), and in group 2 student P was never observed taking the lead.

A major difference between days 1-3 and days 4-5 observed in both groups is a more balanced structure of students taking the lead. Before technology was introduced, one student in each group was seen taking the lead a majority of the time, and other members in the group took the lead much less. However, in the two lessons that incorporated technology, taking the lead was observed more distributed throughout both groups. For group 1 in days 1-3, student A took the lead 12 times out of a total of 23 counts for the group (52.2%), with student O taking the lead 7 times (30.4%), and students N and H taking the lead 2 times each (8.7%). When using technology in days 4 and 5, the totals changed to student A taking the lead 5 times out of a total of 14 counts observed (35.7%), student O 3 times (21.4%), student N 2 times (14.3%), and student H 4 times (28.6%). Group 2 has a similar pattern, with student M taking the lead 3 times (100% of the time), and all others being observed 0 times in days 1-3. For days 4 and 5, student D took the lead once out of the 4 counts observed (25%), student M once (25%), and student F 2 times (50%).

Looking at only the observational protocol data, it is difficult to determine how technology impacted the way students participated in small groups. For behaviors that were observed multiple times by multiple students in the first three lessons, such as students disagreeing, or students giving a mathematical explanation to support their work, they were not observed in the lessons that students used technology in. A possible explanation could be the task students were engaged in when the 10-minute collection of observation data took place. When students were working with technology, the 10-minute collection of data occurred before students were hands on with the technology. In lessons 4 and 5, students were tasked with planning how they would use the technology on paper, by writing down their plan, before engaging with the technology and carrying out the plan. Students disagreeing with another student in their group was observed multiple times before technology was introduced and was not observed after the introduction of technology. The impact of the technology giving students
an immediate response may have contributed to students not disagreeing with one another, since
the technology was proof that a students’ thoughts were correct or incorrect.

Each student in both groups was observed giving mathematical explanations to the group
multiple times throughout the five lessons, and no student stands out as giving a significant
amount greater of explanations. This could suggest that each student felt confident about their
mathematical abilities and wanted to contribute to completing the tasks. The even distribution of
students giving explanations, and no one student standing out as dominating the discussion can
suggest that there was not one mathematical authority in the group. Even distribution of the
students giving explanations also occurred through all five lessons, suggesting that students
adapted to using the technology. Further, it appears that introducing the technology did not
hinder the collaborative practices the students were already exhibiting.

Overall, it seems as though the discussions occurring in the small groups were positive,
and mathematics learning was accomplished. Throughout the five lessons, it was not recorded
that a student’s response was ever ignored in their group, and students interrupting one another
was rarely observed. Students displaying confusion where no other students responded was also
not observed, which suggests that at least during the 10-minutes when data was collected,
students helped each other understand the task. Students excluding themselves or working alone
was only observed from two students before technology, and no students were observed doing
this after technology was introduced. This could suggest a positive impact of the use of
technology on students’ willingness to work together and including all students in a group
discussion.

Formative and Summative Assessments

Formative and summative assessments were used through this study to provide measures
of student knowledge and achievement throughout and after the lessons. The main foci of the
inclusion of exit tickets and the summative test at the end of the unit was to ensure students were
making sense of the unit objectives. The exit tickets that were completed in groups also gave the
researchers some knowledge on students working together.

Student responses to the exit tickets, as well as the post unit test, show that students were
engaged in the lessons, and understood the content. Each of the five lessons included an exit
ticket at the end of the lesson, some of which students completed individually, and some students
worked in their respective groups to complete. One exit ticket in particular asked students to
complete a hand-drawn graph on a Post-It note after watching me walk along a taped line on the
ground. After students individually completed their graph, they then talked with their respective
groups about each graph. After discussing and watching me walk again, students worked
together as a group to draw a final graph on one piece of paper. To turn in the assignment, each
individual students’ graph was placed on a corner of a piece of paper, with the group’s final
graph in the middle of the paper (this document is shown in Appendix E). After looking at how
the graphs evolved in each group, it is evident that each student participated in their group
discussion when creating the final graph, since the final graph submitted in each group is not
identical to any one students’ graph. This means that students conversed about each of their graphs and collectively decided how to most accurately represent my walk along the tape.

The summative assessment used to examine student understanding at the conclusion of the five-lesson unit was a unit test (Appendix F). This test consisted of 6 open-ended items and focused on content covered in the lessons. Questions included reading a graph, developing a story to describe a given graph, and explaining in words how to use the CBR and graphing calculator to duplicate a given graph. The summative assessment, completed at the end of lesson five, provided a measure of how well the students met the goals of the unit. All students earned a score of 4 or higher out of a total possible of 6 (see Table 5 in the Summary section below) suggesting all students had a fairly good understanding of the unit goals.

Discussion

Data from the study presented interesting findings about student attitudes regarding mathematics, student behaviors when working together in small groups, and student attitudes on technology use. My research focus was to examine if there were any correlations between students’ attitudes towards mathematics and the collaborative practices that they exhibited in small group work in the classroom. In addition, I wanted to examine the impact of technology use on student attitudes and the collaborative work of small groups. I will now summarize the findings as they relate to these research foci.

Correlations between attitudes and collaborative practices based on observational protocol

Table 5, below, provides summary data of each student observed in this study with respect to pre/post attitude scores, collaborative behaviors noted and final assessment scores. Students are organized within their respective groups based on a descending order of their pre-mean attitude score. A main goal of this research was to determine if there are any correlations between students’ attitudes towards mathematics and the collaborative practices that they exhibited in small group work in the classroom. Behaviors summarized in the table below represent four behaviors observed most frequently of all 8 students through the observational protocol.

I examined students’ pre attitude scores to determine if there were any correlations between the attitude that students felt before the unit and collaborative practices that they exhibited when working in their groups during the unit. I did not find consistent correlations involving students’ pre attitude scores, however, I did find a correlation between post- attitude scores and the frequency of various collaborative behaviors observed.

In group 1, Student A had the highest post- attitude score, a 4.4, and was observed taking the lead the most (46%), giving a math explanation the greatest amount (43%), and disagreeing with another student the most (50%). However, in group 2, Student P had the highest post-attitude score, but was not observed in any area on the observational protocol the most. In fact, Student P was observed taking the lead the least amount (0%), as well as giving a math explanation the least amount (16%). The other two observations, asking a math question, and disagreeing with another student, Student P was observed doing each one time. The correlation
seen between Student A’s post-attitude score and positive engagements during the lessons is not also true of Student P in group 2. For this reason, it is difficult to determine if having a high positive attitude about math correlates to a high frequency of occurrence in behaviors.

Next, I looked at the lowest post attitude scores in each group. In group 1, Student O had the lowest post-attitude score. Student O was observed disagreeing with another student the least amount (0%), as well as giving a math explanation the least amount (4.8%). The other two observations were seen in Student O, observed taking the lead (27%) and asking a math question (50%), and were each the second highest counts for the group, despite the students’ lowest post-attitude score. In group 2, Student D had the lowest score of 3.4 and had a similar low observation frequency in at least two of the behaviors. Student D was observed taking the lead one time, which is the third highest in the group (14.3%), asking a math question the least amount in the group (0%), giving a math explanation the third highest (24%), and disagreeing with another student the same amount, only once, as all other students in the group (25%). The very little involvement from Student D compared to the other students in their group, along with their low attitude score, suggests that they didn’t feel too positive about mathematics, and therefore, did not engage in as many collaborative practices within their group. The same can be suggested for student O in Group 1, with the lowest post-attitude score for their group, as well as engaging in the collaborative behaviors the least amount.

These findings suggest that a lower attitude score correlates to fewer observations of various behaviors.

<table>
<thead>
<tr>
<th>Student &amp; Group</th>
<th>Pre-Mean Score</th>
<th>Notes regarding overall collaboration (throughout the 5 lessons) based upon observation protocol data</th>
<th>Post-Mean Score</th>
<th>Post Unit Test Score*</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (1)</td>
<td>3.8</td>
<td>Observed taking the lead 4 times (10.8%)&lt;br&gt;O bserved asking a math question 1 time (50%)&lt;br&gt;O bserved giving a math explanation (with or without the inclusion of a tool) 3 times (27.6%)&lt;br&gt;O bserved disagreeing with another student 2 times (20%)</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>A (1)</td>
<td>3.7</td>
<td>Observed taking the lead 17 times (46%)&lt;br&gt;O bserved asking a math question 0 times (0%)&lt;br&gt;O bserved giving a math explanation (with or without the inclusion of a tool) 9 times (43%)&lt;br&gt;O bserved disagreeing with another student 5 times (50%)</td>
<td>4.4</td>
<td>6</td>
</tr>
<tr>
<td>H (1)</td>
<td>3.5</td>
<td>Observed taking the lead 6 times (16.2%)&lt;br&gt;O bserved asking a math question 0 times (0%)&lt;br&gt;O bserved giving a math explanation (with or without the inclusion of a tool) 8 times (38%)&lt;br&gt;O bserved disagreeing with another student 3 times (30%)</td>
<td>4.1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Observed taking the lead 10 times (27%)</td>
<td>Observed asking a math question 1 time (50%)</td>
<td>Observed giving a math explanation (with or without the inclusion of a tool) 1 time (4.8%)</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>----------------------------------------</td>
<td>---------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>O (1)</td>
<td>3.4</td>
<td>Observed taking the lead 0 times (0%)</td>
<td>Observed asking a math question 1 time (33%)</td>
<td>Observed giving a math explanation (with or without the inclusion of a tool) 4 times (16%)</td>
</tr>
<tr>
<td>P (2)</td>
<td>4.8</td>
<td>Observed taking the lead 2 times (28.6%)</td>
<td>Observed asking a math question 1 time (33%)</td>
<td>Observed giving a math explanation (with or without the inclusion of a tool) 7 times (28%)</td>
</tr>
<tr>
<td>F (2)</td>
<td>3.7</td>
<td>Observed taking the lead 1 time (14.3%)</td>
<td>Observed asking a math question 0 times (0%)</td>
<td>Observed giving a math explanation (with or without the inclusion of a tool) 6 times (24%)</td>
</tr>
<tr>
<td>D (2)</td>
<td>2.8</td>
<td>Observed taking the lead 4 times (57.1%)</td>
<td>Observed asking a math question 1 time (33%)</td>
<td>Observed giving a math explanation (with or without the inclusion of a tool) 8 times (32%)</td>
</tr>
<tr>
<td>M (2)</td>
<td>2.5</td>
<td>Observed taking the lead 0 times (0%)</td>
<td>Observed asking a math question 1 time (33%)</td>
<td>Observed giving a math explanation (with or without the inclusion of a tool) 4 times (16%)</td>
</tr>
</tbody>
</table>

Table 5: Summary of Students
*Total score possible for post unit test: 6

In general, I did not find any strong correlations between attitude scores and specific collaborative behaviors that were consistent across both groups. I decided to refer to Esmonde’s (2009) research that provided descriptive labels for collections of collaborative behaviors to see if those might suggest some type of correlation between attitudes and collaborative practices that students exhibited in this research.

**Correlations between Esmonde’s research and collaborative practices seen in this study**

A main interest of this study stemmed from seeing how the students in the study worked in collaborative groups. Esmonde (2009) presented a variety of positions that students working in small groups can adopt. Her labels of expert, novice, and facilitator are explained in table 5 below, along with summaries of how her labels relate to observations seen through this study. In this research, no participating student exhibited all characteristics from a position according to the descriptions provided by Esmonde (expert, novice, and facilitator), however, some of the
elements describing each label are seen throughout the groups. Student A in group 1 was seen taking the lead most often. This student also exhibited high counts of giving explanations to support their work and disagreeing with another students’ response, suggesting they were heavily involved in speaking up in their group. Similarly, in group 2, Student M was seen taking the lead a considerable amount, and as well as giving multiple explanations, both referencing and not referencing a tool. In group 2, it seems as though student M can be considered the most dominant student in their group. The conclusion of one student being dominant in each group in multiple ways (being observed in multiple roles a larger amount than other group members) shows these two students, Student A and Student M, took on the roles of experts within their groups.

The facilitator label that Esmonde suggested has many similarities when thinking about experts as well. On the observational protocol for this research, a student taking the lead can be considered a characteristic of both experts as well as facilitators. For that reason, student A and student M also may fit into the facilitator category. However, another label that could suggest a facilitator role within a student is asking a mathematical question of another peer. Although 5 students were observed asking a question of another student, each student was only observed doing this one time over the five lessons. This suggests that this characteristic was not dominant within any student, and therefore, no student taking on the role of facilitator was observed within this research.

The third category that Esmonde suggested is a novice. Student O in this study was observed taking the lead the second-highest amount in their group but was rarely observed in any other items on the observational protocol. Considering Esmonde’s (2009) characteristics, Student O would be considered a novice since it can be assumed that they did not speak up much throughout discussions, and the group moved on with decisions without them. More specifically, Student N in group 1 was observed working alone the most and can be identified as a novice because of this. However, Student N also was observed in other areas on the protocol, even though those counts are below 2 times, so it is unknown if novice would be an appropriate label.

Attitude scores for students observed fitting into any of Esmonde’s characteristics are included in Table 5, below. Student A was not the student with the highest attitude in the pre-survey but increased in positive attitude throughout the unit to become the student with the highest post-unit attitude score. Student A’s categorization into Esmonde’s “expert” category suggests that although Student A did not have the highest overall attitude out of the eight students, they still took on leading the group, giving numerous explanations, and disagreeing with other students. On the other hand, Student M had the lowest pre-attitude score, and also fit into Esmonde’s “expert” category, being observed doing some of the same things as Student A, who’s attitude score is significantly higher. On the post-attitude survey, Student M had the third lowest (out of eight) attitude score. With such inconsistencies between the group positioning and attitude scores, no correlations between student’s identification as expert, novice, or facilitator and their overall attitude scores was observed.
Correlations between student collaboration and technology use

The three additional questions included on the post-survey were specific to the students’ use of technology. The responses gathered in the data for these three questions were overwhelmingly positive, showing that students had a positive response to the use of technology. Question 2, that asked students the extent to which they thought graphing calculators helped them learn mathematics, was included on both the pre and post attitude surveys. The positive increase of 1.5 in responses for this question from pre to post indicates that students felt graphing calculators had a positive impact on their learning of mathematics after using them for the unit.

Question 8, included only on the post survey, was answered by seven out of the eight students. 6 out of the 7 that answered the question responded that graphing calculators and CBRs
really helped them understand how graphs can show motion, a code number of a 5, and one student answered that graphing calculators and CBRs helped them understand how graphs can show motion some, a code number of 3, and still positive towards technology. The overwhelmingly positive response shows that students saw the impact of graphing calculators and CBRs in their learning of mathematics.

Additionally, the observational protocol data shows that there was a difference in the students in each group that took the lead, among other group behaviors as well. In both groups, during days 1-3, one student was seen taking the lead the majority of times over the others. However, during days 4 and 5, other students in each group began to take the lead as well, with the behavior being seen among almost all students, rather than mostly from one student, suggesting that all students were involved in using the technology to complete the tasks. As a result of question 8, we can see that all students displayed a positive attitude about the use of technology. Each student taking the lead for close to an equal amount of time suggests that because of the positive attitude students felt towards the use of technology in learning math, they felt more confident and willing to engage in taking the lead throughout the discussions within their group.

Final Statements

My research focus was to examine if there were any correlations between students’ attitudes towards mathematics and the collaborative practices that they exhibited in small group work in the classroom, as well as examining the impact of technology use on student attitudes and the collaborative work of small groups. Prior to the teaching of the unit, students generally exhibited feeling positive about mathematics, as well as about the use of graphing calculators in helping them to learn mathematics. I found that when students’ attitudes about mathematics were neutral or less positive, they were not as likely to engage in collaborative behaviors in small groups. In one group, I did find that the student with the highest attitude about math exhibited collaborative behaviors more than other members of their group, however, that was not consistent in both groups. In terms of technology, I found that the majority of students’ attitude scores increased after the use of technology in the lessons. All questions on the post survey asking students about technology resulted in positive responses, with many students feeling as though the technology greatly impacted their ability to learn the mathematics. When working in groups, I found that students in both groups each took the lead for close to an equal amount of time, suggesting that because of the positive attitude students felt towards technology use in learning math, they felt more confident in collaborating with their group.

Personal Thoughts

Through the development of this research, I have learned an immense amount that will prove beneficial in my future career. This study provided me with the opportunity to design lessons from the very beginning, aligning with common core state standards, as well as incorporating technology in a meaningful way. Making connections between what students already know, what they need to know for the current lesson, and where the lesson needs to go in order to align with future lessons was challenging, but eye-opening. Preparing questions that have the ability to lead the class discussion in an appropriate way, such as including a particular vocabulary word, or pointing out a certain step in the procedure, is something I learned that I
need to think about in the planning stages of creating lessons. The feedback I received from Dr. Browning and Mrs. Tillman throughout planning and teaching the lessons allowed me to learn how to revise my work in order to be a better fit for the students. Immersing myself in Mrs. Tillman’s classroom for the semester, and being able to plan, teach, assess, and reflect on my lessons and the work done in the classroom is something I would not have had the opportunity to do through the education curriculum alone at Western Michigan University. Working with and learning from Dr. Browning and Mrs. Tillman during this research gave me hands on knowledge of teaching.

Additionally, I learned that technology can be extremely beneficial in the classroom as long as it is used in meaningful and appropriate ways. For example, if I gave students the graphing technology before talking about parts of a graph, and how to read a graph, they would not have been as successful in using the technology to further understand graphs, since they did not have the beginning knowledge. Instead, I planned lessons that incorporated how to read graphs, and what they show, so that students could then use the technology to go beyond the content I already covered and determine how to read motion in a graph. My experience in learning how to use new technology, planning lessons to allow students to engage with the technology and assessing the outcome of the lessons will prove beneficial in the technology-rich environment that many classrooms are moving towards in the near future.

In my future as a teacher, I can use my findings from this research in many ways. I learned that attitudes do have an impact on students’ participation. In my future classes, I plan on using a similar attitude survey, in combination with careful observation of my students, to learn of their attitudes. I can then use that information when placing students in groups for collaboration. Attitudes that students already have, and will come into my class with, play a major role in their participation, and possibly the outcome of their learning, so I want to make sure I do as much as possible to make my classroom a place for successful learning to take place.

**Limitations & Future Study**

Many observations about student collaboration, student attitudes, and the impact of technology have been shared based on this research, however, the study has limitations as well. To begin, this study presented many changing variables, including a new instructor teaching, new technology, lessons taught in a structure different from what students were used to, as well as two new people to the classroom observing the students. Of course, the students were aware of all of the changes happening in their classroom. It is impossible to determine that the impacts we have found are solely a result of the incorporation of technology. Students could have enjoyed having a new individual teaching for a few days, or the opportunity to use technology otherwise not regularly used in the classroom. Dr. Browning’s presence, and Mrs. Tillman’s new role of observing students while I taught lessons could have encouraged students to be more engaged. On the other hand, these variables also could have hindered some students due to their fear of being embarrassed or answering a question wrong in front of strangers. The various changing variables in the classroom also could have contributed to the attitudes that students felt and recorded on their attitude survey, possibly being altered from how students usually feel when working with mathematics.

In this study, the students were not interviewed nor was there any video recording of the lessons. If I were to do this research again, I would include the interviews and lesson videos to supplement the current data. Although the observational protocol allowed the researchers to look
back on the lessons and the collaboration of the students, taking videos of the lessons would allow more careful analysis of group behaviors. Some contributions of students when working together could have been missed, which have the potential to change some of the conclusions made within this study. With the opportunity to interview students, the researchers would be able to gain a better, more thorough insight into students’ attitudes about mathematics, and even why they chose to participate in a certain way. Past student experiences shape who they are and can be important indicators of their attitude about mathematics and ability to contribute with their peers in small groups. One instance in particular where interviewing students would be very beneficial is to inquire why Student P did not answer a question on the post-attitude survey. As mentioned earlier, there are possible reasons, but without interviewing the student, there is no clear answer.

To further this research, I would like to lengthen the time period that I am in the classroom. I think that with more time to use the technology, and work together collaboratively in groups, students may display different behaviors, or more of the behaviors included on the observational protocol. Correlations between attitudes towards mathematics and their collaborative practices may become more consistent and observable. Additionally, more time in the classroom would lead to the students feeling more comfortable with the researchers in the room, possibly lending towards different results. Although we had a presence in the classroom for a couple of months before beginning research, I only started working with students more closely one week before beginning to teach the unit.

Another topic that is interesting to me is the teachers’ role in the classroom in fostering productive collaborative behaviors. Teacher behaviors that I have noticed include tending towards one gender more than the other or calling on a few students more than other students. I think that some behaviors teachers display when teaching come naturally, and the teacher may not realize as they are teaching. Learning more about this and looking into the impact these behaviors have on students in the classroom would allow me to better understand how my actions as a teacher can impact the students in my class.
References


Appendix A
5-Lesson Unit Plan
Unit Plan for this Research

1. Reading Graphs: “Granny’s Balloon Trip”
2. Interpreting Distance-Time Motion Graphs: Matching Game
3. Linear Relationships: Describing Changing Speeds
4. Technology day #1: Students walking to create a graph shown on paper
5. Technology day #2: Distance-Match feature on CBR and graphing calculator
Appendix B
Lesson Plans
Lesson Plan #1  
Granny’s Balloon Trip

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>5th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials/Technology Needed (Including Handouts)</td>
<td>Granny’s Balloon Trip worksheet for each student (18 copies), graph that I teach from, graph (Michael’s Trip, included at the end of lesson plan) for the launch/assessment at the end of the lesson, rulers for graphing, half sheets of paper</td>
</tr>
</tbody>
</table>
| CCSS (Common Core State Standards) | **Graph points on the coordinate plane to solve real-world and mathematical problems.**  
5.G.1 Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to gravel from the origin in the direction of one axis, and the second number indicates how far to travel from the origin in the direction of the second axis, with the convention that the names of the two axes and coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate).  

5.G.2 Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane and interpret coordinate values of points in the context of the situation. |
| Time | 1 hour |
| Student Objectives | Students will understand the parts of a graph and how they are used to read the whole graph correctly, including the axes and coordinates, and labeling the axes and scale used correctly. Students will also be able to construct a line graph. Students can also plot points from a table onto a graph. In this activity, students can see the connection between the ordered pairs on the table being the actual points on the graph. |
| Launch of Lesson | (#1 in the outline below): I will project a simple graph on the board (Michael’s Trip) and have a conversation about what the graph can tell us. |
| Outline of Lesson | 1. Project the first graph on the board and ask the class to think about two things they can read from the graph and write them down on a piece of paper (half sheets of paper I provide). Once everyone writes something, I will tell the class to talk to their group about what they can read from the graph. (2 minutes). Then I will ask the class to tell me anything they know about the graph pictured. I will write their comments on the board for a visual of what they know. (Be prepared with questions to ask when a student says “I don’t see anything”)  

a. Possible observations they should mention: |
i. Reading specific coordinates and telling what they indicate, for example Michael walked 6 meters at 8:00.

ii. There are points on the graph with line segments connecting each one.

Needs to emerge:
- Can read the scales

Questions:
- Can you tell at what point in the graph is Michael walking to school?
- How do you know where Michael is sitting in math class? What part of the graph tells you that?
- How long did it take Michael to walk to school? Where can you see that?
- How far is Michael’s school from his home? How can you see that?

2. I will ask “If we were to complete a table to show each coordinate, how can we do that?” I will have a table already started (with one of the axes labeled, and two coordinates shown) that I will project and fill out with the class.

<table>
<thead>
<tr>
<th>Time</th>
<th>7:00</th>
<th>8:00</th>
<th>9:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance (mi)</td>
<td>0</td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

3. Pass out the Granny worksheet.
4. I will read the problem on the Granny worksheet and show the students the graph and the table.
5. Students will work in their groups to finish labeling the two scales, and when their whole group is done to flip their papers over.
6. After all groups are done, I will say “One person in your group is going to be in charge of plotting the first three points on the graph. I want everyone to talk and say where the points should go, but only one person plotting the points. Once your group plots the first three points, everyone can pick up their pencils and plot all of the points. Still work together and talk about the graph”
7. Once I notice groups finishing up plotting points, I will pick a group to go to the projector and share their graph with the class. I will first look for a graph that has an incorrect scale. If all of the scales are correct, I will ask for a volunteer to bring their graph to the front. I will ask:
   a. Does everyone’s line graph look the same?
   b. How do you know yours is exactly the same? What on the graph can we compare to check that they are the same?
c. Do everyone's scales have the same numbers in the same order?
d. Are the points that they plotted the same on everyone else’s graphs?
e. How did you use the table to complete the graph? (They need to make the connection between the first coordinate representing the time and the 2nd coordinate representing the height.)
f. Is there any information that they can see in the graph perhaps “easier” than they can see in the table? (this is a matter of opinion, but some may say they see the fact that the balloon is going up and then back down. Some might see that it is coming down a little faster than it went up.
g. I will have another Granny graph plotted, but with an incorrect scale. I will show the class and point out that the scale looks different. (The visual will be slightly different)

8. If there are students who say theirs looks different, I will ask them to bring their graph up to show the class, so we can talk about the differences.
a. We can talk about how the line graph changes and can miscommunicate information if the scales on the axes are not the same distances apart (making reference to the incorrect Granny graph)

9. After everyone has the same graph correctly plotted, I will instruct the class to work on questions 2, 3, and 4 on the back of the page.
a. If running low on time, I will only have the students do questions 2 and 3.

10. After students have had time to work on their own, I will have them turn and talk to their table groups about how they responded. If they want to change their answers, I will ask that they cross out what they are changing, and tell them not to erase anything.

11. Closing activity: I will project the same graph from the beginning of class (Michael’s Trip) and ask the class to add any comments they have to what they already said. Once we are done talking about it, we should have hit:
a. Each mark on the scale increases by one hour (the distances on the scale are representing each hour of the day)
b. The graph that is shown is called a line graph
c. The graph has coordinates plotted.
d. We can read the coordinates plotted, as well as in between them.

12. Exit Ticket: I will pass out a piece of notebook paper to each student. I will project on the board a completed version of Granny’s Balloon Trip with a question under it, “Does this graph tell you anything about how fast the balloon was traveling? If so, how do you see this on the graph? Where is it? If not, why not?

a. Question: was it faster going up or coming down? What on the graph tells you that?

| Assessment          | 1. After the lesson, I will refer back to the original graph I showed in the launch of the lesson with the comments the class described. I will ask the class if there is anything they want to add to what they originally said about the graph (hoping to get specifics about the axes, if they could label anything, or a coordinate).
|                    | 2. I will also use the exit tickets the students complete individually to determine if students understand and are ready to talk about speed of lines in the next lesson. |

Michael’s Trip To School Graph
# Lesson Plan #2

## Distance-Time Graphs Scenario Matching

<table>
<thead>
<tr>
<th>Materials/Technology Needed (Including Handouts)</th>
<th>Printed cards with graphs and scenarios, 2 example graphs and matching scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component focus</td>
<td>Reading distance-time graphs and matching a correct scenario to its graph.</td>
</tr>
</tbody>
</table>
| CCSS (Common Core State Standards)             | Graph points on the coordinate plane to solve real-world and mathematical problems.  
CCSS.MATH.CONTENT.5.G.A.1  
Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate). |
| Time                                           | 45 minutes-1 hour |

### Student Objectives

Students will continue working on how to read a line graph and will be able to connect a story describing a particular line graph. They will need to determine the key variables in the story, connect each one to an appropriate axis (setting the stage for independent and dependent variables), plot key points on the graph based upon the story/scenario and then connect the points with line segments to finish the line graph.

Students will begin to make sense of slope as a measure of distance/time or speed.

### Launch of Lesson

I will use the overhead projector to show a line graph (one from the scenarios package). I will start by having the class tell me anything they notice about the graph. (possible observations are: what the axes represent, what the direction of the line is, scales). I will talk about the graph, pointing to where it changes and what those changes might mean. For the first graph, I will have a scenario to match. For the second graph, as a class we will come up with a scenario that matches the changes in the graph.

### Outline of Lesson

1. I will show the class the first graph. I will ask the class “what do you notice about this graph”. If there are no responses, I will say “can anyone tell me the parts of the graph that you can see in this graph?”, and then “what do these parts of the graph tell us about the graph itself?” (8 minutes)

2. I will read the scenario matching the graph out loud to the class. I will have the students turn and talk to their neighbor about the specific parts of the scenario and where they can see it in the graph. (3 minutes) “Turn and talk to your table...”
group to decide where the different parts of the scenario can be shown in the
graph. What parts of the line graph represent each part of the scenario?"
3. I will ask for ideas of what parts of the scenario go with what parts of the graph.
I will show the class these responses visually on the graph. (3 minutes)
4. When we are done talking about the first graph, I will show the class the second
graph. This time, I will ask them to describe the line to me. (5 minutes)
5. As a class, we will come up with a scenario to match the graph. I will have
backup scenarios ready to be able to give the class a starter if they need it. (2-3
minutes)
6. After we have a couple suggestions of possible scenarios for the graph, students
will turn their chairs to sit with their table groups.
7. I will give each group a bag with all of the graphs and scenarios in it. The
groups will match the scenarios with the appropriate graph. (10-minute group
work time)

**THIS IS WHERE MAREN AND DR B WILL OBSERVE**
8. I will be walking around to ensure that students are talking to their peers and
becoming familiar with the graphs and scenarios.
9. Each group will share a graph and scenario to ensure students have paired up
the correct ones. (8-10 minutes) “Group 1, please pick a graph and a scenario to
bring to the projector that you believe are a match”
10. Exit Ticket: Picking up from Granny’s balloon trip lesson where I asked about
speed of the balloon, I will have the class refer to the walking home at a
constant rate graph. I will pose the question “How would the graph change if
the student were running to school at a constant rate instead of walking?”

<table>
<thead>
<tr>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>In addition to the exit ticket above, as I am observing the groups working, I will notice if students are not engaging with the activity. I will talk to those students, reminding them of the graphs we did in the launch of the lesson, and see if I can answer questions they have. If it seems as though the majority of the class is struggling, I will review the graph I began with, and compare it to another graph that is the opposite.</td>
</tr>
</tbody>
</table>
## Lesson Plan #3
### Describing Changing Speeds

<table>
<thead>
<tr>
<th>Materials/Technology Needed (Including Handouts)</th>
<th>Masking tape, student whiteboards, stopwatch app to project online, post it notes (blank and pre-made with axes)</th>
</tr>
</thead>
</table>
| CCSS (Common Core State Standards)               | CCSS.MATH.CONTENT.5.G.A.1  
Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate). |
| Time                                             | 1 hour |
| Student Objectives                               | Students will walk along a straight path of varying speeds to begin to develop a connection between the slope/steepness of a line with their speed. Students will create a graphical representation of their movement. |
| Launch of Lesson                                 | The class will look at the graphs from lesson 2 again. (I will project the graphs and scenarios to jog their memory). We will talk about how we were matching the graphs to their scenarios/stories yesterday, and I will explain to the class that today we will be matching scenarios to graphs (visual representations) that we will make (construct) ourselves.  
1. I will project graph #1 (shown below). I will ask “what are the coordinates of point A? What does that mean? Then, I will ask for the coordinates of point B. I will also ask what those mean (looking for: A: 0 meters away at 0 seconds, and B: 1.5 meters away after 4 seconds  
2. Project Graph 2. Ask for coordinates for point A and B same as above, have students help find points C and D.  
3. Ask what they notice about the coordinates for point B and point C. Should notice that the distance is the same in both. What does this mean? If the distance is the same, what is happening?  
4. SCALE: Let’s look at the axes. I will point to distance on the y and time on the x. I will ask what they notice about the numbers on the axes: they are equal distances apart.  
5. Those distances between the points is called a scale.  
6. The axes are just like a number line, with the same distance between each number. |
<table>
<thead>
<tr>
<th>Outline of Lesson</th>
<th>PART I (20 minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I will lay out a 3 meters long line of masking tape that will be the “path”, marked with half meter units.</td>
</tr>
<tr>
<td>2.</td>
<td>Students will have their individual white boards, and I will instruct them to draw the two axes (I will draw them on the board so they can copy). Based upon what we did the lesson before, I will ask students what labels should go on each axis (I will add to mine on the board, so they add to theirs in the correct place) before beginning today’s lesson. (2 minutes)</td>
</tr>
<tr>
<td>3.</td>
<td>Setting the stage: I will play a video of me acting out a scenario (Walking slowly about 1.5 meters, then stopping for 3 seconds, then walking very fast to the end) and ask the class to watch my motion or movements carefully. (2 minutes)</td>
</tr>
<tr>
<td>4.</td>
<td>Question: “As you watch me, draw a graph on your whiteboard that describes my movements during my walking trip that includes specific details. For example, your graph should show how my speed changed and where and when it changed. Watch the meter marks on the tracks to help you with these details.” We will watch the video two times, so take your time focusing on my motion.</td>
</tr>
<tr>
<td>5.</td>
<td>After I play the video, I will have the students turn and talk in their groups to compare what their graphs look like. (3 minutes)</td>
</tr>
<tr>
<td>6.</td>
<td>I will pick students’ graphs (preferably two different ones) to show the class. After talking about the ones I show, If there are different interpretations, I will play the video of my trip again, and the students will determine which of their descriptions is most accurate. (5 minutes)</td>
</tr>
<tr>
<td>7.</td>
<td>I will ask the class to summarize what were some key things they noticed in my movements that helped them make their graph. (5 minutes) These key things should include: stopping, walking fast, how long I stopped for, how long I walked for, etc.</td>
</tr>
<tr>
<td>PART 2: (25 minutes)</td>
<td>8. Students will work in groups to plan a trip (make a scenario/story) along the tape track. I will instruct them that it should be different than the trip I did today.</td>
</tr>
<tr>
<td></td>
<td>9. “In your small group, secretly plan a 10 second trip along the 3-meter tape. Be sure your trip changes speed at some point. Then draw a graph that shows your trip.” (Allow 5-8 minutes for discussion) If students struggle to begin, I will remind them of the scenarios from previous lessons, like a student walking from home to school, stopping in math class, and then continuing back home, to help them get started.</td>
</tr>
<tr>
<td></td>
<td>10. When I have seen that each group has constructed a graph and shared their scenario with me, I will pair up two groups. I will have the students exchange graphs with the other group, and they will interpret and act out the other groups’ trip, practicing on the strip of tape. When both groups believe they have created a correct scenario to match the graph, then they will take turns walking the trip for</td>
</tr>
</tbody>
</table>
the other group to observe and provide feedback. Students will be able to see how they need to change their graphical representation or their scenario/story if any issues arise with how the graph was interpreted. (10-12 minutes) (Physically switch the papers, not moving the groups together, to have them act out each other’s scenarios. Then, I will put the two groups together to act out the scenario in front of both groups) -Pair Maren’s observed group with table 1 and Dr. B’s observed group with table 2.

11. Once both groups have acted out the others’ trip, I will bring the class together. As a class, we will talk about the different trips we created or interpreted, and what we learned about how distance and time are shown on a graph. I will use their graphs, as well as mine from the beginning as models. (3 minutes)

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Post it note exit task: (15 minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I will give each student a post-it note. I will project a post-it note on the board with pre-drawn axes, so students will copy onto their post it. I will play the video of my second trip: “run for 3 steps, then stop for 5 seconds, run 3 more steps, stop for 5 seconds, then walk slowly to the end.” Before I play it, I will explain to them that they will create a graph like we did at the beginning of class, that represents what my new trip looks like. (2-4 minutes)</td>
</tr>
<tr>
<td>2.</td>
<td>Once I play the video and each student has their post it note filled out, they will turn and talk about how their graphs look similar and different. Students will place their individual post it notes on the handout provided (see “Stick It Together” handout) and write their name on the paper where they place theirs. Then,</td>
</tr>
<tr>
<td>3.</td>
<td>I will give each group a new post it note where they will draw one graph that they as a group feel represents my trip. Remind the students to not change their original graphs they drew, instead just work together to create a group graph that is agreed upon by all members. The groups will place their group post it note in the center box on the provided handout. (10 minutes)</td>
</tr>
<tr>
<td>4.</td>
<td>I will collect the handouts with all of the post it notes completed.</td>
</tr>
</tbody>
</table>
Lesson Plan #4  
Lesson #4 of Unit: CBR & Graphing Calc. Lesson #1: Matching

<table>
<thead>
<tr>
<th>Materials/Technology Needed (Including Handouts)</th>
<th>Masking tape, CBR (calculator-based ranger), graphing calculators, multiple copies of all graphs, exit ticket papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCSS (Common Core State Standards)</td>
<td>CCSS.MATH.CONTENT.5.G.A.1 Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate). CCSS.MATH.CONTENT.5.G.A.2 Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.</td>
</tr>
<tr>
<td>Prerequisite concepts</td>
<td>Know how to read and construct an x,y (specifically distance/time) graph, and understand the different ways motion can be displayed in a graph</td>
</tr>
<tr>
<td>Time</td>
<td>45 minutes to 1 hour MAREN HAS PLC’S TODAY</td>
</tr>
<tr>
<td>Student Objectives</td>
<td>Students will begin to learn how to use the CBR and graphing calculator. Students will walk along a line marked with distance measurements so that their movement mirrors a given distance/time graph. From this, students will begin to understand how a distance/time graph can represent a person’s motion, focusing on a meaning for positive, negative and zero slope with respect to walking away from or towards the motion detector or not walking at all. Students will connect this lesson to previous lessons in which we saw that stories can be created from distance/time graphs.</td>
</tr>
</tbody>
</table>
| Launch of Lesson                                | 1. I will give images of the 6 graphs to each group. Working together in their groups, they will match the type of motion to the graph. They will write the type of motion on each graph. I will have the list of the types of motion the graphs are displaying (below) on the board. (Allow 8-10 minutes)  
2. Questions to ask groups: a. How do you know if the slope is positive or negative?  
Types of motion that graphs will show:  
a. Walking at a steady speed away from the starting point: a straight line with a positive slope  
b. Walking at a quick steady speed: a straight line with a steep positive slope |
c. Not walking at all: a horizontal line

d. Walking towards the starting point from a point further away at a steady pace: a straight line with a negative slope

Number 4 in this picture is incorrect, correct description is: “walking towards the starting point from a point further away (straight line with a negative slope)”

Outline of Lesson

1. CBR Overview: A CBR is a motion sensor, that with the graphing calculator, will produce a graph of your motion. You will walk in front of the CBR. So, one person will need to be holding the CBR while another person walks. Your group will decide how to do this. It picks up any motion in front of it, so we will spread out so every group has enough room.

2. How To Treat Technology Reminder: Technology is expensive and a tool. We will use the technology as a math tool, which means we will be focused on the math problem. Remember that just like your chromebooks in the classroom, the CBR and graphing calculators will be treated nicely, we will not put them on the floor, or throw them, or do anything that is not related to the task I am going to talk about.


4. I will pass out a CBR and graphing calculator to each group.

5. Each group will be given a basic motion graph. They will write a plan of how they think they will need to walk in order to produce an identical graph on the
calculator. (Prompt for their plan: “Describe how you would have to move in front of the CBR in order to create a ___”) Once I have viewed their plan, they will be able to begin.

6. 2 groups will be in the classroom, and the other 2 groups in the hallway.

7. Masking tape will be on the floor marking 1-meter intervals from 0 meters to 3 meters.

8. Students will work as a group to model the movement shown in the graph, matching the distance traveled and the time intervals. (20 minutes) By using the technology, students will be able to visually see if how they are walking is creating the graph correctly, or if they need to change their original plan of walking. I will ask each group if their plan worked out and resulted in the desired description, or if not, what they can change to make it happen.

Some roles that students may assign within their groups:
   a. One person can act as a timer and count the seconds out loud so that the student walking has an idea of the time.
   b. One group member can be the walker who listens to the other students who are able to visually see the graph on the calculator.
   c. The other students can be watching the graph to tell the walker how to walk, as well as keeping track of the time.

If students are completed early, I will give them an inverted U graph (or parabola) and ask them to walk it. Students will write a plan before they begin walking, which I will review before giving them the okay to move on to the technology and walking. The parabola’s description would be “moving away from the starting point and returning to it”.

| Assessment | 9. Once finished in the hallway, students will return to the opener of the lesson with the 6 graphs and determine if they still agree with their original answers (self-assessing after working on the task and visually seeing the graphs with the technology) (10-15 minutes)  
10. I will be walking around to see how students are changing their previous responses and talking with groups who may have incorrectly matched their graphs and type of motion.
11. For an exit ticket, I will have students explain how their speed (both in direction and size/value) is displayed on a graph of a line and draw a graph with an explanation to support their thinking. |

| Accommodations for Learners | 1. If a group is finished and has modeled their graphs correctly with time remaining, I will ask them to walk an inverted U graph.  
2. If a group is struggling throughout, I will offer suggestions such as the possible tasks each group member can act in to get the students started. |
Lesson Plan #5
Lesson #5: Distance-Match with CBR & Graphing Calculator

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>5th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials/Technology Needed (Including Handouts)</td>
<td>CBR, Graphing Calculator, cables to connect technology</td>
</tr>
</tbody>
</table>

| CCSS (Common Core State Standards) | CCSS.MATH.CONTENT.5.G.A.1 Use a pair of perpendicular number lines, called axes, to define a coordinate system, with the intersection of the lines (the origin) arranged to coincide with the 0 on each line and a given point in the plane located by using an ordered pair of numbers, called its coordinates. Understand that the first number indicates how far to travel from the origin in the direction of one axis, and the second number indicates how far to travel in the direction of the second axis, with the convention that the names of the two axes and the coordinates correspond (e.g., x-axis and x-coordinate, y-axis and y-coordinate). |
|-----------------------------------| CCSS.MATH.CONTENT.5.G.A.2 Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation. |

<table>
<thead>
<tr>
<th>Prerequisite Concepts</th>
<th>Know how to read and construct an x,y (specifically distance/time) graph, and understand the different ways motion can be displayed in a graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>1 hour</td>
</tr>
<tr>
<td>Student Objectives</td>
<td>Students will create a distance/time graph to match a given graph. Students will draw upon what they learned in the previous lessons to create a plan for their matching walk, carry out their plan, and then assess their performance by examining their path displayed on the calculator screen.</td>
</tr>
<tr>
<td>Launch of Lesson</td>
<td>I will describe the matching task that has students using the CBR to display their walking pattern as they did in the previous lesson, but this time they will be trying to match a graph that is given by the CBR. I will remind the students that the CBR picks up motion in front of it and can create a graph of the motion it detects.</td>
</tr>
<tr>
<td>Outline of Lesson</td>
<td>1. I will set up the CBR in the front of the room. The graphing calculator will randomly generate a graph, which the class will be able to see on the projector. As a class, we will determine a plan for how we should walk in front of the CBR in order to create this graph. (5 minutes) I will choose a volunteer to come up and walk our path for us. The class will be able to see the progress because I will keep the graphing calculator under the projector as the volunteer is walking. After the volunteer walks, I will have the class talk to their table groups about how it went, and what they think could be done differently to get a closer version of the graph (including where the volunteer started, if it wasn’t in the</td>
</tr>
</tbody>
</table>
right place, the direction walked, how fast or slow they walked, etc. (5 minutes) After a few minutes of talking, I will tell the class that they are going to get to do this with their groups.

2. Students will be sitting with their groups that they will work with. I will let the class know which two groups will be going out in the hallway with Mrs. Tillman and Dr. Browning and let the other two groups know they will be staying in the classroom with me. Before students begin the task, we will review instructions on the use of the CBR and graphing calculator as a whole class. Directions for getting to the distance match function:

a) On graphing calc, choose “set up” option  
b) Choose option #3: Distance Match  
c) Choose “start” option  
d) Choose “next” option  
e) Study the graph provided  
f) Decide on a plan for where to start in reference to the CBR, how to walk, etc.  
g) Choose “start” option  
h) Walk the path you decided  
(10 minutes for technology set up)

3. The graphing calculators produce random piece-wise graphs, so each group could get a different graph. Students will be able to try multiple times, until they think they have created their best possible match. They will show me this best match for later display to the class. I will also take a picture in case it is accidentally cleared, or they want to try another matching graph. For students who finish quickly, they will get a new graph on the calculator and walk another match.

4. Students will move to their space and begin to work on walking their graph. (30 minutes)

5. After each group has completed at least one math, I will allow students to finish the walk they are currently on and return to their seats in the classroom, staying with the group that they worked together with. We will talk as a class, and students will be able to show their graphs either on their calculators, or on my phone if I took a picture. Students will show their best match, and we will discuss how they were able to walk the graph correctly. (5 minutes)

**Assessment**

I will be assessing students by their completion and accuracy of creating a graph. Although it will most likely be slightly off, students should be close to the shape of the graph. I will walk around to groups and evaluate their graphs when they finish a walk with them. If they think they can do better, they will retry. If they think it is as close as they will get, they will get another graph on the calculator and walk a new one after I have taken a picture of their graph for later discussion.
| Exit ticket | Students will complete a short-response assessment (below) consisting of 5-10 questions that examines their understanding of distance/time graphs and the slope of these graphs as well as assessing their skills of plotting points and reading information from a graph. (10 minutes to complete assessment) |
Appendix C
Observational Protocol
<table>
<thead>
<tr>
<th>Action</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did a student take the lead in the activity?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did a student ask a math question of another student?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y: it was answered, N: it was not answered</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did a student give a mathematical explanation to support their work/answer?</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Did a student give a mathematical explanation referencing a “tool” be it paper or technology?</td>
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<td></td>
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<tr>
<td>Did a student display confusion where no other students responded to their confusion?</td>
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<tr>
<td>Did a student interrupt another student?</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Positive or negative.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did a student disagree with another student’s response?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y: resolved N: not</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Was a student’s response ignored?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Were students excluded during a problem discussion or worked alone?</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Appendix D
Pre- and Post- Attitude Surveys
Mathematics Pre-Survey

The questions below are designed to share your ideas and thoughts about learning mathematics. On these questions, you will be asked to circle your answer on a scale from 1 to 5. Only choose one number for your response. If you don’t understand what a question is asking, just raise your hand and we will try to help make the question clearer.

Survey questions: clearly circle your answers

1. My confidence in my own math abilities is:
   - 1 Very weak
   - 2 Weak
   - 3 Average
   - 4 Strong
   - 5 Very strong

2. I think using graphing calculators to help me learn math is:
   - 1 I don’t know
   - 2 Not very helpful
   - 3 Somewhat helpful
   - 4 Helpful
   - 5 Very helpful

3. When it comes to solving math problems, I am:
   - 1 Not good at all
   - 2 Good sometimes
   - 3 Average
   - 4 Good most of the time
   - 5 Good all of the time

4. When it comes to liking math:
   - 1 I do not like it at all
   - 2 I only like it a little
   - 3 It’s okay
   - 4 I like it a lot
   - 5 It is my favorite subject

5. Doing math is:
   - 1 Impossible for me
   - 2 Mostly hard for me
   - 3 Okay for me
   - 4 Mostly easy for me
   - 5 Always easy for me

6. If you asked me if math is important, I’d say:
   - 1 It is not important at all to me
   - 2 It is not very important to me
   - 3 It is somewhat important to me
   - 4 It is important to me
   - 5 It is very important to me

7. When it comes to learning new math concepts:
   - 1 I learn new math concepts super slowly
   - 2 I learn new math concepts kind of slowly
   - 3 I take an average amount of time to learn new math concepts
   - 4 I learn new math concepts kind of fast
   - 5 I learn new math concepts very quickly
Mathematics Post-Survey

The questions below are designed to share your ideas and thoughts about learning mathematics. On these questions, you will be asked to circle your answer on a scale from 1 to 5. Only choose one number for your response. If you don’t understand what a question is asking, just raise your hand and we will try to help make the question clearer.

Survey questions: clearly circle your answers

1. My confidence in my own math abilities is:
   1 2 3 4 5
   Very weak Weak Average Strong Very strong

2. I think using graphing calculators to help me learn math is:
   1 2 3 4 5
   I don’t know Not very Somewhat Helpful Very helpful
   helpful helpful

3. When it comes to solving math problems, I am:
   1 2 3 4 5
   Not good at all Good Average Good most of Good all of the
   sometimes time time

4. When it comes to liking math:
   1 2 3 4 5
   I do not like it I only like it a It’s okay I like it a lot It is my favorite
   at all little

5. Doing math is:
   1 2 3 4 5
   Impossible for Mostly hard Mostly easy Always easy for me
   me for me for me

6. If you asked me if math is important, I’d say:
   1 2 3 4 5
   It is not important It is not very It is somewhat It is important It is very
   at all to me important to me important to me important to me

7. When it comes to learning new math concepts:
   1 2 3 4 5
8. I think using graphing calculators and CBRs (motion sensor):

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Did not help me understand how graphs can show motion</td>
<td>Helped me understand how graphs can show motion</td>
<td>Helped me understand how graphs can show motion</td>
<td>Helped me understand how graphs can show motion</td>
<td>Really helped me understand how graphs can show motion</td>
</tr>
<tr>
<td>2</td>
<td>Helped me understand how graphs can show motion just a tiny bit</td>
<td>Helped me understand how graphs can show motion some</td>
<td>Helped me understand how graphs can show motion well</td>
<td>Helped me understand how graphs can show motion well</td>
<td>Really helped me understand how graphs can show motion</td>
</tr>
</tbody>
</table>

For questions 9 and 10, please write your answer in the space below the question.

9. Was your use of graphing calculators in Miss. Kukulka’s lessons the first time you have used them at school?

10. Would you want to use technology, such as graphing calculators and CBRs (motion sensors), more often in your learning? Why or why not?
Exit Ticket Assignments Used in Each Lesson

Lesson 1: I will pass out a piece of notebook paper to each student. I will project on the board a completed version of Granny’s Balloon Trip (the graph used in the opener and throughout lesson 1) with a question under it, “Does this graph tell you anything about how fast the balloon was traveling? If so, how do you see this on the graph? Where is it? If not, why not?”

Lesson 2: Picking up from Granny’s balloon trip lesson where I asked about speed of the balloon, I will have the class refer to the walking home at a constant rate graph (one of the graphs that students worked with in lesson 2). I will pose the question “How would the graph change if the student were running to school at a constant rate instead of walking?”

Lesson 3:

a. I will give each student a post-it note. I will project a post-it note on the board with pre-drawn axes, so students will copy onto their post it. I will play the video of my second trip: “run for 3 steps, then stop for 5 seconds, run 3 more steps, stop for 5 seconds, then walk slowly to the end.” Before I play it, I will explain to them that they will create a graph like we did at the beginning of class, that represents what my new trip looks like. (2-4 minutes)

b. Once I play the video and each student has their post it note filled out, they will turn and talk about how their graphs look similar and different. Students will place their individual post it notes on the handout provided (see “Stick It Together” handout) and write their name on the paper where they place theirs.

c. Then, I will give each group a new post it note where they will draw one graph that they as a group feel represents my trip. Remind the students to not change their original graphs they drew, instead just work together to create a graph that is agreed upon by all members. The groups will place their group post it note in the center box on the provided handout. (10 minutes)

d. I will collect the handouts with all of the post it notes completed.

Lesson 4: Students will explain how their speed (both in direction and size/value) is displayed on a graph of a line. Students will also draw a graph with an explanation to support their thinking.

Lesson 5: Students will complete the short-response, post-unit assessment (Appendix F) that examines their understanding of distance/time graphs and the slope of these graphs as well as assessing their skills of plotting points and reading information from a graph.

Stick it Together Handout from Lesson 3:
Post-Unit Assessment
Post-Unit Assessment from Lesson 5:

USE the following graph for questions 1-3

1. What are the coordinates of point A? (___,___)
2. What do those numbers tell you?

3. Describe a plan for walking the graph above using a CBR (motion sensor). Be sure to include time and distance in your answer.

4. Draw a graph of a person moving away from the CBR at a steady pace for 5 seconds.
5. What does the above graph tell you about a person's motion? Be sure to include distance and time in your answer.

b. Create a scenario (story) to match this graph. Be sure to include times and distances.