IMPACTS OF JOURNALING ON MATHEMATICAL PERFORMANCE

by

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The purpose of this study was to determine the impact that journaling would have on students' academic performance in mathematics. Alongside this, student perceptions on writing in the mathematics classroom were also observed through surveys. Journaling was chosen as the instrument to be given to the experimental groups. The study applied an explanatory mixed-methods research design which consisted of a pre-test and survey and post-test and survey to see what changes occurred between the two groups of students that consisted of a mixture of sixty ninth and tenth graders.

IMPACTS OF JOURNALING ON MATHEMATICAL PERFORMANCE

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Middle Grades Education with a Concentration in Mathematics, MAEd

by

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Introduction

The purpose of this action research project was to describe the impact that writing in the mathematics classroom may have on student performance and perceptions. My research focused on journal writing with ninth and tenth grades students, while also collecting data on students' perceptions of the use of writing in the mathematics classroom.

This topic is one that has become more widely implemented amongst mathematics educators because of the increased level of rigor stated in the standards and then portrayed through the end-of-year tests (NC Department of Public Instruction, 2018). For some of the end-of-year tests, it requires "students to not only recall information, but also apply concepts and skills and make decisions" (NC Department of Public Instruction, 2018). This was because there were not only multiple-choice questions, but also numeric entry and technology enhanced questions such as multiple select and drag-and-drop (NC Department of Public Instruction, 2018). From my own personal experience, and in discussion with other mathematics teachers, it is hard visualizing what students were thinking during or after a lesson if they were not constantly asking questions and being monitored one-on one by the teacher. It is one thing for students to orally answer a question or complete multiple-choice questions, but actually having students explain their thought processes through writing could help teachers get a better viewpoint on if students were really grasping the material (Pass, 2015).

Although end-of-year test scores are something that were always on my mind as a mathematics teacher, my main goal for wanting to pursue this study was to see what impact, either positive, negative, or neutral, writing would have on students' overall understanding of the content. Teaching at an International Baccalaureate school, a school that focuses on inquiry, open-mindedness, communication, and reflection, to name a few, pushes me to think more about

how to make my content cross-curricular, thus a need for writing in all subject areas. From the years that I have taught in the secondary mathematics classroom, I have seen the majority of students struggle to give explanations for how they arrived at an answer or have seen them struggle with just being able to ask a clarifying question to better understand the material. I want to help students be better communicators in math, more specifically through non-verbal communication like writing, so that they feel more confident in their abilities.

In this study, I looked at pre and post test data, as well as formative assessment data throughout the unit, amongst control and experimental groups to see if the incorporation of structured writing through journaling would have a positive impact on student performance. I also believed it would prove to be useful to give students an anonymous survey that they fill out at the beginning and end of the study to see what their perceptions were about writing in math and if they change over time.

Literature Review

Writing in math is a concept that has been around for a while but has still not taken off in the world of education. Based on standard three for mathematical practice, "construct viable arguments and critique the reasoning of others", students should be able to develop arguments through prior knowledge and definitions (The National Council of Teachers of Mathematics, 2010, p. 6). They should also be able to analyze situations through a step-by-step process and provide both examples and counterexamples (The National Council of Teachers of Mathematics, 2010). As students' progress in their understanding, they will determine if processes make sense and come up with questions for more clarification (The National Council of Teachers of Mathematics, 2010). It is important to increase the level of rigor for students in order to achieve the goals of this standard. Di Pillo, Sovchik, and Moss (1997) stress that with this continued push for a wide range of mathematical thinking, the need for writing is becoming more evident.

Mathematics communication covers a wide-range of opportunities to enhance student learning (Sammons, 2018). Communication can be oral, representative, or written, and learning these different forms of communication can help students learn important skills that can benefit them throughout their entire life, not just the classroom (Sammons, 2018). According to Bossé and Faulconer (2010), "students learn mathematics more effectively and more deeply when reading and writing is directed at learning mathematics" (p. 1). The current levels of reading and writing in math do not promote rigor and have teachers leading the majority of these activities, making it not student-centered (Bossé & Faulconer, 2010). Reading in math requires students to not only read from left to right, but examine graphs, tables, and special symbols only used in math (Bossé & Faulconer, 2010). Writing in math requires direct instruction, an in-depth knowledge of academic vocabulary, and a lot of practice (Bossé & Faulconer, 2010). It is

important to establish expectations that reading and writing in math will be a norm and to model the importance it represents (Bossé & Faulconer, 2010). The incorporation of reading and writing in math can lead to students better grasping the content and being able to apply their knowledge in other ways (Bossé & Faulconer, 2010).

It is important when looking to implement reading and writing in math to give students a clear purpose for the assignment and make sure that it presented at an appropriate level of difficulty, depending on student comfort levels (Bossé & Faulconer, 2010). Formal writing in math will be something that must happen gradually in order for students to become more comfortable with the writing and to start to master its purpose (Bossé & Faulconer, 2010).

Writing in math can be used to help teachers assess student thinking (Casler-Failing, 2013). It can reveal gaps in student understanding and help teachers develop methods towards closing those gaps (Casler-Failing, 2013). According to Williams (2003), writing in math may help students "better organize their thought processes when they attempt to solve problems" (p. 185). It can also be used as a reflection tool by having students write during the solving process (Casler-Failing, 2013). Through the implementation of writing in math, students will be able to easily see what concepts they understand better than others if they have an easier time being able to write about them (Glogger, Schwonke, & Holzäpfel, 2012).

A specific type of writing that has been used in mathematics classes is journaling. Journal writing can be defined as a technique that actively involves students writing about their learning in mathematics (Neill, 2005). Journal writing consists of prompts with both student and teacher responses (Lynch-Davis, 2011). It should not just be a cyclical idea but instead one in which the prompts were created based on student responses (Lynch-Davis, 2011). This means that instead of the teacher giving prompts, students responding, and then teachers providing

feedback, the process should be intertwined where students' responses inform further instruction and contribute to future prompts. It can happen at any part in the learning process to show teachers students' thoughts and feelings (Neill, 2005).

While there is plenty of evidence in mathematical standards and definitions for the need of writing and the effects it can have, there were some cons to journal writing in the mathematics classroom and writing in general. According to Kenney, Shoffner, and Norris (2014), some teachers were reluctant towards implementing writing in the math classroom because it is not something they did when they were in school, and they have a preconceived notion that students will think they were making the class comparable to an English class. While some teachers may not be completely against the use of writing, some argue that certain organizational techniques may hinder students from tending to the specific math task (Brozo & Crain, 2018). In summary, teachers with this view think that writing will make students focus more on the writing itself rather than the mathematical concepts being learned or reviewed. Another downside to the implementation of writing in mathematics is that the vocabulary is rarely used in students' daily lives, therefore, it can be a challenge for them when it comes to trying to communicate their thoughts orally or in writing (Tan & Garces-Bacsal, 2013).

There were many upsides to incorporate writing, more specifically journaling, in the mathematics classroom. This educational strategy can provide the teacher with useful information to drive further instruction and understand student knowledge in new ways (Seto & Meel, 2006). More specifically, it allows teachers to better examine students' thinking by seeing methods used and explanations or justifications towards solving (Casler-Failing, 2013). It can also increase conceptual understanding and enhance procedural knowledge among students and increase rapport with the teacher (Tan & Garces-Bacsal, 2013). Along with the positive effects it

can have with regards to academics, based on a study done by Di Pillo et al. (1997), a large portion of student attitudes towards writing in math were positive which contributed to increased student engagement.

With regards to writing in math with how it has been implemented through the overall process and data collection, there were a number of techniques that have been used. It can be determined that there is still a great deal of research to do with regards to the best methods since there seem to be so many possible ideas towards implementation. In one particular study, the teacher looked at using Knowledge Structures (KS) to determine if there would be a difference in the meaning based on the use of linguistics (Huang & Normandia, 2007). Students were given take-home prompts to complete over a duration of approximately two weeks; there was a strong focus on conceptual and procedural knowledge with semantics and linguistics being the forefront to determine how well students understood the material (Huang & Normandia, 2007).

A more structured study focused on a teacher's development of their own organizational tool for students to solve math problems (Brozo & Crain, 2018). It consisted of a five-step process that required students to determine what the problem was asking, develop a plan for solving, solve the problem and reflect on why they did certain steps, defend their chosen technique, and make connections or come up with alternative methods (Brozo & Crain, 2018). The teacher then took student responses and grouped students together to go over the responses and give feedback through a positive comment, question, and suggestion to make it better, if applicable (Brozo & Crain, 2018). This technique focuses on providing students with a systematic way to answer problems and may be useful when first starting out with writing in the math classroom.

According to a study by Page and Clarke (2014), teachers focused on journaling to better understand students' feelings and beliefs towards math as they were learning the material. Through this study, teachers were able to get honest feedback from the students to help drive instruction and self-assess (Page & Clarke, 2014). Although student achievement was not the goal of journaling, due to increased awareness of math and better student buy-in, there was a positive effect on academic success (Page & Clarke, 2014). Another way to determine students' feelings and suggestions regarding the class have been through the use of pulse checks (Seto & Meel, 2006). These were similar to questionnaires given in other studies, such as one done by Tan and Garces-Bacsal (2013) that had students give both quantitative and qualitative feedback on thoughts and feelings towards writing after the study was completed.

Journal writing has been used on a more academic level to provide the teachers with significant feedback on student knowledge and understanding (Seto & Meel, 2006). There were many ways that journal writing has been implemented. In one study, students were given a weekly question that consisted of things such as logic problems and math puzzles (Casler-Failing, 2013). The teacher used the same prompts across grade levels to see how the strategies progressed from one year to another (Casler-Failing, 2013). In another study, students had to re-write a problem in their own words to show if they knew what to look for and what was being asked of them (Thompson, 2010).

More explicit ways journaling has been used is by giving students specific prompts to answer. In a study performed by Seto and Meel (2006), prompts varied from reflection and explanation type questions to error analysis, procedural knowledge, and feedback. The prompt responses were used as a formative way to help the teacher determine students' current knowledge and misconceptions that could then direct the teacher on what should be retaught or

what should be taught in a different way for future lessons (Seto & Meel, 2006). In a study by Di Pillo et al. (1997) prompts ranged from concepts and procedures to better assess student understanding, students' attitudes towards how class was going, and reflection questions.

Some studies have focused on giving pre and post-tests along with the journaling to help teachers see if there has been an increase in knowledge due to the implementation of writing. The majority of studies that followed these guidelines had students journaling multiple times a week for at least a six-week period (Martin, n.d.). In one particular study, students were split into two groups, the journal writing and no journal writing group (Tan & Garces-Bacsal, 2013). Both groups were given worksheets where the classes either went over common mistakes in a whole-group setting or the teacher gave individual feedback for less common errors (Tan & Garces-Bacsal, 2013). The journal writing group was given a writing task to complete in addition to the worksheets that they could complete at home, turn in, and receive feedback within two days (Tan & Garces-Bacsal, 2013). The results from this study showed an increase in scores for the journal writing group compared to the no journal writing group (Tan & Garces-Bacsal, 2013).

In another instance, a treatment and control group were created to see the effects that writing in math would have on the difference between pre and post-test scores (Williams, 2003). Each group learned about problem solving and were required to complete regular homework assignments (Williams, 2003). In addition to the traditional homework, students were given five nonroutine problems that required a more analytical approach that were scored on a rubric scale of zero to four, based on correctness and appropriate strategies used (Williams, 2003). Students in the experimental group had to write one to two paragraphs to go along with their work to explain the processes used for solving (Williams, 2003).

In a final study, two teachers, one fifth and one sixth grade, had students answer specific prompts by writing in journals three to four times a week for an eight-week period (Di Pillo et al., 1997). Teachers responded to students' journal entries with positive comments or guiding questions and also kept their own journal to keep track of reactions towards student responses and reflect on how the responses impacted future instruction (Di Pillo et al., 1997). The students completed 25 prompts that varied in purpose to help teachers the effects they would have on students' knowledge and understanding, as well as their feelings (Di Pillo et al., 1997).

It can be concluded that it is important to take into consideration how writing can be used to enhance student knowledge as well as a way to show students' feeling towards writing in math. The information provided by writing, more specifically journaling, can give teachers needed information to guide further lesson and give students a deeper understanding of the material and way to communicate both knowledge and confusion (Seto & Meel, 2006). Based on knowledge acquired through the literature review, my research question will be: Does structured written communication through the form of journaling impact ninth-grade and tenth-grade mathematics students' academic performance? A sub question that stems from this will be: How does the implementation of written communication in the mathematics classroom affect student perceptions of math and writing?

Methodology

Participants

Teacher. The educator participant in this study was myself, a Grade 9 and 10 mathematics teacher teaching Math II, Math III, and Pre-Calculus. Going on four years, I have been teaching at the same school and have taught many of the same students for more than one year due to moving up a grade level. I hold a bachelor's degree and am pursuing a master's degree to focus more on secondary education with a concentration in mathematics.

Students. The participants in the study were 60 ninth and tenth grade students (28 girls and 32 boys) ranging from 14 to 17 years old. Students were of mixed abilities all from the same school. The 60 students take Math III and were comprised of two treatment groups and two control groups. The treatment group comprised 29 students (12 girls and 17 boys) in ninth and tenth grade. Out of these 29 students, 38% were African American, 42% were Caucasian, 10% were Hispanic, and 10% were classified as Other. The control group contained 31 students (16 girls and 15 boys) in ninth and tenth grade. From the 31 students in this group, 23% were African American, 58% were Caucasian, 13% were Hispanic, and 6% were classified as Other. The groups were comparable based on class size, number of minutes of mathematics instruction (80 minutes), standards being learned, and students receiving accommodations through individualized education plans (IEPs) and 504 plans.

Setting

School setting. The selected participants were ninth and tenth grade students from the high school program of only 107 students but an overall school population of 753 students (North Carolina School Report Cards, 2017). The International Baccalaureate and Magnet school contains Grades 6 through 10 and is located in an urban region in the eastern portion of

the United States. The school is considered a Title I school, one that receives funding to aid in "providing all children a significant opportunity to receive a fair, equitable, and high-quality education, and to close the achievement gaps" (North Carolina School Report Cards, 2017). According to the North Carolina School Report Cards (2017), 55.6% of students were economically disadvantaged.

Class setting. In the classroom there was only me, the teacher, and the student participants. The average class size of Math III students was about 15. All students had access to technology through Chromebooks and TI-83+ calculators. Students had the freedom to sit where they would like, and desks were set up in a U-shape for the outer portion of the room and in groups of two to three in the center of the room.

Research Procedures

Research design. This was an explanatory mixed-methods research design. This design was most appropriate for my research questions because I focused mostly on quantitative data through student scores on assessments and survey data but also looked at qualitative data related to students' perceptions of writing in math. I collected data at the beginning and end of the study, as well as more quantitative data throughout the study since it was my main focus.

Selection of groups. I taught four Math III classes, two ninth grade and two tenth grade. One of each grade level made up the experimental and control groups so that both grade levels were represented in each group. As stated previously, the groups were comparable based on class size, number of minutes of mathematics instruction (80 minutes), standards being learned, and students receiving accommodations through individualized education plans (IEPs) and 504 plans.

Experimental implementation. The main purpose of this action research study was to determine how journaling would impact mathematics students' academic performance. In order to address this stated purpose, I developed a mathematics pretest and posttest to provide baseline data and final data regarding student performance, respectively. After reviewing various forms of tests, I chose to use Problem-Attic, an online database consisting of premade questions to match each standard, since it was what my students were most comfortable and experienced with (EducAide Software, 2019). Because my focus was on journaling, I developed a series of journal prompts for students in the experimental group to answer. Students had at least one journal prompt a day since classes meet every other day. One example of a journal prompt is as follows: Using your knowledge of the sine function, what steps should you take to be able to graph a specific sine equation? (See Appendix B). From the resulting student score reports, I looked at students' overall percent correct from the start to conclusion of the study.

To enhance this action research study, I also looked at how written communication in the math classroom affected student perceptions of math and writing. To measure student perceptions of writing in math class, students in the experimental group completed a survey of 12 questions that consists of Likert-scale and open-ended questions at the start and end of the study.

Materials and expectations. In order to complete this study, all student participants needed a journal for their entries. The journals stayed in the classroom at all times to avoid getting lost. Because all Math III classes were roughly at the same pace, I needed to keep in mind that the experimental group may get slightly behind the control group due to the nature of writing taking a longer amount of time to complete.

To assist students in the experimental group with journaling, I gave them explicit guidelines on how to structure their entries. The guidelines included the time allotted for each

journaling session, for the students to write in complete sentences, and a detailed description of the journal prompt. For organization of the actual journals, students needed to keep their journal prompts in order and make sure handwriting and graphics were legible. While students were journaling, the expectation was that they were working silently the entire time. In most cases, students were given a time limit to encourage them not to overthink the prompt or take up too much class time.

Data Collection and Measures

My plan was to collect quantitative mathematics pre-test data on student performance and mixed methods survey data regarding their perceptions of writing in math class before starting the study. During the use of journaling, I monitored student understanding in the experimental group by providing feedback on writing prompts and required students to add details or make corrections. To end the study, I collected quantitative post-test data on student performance and qualitative survey data regarding their perceptions of writing in math.

I collected data on student performance from all groups, experimental and control, from the pre-test (see Appendix C). This helped me see where everyone was starting and if the groups were comparable from the beginning. If the pre-test test was not comparable, I would take this into consideration when analyzing the data. The experimental groups completed a survey related to writing in math at the beginning of the study to help me see their current feelings before implementing journaling in class. This helped me see what students' current thoughts were. The questions start off more generic to determine students' feelings on writing in math and other classes, then moves to more specifics with how writing can affect mathematical understanding, and finally requires students to think more deeply about what impacts writing has made and will continue to make on their understanding of math.

Although students had not done a lot of writing in my class previously, I wanted to see their perceptions on it before we began to see if students had negative connotations from the start and if those change over time. The survey (see Appendix D) was created to closely resemble another study survey used by Reilly (2007). As we progressed through the unit, I closely monitored student understanding in the experimental groups by providing feedback on their journal prompts. At the close of the study, both groups took the same post-test (see Appendix E) to help me collect more data related to academic performance. I also gave the experimental group the same survey, regarding perceptions on writing in math, they took at the beginning of the study, to see how/if their perceptions about writing in math have changed.

Data Analysis

Pretest and posttest data on mathematical academic performance was collected and stored in a spreadsheet software on Google Sheets over the course of the study. To perform t-tests in order to determine statistical significance of any data collected during the study, I used MATLAB. After completing the pretest, statistical measures were performed on the scores from both the control and experimental groups to see if there was a statistical significance in the level of prior knowledge between the two groups. This was important because it could have an impact on the rest of the data.

Upon its conclusion, statistical measures were performed on all assessment data to see how students in each group progressed and determine statistical significance. Because I collected both pretest and posttest data on student performance for the experimental and control groups, this falls under the repeated-measures *t* test. This test was used to examine differences in scores before and after the study for each group. This would show if there was a statistically significant change in score after the treatment period for the experimental and control group.

Both control and experimental groups posttest data were compared to determine effectiveness of the treatment. Based on the statistical significance, I determined if the results made little to no impact on the experimental group or if there was a large enough impact that the results were because of the treatment. To actually determine if scores were impacted from the treatment, the independent measures *t*-test was used on posttest data from the experimental and control groups.

Information obtained from the self-report survey conducted at the beginning and end of the study was assessed upon completion of the experiment. To assess the quantitative portion of the survey, the Likert-scale questions, I used the mean measure of central tendency to more accurately reflect students' answers. To assess the qualitative portion of the survey, the open-ended questions, data was entered into Google Sheets to help categorize common themes of student answers. As I read through the answers, I summarized what was written and kept a tally of how many similar responses occurred in each category. Based on the answers, the most frequent responses impacted how to answer the sub-research question of student perceptions on writing in math.

Validity and Trustworthiness

This study had both descriptive and interpretive validity. On the basis of descriptive validity, factual information provided accurately represented what occurred during the study, and interpretive validity focused on correctly representing participants' (Mertler, 2017). This was especially important to keep in mind when describing students' perceptions and attitudes towards writing in math.

To maintain trustworthiness, credibility and dependability were established. To ensure that results were believable, I triangulated the different data collected to analyze all aspects of the

study. It was important to remember that situations may change over time. If a change affected the study in some way, I made a note of those changes; however, the idea of being as stable as possible helped to make sure data was not adversely affected (Mertler, 2017).

Results

Journal Prompts

Although the journal prompts did not provide specific data that can be compared from the beginning to the end of the study, they did provide formative feedback during the study to assist with instruction. After students completed each journal entry, I provided feedback, whether positive or constructive, and then required students to make corrections, if necessary. Depending on the prompt, it provided me with specific knowledge on student understanding. In Prompt 1, for example, it helped me see if students really understood the math vocabulary and specific trigonometry functions (Appendix F). In Prompt 3, it allowed me to see if students could determine the error made in the provided work and to make sense of the answer in the context of the scenario (Appendix G). This really helped me see if students understood the various formulas and if they truly understood what the answer meant. In Prompt 8, it showed me if students understood the rules of transformations and could relate what they were learning to the real world (Appendix H). All of this information not only helped me see what students understood or had misconceptions about, but provided students insight into what information they understood and what they still needed help with. This relates to some of the student responses later seen through the mathematics survey.

Pretest and Posttest Data

Both control and experimental groups pretest results were gathered and compared. The average pretest scores for the control ($M = 15$, $SD = 16$) and experimental ($M = 21$, $SD = 17$) groups were determined. An independent measures t-test was performed to determine the statistical significance, if any, of the two groups. The p-value for the t-test was determined to be 0.1202. Because $p > 0.05$, there was not a statistically significant difference between the control

and experimental group pre-tests. This signifies that the two groups were starting at similar knowledge levels prior to instruction.

A repeated measures t-test was performed for both the control and experimental group to see what changes occurred from the pre to posttest within each group. Upon completing a repeated measures t-test between the pre to posttest data, the control group posttest score (M = 69, SD = 19) had a p-value of 7.6057e-14. This shows that the data collected was statistically significant, meaning growth occurred over the course of the action research study with no treatment. Upon completing a repeated measures t-test between the pre to posttest data, the experimental group posttest score (M = 79, SD = 17) had a p-value of 1.7849e-13. This also shows that the data collected was statistically significant, meaning growth occurred over the course of the action research study with treatment.

To determine the difference between the posttests of the control and experimental groups, another independent measures t-test was performed to see if the treatment positively impacted student scores. The p-value for t-test was determined to be 0.0402. Because $p < 0.05$, there was statistically significant evidence that the treatment positively impacted student scores in the experimental group.

Mathematics Classroom Survey Data

A mathematics classroom survey was given to the experimental group both before starting the research study and upon completing the study. Because we had not previously done a lot of writing activities in my classroom, I wanted to find out some basic information from my students regarding their perceptions on writing in math prior to journaling. Upon completing the study and the treatment of journaling in the classroom, students completed the same survey to see if their views had changed. As shown in Table 1, there were a few questions that had more of

a change from the beginning to the end of the study than others, but the only question with a statistical significance was question one, with a p-value of 0.0294. This makes sense because students did writing prompts each class period for the duration of the study. No other conclusions can be made due to p-values > .05.

Table 1

Experimental Group Likert-Scale Survey Results

Question number:	Survey question:	Pre study average:	Post study average:
1	I often have to write in math classes.	3.25	3.86
2	I enjoy writing in math class.	3.25	3.52
3	I enjoy writing in other classes.	3.04	3.1
4	I understand math concepts better if I have to write about them during a unit.	3.36	3.83
5	I understand math concepts better if I have to write about them at the end of the unit.	2.96	3.45
6	A math class that uses writing activities helps me learn better than a math class that does not use writing activities.	3.07	3.52
7	Doing even more writing activities in math classes would improve my learning/understanding.	3.18	3.59

Note: Students answered questions based on a scale of 1-5, with one being strongly disagree and five being strongly agree. Averages of the entire group's responses were rounded to the nearest hundredth.

The open-ended questions, questions eight through twelve, provide a lot of details on what students' view as being important or what was most memorable to them. It was hard to compare qualitative data that was open-ended because the answers provided varied greatly. It should be noted that some students provided more than one answer for various questions, like question ten, and some students decided not to answer a particular question at all.

Question 8 asked students to "Describe how some writing activity changed the work you did for a math quiz or test". Upon completing the study, it can be observed that students' answers involved higher orders of thinking (See Table 2). They discussed how key concepts used in writing helped remind them of material on a test, how writing activities gave them a different way to study, offering a new perspective, and how writing about the material helped them learn from their mistakes during the unit so they would be less likely to make those mistakes again. These answers show much more thought rather than the initial responses of how writing assists with their studying or helps with memorizing formulas.

Table 2

Question 8: Describe how some writing activity changed the work you did for a math quiz or test.

Top answers before the study:	Top answers after the study:
Better able to express how to solve problems (7 votes)	Helped me better understand the material (9 votes)
It assisted with my studying (6 votes)	It reminded me of key concepts essential for the test (5 votes)
Helped with memorizing formulas (3 votes)	Helped jog my memory prior to the test (3 votes)
	It gave me a different way to study (3 votes)
	Helped me learn from mistakes so I wouldn't make them again (2 votes)

Note: These were the most common answers students gave. Other answers were either only given by one student or did not make sense in the context of the question.

Question 9 asked students to "Describe in detail one writing activity you have done for math class". In looking at the answers before the study, this shows what writing activities we have done in class prior to the study that have stuck out the most to students (See Table 3). While notes were the dominant answer among students, it was good to see that students remember doing other activities like creating posters and completing error analysis problems.

Looking at the responses after the study, it was no surprise that the most common answer was writing prompts since we did them every class for the duration of the study. Question 10 was similar to question nine, but just asked students to list other writing activities they had done. This was included to show me what other activities students remember most. There were similar responses between the start and end of the study, and I believe it shows that we have completed a variety of writing activities to change up how writing was implemented in the classroom and provide students multiple ways to express their thoughts through writing (See Table 4).

Table 3

Question 9: Describe in detail one writing activity you have done for math class.

Top answers before the study:	Top answers after the study:
Notes (8 votes)	Writing prompts (20 votes)
Math topic poster (6 votes)	Notes (3 votes)
Test corrections (4 votes)	
Error analysis (3 votes)	

Note: These were the most common answers students gave. Other answers were either only given by one student or did not make sense in the context of the question.

Table 4

Question 10: List some of the other types of writing activities you have done for math class.

Top answers before the study:	Top answers after the study:
Notes (8 votes)	Notes (11 votes)
Test corrections (6 votes)	Projects (5 votes)
Math topic poster (5 votes)	Error analysis (4 votes)
Projects (5 votes)	Writing prompts (3 votes)
Warm-Ups (3 votes)	Math topic poster (3 votes)

Note: These were the most common answers students gave. Other answers were either only given by one student or did not make sense in the context of the question.

Question 11 required students to specifically think about how writing has changed the way they learn math. Before completing the study, it was interesting to see that the top answer was simply "It hasn't" (See Table 5). Upon completing the study, there was a large difference in the types of answers provided showing that writing in class changed students' views on how it helps with learning math. Numerous students agreed that writing helped them remember information better and increased their understanding of a topic. This leads me to believe that based on the survey, writing had a positive impact on the majority of students, as far as how they learn math.

Table 5

Question 11: How has writing changed the way you learn math?

Top answers before the study:	Top answers after the study:
It hasn't (6 votes)	Helped me remember information better (11 votes)
Gives me a different approach (4 votes)	Increased my understanding of a topic (10 votes)
Better understand through steps (4 votes)	It has made me reflect on my understanding of what I do/don't know (4 votes)
Better remember formulas (3 votes)	

Note: These were the most common answers students gave. Other answers were either only given by one student or did not make sense in the context of the question.

Question 12 required students to reflect on the importance of writing to learn math. In Table 6, it can be observed that there were similar answers across the board. From the beginning to the end of the study, it can be concluded that students believe writing in math was important to one's learning and there were a number of reasons why. One reason that stood out at the end of the study was that writing helps you show what you know and what you still need to work on. When reading through student responses, students related this question to their journal prompts

because they said having to write made them think more about the topic and depending on how easy it was for them to write showed them if they really understood the topic or not.

Table 6

Question 12: What do you think is important about using writing to learn math?

Top answers before the study:	Top answers after the study:
Helps with better understanding a topic (10 votes)	It deepens your understanding of a topic (7 votes)
It makes you think differently about a problem (5 votes)	It makes you think about the math in a different way (6 votes)
It helps with remembering information (4 votes)	Helps you show what you know and what you still need to work on (4 votes)
Nothing (2 votes)	It helps you explain math to others (2 votes)
	It helps with retention of information (2 votes)

Note: These were the most common answers students gave. Other answers were either only given by one student or did not make sense in the context of the question.

Conclusion

The purpose of this study was to determine the impact that writing would have on students' academic performance and gain insight into students' perceptions on writing in the mathematics classroom. Upon completing the study, it can be concluded that there was enough statistically significant evidence on the use of journaling to show that the experimental group scores were positively impacted by this treatment. While I was able to determine the impact writing had on academic performance, I believe it would be useful to complete this study again with a larger group of students and for a longer period of time (more than a unit, which was done in the study).

The insight gained from student responses through the survey help me determine that the increased use of writing in the classroom did positively change the majority of students' opinions. Whether they found that writing increased their understanding or required them to think more critically, it was evident that the majority of students realized the need for writing in the mathematics classroom. This does not go without saying that I still had some students that did not see the value in writing or felt it did not make a difference in their understanding. If I were to do this part of the study again, I would change the question about students describing a writing activity they have done in class to include what made it a good activity that helped their understanding and/or what could have been changed to make the activity better.

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APPENDIX A: PERMISSION AND ASSENT FORMS

Dear Parent/Guardian,

As part of my Masters of Middle Grades Education degree requirements at East Carolina University, I am planning an educational research project that will help me learn more about the impacts of journaling on mathematical performance. The fundamental goal of this project is to improve student academic performance through the use of writing. I have investigated an effective instructional practice, mathematical journaling (answering various prompts to better understand the content) that I will be implementing during daily instruction in Spring 2019. I am going to track student improvement during instruction and collect relevant data for roughly 4-5 weeks.

This project has been approved by my instructor at ECU, Dr. Jessica Chittum, and the ECU Institutional Review Board.

I am asking permission to include your child's progress in my project report. Your child will not be responsible for "extra" work as a result of this project. The decision to participate or not **will not** affect your child's grade. I plan to share the results of this project with other educators through presentations and publications to help educators think about how they can improve instruction in their own classrooms. I will use pseudonyms to protect your child's identity. The name of our school, your child, or any other identifying information **will not** be used in my final report. Please know that participation (agreeing to allow me to include your child's data) is entirely voluntary and your child may withdraw from the study at any point without penalty.

If you have any questions or concerns, please feel free to contact me at school at 336-703-4168 or e-mail me at eesloop@wsfcs.k12.nc.us You may also contact my supervising professor at ECU, Dr. Jessica Chittum, at chittumj15@ecu.edu and 252-737-2486. If you have questions about your child's rights as someone taking part in research, you may call the Office of Research Integrity & Compliance (ORIC) at 252-744-2914 (days, 8:00 am-5:00 pm). If you would like to report a complaint or concern about this research study, you may call the Director of the OHRI, at 252-744-1971.

Please indicate your preference below and return the form by 22 April 2019.

Your Partner in Education,

Emily Evans Sloop

As the parent or guardian of _____,

- ☐ **I grant permission for Mrs. Emily Sloop to use my child's data in the educational research project described above regarding journaling in mathematics instruction. I voluntarily consent to Mrs. Emily Sloop using data gathered about my child in her study. I fully understand that the data will not affect my child's grade and will be kept completely confidential.**

- ☐ ***As the parent or guardian of _____, I do not grant permission for my child's data to be included in the study.***

Signature of Parent/Guardian: _____ Date: _____

Assent Form

Things You Should Know Before You Agree To Take Part in this Research

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IRB Study #_____

Title of Study: Impacts of Journaling to Enhance Mathematical Performance in Ninth and Tenth Grade Students

Person in charge of study: Mrs. Emily Sloop
Where they work: Paisley IB Magnet School

Study contact phone number: 336-703-4168
Study contact E-mail Address: eesloop@wsfcs.k12.nc.us

People at ECU study ways to make people's lives better. These studies are called research. This research is trying to find out how to improve students' academic performance through the use of writing.

Your parent(s) needs to give permission for you to be in this research.

You may stop being in the study at any time. If you decide to stop, no one will be angry or upset with you.

Why are you doing this research study?
The reason for doing this research is to see what impact writing in math class may have on students' academic performance.

Why am I being asked to be in this research study?
We are asking you to take part in this research because…you can help us to see if writing actually does help improve students' scores. This could be beneficial to both you and future students.

How many people will take part in this study?
If you decide to be in this research, you will be one of about 60 people taking part in it.

What will happen during this study?
During this study all participants will take a pre and post-test. A quiz will be given during the study and class will basically run just like normal. For students in the group that will use journaling, we will complete one prompt each class period that may take anywhere from five to ten minutes. Students in the journaling group will also take a survey at the beginning and end of the study to demonstrate their feelings on writing in math.

This study will take place at Paisley IB Magnet School and will last four to six weeks.

Who will be told the things we learn about you in this study?
Results of the project will be shared with other teachers so they can get better at teaching. I won't use your real name when I talk about the results of the project.

What are the good things that might happen?
Sometimes good things happen to people who take part in research. These are called "benefits." The benefits to you of being in this study may be that it can reveal a new technique to assist in mathematical learning, thus an increase in academic performance.

What are the bad things that might happen?
There are no known risks of this study. The only downside is that journaling may not be the most effective use of writing to enhance academic performance in math, but we will not know this until we try.

What if you or your parents don't want you to be in this study?
If you wish not to participate in this study, this only means that I will not use your scores in my research data. You will still participate in the everyday classroom activities like always.

Will you get any money or gifts for being in this research study?
You will not receive any money or gifts for being in this research study.

Who should you ask if you have any questions?
If you have questions about the research, you should ask the people listed on the first page of this form. If you have other questions about your rights while you are in this research study, you may call the Institutional Review Board at 252-744-2914.

If you decide to take part in this research, you should sign your name below. It means that you agree to take part in this research study.

_____ _____
Sign your name here if you want to be in the study Date

_____
Print your name here if you want to be in the study

_____ _____
Signature of Person Obtaining Assent Date

_____
Printed Name of Person Obtaining Assent

APPENDIX B: JOURNAL PROMPTS FOR EXPERIMENTAL GROUP

Prompt 1: Imagine you are teaching someone about how to find the side lengths and angle measures of a right triangle. You are given that one angle is 40 and the hypotenuse is 10. If they are solving for the other angle and both legs, what steps must they take? You may draw a triangle to start but explain in complete sentences what they should do to solve. You do not actually have to find the final answer. Be sure to use math vocabulary in your explanation.

Prompt 2: In your own words, what is a coterminal angle? Why are they important in trigonometry?

Prompt 3: Below is a student's work on converting from degrees to radians.

45 deg. 180 deg. = 8100 = 2578.3

What error did the student make? Does the answer the student got make sense? Explain.

Prompt 4: What tips would you give to someone trying to learn the unit circle? Is there anything creative to help them learn the patterns?

Prompt 5: In your own words, describe what the period of a sine or cosine function is. What is the difference between a sine and cosine function on a graph?

Prompt 6: Using your knowledge of the sine function, what steps should you take to be able to graph a specific sine equation? You may write your answer as a bulleted list.

Prompt 7: Now that you have learned about sine and cosine functions on the graph, create a Venn Diagram comparing and contrasting the two. Possible ideas are the way the graphs look, how to write the equations, how to setup the table, etc.

Prompt 8: Create your own sine or cosine equation that includes at least three transformations. Describe where each transformation is located in the equation and what it would do to the parent function. What is an example of a sine or cosine equation being used in real life?

Prompt 9: Write down anything and everything you will need for the test. This can include formulas, graphs, steps for solving certain things, etc.

APPENDIX C: MATHEMATICS PRETEST

Math 3 Unit 7 Pre Test

Name: _____ **Date:** _____

1. Express $160°$ in radian measure.

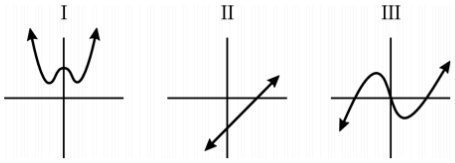
   A. $\frac{8\pi}{9}$ B. $\frac{7\pi}{9}$ C. $\frac{2\pi}{3}$ D. $\frac{5\pi}{9}$

2. Which of the following correctly describes the range of the function $y = 5\sec 3x$?

   A. $y \le -5$ and $y \ge 5$ B. $y \le -5$ and $y \ge 3$

   C. $-5 \le y \le 3$ D. $y \le -5$ or $y \ge 5$

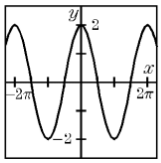
3. Which of the following graphs represent an odd function?

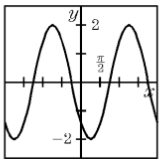


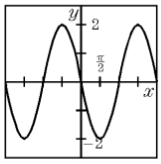
   A. I only B. II only

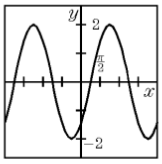
   C. III only D. II and III

4. Which of the graphs shown is the graph of $y = -2\cos\left(x - \frac{\pi}{2}\right)$?

   A.


   B.


   C.


   D.


5. Which of the following angles is coterminal with $-730°$?

   A. $20°$ B. $210°$ C. $350°$ D. $610°$

6. Find the phase shift and period for the function $y = 3\sin 2\left(x - \frac{\pi}{3}\right) - 1$.

   A. phase shift: $\frac{\pi}{3}$; period: 2π

   B. phase shift: $\frac{\pi}{3}$; period: π

   C. phase shift: $-\frac{\pi}{3}$; period: $\frac{\pi}{2}$

   D. phase shift: $-\frac{\pi}{3}$; period: $\frac{\pi}{2}$

APPENDIX D: MATHEMATICS CLASSROOM SURVEY

"This survey is designed to help […] gain some insight on how effective various aspects of your math classes are for you as a student. You are being asked to evaluate which methods you feel are the best for learning math. Your responses will help math teachers improve the math curriculum in order to enhance students' learning experiences" (Reilly, 2007, p. 127).

Please answer all items as completely and honestly as you can.

Please rate your feelings on a scale of 1-5, use the scale below as an example.

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

1.	I often have to write in math classes.	1	2	3	4	5
2.	I enjoy writing in math class.	1	2	3	4	5
3.	I enjoy writing in other classes.	1	2	3	4	5
4.	I understand math concepts better if I have to write about them during a unit.	1	2	3	4	5
5.	I understand math concepts better if I have to write about them at the end of the unit.	1	2	3	4	5
6.	A math class that uses writing activities helps me learn better than a math class that does not use writing activities.	1	2	3	4	5
7.	Doing even more writing activities in math classes would improve my learning/understanding.	1	2	3	4	5

Please answer these questions in as much detail as possible.

8. Describe how some writing activity changed the work you did for a math quiz or test.

9. Describe in detail one writing activity you have done for math class.

10. List some of the other types of writing activities you have done for math class.

11. How has writing changed the way you learn math?

12. What do you think is important about using writing to learn math?

APPENDIX E: MATHEMATICS POSTTEST

Math 3 Unit 7 Post Test

Name: _____ **Date:** _____

1. Convert to radians: $315°$

A. $\frac{7\pi}{4}$ B. $\frac{7\pi}{8}$ C. $\frac{11\pi}{6}$ D. $\frac{5\pi}{3}$

2. Express $\frac{11\pi}{3}$ radians in degrees.

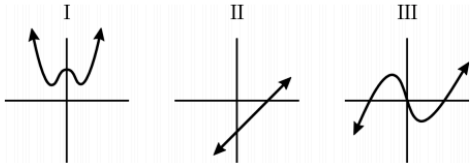
A. $145°$ B. $300°$ C. $630°$ D. $660°$

3. Which of the following correctly describes the range of the function $y = 3\sec 2x$?

A. $y \leq -3$ and $y \geq 3$ B. $y \leq -3$ or $y \geq 3$

C. $-3 \leq y \leq 3$ D. $y \leq -3$ or $y \geq 2$

4. Of the three functions shown, which are neither odd nor even?



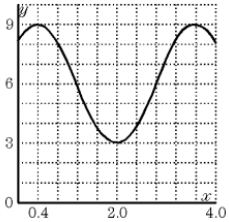
A. I only B. II only

C. III only D. II and III

5. Find the amplitude for the sinusoidal graph.

A. 9 B. 3

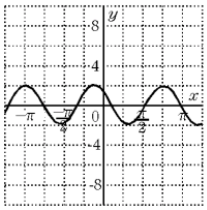
C. 1.5 D. 0



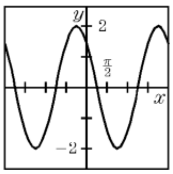
6. What would be the period for the graph shown if we consider the graph to be a cosine function of the form $y = a\cos(x - c)$?

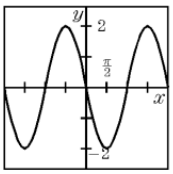
A. $\frac{7\pi}{8}$ B. 2π

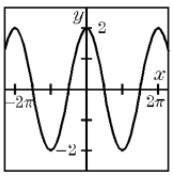
C. $\pm 2\pi$ D. 0

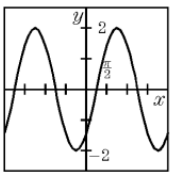


7. Which of the graphs shown is the graph of $y = -2\sin x$?

A.


B.


C.


D.


8. The graph of $y = 4\cos x - 2$ compared to $y = \cos x$ will have moved:

A. 2 units down, expanded vertically by a factor of 4

B. 2 units left, expanded vertically by a factor of 4

C. 2 units right, expanded vertically by a factor of 4

D. 2 units right, compressed vertically by a factor of $\frac{1}{4}$

9. The graph of $y = \cos x$ is transformed to $y = a\cos(x - c) + d$ by a vertical expansion by a factor of 3, then translated $\frac{\pi}{2}$ units left and 2 units up. The new equation is:

A. $y = 3\cos(x - \frac{\pi}{2}) + 2$

B. $y = 3\cos(x + \frac{\pi}{2}) + 2$

C. $y = \frac{1}{3}\cos(x - \frac{\pi}{2}) + 2$

D. $y = 3\cos(x - \frac{\pi}{2}) - 2$

10. Which of the following angles is coterminal with $-610°$?

A. $20°$ B. $70°$ C. $110°$ D. $610°$

11. What is the reference angle of $-820°$?

A. $-80°$ B. $-60°$ C. $10°$ D. $80°$

12. Find the phase shift and period for the function $y = 2\sin 3\left(x - \frac{\pi}{2}\right) + 1$.

A. phase shift: $\frac{\pi}{2}$; period: $\frac{2\pi}{3}$

B. phase shift: $-\frac{\pi}{2}$; period: $\frac{2\pi}{3}$

C. phase shift: $-\frac{\pi}{2}$; period: $-\frac{2\pi}{3}$

D. phase shift: $\frac{\pi}{3}$; period: 3

13. For $y = 17 + 8\cos 6(2\theta - 32)$ state the (1) amplitude, (2) period, (3) vertical shift (positive or negative), and (4) phase displacement.

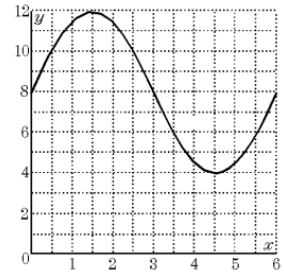
A. (1) 8, (2) $\frac{\pi}{6}$, (3) 17, (4) 16

B. (1) 17, (2) $\frac{\pi}{3}$, (3) 8, (4) 32

C. (1) 17, (2) $\frac{\pi}{6}$, (3) 17, (4) 32

D. (1) 8, (2) $\frac{6}{\pi}$, (3) 16, (4) 17

14. The graph shown has the form $y = a\sin x + d$. What is the equation?



A. $y = 8\sin x + 12$

B. $y = 4\sin x + 12$

C. $y = 4\sin x + 8$

D. $y = 8\sin x - 4$

15. At a seaport, the depth of the water, h meters, at time t hours, during a certain day is given by

$$h = 2.5\sin 2\pi\frac{(t-4)}{12.4} + 1.6$$

What is the depth of the water at 3:00 am?

A. 0.39 m

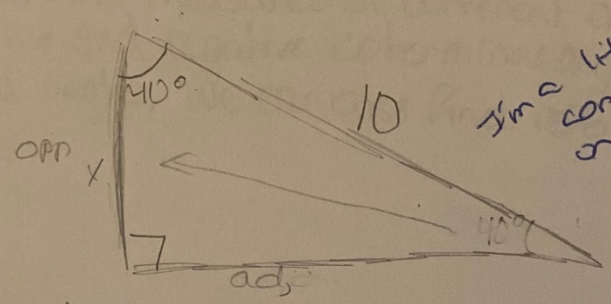
B. 2.81 m

C. 1.62 m

D. 0.05 m

APPENDIX F: PROMPT 1 SAMPLE RESPONSES

Prompt 1: Imagine you are teaching someone about how to find the side lengths and angle measures of a right triangle. You are given that one angle is 40 ∘ and the hypotenuse is 10. If they are solving for the other angle and both leg,s what steps must they take? You may draw a triangle to start but explain in complete sentences what they should do to solve. You do not actually have to find the final answer. Be sure to use math vocabulary in your explanation.



I'm a little confused on your picture.

So, all we know is two things, one angle measures 40° and the hypotenuse is 10. In order to find the opposite side or leg, you would use sin (because of $\frac{O}{H}$), it would be $\sin 40° = \frac{x}{10}$, in order to find the angle measure, you multiply the denominator of both sides to get $10(\sin 40)$ and depending on that you can use the inverse property ($\sin^{-1}$). For the other leg, you would use cosine because of $\frac{A}{H}$, to get $\cos 40° = \frac{x}{10}$, multiply the denominator to get $10(\cos 40°)$ and to find the angle measure, use $\cos^{-1}$.

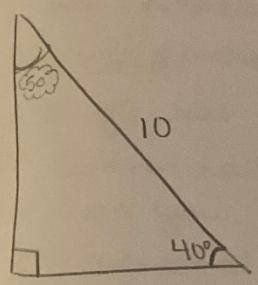
Good. Is there a different way?

Is there any easier way to find the other side.

you can also add 90 + 40 to get 130 and subtract that the other angle measure.

you can use $a^2+b^2=c^2$ to find the other side.

Prompt 1: Imagine you are teaching someone about how to find the side lengths and angle measures of a right triangle. You are given that one angle is 40 ∘ and the hypotenuse is 10. If they are solving for the other angle and both leg,s what steps must they take? You may draw a triangle to start but explain in complete sentences what they should do to solve. You do not actually have to find the final answer. Be sure to use math vocabulary in your explanation.



① To find other angle, we know triangles are equal to 180°. So you add 90° and 40° together to get 130°, then subtract by 180°. So the other angle is 50°. Good!

② To find the side lengths you use the angle, hypotenuse, and side length your trying to find. For example, if your trying to find the bottom leg you use sin, cos, and tan. $S\frac{O}{H}$, $C\frac{A}{H}$, $T\frac{O}{A}$ is a good way to remember. So the bottom leg is adjacent to the angle so it would be adjacent and hypotenuse which is cosine. Then you use cosine and enter 40, set cos(40) equal to $\frac{x}{10}$ to find answer. Multiply 10 to both sides so you end up with $10(\cos(40)) = x$. Then, enter into calculator and solve for x. Same for the other leg except this time it would be opposite over adjacent.

Good step by step explanation!

$\cos(40) = \frac{x}{10}$

$10 \cdot \cos(40) = \frac{x}{10} \cdot 10$

round as directed*

$10(\cos(40)) = x$

$\boxed{7.66 = x}$

opposite → $\sin(40) = \frac{x}{10} \cdot 10$

$10 \cdot \sin(40) = \frac{x}{\cancel{10}} \cdot \cancel{10}$

$10(\sin(40)) = x$

$\boxed{6.43 = x}$

APPENDIX G: PROMPT 3 SAMPLE RESPONSES

Prompt 3: Below is a student's work on converting from degrees to radians.

45 deg. • $\frac{180\ deg.}{\pi} = \frac{8100}{\pi} = 2578.3$

What error did the student make? Does the answer the student got make sense? Explain.

Good!

The student did 180/π instead of π/180 to go from degrees to radians. The answer does make sense because the math is right. The setup should be $45 \cdot \frac{\pi}{180}$.

Does 2578.3 make sense on the unit circle?

no, because the unit circle only goes to 360°. You would have to find a positive coterminal angle.

Prompt 3: Below is a student's work on converting from degrees to radians.

45 deg. • $\frac{180\ deg.}{\pi} = \frac{8100}{\pi} = 2578.3$

What error did the student make? Does the answer the student got make sense? Explain.

$\frac{45}{1} \cdot \frac{180}{\pi}$

Good. The student made the error by mutiplying by $\frac{180}{\pi}$ when they should have mutiplyed by $\frac{\pi}{180}$. Their answer does not make sense because radians are supposed to be small and their answer is very big.

Good job noticing this. what's the largest it should be in radians on the unit circle?

the larges it could be is 2π

APPENDIX H: PROMPT 8 SAMPLE RESPONSES

Prompt 8: Create your own sine or cosine equation that includes at least three transformations. Describe where each transformation is located in the equation and what it would do to the parent function. What is an example of a sine or cosine equation being used in real life?

- The ferris wheel is an example for graphing trigonometry function because it goes up and down

Good!

$$y = 5\cos\left(\frac{\pi}{6}(\theta - 4)\right) + 5$$

vertical expansion

Right 4

UP 5

Prompt 8: Create your own sine or cosine equation that includes at least three transformations. Describe where each transformation is located in the equation and what it would do to the parent function. What is an example of a sine or cosine equation being used in real life?

$y = -3\sin\left(\frac{\pi}{3}(\theta+6)\right)(-3)$

opens down

amplitude of 3 - vertical expansion by factor of 3

what does this do?

left 6 Horizontally

down 3 vertically

A Sine Function could be used in real life to model the height of tides at the ocean as the moon pulls and releases.

Great!

APPENDIX I: IRB APPROVAL LETTER

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board
4N-64 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** ·
www.ecu.edu/ORIC/irb

Notification of Exempt Certification

From:	Social/Behavioral IRB
To:	Emily Sloop
CC:	
	Jessica Chittum
Date:	4/23/2019
Re:	UMCIRB 19-000605 Sloop: Impacts of Journaling on Mathematical Performance

I am pleased to inform you that your research submission has been certified as exempt on 4/23/2019. This study is eligible for Exempt Certification under category #1.

It is your responsibility to ensure that this research is conducted in the manner reported in your application and/or protocol, as well as being consistent with the ethical principles of the Belmont Report and your profession.

This research study does not require any additional interaction with the UMCIRB unless there are proposed changes to this study. Any change, prior to implementing that change, must be submitted to the UMCIRB for review and approval. The UMCIRB will determine if the change impacts the eligibility of the research for exempt status. If more substantive review is required, you will be notified within five business days.

The Chairperson (or designee) does not have a potential for conflict of interest on this study.
