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The Impact of Frayer Models in a Mathematics Classroom

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The purpose of this action research study was to explore the impact that Frayer Models have on students' attitudes towards mathematics. I conducted a two-week unit on transformations, where students were introduced to a classroom focused on academic language, supplementing their learning with Frayer Models for homework and in-class assessments. I assessed their attitudes towards mathematics before and after the use of the Frayer Models, where I analyzed the effect that the Frayer Models had on the students and their use of academic language. It was evident that most of the students' found the focus on academic language beneficial to their learning, thus positively affecting their attitude and confidence level with mathematics as a whole. Although some students did not find an appeal for Frayer Models as much as others, the models still helped students in the learning of the terms and developing a better understanding on mathematics being a reflective process involving reasoning and sense-making.

Introduction

Language is something that we use every day in society, yet do not think much about. The basis of human interaction and thought is centered around language itself. When it comes to learning mathematics, language becomes a large focus of our studies, as it involves an understanding for concepts and relationships (Adams, 2010). Language is a tool that can be used to further mathematical thinking and learning through the expression of new ideas and information, as there is more to mathematics than content and specific procedures. The methods and means of teaching mathematics is constantly evolving. Placing a focus on students' mathematical understanding has become one of the emphases of reform. There has been a heavier emphasis placed on student thinking and problem-solving, rather than the traditional classroom environment. Literacy instruction is just one of the many strategies that can be implemented that can make this type of classroom environment a reality for all students. Students should be able to have experiences that help them to see the power and precision of using mathematical language, which NCTM has noted as one of their expectations for student learning (Adams, 2010). With content literacy being implemented into the classroom, students are able to gain these experiences where they are able to communicate their thinking clearly and use mathematical language when expressing ideas. As content literacy allows students to interact with various disciplines, general strategies can be adapted for specific mathematical use in the classroom. One tool that is heavily utilized across content areas is the Frayer Model. The Frayer Model is a form of a graphic organizer, which assists students in understanding the various aspects of vocabulary and new concepts (Armstrong, Ming, & Helf, 2018). Students are given the opportunity to explore academic language in a precise, yet visual way, paving the way for students to become mathematical thinkers in the classroom.

Throughout my K-12 schooling there was little emphasis placed on being mathematical thinkers first in the classroom. My mathematics teachers adopted the traditional style of teaching, where our success was measured on how well we did on homework assignments, quizzes, and tests. The lecture-based classes left little room for our brains to be active thinkers in the classroom. There were many instances where we just copied notes down from the board, which often included the steps to solving a given problem. The expectation was never placed on us to use proper terminology or communicate our thoughts and ideas clearly; in fact, we never had the opportunity to explore, discuss, write ideas, or problem-solve due to the lecture-based environment. As this was the type of classroom I had always been in, I did not think anything about it. I had always had an interest in mathematics, so I enjoyed learning and knew that the thirty homework problems were just part of mathematics class. It was not until I came to BGSU that I realized the ideal mathematics classroom is far from what I had experienced. There were tasks that could be implemented that allowed formulas to be derived and connections to be made across content areas. Homework could be more than problems from a textbook and assessment looked different than just a test. Rather than being told the steps to a formula, I could figure them out myself. The preciseness of mathematical language began to be a priority in an active classroom environment. To communicate and express my ideas clearly, I needed to use the correct term in an appropriate way so that my peers could follow along with my ideas. Vocabulary was so critical; a small misconception could affect your solution strategy entirely.

Through the knowledge I had acquired through my mathematics education courses, I began to reflect on my past educational experience. If a stronger emphasis had been placed on academic language, would my classmates have expressed a more positive attitude towards mathematics? Understanding the language and meaning behind the words being used made the mathematics being taught much easier to learn. Several of my classmates did not understand when and where they would ever use this mathematics, which could have stemmed from simply not seeing mathematics as a language itself. The methods and teaching styles that a teacher incorporates into the classroom have a direct impact on student learning. It is the responsibility of the teacher to be knowledgeable in the various strategies that can be implemented to foster an environment that uses academic language precisely. Mathematics is used every day in society, meaning that the academic language used will be carried out and used in future settings; so, conducting this research could potentially give other educators an idea of how content literacy can be incorporated in the classroom.

The findings of this study are not intended to be generalized for all mathematics classrooms. With having a small sample size of students, the diversity among students becomes a limitation. Students will be coming from various backgrounds with different experiences, all which will affect their classroom performance. The study is intended to analyze the impact Frayer Models have on student attitudes in a mathematics classroom. It is hypothesized that by incorporating content literacy into the classroom, the students will acquire a greater appreciation for mathematics, thus positively affecting their attitudes towards the subject.

Literature Review

The purpose of this action research study is to see if an emphasis on academic language has a positive impact on students' attitudes towards mathematics. Frayer Models support the use of proper academic language, as students are building and strengthening their vocabulary (Armstrong, Ming, & Helf, 2018). When students are able to understand the language and meaning behind the concepts being taught, their knowledge can be taken to the next level. It is important that teachers understand the importance of supporting the use of academic language, as well as what vocabulary-based instruction may look like in the classroom. In addition, student attitudes are affected by the teacher's actions and knowledge in the classroom. The idea that attitude is influenced by the teacher will be addressed further, as well.

Importance of Academic Language

Background information. Language is used everywhere – from the conversations we have to the information we write down; we use language every day. When students are learning mathematics, it is like learning a new language (Bruun, Diaz, & Dykes, 2015). With every new language comes a vocabulary, complete with symbols and terminology. Vocabulary instruction is imperative to students learning of mathematics. Much of mathematics education has evolved from numerical computation to solving problems. When solving problems, students have to make sense of the question and operation itself, which requires understanding the academic language used, as well as the word structure. Without understanding the vocabulary of mathematics, students' ability to apply their math skills suffer; simply performing computations is not enough to solidify the depth of mathematical thinking needed (Bruun, Diaz, & Dykes, 2015). When students are using proper academic language, they are not just communicating to learn about the mathematics, but rather learning to communicate mathematically about their thoughts and ideas.

Vocabulary has changed its look in many classrooms throughout the years as communication has become an expectation for many educators to follow. The National Council of Teacher of Mathematics (NCTM) and the Common Core State Standards in Mathematics (CCSSM) have established goals and expectations that directly reflect the incorporation of mathematical vocabulary in the classroom (Adams, 2010). NCTM published five process standards that reflect the processes students should be engaging with in the classroom. Of these five processes, communication and language were one of the components deemed as important for students (NCTM, 2000). Through the communication standard, students are expected to be using mathematical language precisely when communicating and expressing ideas. These process standards were the basis for the development of eight Standards for Mathematical Practice that address behaviors and expectations that all educators should "seek to develop in their students" (CCSSM, 2010). In particular, SMP #6, attend to precision, is related to this idea of effective communication and reasoning in the classroom. The standard has a strong emphasis on language meaning and precision, which has a strong connection with the communication process (CCSSM, 2010). The process standards are connected to the SMP's as they are highlighting the same skills, just in different ways (Brahier, 2016). With the implementation of these foundational works and standards, the emphasis on language development has become a prominent focus for teachers and students.

Teaching vocabulary is something that is done across content areas and disciplines. However, despite there being various strategies available to help teach vocabulary, many are still using word lists where students look up the definitions themselves. Students need to be able to make connections to something they already know in order for the information to be stored in their permanent memory, which is why these word lists have been shown through research to be ineffective (Collier, 2007). Connections are important; if students are simply writing down a new definition or term without supplemental information, it does not make any sense to them. To the students, it is just another word to memorize. Integration is an important part of classroom instruction for this reason; students need to relate what is being taught with something they already know or are familiar with. For students to be mathematically proficient, there needs to be a continuous integration of critical skills, like concepts, procedures, and problem solving

(Riccomini, Smith, Hughes, Fries, 2015). The use of proper academic language has a direct connection. Communication and reasoning are built in with these critical skills that students are to be utilizing in the mathematics classroom.

Complexity of the language of mathematics. Students should be given the opportunities to be engaged with vocabulary terms throughout the classroom due to the complexity of the language of mathematics. Even though the language can be difficult to become acquainted with, mathematical reasoning needs to be communicated to establish higher order thinking in students (Riccomini, Smith, Hughes, Fries, 2015). With reasoning becoming more apparent in the classroom, language has also developed. However, mathematical language is not limited to reading, writing, and communication, but also “requires building meaning with symbols, contexts, graphs, diagrams, and other models as well as the ability to connect and translate” (Thompson & Rubenstein, 2014, p. 105). It is evident where the complexity of the language has its roots, but these difficulties only combine to create a valuable learning experience for students.

Even though there are many components to mathematical vocabulary, words hold an important role. Words are used inside and outside the classroom, which is why teachers should consider all students to be math language learners. The challenge that the language of mathematics brings about is often found in the English language, as many of the words that are known to a student already hold a different meaning in the mathematics classroom (Dunston & Tyminski, 2013). Although there are words that are more specific to the field of mathematics like integer or polynomial, there are many word combinations that portray different meanings. For example, table, leg, and side are words that are already probably present in a student’s vocabulary, but the mathematical concepts they are about to learn do not hold the same meaning (Dunston & Tyminski, 2013). Without clarification, this simple misconception of terminology can greatly affect a student’s understanding and attitude in the mathematics classroom. In addition to these words having shared meanings in the English language and within mathematics, it is often common to find shared words across other disciplines. The words divide, density, solution, and radical are just some of the terms that are frequently used in a science classroom (Thompson & Rubenstein, 2000). Of course, these words have different technical meanings, as well. These pitfalls explain how some students view the mathematics classroom as another country, where they are using a foreign language that they know nothing about (Thompson & Rubenstein, 2000). As the educator, these concepts and phrases are far from unfamiliar, so it is easy to forget that it is not so simple to students. However, this is why it is important that the teacher addresses various strategies and standards in the classroom so using academic language in the classroom becomes comfortable to use.

Approaches to Teaching Academic Language

The Frayer Model. Despite the difficulty and complexity that comes about when learning language, there are several strategies that can be consistently implemented into the classroom that can help to resolve and prevent any issues for students. Many of these approaches have a visual aspect to them, which gives students the opportunity to see the meaning of words in a way that they can make connections and determine relationships. One strategy that is commonly used among educators is the Frayer Model. A type of graphic organizer, the Frayer Model encourages inquiry in the classroom among students, as they identify characteristics, examples and nonexamples, as well as providing a definition in their own way that makes sense to them (Dunston & Tyminski, 2013). However, the Frayer Model can be adapted to include drawing a visual picture, rather than including characteristics depending on the type of students in the classroom. The Frayer Model can be used in a variety of ways in the classroom, such as a form of assessment, a homework assignment, or even just for use for studying.

Through a study conducted with the Literacy Instruction in Math and Science for Secondary Teachers (LIMSST), several teachers from these content areas worked for a week in the summer on developing their literacy strategy use and knowledge for preparation for the upcoming school year (Adams, 2010). The focus was to make teachers more aware of the benefits of teaching content literacy, learning how students use and depend on language in the classroom. Throughout the school year, these teachers practiced and incorporated literacy strategies into their classrooms. The Frayer Model was a favorite among teachers, as students are given the opportunity to explain their understanding (Adams, 2010). In another study presented by Bruun, Diaz, and Dykes (2015), it was found that students who used the Frayer Model were much more confident with using and understanding vocabulary. On the vocabulary pre-test taken before the study, students appeared flustered and frustrated, unsure about many of the meanings and definitions of the terms presented (Bruun, Diaz, & Dykes, 2015). However, on the post-test, students exhibited confidence and ease, showing a new conceptual understanding for the mathematics they were presented with. Despite differences among the studies, through the use of the Frayer Model diagram, students were engaging in inquiry learning, as well as showing more confidence in the subject of mathematics itself.

Attitudes

Student’s exhibit different interests, beliefs, and backgrounds, which all have a factor on their behavior and attitude towards certain subjects in school. There are many factors that can account for student’s attitude towards academics. To truly understand the differences among student performance, a variety of factors, including attitude, must be considered (Mata, Monteiro, & Peixoto, 2012). An attitude can be negative or positive, both of which affect student performance in the classroom. Students that portray a negative attitude towards a subject, such as mathematics, their behavior and achievement will be affected negatively, as well. When one carries a positive attitude, their confidence is increased with a willingness to learn (Lourdes, Monteiro, & Peixoto, 2012). Negative attitudes in the mathematics classroom can be a result of many reasons, such as repeated poor grades or continued difficulty when trying to complete assignments. Their negative attitude could have been developed due to a specific teaching strategy or environment, as well. As the teacher in the classroom, it is important to be aware of effective practices that promote a positive learning environment for students to be successful. It is crucial that students see and use mathematics in a positive way, as communicating mathematically and being thinkers inside and outside the classroom is a growing trait.

Teacher's play a prominent role in the success of students in the classroom. The teaching strategies and approaches adopted by the teacher can have a variety of looks depending on the views of the teacher. When students are able to communicate and understand mathematics in a positive learning environment, students hold more confidence in themselves. With supportive, motivational, and encouraging teachers, a positive attitude is revealed with students (Lourdes, Monteiro, & Peixoto, 2012). Language is a growing component in education that is reflected by student attitude in the classroom. As discussed earlier, the practices and strategies that teachers adopt all have an effect on student attitude. With a positive attitude, students are more confident in their abilities to share ideas and participate as mathematical thinkers, not just as a student performing computations.

Methodology

Participants

The participants of this study were students in one eighth-grade advanced pre-algebra classroom in a suburban school setting. There were 15 students that took part in the designed study. All students were provided the same experience inside the classroom.

Procedure

Data Collection. In preparation of the study, all of the student participants completed a survey before the Frayer Models (Appendix A) were introduced in the classrooms. Students rated a series of questions regarding their feelings and attitudes towards mathematics, as well as their experience, knowledge, and confidence level with using academic language. To solidify the anonymity of the research, I used a uniquely generated student code to keep their identity confidential. Quantitative measures were taken through the survey, as students rated these questions on a Likert scale from 1-5, with 1 ranking for ‘Strongly Disagree,’ with 3 being ‘No Strong Opinion,’ and with 5 being ‘Strongly Agree.’ Qualitative data was also gathered from observing student work on assignments and tests, as well as through the written prompts and questions asked on the surveys themselves. The open-ended questions pertained to student attitudes about mathematics, as well as their experience with using academic language in the classroom.

I selected a Frayer Model (Appendix B) that seemed to best fit the students in my classroom for the given two-week unit, which was focused on transformations. The Frayer Model followed the basic organization of the four-rectangles with space for students to record their thoughts, drawings, and examples. The four rectangles included: definition, facts/characteristics, example, and non-example. These were incorporated into the classroom during the various lessons in the unit for students to complete in class, for homework assignments, and for assessment at the end of a lesson. Students completed Frayer Models for the following key terms in the transformation's unit: rotation, reflection, translation, dilation, similarity, congruence, and scale factor. Students typically completed the graphic organizers individually; however, peer and class discussion were used as needed to discuss student thoughts and ideas. When explaining the purpose and the goal of the Frayer Model, I encouraged the creativity and individuality of students to be expressed as I noted this was for their benefit while studying transformations. As each student in the classroom learns and expresses themselves differently, I made clear to students that this Frayer Model was to be created in a way that best represented their learning. By presenting the purpose of the organizers this way, students were engaged in a learning experience that related to their individual needs, but also extending their mathematical knowledge of the terminology.

To support student use of these academic language terms in the classroom, several language supports were incorporated throughout the lessons to give students the opportunity to use these words fluently and conceptually understand their meaning. Strategies such as think-pair-share, notice and wonder, and what does not belong were used as academic language supports to get students communicating and thinking mathematically in the classroom. These strategies supplemented the use of the Frayer Model to build continuous connections and experience with the terminology, promoting communication, reasoning, and sense-making amongst students. Students often used what was presented and discussed in these strategies to complete their Frayer Model graphics. Two examples of student responses in this research study are shown below (see Figure 1 and Figure 2), representing students using an example with Ms. Pac Man when exploring rotations.

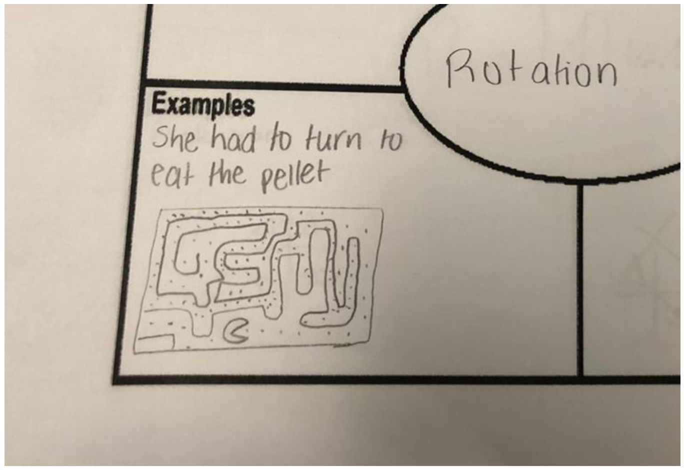

Figure 1. Student using Ms. Pac Man to depict an example of a rotation.

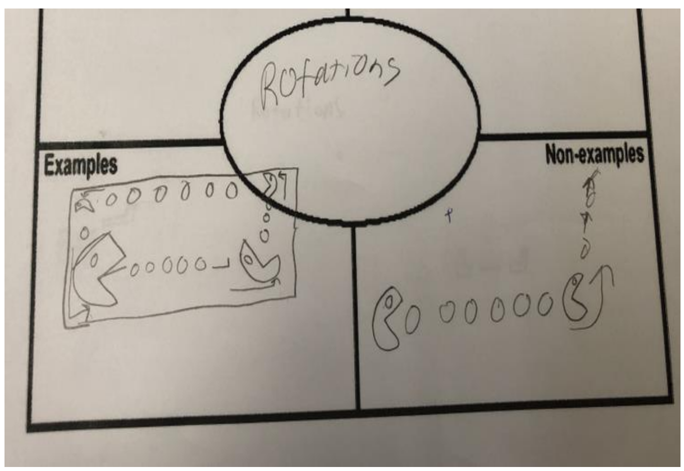

Figure 2. Student using Ms. Pac Man for both an example, and a non-example, with rotations.

The students worked through the transformation's unit, completing all 7 of the given key terms in the unit. Students were asked open-ended questions through class time to extend their knowledge and understanding of transformations. Some examples of questions I presented to students included: "What connections can you make to help you understand this term?" and "How could you represent your thinking in more than one way?" The intent of asking these questions were to support student understanding in the classroom while creating relationships amongst the content. Student reaction and responses to these questions were carefully noted in how they completed their Frayer Model. All the Frayer Models for each student were collected. I analyzed and provided feedback to students to reflect and use with their learning. The feedback given was specific to each student, where I focused on the mathematical content and accuracy of their statements, not on how they chose to represent their learning, as the intention of the Frayer Model was to give students the opportunity to express themselves in their own way while learning the academic language of the unit. Two student responses in this research study with feedback provided are shown below (see Figures 3 and 4), with each representing a different student approach to completing the Frayer Model for the term dilation.

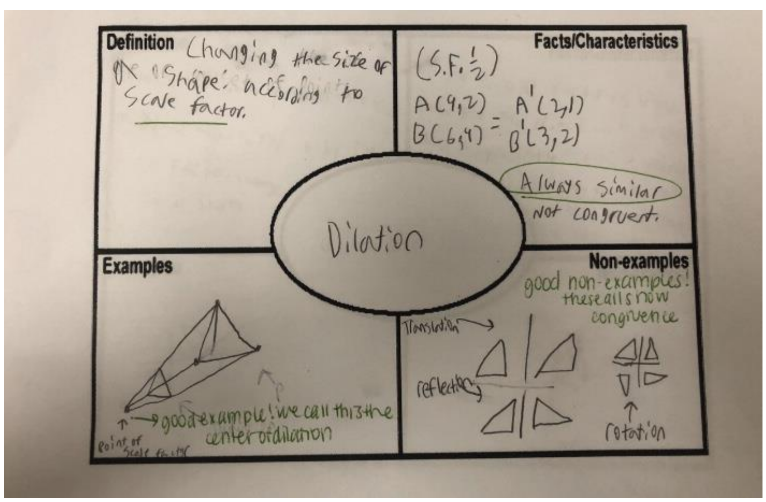

Figure 3. Student example of their Frayer Model for ‘dilation’ with given feedback provided.

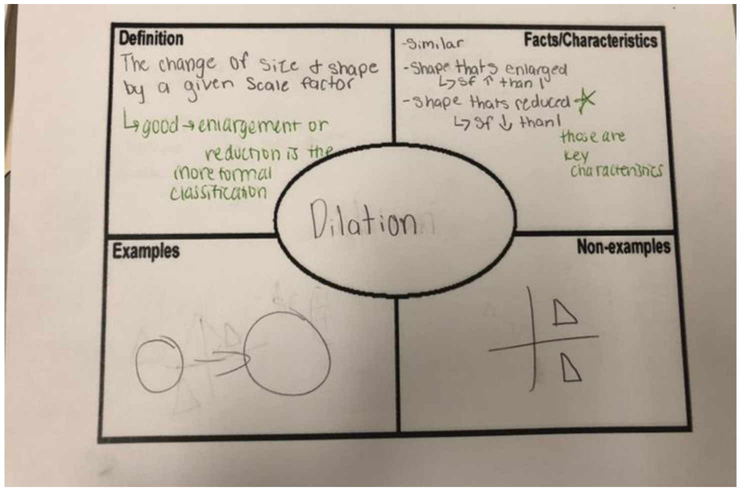

Figure 4. Student example of a Frayer Model for ‘dilation’ completed using a different approach with given feedback provided to the student.

At the conclusion of the research study, student participants were asked to take part in a post-survey (Appendix C) to assess the impact the content literacy had on student attitudes toward mathematics. Students ranked several statements on a Likert scale from 1 – 5, with 1 being ‘Strongly Disagree,’ 3 representing ‘No Strong Opinion,’ and 5 being ‘Strongly Agree.’ The questions on the pre-survey (Appendix A) aligned with the questions on the post-survey, with six of the questions on the pre-survey being the same on the post-survey. The other two questions related directly to one another. For example, question 5 on the pre-survey stated, “I understand the mathematical language and vocabulary used in class,’ whereas question 5 on the post-survey stated, “I understood the mathematical language and vocabulary used in class better when there was a focus on using formal language.” The questions were posed purposefully to gain an overall picture of their experience in the classroom with academic language. Qualitative measures were also taken on the post-survey, where students answered six open-ended short response questions pertaining to their attitude and confidence with mathematics in relation to the use of the Frayer Models. The six questions focused on how students' attitudes and beliefs about academic language may have changed compared to the beginning of the unit, as well as their opinion on the use of the Frayer Model.

Data Analysis

I utilized both quantitative and qualitative data through the results from student participation. I quantitatively analyzed the survey results from students, where I compared values from the first survey to the second survey. I calculated the mean for both surveys and compared the change between the first and second survey, analyzing the difference between the two values. In addition, I qualitatively examined student responses to given questions and prompts regarding their use of academic language. Using the anonymous set-up of the survey with their initials and birth month, I compared student answer and responses with their pre-survey data to their post-survey information following the completion of the unit. In addition to the surveys, I made note of any significant remarks and occurrences in the classroom while working on various in-class assignments and tasks, as well as analyzing homework and assessments when given.

The chart shown below (see Figure 5) depicts the comparison of students' average ranked statements on the Likert scale. The pre-survey represents students' attitude and experience with academic language, where the post-survey measured how students felt about their confidence and attitude following a focus on academic language with the Frayer Model in the classroom. These values were compared, and the mean values of each of the eight questions are represented in Figure 5 shown below.

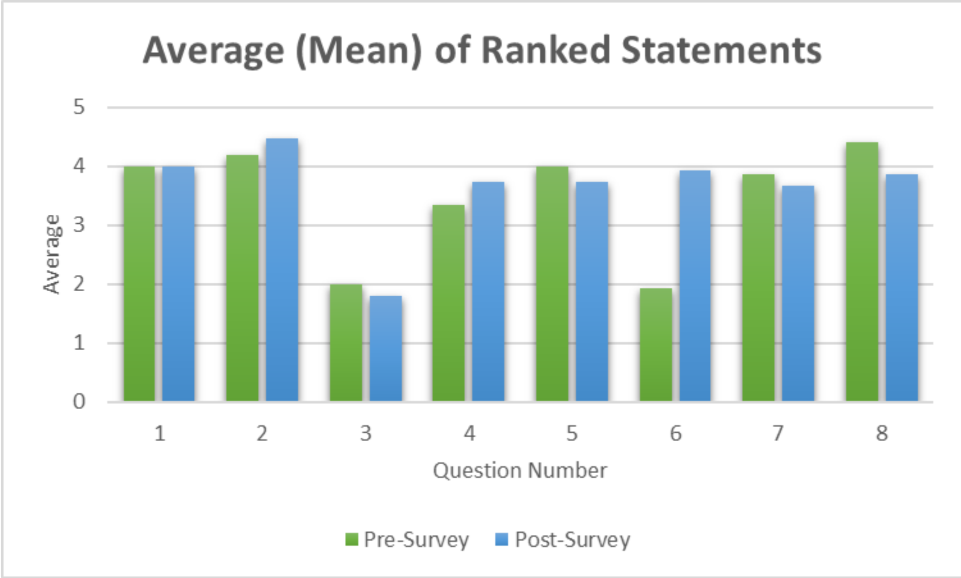

Figure 5. Student comparison of mean values from the pre-survey with the post-survey.

By quantitatively analyzing the given data, you can see in Figure 5 there are differences amongst the values in each survey. The difference between some of the questions were greater than others but provided an insight on the impact the Frayer Models caused for the students. When examining the average for each question, I looked at what each question was focusing on to provide a more in-depth analysis. Questions 1 – 4 focused on student attitude and confidence with their performance in mathematics, whereas questions 5 – 8 were prominently about academic language and the use of Frayer Models to support their learning. It is important to note that question 5 and 6 vary slightly on the pre- and post-survey but are related directly in how the given statement is presented.

It became clear that student confidence and attitude levels were affected before and after the incorporation of academic language supports, as shown in question 2, which asked students the following statement: “I am confident I can learn mathematics.” The difference in the average was approximately .267, showing that more students felt they were capable of learning mathematics after the transformation's unit. In addition, question 3 asked students the statement: "When I think about mathematics, I feel nervous, anxious, or sick." When comparing the average with the pre- and post-surveys, students recorded a 1.8 average on the post-survey, which is a decrease in the average of approximately .200 from the pre-survey to the post survey. The differences in the average for both questions 2 and 3 indicated a more positive feeling of confidence and ability levels in the mathematics classroom by the student participants in the classroom.

As mentioned, several academic language supports were used throughout the unit to supplement the use of the Frayer Models. Students used think-pair-share, notice and wonder, and other strategies through the tasks and problems presented in the classroom while learning about each of the transformations. With these strategies implemented, students were engaging in more mathematical reasoning and sense-making in combination with increased communication with peers, where they were able to use the academic language terms of the unit. For example, students were presented a real-life picture of swans in water depicting a reflection, where I asked them to write down what they noticed and wondered about the image. A student remarked, *"I am wondering what this has to do with math?"* Students were challenged with the task to reason mathematically and make connections in order think deeply about the two swans shown and draw appropriate conclusions. These types of situations were common in the classroom throughout the research, as they were being given the opportunities to think about mathematics in a different context than they previously had in the classroom. In accordance with this situation, question 4 on the pre- and post-survey asked students: "I enjoy solving problems and being challenged." When analyzing the data, there was an increase in the mean by approximately

.400 from the pre-survey to the post-survey. This question was one that presented one of the highest differences from the pre-survey to the post-survey, where the student participants demonstrated an increased sense of enjoyment and engagement in solving problems and being challenged in the classroom.

The last four questions on both the pre- and post-survey focused on the Frayer Model and academic language more prominently than the other questions. With the pre-survey, the student participants had an average of approximately 1.8 when being asked, “The symbols and terms used in mathematics confuse me.” Only one student of the 15 participants provided a ranking above a 3 for this given question, showing that most of the students felt comfortable with the language in the class. When looking at the post-survey, an average of approximately 3.933 was recorded for question 6, which asked students the following statement: “The symbols and terms used in mathematics are better understood when represented in an organizer, like a Frayer Model.” The average indicates that the Frayer Model was well-liked when being used to support the symbols and terms being used by a majority of the students in the classroom, but not all of them. When analyzing the data, it became apparent that the students who prefer to represent something visually, like a picture or a graph, were the ones that felt the Frayer Model helped when supporting their learning. The following chart below, see Figure 6, represents the following data trend from the post-survey with student preference in how they represent their information. Out of the 15 student participants, 10 of the students indicated a 4 or higher on the Likert scale for question 7, which asked the following statement: “I would rather represent something visually, like a picture or graph, than through words and numbers.” Of those 10 students, 9 of them ranked the statement asked on question 6 about the Frayer Model with a 4 or higher. This indicated these 9 students believed the terms and symbols were better understood in a Frayer

Model. Those that indicated a 3 or lower on their attitude about representing something visually, also indicated a 3 or lower about their use of the Frayer Model in terms of helping their understanding with academic language. The data presented showed that the Frayer Model was more appealing and useful to those that preferred using more visual models.

Question 6	Question 7
3	3
4	4
3	4
3	2
3	3
4	4
3	2
5	5
4	4
4	4
4	4
4	4
5	4
5	5
5	3

Figure 6. Comparison of students on the post-survey with using the Frayer Model to help understand the terms and symbols vs. student preference on visual representation.

In addition to the quantitative data, qualitative data was also analyzed in this research study through the open-ended short response questions students completed on both the pre-survey and the post-survey. The open-ended questions on the pre-survey asked students to describe their experience with using academic language in the mathematics classroom and how confident they felt when using and understanding the terms and symbols. Of the 15 students, only 2 students indicated that academic language was not heavily encouraged by teachers in the past. However, of the students that said yes, in their description of their experience, several revealed that academic language was not encouraged in many other ways in the classroom. The descriptions provided made clear that academic language may have been presented in the classroom but was not supplemented with additional supports or activities to give students the opportunity to conceptually understand the meaning and context behind the words. This directly correlated with how students felt in terms of their confidence level and their perception of mathematics, in general. Some of the student examples are provided below:

- *"I have not been encouraged much in other ways by teachers in the past."*
- *"There are sometimes when I feel dumb for not remembering the words. Other times there are things I don't understand."*
- *"I feel mostly confident in explaining my work with these symbols and language, but it can be confusing at times. If there was a focus on getting better at understanding the terms used, then I feel like I would be better with math in general."*
- *"I feel like I would do better if there was a focus on language because math vocabulary can be confusing."*
- *"No there is not really a focus. There is more of a focus on learning the material to get the right answer."*
- *"No, because I still need to understand how to do the actual problem. The symbols matter but not as much as solving the problem does."*

The example student responses show that the environment of their past mathematics classroom did not support an in-depth experience with using proper academic language with other strategies. Students held the belief that solving the problem and getting the answer right was the most important aspect of their learning in mathematics, rather than conceptually understanding the meaning of the problem presented. With a focus on academic language in the classroom by incorporating more opportunities to think and reason mathematically, students' attitude and confidence could be positively affected, as well.

Students were asked eight open-ended short response questions on the post-survey where students reflected on their experience from the beginning of the unit to the end of the study. The questions ranged from how their perception of academic language changed, to how they felt in terms of confidence with mathematics and their attitude, as well as questions about the use of the Frayer Models. By analyzing the data of their responses, 12 of the 15 student participants indicated they felt more confident and held a better attitude of their abilities and math in general when there was a focus on academic language in the classroom. From the data analysis, it is evident that several students adopted a more positive outlook on mathematics, moving away from the mindset that you need to get the answer correct to be successful. The remaining three student participants indicated their confidence levels and attitude did not change much because they felt they understood the mathematics and terms throughout the unit to the point where they did not need to do a Frayer Model. When analyzing the three students who indicated a minimal change in attitude, these students were ones that indicated on the Likert scale they did not prefer to represent something visually in mathematics. Several student responses pertaining to their confidence level and attitude with academic language are provided below:

- *"I understand how to represent a math problem by using formal and informal language."*

- *"Yes, I do feel more confident in my abilities because I have been using the appropriate words, labels, and symbols. I have been getting better and more comfortable at using the academic language."*
- *"Using the academic language is important because some words could mean different meanings, so with appropriate language, people will understand what you are talking about."*
- *"I do feel more confident, but I have to get the hang of it more and be able to talk that way more."*
- *"At first, I didn't know how to do it and didn't think language was important. Now I can see how important those things are and I see how much I should know them."*
- *"[Academic] language helps me understand/helps us understand how to do the math work and it makes it easier to remember.*
- *"It helped me understand everything a little better. Without academic language, I would not have understood everything completely."*
- *"[Academic language] is important because we need to understand how to translate words to numbers or numbers to words."*
- *"You can express your thinking with academic language and symbols."*

As you can see from these student responses, just from a two-week unit with a focus on academic language, students had shifted in their mindset. This positively affected their attitude and confidence levels. In the pre-survey, many students did not see academic language in this way, let alone viewing mathematics as a process. The last student response highlighted that academic language can be used to express your thinking, which is the same student that indicated the following statement in the pre-survey: "*There is more of a focus on learning the material to* *get the right answer."* This instance is just one example of how this student saw the mathematics being used in the classroom, where the student adopted thinking mathematically and sense-making, rather than just getting the right answer. The focus of the classroom environment created in the research study was not on just solving exercises but using the academic language to help them foster a better attitude for mathematics. Students have not had much experience with using academic language, as can be observed through their comments about becoming more comfortable using the correct language and understanding why. With more exposure to academic language supports, students will build fluency and be more precise in their conversations when interacting with peers.

Along with responding to questions with their attitude and confidence in mathematics with academic language as a whole, students also answered questions pertaining directly to the Frayer Models that were used. The last two questions asked students about how they liked the Frayer Models and how they affected performance in the classroom while studying transformations. When analyzing the data, nine of the student participants indicated positive remarks and statements about the use of the Frayer Model in terms of the incorporation in the classroom and how the graphic organizers helped them. In comparison to the quantitative measures taken, the same nine students were also the ones that indicated a 4 or higher on the Likert scale on the post-survey about the Frayer Model supporting their learning of the vocabulary, which was presented in Figure 5. The students provided insight on their thoughts and experiences, where some of the significant comments are provided below:

- *"I liked them because if I didn't understand and needed an example there was one on the paper, and if I needed the definition, I could look at that."*
- *"Yes and no. They were boring, but they were also helpful at the same time."*

- *"I liked them because after learning about the specific topic I can write it down so I can reflect on my learning."*
- *"Not a big fan of the definition box, but they were helpful. They were helpful at the end of the lessons and you write down what we learned."*
- *"Not really. I paid attention in class enough that I could use and understand the vocabulary without the Frayer Model.*
- *"They helped out a lot. It helped me understand with more clarity."*
- *"I liked using the Frayer Models because it helped me visualize what was going on and to understand it."*
- *"I like the Frayer Model because it illustrates my thoughts in an organized way so I can understand the material a lot better."*

When looking at these particular statements provided by students, majority of the comments were positive on how they liked the incorporation of the Frayer Model, thus positively affecting their attitude. Students commented how the graphic organizer gave them the opportunity to reflect on their learning and visualize what was taught in the lesson. One student commented how the Frayer Model was boring, with others not favoring the definition box; but they still commented how it served some benefit to them in their learning. Despite not all students favoring the use of this particular graphic organizer, all of the student participants were able to correctly identity the four types of transformations on the final unit test when given a general definition. This shows that the given instruction and supplemental strategies in the classroom did positively affect student learning, with students scoring an average of an 83% on the final test.

Conclusion

By conducting the action research study, I was presented with data that providedinformation about student attitude and confidence levels in terms of incorporating a focus of academic language with Frayer Models. The data gathered and observed aligned directly with the literature that was reviewed. Students provided both quantitative and qualitative measures that I was able to analyze to help to draw appropriate and in-depth conclusions. With the student participants in the study, the students as a whole enjoyed having a focus on academic language in the classroom, thus liking the use of the Frayer Model in the classroom. As a result, students' attitudes and confidence levels correlated with the preferred additional supports of academic language. Even though all students did not prefer the method of the graphic organizer, students did comment on how the environment and structure of the classroom did help them learn. If the student was not a visual learner or did not favor the use of the Frayer Model, the data provided by the students indicated they did prefer a focus on academic language in the classroom, as it helped them learn the material.

The students discovered that mathematics was not just about getting the right answer or solving a given exercise; rather they found that learning mathematics was more of a process. Students indicated the Frayer Model gave them the opportunity to be reflective in their learning and express their thinking in more than one way. I was surprised to discover in my data that there was such a significant increase in student confidence and enjoyment of solving problems. The average increased in the post-survey by quite a bit. The environment of the classroom was supportive to students in their ability to talk and converse their ideas with peers and think and reason mathematically, as the activities used were supplementing the use of the Frayer Model. These academic language support showed students that mathematics can be so much more, and that academic language holds such a powerful role in the classroom. The Frayer Model may have affected some of the student participants, but the focus on academic language in general did show an impact for student learning and development in mathematics.

There were limitations present in this action research study that affected the data, where I am not able to generalize this for all eighth-grade pre-algebra classes. I only conducted the research with one class, where I had a small number of student participants. With a greater sample, the outcome of the research may have been altered due to more opinions, responses, and experiences that would be considered. The students in the classroom have not been accustomed to the classroom environment where academic language was a focus in many ways, especially in ways that gave them the opportunity to make connections and reason mathematically with themselves, and with their peers. In addition, this was the first-time students were introduced to Frayer Models in the mathematics classroom. I only used the Frayer Models and academic language supports for one unit spanning two-weeks in time. To make further conclusions about the data provided, I would need to use the Frayer Models throughout several other units spanning across more time in the classroom.

Despite the limitations the research did provide, I was able to gain several ideas provided by the students that I can use as I go forth in my career as an educator. Students indicated that the Frayer Models helped them in visualizing and reflecting with the mathematics they were learning, which showed me that the students were seeing mathematics in a different light. These were being used to support them in their development as they became more acquainted with using academic language. In the responses, students indicated the more they focus on being formal in their language and become more comfortable in the environment, they would be able to use the given terms and symbols more fluently. Using this information, I intend to carry these ideas into the classroom, giving students more opportunities to use academic language and supplement their learning with the Frayer Models.

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Appendix A

Student Pre-Survey

Attitudes Toward Mathematics Pre-Survey:

First letter of your first name: ______
Middle Initial: ______
Last letter of your last name: ______
Month you were born in (1-12): ______

Please respond to the following statements honestly. The following statements will be ranked from 1 to 5, with 1 being 'Strongly Disagree' and 5 being 'Strongly Agree.' Place an 'X' in the box that best represents you.

Statement:	Strongly Disagree **1**	Disagree **2**	No strong opinion **3**	Agree **4**	Strongly Agree **5**
EXAMPLE: I love ice-cream					**X**
1. I love mathematics					
2. I am confident I can learn mathematics					
3. When I think about mathematics, I feel nervous, anxious, or sick					
4. I enjoy solving problems and being challenged					
5. I understand the mathematical language and vocabulary used in class					
6. The symbols and terms used in mathematics confuse me					
7. I would rather represent something visually, like a					

picture or graph, than through words and numbers					
8. I am comfortable justifying my reasoning and showing my work					

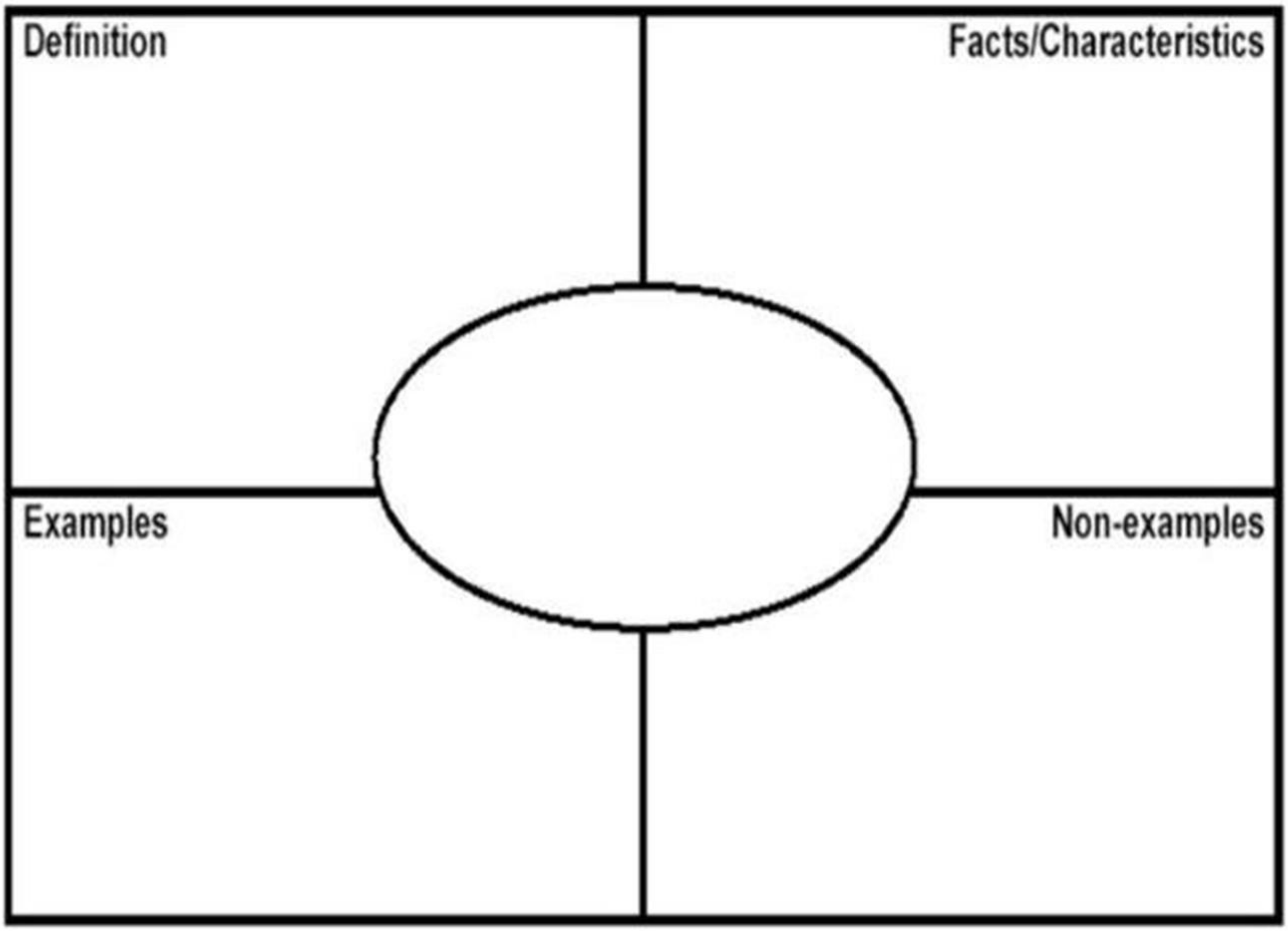
Please answer the following questions to the best of your ability. The more you write and describe your thoughts, the more beneficial your response will be for me.

Describe your experience with using academic language in the mathematics classroom. Academic language refers to the appropriate terms and vocabulary used in the classroom for certain topics. Has using proper language, through verbal and written aspects, been encouraged by your teachers in the past?

Do you feel confident that you are using the appropriate words, labels, and symbols when justifying or explaining your work? If yes, and there was a focus on academic language in the classroom, would you have a better attitude about your abilities and math as a subject?

Appendix B

Selected Frayer Model



Appendix C

Student Post-Survey

Attitudes Toward Mathematics Post-Survey:

First letter of your first name: _____
Middle Initial: _____
Last letter of your last name: _____
Month you were born in (1-12): _____

Please respond to the following statements honestly. The following statements will be ranked from 1 to 5, with 1 being 'Strongly Disagree' and 5 being 'Strongly Agree.' Place an 'X' in the box that best represents you.

Statement:	Strongly Disagree **1**	Disagree **2**	No strong opinion **3**	Agree **4**	Strongly Agree **5**
EXAMPLE: I love ice-cream					**X**
1. I love mathematics					
2. I am confident I can learn mathematics					
3. When I think about mathematics, I feel nervous, anxious, or sick					
4. I enjoy solving problems and being challenged					
5. I understood the mathematical language and vocabulary used in class better when there was a focus on using formal language					
6. The symbols and terms used in mathematics are better understood when					

represented in an organizer, like a Frayer Model					
7. I would rather represent something visually, like a picture or graph, than through words and numbers					
8. I am comfortable justifying my reasoning and showing my work					

Please answer the following questions to the best of your ability. The more you write and describe your thoughts, the more beneficial your response will be for me.

While learning about transformations, there were several vocabulary terms we were using when learning about each of the different transformations. There was a strong focus on formalizing your language and moving from informal ideas to more formal ideas. With your experience now, how has your perception of using academic language changed throughout the unit?

____

____

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____

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____

____

Why is using appropriate language and symbols important?

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____

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Do you feel confident in your abilities to use the appropriate words, labels, and symbols when justifying or explaining your work? Explain why or how you feel confident.

Do you feel you have a better attitude about your abilities and math as a subject now that formal academic language was a focus in the classroom?

We used several academic language supports in the classroom throughout the unit, such as Think-Pair-Share, Notice and Wonder, and What Does Not Belong to get you talking about mathematics language being used in the given lessons. At the conclusion of each lesson, we completed a Frayer Model for our key terms. How did you like the use of Frayer Models?

Do you feel like the Frayer Models helped your attitude and confidence about the unit in terms of understanding the words and symbols used?