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Making the Language of Secondary Math Classrooms More Comprehensible for English Learners

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MAKING THE LANGUAGE OF SECONDARY MATH CLASSROOMS MORE COMPREHENSIBLE FOR ENGLISH LEARNERS

by

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CHAPTER ONE

Introduction

Introduction

In this chapter, I will first explain how my personal teaching experiences have formed my opinions about ELs in content classes and why I believe it is important for teachers to be knowledgeable in how language is used in their specific content area. Next, I will provide an explanation of the content and rationale behind this project. Finally, this chapter will explore how this project fits into the larger picture of supporting EL language development in a mathematics classroom. By explaining my personal journey and experiences in teaching math paired with the current growth my district is experiencing, the reader will be able to understand the development of my research question; *How can secondary mathematics teachers make language features in the mathematical register more comprehensible for English learners within a mainstream mathematics content classroom?*

As a high school math teacher who teaches remedial, or bridging, content classes, I have often had many English learners (ELs) in class. I have felt the frustration of trying to work through a language barrier to teach content material and feeling helpless about how to make content accessible for ELs. After multiple explanations with visuals and charts with no progress, both teacher and student are frustrated and disheartened. I have also heard colleagues make comments like, “I just don’t know how else to explain it!”

Math teachers feel the pressure of teaching content standards and are skilled at breaking apart complex mathematical content so learners can understand it. Generally speaking, math teachers are not trained linguists and do not always recognize how to overcome language and communication barriers, especially with ELs. Part of the problem is that mathematics uses language in specific and nuanced ways that are particular to the world of mathematics (Halliday, 1978). Teachers are fluent and comfortable using this mathematical register and do not always recognize that students, especially ELs, are struggling to understand how the language is being used and how the language and mathematical concepts relate to one another (Schleppegrell, 2007). The purpose of this project will be to answer the question: *How can secondary mathematics teachers make language features in the mathematical register more comprehensible for English learners within a mainstream mathematics content classroom?*

In my experience, teachers are often willing to help ELs in their classroom but are unprepared and untrained in how to support and teach the language skills necessary for success in a high school mathematics content classroom. Often teachers have many years of experience and are following best practice measures for math content yet still feel like they are failing to help their ELs. The rural Minnesota schools I have worked in have also had unexpectedly rapid increases in their EL population. As a result, schools were not always prepared to train teachers on best practices for ELs in content classrooms. Teachers have largely learned how to help ELs by trial and error, some with more success than others.The school where I teach had a large influx of Spanish speaking students this past school year and the school is already trying to prepare teachers for an influx of students with low English proficiency in their classes next year. With teacher support, these students are capable of attaining academic success in mainstream content classes

(Adoniou, 2014). The goal of this capstone is to create supplemental materials to support EL language acquisition for an algebra 1 course. I will be using the 8th grade Minnesota state standards (MDE, 2007) to align with specific topics. My goal is to create supplemental materials that can be incorporated into any algebra course. The curriculum used at my high school is *Algebra I: Common Core* published by Pearson (Charles, R. I., Kennedy, D., Hall, B., Murphy, S. J., Wiggins, G., Bellman, A. E., Bragg, S. C., Handlin, W. G., 2015) along with teacher-created materials that are aligned with MN state standards.

My Immersion Experience

Upon graduation from a small Midwestern college with a BA in mathematics and a 5-12 teaching license, I immediately left the United States and spent my first year after college teaching 2nd grade at a private school in a small town in Guatemala. My Spanish was choppy at best and I was definitely learning the language while also trying to teach entirely in Spanish. My students did not speak English and I was completely ignorant of how a Guatemalan school system functioned. Nevertheless, I loved the challenge, the language, and the adventure of experiencing a new culture. Set up like a country schoolhouse, two local teachers and I taught grades K - 5 with limited textbooks, no technology, and no government mandated standards. All of our students were ineligible to attend the local public school because they were multiple grade levels behind their peers, or they had failed a grade more than once and were not allowed to repeat again. Social promotion, special education, and handicap accessibility are not norms of the

Guatemalan school system. Many of our students would have been receiving special education support had they been in the United States school system.

Throughout my time in Guatemala, my Spanish improved and my perspective on school and teaching was affected. It became apparent that material things were not the primary components necessary to facilitate student success. Rather, a knowledgeable teacher who could help students grow was paramount.

Teaching in the US

Upon returning back to the United States, I wanted to work in a school district with an EL population where I could continue working with students from around the world. After living in a foreign country and learning to speak the language, I felt a connection with ELs as they begin to navigate a new country and educational setting. In my years of teaching, I have worked in two rural Minnesota districts both of which have approximately 25% of the student body identified as ELs (MDE, 2020). I have been teaching pre-algebra and algebra classes, which are typically 8th grade standards in MN, as bridging classes to help these students prepare for more rigorous-level math classes. Because my classes are not specifically EL classes, I have always had a mix of students who need support in various ways, not just language. Many content teachers have experienced the same. In some cases, individual education plans (IEPs) give a teacher direction as to which specific supports a student needs, however, no such document exists for ELs. Through largely trial-and-error and short workshops, I learned some techniques to better help my ELs. After 7 years of teaching, I had come to a point professionally where I felt I was not meeting the needs of ELs as well as I could. I wanted a better understanding of how to help them, so I enrolled in a Master of Arts program in teaching ESL. I am now dual-licensed to teach both mathematics and ESL.

Language in Math

After finishing the coursework and teaching EL language courses, I can confidently say that my first love is teaching math. I do not particularly like breaking apart English or designing activities to help students become better readers and writers. I am more interested in mathematical concepts and finding ways to spark students' interest in math. However, I recognize that my knowledge in teaching language concepts has impacted how I view the language used in my math classroom. Like many math teachers, I was unaware of specific grammatical features in mathematics that are difficult for students, particularly ELs, to understand. Word problems in particular can be especially difficult for all students. Because the language of math made sense to me, I did not spend much time breaking it down or focusing on it within the classroom. With my dual knowledge of both mathematical concepts and teaching ESL, I have realized that language is used in very specific and unique ways within a mathematics classroom (Brenner, 1998; Chan, 2015; Simpson & Cole, 2015; Schleppegrell, 2007). Secondly, I have learned that much of the difficulty for ELs in accessing math content is because of the language used to present that content. More than just creating activities focused on mathematical concepts, the language of math also needs to be taught in a math classroom if ELs are going to be successful.

As Schleppegrell (2007) states, part of the teacher's job is to guide students from informal, everyday ways of thinking and speaking, into more academic and formal ways of thinking and speaking. Many math teachers are not fully equipped to help students navigate the language used in mathematics. They do not see the difficulties of mathematical language because they themselves are fluent in it (Adoniou, 2014). In this way, the language of math and other content areas becomes invisible to the teacher while causing a barrier for students. Teachers need to be made aware of the barrier and be provided with effective tools and knowledge to help break it down in their classrooms. My goal is to provide one such tool teachers can use and adapt to fit their own unique classroom. Additionally, this could act as a template for ideas that teachers can modify and expand into other topics and classes.

Capstone Context and Rationale

In 2019, approximately 7% of Minnesota's total population was born in foreign countries (Minnesota Legislature, 2020) and Minnesota has the highest per capita of refugee arrivals in the United States (Lutheran Social Service, 2020). Also in 2019, Minnesota had the largest Somali population in the US and the second largest Hmong population (Minnesota Legislature, 2020). Statewide, 8.5% of all students are identified as English Learners (ELs) (MDE, 2020). ELs in Minnesota are assessed on a scale of 1-5 using the WIDA ACCESS testing. The ACCESS test is an English proficiency test all ELs take in Minnesota. Level 1 is the lowest level of proficiency, many level 1 students speak no English. Students who test at a level 5 are considered English proficient at their grade level and they are exited from EL services (WIDA, 2020). I teach math in a rural Minnesota high school where 22% of the student body is identified as EL (MDE, 2020). For the past 5-7 years this district's greatest incoming EL population has been refugee

Somali Students with Limited or Interrupted Formal Education (SLIFE). To service the EL students, the high school created a variety of classes to teach much of the necessary content from grades K-8. The school also created remedial level courses taught by mainstream teachers to prepare ELs for the demands of mainstream content courses. A majority of students have been successful with this set-up and have greatly benefitted by having classes that build their background knowledge so they can thrive in a mainstream setting. Currently, there are no new incoming SLIFE in this demographic. Instead, our current incoming EL students are from Latin American countries and most have a solid educational background. The sheltered content classes in place are inappropriate for these learners as they already have background knowledge in many subjects. However, they do need extensive language support in order to function in a mainstream class. Language support does not change the rigor of the academic content, it simply makes the language more accessible to ELs. One example of a language support would be providing sentence starters for a writing activity, students can then use their content knowledge to write their sentences. Because of this shift, our high school will be pushing many more level 1 and 2 students into mainstream courses next year. The difficulty now is supporting teachers who will have more low English proficient students in mainstream content courses than they have had in the past. My capstone project will be designed for an algebra classroom, which is the first math class most of these new EL students will take in our building. I aim to create materials that will provide teachers with a means to help support the language development of these low-level EL students. Ideally, after using prepared supports, teachers will feel confident designing their own versions for other topics and will feel better-equipped to incorporate the language of mathematics into their classroom.

Conclusion

This chapter explained my personal journey as a teacher and the rationale for my research question. My goal is to answer the question: *How can secondary mathematics teachers make language features in the mathematical register more comprehensible for English learners within a mainstream mathematics content classroom?*

In Chapter Two, I will review the literature about how language is used in the mathematical content and what teachers can do to help students access the content through the language. This chapter will lay-out specific grammatical features and vocabulary inconsistencies that are unique to the language of mathematics. Chapter Three will be an outline of my research project. It will explain what I will create and the timeline I will be working on. Finally, Chapter Four will contain my reflections about the finished project.

CHAPTER TWO

Literature Review

Introduction

The purpose of this capstone is to explore the unique ways that language is used within the mathematical register and to offer insight for math teachers to help ELs become more familiar with formal mathematical language. Researchers Schleppegrell, (2007), Simpson & Cole (2015), Slavit & Ernst-Slavit (2007) have acknowledged that students need to be taught how to move from their everyday, informal language to more formal, academic, mathematical language. Math teachers are comfortable interpreting mathematical language, however, the specific skills students need to be successful are often invisible to them. Essentially, many teachers are too good at academic language to recognize the areas of difficulty for their students (Adoniou, 2014; Townsend, Filippini, Collins, & Biancarosa, 2012). This project aims to help teachers identify specific aspects of mathematical language that cause confusion for ELs and provide strategies teachers can implement to help students interact more fully with the language and content of mathematics. My specific research question is: *How can secondary mathematics teachers make language features in the mathematical register more comprehensible for English learners within a mathematics content classroom?*

This chapter is divided into four main sections. The first section defines the mathematical register and explains grammatical features which are unique to this register. The uniqueness of these features make them difficult for all students, especially ELs, to comprehend and produce on their own. The second section outlines common difficulties ELs have when interacting with the mathematical register. This section focuses on language features that are not necessarily unique to the language of mathematics, but they are used more heavily than in other domains and frequently cause confusion for ELs. The third section looks at how teachers can use their own language to assist ELs within the classroom. The final section argues the benefit of providing language opportunities within a classroom and gives some ideas for how to create authentic and effective language opportunities specifically for ELs.

The Mathematical Register

A common difficulty in many mainstream math classrooms is students' unfamiliarity with how formal language is used in mathematic communication. In 1978, linguist Michael Halliday used the phrase "mathematical register" and defined this register as "the meanings that belong to the language of mathematics…and that a language must express if it is used for mathematical purposes" (p. 195). Since Halliday, other researchers including Brenner (1998), Chan (2015), Simpson & Cole (2015), and Schleppegrell (2007) have looked into specific linguistic features used in the mathematical register and how these features cause difficulty in classrooms, especially for non-native English speaking students. Schleppegrell (2007) says that in all subject areas students must learn to change from informal, everyday language into the "technical and academic ways that are necessary for disciplinary learning in all subjects" (p. 140). In the mathematical register there are some common linguistic features that most students are not familiar with. Three main features are: technical vocabulary (Brenner, 1998), multiple semiotic systems, and complex grammatical patterns (Schleppegrell, 2007).

Technical vocabulary. While vocabulary is one of the most obvious areas of potential linguistic difficulties in any academic discipline, mathematics has two different types of distinct vocabulary. Technical vocabulary is made up of words that are unique to the study of mathematics (Chan, 2015). Learners cannot use their everyday life experiences to access meaning for these words and need to be explicitly taught how to use them. A few examples of technical vocabulary words include: equilateral, equiangular, polynomial, and isosceles. These words are not used in everyday language and students will most likely only encounter them in a mathematics classroom. The second type of vocabulary is specialized usage of everyday vocabulary (Brenner, 1998; Chan, 2014; Halliday, 1978; Schleppegrell, 2007). Many words that students are already familiar with in their everyday language have a new, different, and highly technical meaning when used in mathematics. For example, the word *positive* is used in everyday language to mean something is morally good or uplifting whereas its opposite *negative* describes something that is bad or false. In mathematics the words *positive* and *negative* are still used as opposites of each other, but there is no notion of morality attached. Instead, *positive* refers to the numbers on the number line that are located to the right of zero and *negative* refers to the numbers located to the left of zero. Students often combine their everyday definition and the technical definition and will say that negative numbers are bad. Questions like, "is it ok if my answer is negative?" show an unease and discomfort with the 'bad' numbers (Brenner, 1998; Chan, 2014; Halliday, 1978; Schleppegrell, 2007).

Multiple semiotic systems. A semiotic system is a system that creates meaning. Mathematics uses not only written and oral language but also algebraic symbols and visuals like graphs and charts (O'Halloran, 2000; Schleppegrell, 2007) It is common for a typical textbook problem to require students to translate between all three systems. For example, in a beginning level algebra course students learn about different properties of lines. One introductory task using lines requires students to read a written description about the properties of a line, use that information to write an equation using algebraic symbols, and finally construct a graph of the line on a coordinate grid. This single problem requires students to take information from one semiotic system and translate it into two other semiotic systems each of which have their own embedded rules (O'Halloran, 2000; Schleppegrell, 2007). Simpson and Cole (2015) describe learning these systems as "analogous to learning a foreign language and involves an understanding of vocabulary, syntax, word order, and abbreviations unique to mathematics" (p. 370). Students must learn to decipher when to use each system and be comfortable following the standardized rules required for each system. Rojano, Filloy, and Puig (2014) state that another difficulty with the multiple semiotic systems is that students must understand the interconnection between them. O'Halloran (2000) explains this interconnection:

> The mathematical symbolism contains a complete description of the pattern of the relationship between entities, the visual display connects our physiological perceptions to this reality, and the linguistic discourse function to provide contextual information for the situation described symbolically and visually. (p. 363).

When students read a word problem, they need to be able to translate it into an algebraic equation. The students must then solve the equation and relate the algebraic answer back into the context of the written word problem. For the students to accurately complete the single word problem they must understand how to translate the written English into algebraic symbols or equations, use the procedural rules within the algebraic system to solve the equation, and then translate the answer found in the algebraic system back into the written English system and explain what it means in that context. Even if the student understands the mathematical concept being targeted, there are multiple steps where the student must interact with and interpret different language systems in order to complete the problem.

Complex grammatical patterns. One grammatical pattern that can cause difficulty for students is nominalization (Chan, 2015; Schleppegrell, 2007). Nominalization is when a process, usually expressed by a verb, is expressed as a noun. Even the most basic mathematical operations are treated this way: the process of *addition* is expressed as the noun *sum*, and *subtraction* as *difference* (Schleppegrell, 2007). To demonstrate nominalization Schleppegrell uses the following: "the sum of the squares of two consecutive positive even integers" (p. 146).

In this example the noun *sum* refers to the process of adding while the noun *squares* refers to the process of squaring a number, or multiplying a number by itself. In order to make sense of these dense phrases, students must recognize the relationship between the nouns and the mathematical reasoning processes (Schleppegrell, 2007). Nominalization can also contribute to confusion between word families (Chan 2015). Learners are often not familiar with word families and tend to view each word as an individual vocabulary word rather than recognizing them as grammatical variations of the same concept. These relationships are often not explicitly taught which can contribute to students' misconceptions and confusion. For example, the words *factor*, *factorize*, and *factorization*, mean essentially the same concept but express that concept as different parts of speech. For example, *factor the expression*, and *find the prime factorization of the expression* essentially mean the same thing. In the first phrase the word *factor* is functioning as a verb and tells what process needs to be carried out. In the second phrase *prime factorization* is a noun referring to what the answer needs to be. Students need to know that to find the *prime factorization* you must use the process of *factoring* (Chan, 2015).

Chan (2015) also identifies difficulties for students at the discourse level. The following example from the textbook used in my school's algebra 1 class shows this difficulty,

> A recipe for 12 corn muffins calls for 1 cup of flour. The number of muffins you can make varies directly with the amount of flour you use. You have 2 ½ cups of flour. How many muffins can you make? (Charles, R.I. et al, 2015, p. 304)

This single problem contains four sentences. The first sentence presents the topic and gives a point of reference between the two variables, *muffins* and *flour*. The second sentence gives the mathematical relationship of *varies directly* which dictates the formula students will need to use. The third sentence gives a specific scenario; finally, the last sentence asks for a specific calculation. As Chan says: "any failure in linking up the above pieces of information may make the calculation inaccurate or even impossible on the part of the learners" (2015, P. 310). Additionally, rather than explicitly explaining what steps to follow, the steps are implied and students must make sense of the logic flow in order to solve it (Chan, 2015).

In summary, the mathematical register has three main grammatical features: technical vocabulary, multiple semiotic systems, and complex grammatical patterns (Brenner, 1998; Schleppegrell, 2007). These features are unique to the mathematical register and students generally encounter them only in the mathematics classroom. These features need to be explicitly taught to all students to help them move from their everyday language into formal, mathematical language (Schleppegrell, 2007). The next section looks at some language features that, although not unique to the mathematical register, they are commonly used and frequently cause difficulties specifically for ELs.

Difficulties for ELs within the Mathematical Register

The three features discussed above, technical vocabulary, multiple semiotic systems, and complex grammatical patterns, make comprehension of mathematical texts difficult for all students (Brenner, 1998; Schleppegrell, 2007). These features focus on the construction of language within mathematics, but they do not describe how mathematical language needs to be interpreted. Beyond using specialized language features, Andiou (2014) describes how the mathematics register also needs to be read and interpreted differently from other disciplines. In the mathematical register there is almost no redundancy, meaning every word can be crucially important to understanding the meaning of a text (Andiou, 2014). Often, mathematical sentences are not meant to be interpreted chronologically. Instead, information provided at the end of a sentence must be calculated or interpreted first in order to make sense of the previous information. Barwell (2014) also notes the difficulty students have in reconciling formal mathematical talk with their daily informal discourse. Speaking informally with peers requires a different skill set than writing in the mathematic register. Students may struggle to switch between social requirements and formal academic language in a classroom setting (p. 914).

Interpreting texts. Word problems are key for developing meaning and connecting mathematics to real-life contexts. They are practiced around the world and have proven to be notoriously difficult for students (Rosales et al., 2012) They are especially problematic for ELs as they make the mathematical content even more difficult for ELs to access (Moschkovich, 1999; Slavit & Ernst-Slavit, 2007). One difficulty for ELs is that they are often unfamiliar with the context these word problems are set in (Chan, 2015; Rosales, Vincente, Chamoso, Munez, & Orrantia, 2012). Identifying positive and negative numbers is a fairly straightforward mathematical concept, but when asked if a ‘floating balloon’ is a positive or negative situation, the problem is impossible if the student does not know the word *balloon* or *floating*. Even if students understand the context the specificity of word phrases can also cause difficulties (Rosales et al., 2012). Mathematically *more than* means the operation of addition while *is more than* means the symbol >. This very nuanced difference is easily misinterpreted by ELs. Students may feel confident that they know what something means and then be confused when the meaning is apparently different and they do not understand why. Depending on a student's native language, it is also possible that the mathematical register does not translate into their home language. Not all languages have developed in the same way and some languages have not developed a mathematical register that is as precise as English (Schleppegrell, 2007). This can make it difficult for students to talk about mathematical concepts in their native language when there is no parallel vocabulary for them to use (Slavit & Ernst-Slavit, 2007). As a result, students may use code-switching and substitute in the English vocabulary word needed for the mathematical topic.

Another skill that is difficult for ELs is learning to interpret word problems non-chronologically (Schleppegrell, 2007). Information that must be processed first is often at the end of the problem while the beginning often gives background information that will not be needed until later in calculations (Adoniou, 2014). The previous discussion about embedded clauses gives specific examples of how this interpretation must be done out of order of how it appears in the text. Reference words are often used in these types of problems which further compound the problem and make it much more difficult for students to correctly interpret the relationships described (Chan, 2015).

No Redundancy. Due to the previously explained grammatical features used in mathematical texts, they are very dense and do not have context clues students can use to figure out the meaning of words they do not know (Schleppegrell, 2007; Quinnell 2011). A common tactic when reading in other content areas is to read the sentences surrounding an unknown word and use context clues to figure out the meaning, but this is not usually possible in mathematics (Chan, 2014). Because of nominalization and dense noun phrases, there is generally very little extra context given to help students figure out meaning based on the text given (Quinnell, 2011). Texts, such as word problems, are short and succinct with every word giving meaning to the mathematical interpretation. This lack of extra context can be baffling for students. Technical vocabulary words are often the key to understanding or interpreting a text so students who do not fully understand some words will be incapable of accurately decoding the meaning. Students need to be explicitly taught how to decode the meaning of a text (Adoniou, 2014). Without explicit instruction students will try using skills from other domains and then become frustrated when those tactics do not work.

Teacher Language Use

Schleppegrell (2007) states that one of the key goals of a mathematics teacher should be to help students move from using the informal register to a more formal mathematical language (p. 140). Informal language is the words and phrases students use when talking with peers (Schleppegrell, 2007). If students are asked to discuss topics with their classmates they will naturally use the informal language they commonly use with each other. Ideally, they will learn to use more formal mathematical language in these situations and begin using mathematical vocabulary and phrases as they communicate with their peers. Supporting students' oral language skills and providing opportunities within the classroom for students to practice are crucial to helping them learn and transition to using the more formal language. Research has shown that students can acquire social language in about two years, but that it takes around seven years for students to acquire academic language (Slavit & Ernst-Slavit, 2007). It is natural that students will need extra time and exposure to learn to use mathematical language. Since the mathematics classroom is the only time students will be exposed to formal mathematical language, it is especially important that teachers provide adequate exposure and guidance to help students become familiar within the language of mathematics (Chan, 2015; Rosa, 2019; Moschkovich, 1999; Schleppegrell, 2007). Also, many students will not have developed a formal mathematical register in their native language giving them less background knowledge to pull from, from a language perspective. They will need to be exposed to the formal language in multiple formats: reading, writing, speaking and listening (Moschkovich, 1999).

Mathematics teachers need to first be aware that elements of the mathematical register have become invisible to them. Teachers are so familiar with the mathematical register that they don't spend time teaching specific language features within their classes (Adoniou, 2014). Many students, not only ELs, struggle with the language requirements in mathematics classrooms. Rosa (2019) says teachers need to be aware of how they personally use language in the classroom and then incorporate language learning into their curriculum in conjunction with mathematic content. Hughes, Powell, and Stevens (2016) discuss the importance of teachers using precise mathematical language in the classroom. When teachers are precise in their language they actually make the content more comprehensible and understandable for students. In an effort to make the language more understandable to students it is tempting to use less accurate language that the students are more familiar with. This tactic, while well intentioned, can actually lead to mathematical misconceptions with later concepts (Gough, 2007; Hughes et al., 2016).

Teachers need to not be afraid to spend time explicitly teaching the language of mathematics in order to enable their students to .

Accuracy and precision. In a well-intentioned effort to help students understand difficult concepts, teachers often use less precise language that the students are more familiar with (Hughes et al., 2016). While this tactic can be beneficial in a specific situation, it can cause confusion later in a student's mathematical experience. Hughes et al. (2016) gives an extensive list of ways teachers can inadvertently cause confusion through language, one of which references imprecise language in elementary school and children's books that causes misconceptions of counting. Using sentences like '1 is the first number' gives the impression that there are no numbers before 1. In reality the whole set of negative numbers are before one. Instead, it would be more accurate to say 'let's start counting with 1' which gives the impression that we are choosing to start with 1, but we could start with a different number if we wanted to. It does not imply that 1 is first and should always be first (Hughes et al., 2016). Fractions are another mathematical topic where imprecise language leads to student misconceptions (Gough, 2007). Referencing 'the top number' and 'the bottom number' makes the fraction sound like two separate values when in actuality it is a single number expressed with two digits. Replacing the locational language with the actual terms 'numerator' and 'denominator' can help students better understand that the fraction is a single entity and not two separate numbers. These two examples are a brief glimpse of how teachers' use of informal language actually makes mathematical concepts more difficult for students to fully understand.

Explicitly teaching language. As Adoniou (2014) points out, teachers can become blinded to the language of the mathematical register because they are so familiar with it. It is important to explicitly teach not only vocabulary, but also language interpretation skills for mathematical texts. Students need to be taught how to interpret a word problem. As previously discussed, it is not possible to read from start to finish and execute the problem chronologically (Schleppegrell, 2007). Teachers need to teach students how to identify what the problem is asking for, how to identify relevant information, and how to interpret reference words within problems. Visual aids like graphic organizers, pictures, sentence frames, bulletin boards, graphs and diagrams can help students, especially ELs, interpret information correctly (Rosa, 2019; Quinnell, 2011; Slavit & Ernst-Slavit, 2007). If students attempt to interpret a mathematical text the same way they read a novel they are going to be confused and discouraged. Students also need to be taught how to interpret between the multiple semiotic systems of math (O'Halloran, 2000; Quinnell, 2011). Simply understanding the meaning of a text written in English is not sufficient, students must then translate that meaning into mathematical symbols and sometimes graphs or charts. They must also have an understanding of the rules and expectations used within these alternate forms of expressing meaning. Of the three semiotic systems, teachers already spend time teaching the 'rules' of using algebraic symbols and creating graphs and charts. The specifics of language use should not be excluded from this teaching (O'Halloran, 2000; Rosa, 2019; Quinnell, 2011; Slavit & Ernst-Slavit, 2007; Schleppegrell, 2007).

Modeling versus eliciting. Although explicitly teaching vocabulary and grammatical structures is important, Moschkovich (1999) argues that this is not sufficient for ELs to adequately learn the formal language of mathematics. Teachers also need to get ELs involved in discussion and give them plenty of opportunities to interact and practice using the formal language. Moschkovich (1999), Schleppegrell (2007) and Slavit and Ernst-Slavit (2007) all state that teachers need to allow students to make mistakes and not only focus on the technical aspects of the language. Helping students to express their thinking and reasoning is just as important. While students are still acquiring the formal language, they need to practice it and to do so they will make mistakes. Rather than critiquing or correcting their language, teachers can restate their expressions in more formal language but then have the student continue to explain their thought process. Encouraging students to explain their thinking to each other can be another way teachers facilitate student use of language. As Moschkovich (1999) states, “by focusing on mathematical discourse, teachers can move beyond focusing on errors in English vocabulary or grammar to hear and support the mathematical content of what students are saying” (p. 12). Many researchers have focused on grammatical features of the mathematical register and the importance of teaching students how those features work. However, Moschkovich (1999) and Slavit and Ernst-Slavit (2007) emphasize that giving students the freedom to make mistakes and having a conversation that clarifies and affirms their thinking and language is a necessary part of accomplishing Schleppegrell’s (2007) goal of moving students from informal to formal language. Teachers can model the precise language and recast student statements to clarify meaning and model the formal language. This must also be paired with eliciting responses from students about their thinking process. Simpson and Cole (2015) explain that eliciting must go beyond a simple ‘agree or disagree’ and elicit students' thoughts on the processes they are using. As Simpson and Cole (2015) observed, with consistent language modeling by the teacher and eliciting techniques that focused on students’ thinking while allowing them to make mistakes, students can make progress and learn to use the formal mathematical register in the classroom.

The previous section looked at what teachers can do to support their students’ language acquisition. These ideas focused on what the teacher can personally do to help students access the mathematical register. The next section will give more details about specific classroom practices that will provide students with opportunities to practice their own language skills.

Language Opportunities

Traditional mathematics classrooms generally rely heavily on explicit instruction of material with students showing comprehension by completing problem sets. This set-up provides little opportunity for students to produce language or engage with mathematical language. If students are to learn the language along with content they need to be given opportunities to both interpret and produce mathematical language (Schleppegrell, 2007). Simpson and Cole (2015) studied the success of student discussions in the mathematics classroom. They noted that as students practiced using precise mathematical language to explain their thinking they also had a better understanding of the mathematical content. These results are not possible if students are not given opportunities to practice using mathematics language in the classroom. Researchers have found a variety of ways that teachers can provide students with opportunities to engage in rich mathematic language which helps to deepen their understanding of the mathematics content (Adoniou, 2014; Rosa, 2019; Hughes et al., 2016). Others have pointed out the importance of giving students opportunities to make mistakes, use the informal language they have, and clarify their meaning to peers and teachers (Moschkovich, 1999; Slavit & Ernst-Slavit, 2007; Schleppegrell, 2007).

Discussions. Discussions are probably the most researched type of language interaction in the mathematical classroom. They give students an opportunity to both interpret and create language in a non-threatening environment. Discussions are also incredibly flexible because they can include large group, small group, partners, peer-to-peer and student-to-teacher varieties (Adoniou, 2014; Rosa, 2019; Simpson & Cole, 2015; Schleppegrell, 2007). However, Slavit and Ernst-Slavit (2007) and Adoniou (2014) point out that conversations and discussions in the math classroom can become a barrier for ELs. This is a valid point that needs to be considered. Moschkovich (1999) stresses that in discussions with ELs, it is more important to focus on the mathematical content the student is conveying rather than the vocabulary the student uses. By validating students' responses and encouraging students to share their conjectures and explanations, ELs will be able to participate in discussions using the language they already possess. These discussions will help students develop mathematical thinking skills which can lead to them using more precise and formal language as they become more familiar with the mathematical register. Rosales et al. (2012) also notes that when teachers emphasize mathematical reasoning skills and not only the mechanical aspects of math, students tend to comprehend mathematical concepts better (p. 1193).

Language supports. Personally I have heard math teachers make comments like, "I'm a math teacher, not a language teacher." I believe these statements are often coming from a feeling of inadequacy or confusion. Math teachers are used to breaking difficult math concepts apart into understandable steps for students. They are capable of doing the same for the language requirements of math, but many are uncertain how to go about doing so. Halladay and Neumann (2012) propose some strategies used in reading classrooms that can also be beneficial in learning the language of math. Their first suggestion is to have students make predictions about problems before solving. These predictions make students analyze the mathematical content and then share their thoughts with others. Asking students to compare and contrast current problems with past problems can help them think critically about their current problem and recall knowledge they have learned previously (Halladay & Neumann, 2012). A third strategy is to have students discuss why different strategies for solving a problem were helpful. This enables students to hear other people's thought processes and can help them make choices about strategies to use in the future (Halladay & Neumann, 2012; Schleppegrell, 2007; Moschkovich, 1999). Researchers have also found that using visuals such as graphic organizers, mind maps, drawing pictures, and graphs and charts help students organize their thoughts and interpret mathematical texts (Rosa, 2019; Quinnell, 2011; Slavit & Ernst-Slavit, 2007). These supports can also be a valuable insight for teachers to identify misconceptions or misunderstandings in a student's thinking. They also provide students with another opportunity for writing in the mathematical register. Sentence starters and sentence frames can be helpful for ELs during discussions and written responses (Rosa, 2019). These supports do not water-down the mathematical content, they simply provide students with a language starting point so they can express their thinking. These supports can help students more fully express themselves and they are a good way to help students use the formal language being taught.

Conclusion

While mathematics teachers are experts in their field of mathematics, the majority are native English speakers who have not struggled to learn mathematical concepts. Many are experienced teachers who are well equipped to teach mathematical content. However, with the rising population of ELs in mainstream classrooms, these experienced teachers are faced with a new challenge, how to teach the language of mathematics simultaneously with the content required by state standards. My goal is to offer practical strategies and ideas that teachers can implement into their already existing curriculum. Rather than changing what teachers already do, much of which is very effective, my goal is to provide secondary math content teachers with strategies and philosophies that will help them make mathematical language more accessible to their ELs.

To summarize, this chapter provided an overview of the mathematical register, how teachers can be cognizant of their own language use within the math classroom, and some strategies teachers can implement to help ELs more fully comprehend mathematical concepts. Since language is the tool students must use to learn mathematical concepts it is important that teachers are using language accurately and precisely while helping students move from their informal, daily language to the more formal mathematical register. Since teachers are so fluent in mathematical language, they may be unaware of what specifically is causing students to struggle making them ill equipped to help those students. By looking at specific grammatical features and specialized interpretation skills, teachers will be more aware of what is causing confusion and misinterpretation for their students. The mathematics classroom is not traditionally a place for discussions and language activities and many math teachers are unaware of the benefits of teaching the language of mathematics in their classrooms.

In chapter three I will explain my process for creating a curriculum supplement for an algebra class to help foster language development for ELs. I will be tailoring this to fit with the 8th and 9th grade Minnesota state standards for algebra. Since there will be multiple teachers in my building teaching algebra classes with low level ELs, my aim is to create a supplemental curriculum that we can all use to provide the language supports necessary for ELs in these classes.

CHAPTER THREE

Project Description

Introduction

My research question is: *How can secondary mathematics teachers make language features in the mathematical register more comprehensible for English learners within a mainstream mathematics content classroom?* This chapter starts with an overview of the entire project. Next, I will explain the two main frameworks that will be used to design the project: Backward Design (Wiggins & McTighe, 2011) and Mutually Adaptive Learning Paradigm (MALP) (Marshall & DeCapua, 2013). These frameworks have different strengths that work together to ensure the resulting curriculum is sound in both content and meeting the needs of ELs.Third, I will describe why I chose these two methods and how they can both be implemented in the same curriculum. The next section describes the specific audience this curriculum is being created for. While I have a specific audience in mind as I write this project, my hope is that it will be implementable by a much broader audience as well. The following section contains a description of the project, including what technology and programs were used in its creation. This section includes specifics of what is and is not included in the final project. And finally, the chapter concludes with a timeline of the steps involved in creating the project.

Project Overview

This project is a curriculum supplement for a MN standards based algebra course. While this course is taught at a high school with students in grade 9, it is a remedial course that is covering 8th grade standards to prepare students for success in later classes.

This supplement provides eight activities designed to help beginning ELs (Wida levels 1 -3) access the language of lines. Graphing lines and manipulating equations that represent lines is a main topic of the 8th grade MN state standards (MDE, 2007). One standard that is addressed is benchmark 8.2.4.3 which states students should be able to "express equations in slope-intercept, point-slope, and standard forms, and convert between these forms. Given sufficient information, find the equation of a line." (Minnesota STEM Teacher Center, 2020; MDE, 2007). Although these supplemental materials were designed with a specific MN high school in mind, they are implementable for any mainstream algebra course at other locations as well. Each activity also includes assessment options and ideas. All activities can be used or adapted into formative or summative assessments depending on how an individual teacher decides to use them in the classroom. The next section will give details about the frameworks that will be used to design the curriculum. This will cover what the two frameworks are, why they were chosen, and the strengths they each contribute to this specific curriculum project.

Frameworks

This project was designed using two frameworks. The first framework is backward design (Wiggins & McTighe, 2011) and the second is the Mutually Adaptive Learning Paradigm (MALP) (Marshall & DeCapua, 2013). The backwards design framework was used to create resources focused on the standards, while MALP ensured that these resources were aimed at specifically helping ELs access the language and mathematical content.

Backward design is a method of first identifying the desired outcomes of a unit of study, then designing the assessments that will best show those outcomes, and lastly designing the learning activities that help students learn the desired material (Wiggins & McTighe, 2011). The emphasis of the first stage, desired results, is not merely a list of content covered. This stage goes further in depth and forces teachers to specify what they want students to be able to do or understand at the end of the unit. More than listing skills students should be able to use, the teacher needs to identify how and why the student will be able to apply those skills and then assessments are designed around this larger goal of how and why. Once the assessments have been designed, the teacher designs learning tasks as the final step. This backward design concept ensures that all learning tasks are focused on the end goal of the unit (Wiggins & McTighe, 2011). This was important for me as I was designing supplemental resources that needed to align with existing state standards.

The Mutually Adaptive Learning Paradigm (MALP) is a lens that can be applied to any element of a curriculum in order to ensure that the resource is accessible to ELs. The basic premise behind MALP is acknowledging students' customary and preferred ways of learning and helping them transition to a Western-style way of learning (Marshall & DeCapua, 2013). Many cultures do not use a Western style of learning; therefore, many EL students are unfamiliar with the expectations and ways of thinking that are normal and expected in typical US schools. MALP is a way for teachers to meet students in their preferred way of learning and help them transition to the Western style of learning (Marshall & DeCapua, 2013). Figure 1 comes from Marshall and DeCapua. It contrasts struggling learners preferred ways of learning with Western Style Education. The gray boxes are the path of MALP whereby a teacher introduces a new concept in a way that the learner can connect to it and transitions into academic tasks that require individual accountability for the learner (Marshall & DeCapua, 2013, p. 32).

Figure 1

Mutually Adaptive Learning Paradigm (MALP)

Components of Learning	Struggling L2 Learners	Western-Style Education
ACCEPT CONDITIONS from learners	Immediate Relevance	Future Relevance
	Interconnectedness	Independence
COMBINE PROCESSES from learners and Western-style education	Shared Responsibility	Individual Accountability
	Oral Transmission	Written Word
FOCUS on Western-style learning ACTIVITIES with familiar language and content	Pragmatic Tasks	Decontextualized Tasks

Note: taken from (Marshall & DeCapua, 2013, p. 32)

For many ELs, there is a cultural disconnect that adversely impacts their educational success in a US high school (Marshall & DeCapua, 2013). Implementing MALP consists of a 3-part checklist to help teachers design a curriculum that will help students overcome this disconnect. MALP requires teachers to begin with the learners conditions by making the topic immediately relevant. The next step is to use oral transmission and shared responsibility as scaffolds to accessing or producing written word and individual accountability. These two parts set the learner up for success for the required academic task (Marshall & DeCapua, 2013).

These two frameworks together will lay the foundation for a supplemental curriculum that focuses on state standards while meeting the specific needs of ELs in the classroom. In the next section I will discuss more specifically why I chose each method and how they can work together.

Choice of Method

Understanding by Design begins with the teacher looking at the end result they want achieved and then designing activities with that goal in mind (Wiggins & McTighe, 2011). MALP can be applied in the same 'looking backwards' format by taking the academic activity designed to meet the standard and then building in the scaffolds to specifically support ELs (Marshall & DeCapua, 2013). I think this pairing is a strong method of creating resources that are aligned to specific state standards, academically rigorous, and yet provide the support that ELs need to be successful with the task. One difficulty I foresee in teachers implementing these activities is that MALP (Marshall & DeCapua, 2013) requires using oral communication to scaffold to the written word which will require a person to help scaffold the material. This does not need to be an adult, rather, it could be accomplished by using student groups to create the oral scaffolding.

By using Understanding by Design (Wiggins & McTighe, 2011) to create strong academic tasks aligned to state standards and MALP (Marshall & DeCapua, 2013) to create scaffolds specifically for ELs, I created resources that any algebra teacher can embed within their lessons to help support EL students. In the next section I will detail the specifics of my immediate audience for this curriculum project.

Audience

This supplemental curriculum was designed specifically for a 9th-grade algebra 1 class that covers linear algebra concepts as defined by the MN state standards (Minnesota Department of Education, 2007). The class primarily covers 8th grade standards and many students in the class were unsuccessful in a linear algebra class during the previous school year. Typically, there are between 50%-80% EL students at WIDA levels 1-3. This class is taught in a rural Midwest high school which has 1300 students in grades 9-12. The largest demographic groups of students at the high school are: white (44%), Hispanic (32%), black/African American (19%), and Asian (5%). In this student demographic, 22% are currently receiving EL services and 80% of the ELs are at a WIDA level of 3 or lower. Of the total student body, 55% receive free or reduced lunch and 77% of graduates attend an institution of higher education. As of 2018, 100% of students identified as EL who took the 11th grade MCA math test received a score of “does not meet.” (MDE, 2020) This clearly shows that students who are receiving EL services in 11th grade are struggling in mainstream math classrooms and not finding success with advanced mathematics.

While it is clear that EL students are struggling in math classrooms at this particular school, I do not believe that this is an isolated occurrence. Although the supplemental resources are built for the specific needs of this school, the materials could also be utilized in other schools which also offer algebra 1 classes. The next section will give a description of what the supplemental curriculum does and does not include.

Project Description and Assessment

This curricular project is designed for an algebra course that already has a curriculum in place, while some of the resources can be used in place of existing materials, it is not intended to be a complete curriculum. As such, I did not create presentations or lessons for any topics. Nor did I create units that are sufficient to fully teach a topic. It is expected that teachers already have materials for teaching the entire algebra course and I have created eight activities and given ideas for how to implement them into classroom lessons and existing assessments. The activities are unique in content and strategy. Ideally teachers can adapt each one for more topics and have a toolbox of eight different strategies to help ELs within their classroom. These activities are designed for linear equations, forms of a line, and interpreting linear graphs, but all of the strategies used could be adapted for any topic in a math classroom. Each activity includes a teacher version where I have included suggested answers and 'teacher talk' tips and hints for successful implementation. There is also a student version that can be printed and handed directly to students. Before each activity is an informational page which explains the rationale behind the strategy and gives multiple ideas for how to use the activity in a classroom. The final section of the informational page explains how the strategy can be used as an assessment tool. Sometimes the activity itself can be used as an assessment or included on an existing assessment, other times this section gives ideas for how to modify assessments so ELs are not prevented from accurately demonstrating their content knowledge because of their English skills.

The specific midwest high school classroom has multiple native languages represented in the EL population. As such, these activities are designed to be implemented completely in English. The teacher does not need to speak the native language in order to use them and students with different native languages can use them together in the same group.

To create the curriculum I used a variety of computer programs. The two main programs used were Microsoft Word 2010 and SmartNotebook 16.2. Both programs are provided through my school and the classroom technology is set up to accommodate both. Additionally, both programs have easy to use equation editors and other features necessary for typing mathematical content. In order to easily share the finished project among different platforms, I have created a PDF version as well. All clip-art and pictures are from Microsoft Word while other tables and charts I created in SmartNotebook and copied them into the final project. The linear graphs I created using the online graphing calculator Desmos (Desmos, 2020).

In summary, I designed a supplemental curriculum that is aligned to the 2007 MN Academic Standards for Mathematics. It is designed to meet the needs of a specific high school in MN, but could be used in any algebra course that teaches linear graphs. The curriculum includes eight unique activities teachers can use to help their ELs access the language used within a mainstream algebra classroom. Each activity also has ideas for how to incorporate it into an assessment or ideas for modifying assessments so ELs can better demonstrate their knowledge of the content. Next I will lay out the timeline that will be used to create the curriculum.

Timeline

Beginning in May of 2020, I reviewed the two frameworks being used, Understanding by Design (Wiggins & McTighe, 2011) and MALP (Marshall & DeCapua, 2013). By the end of May I chose the six MN standards that are the focus of the curriculum. In June of 2020 I began creating activities based on the state standards. In July I shared the activities with a fellow math teacher to get her feedback. By July 2Ist had finished creating materials and incorporated feedback. In the beginning of August I converted the finished project into a single PDF document, and by the end of August I had finalized and submitted the capstone project.

Conclusion

In conclusion, this project is a supplemental curriculum consisting of eight activities designed for a rural MN high school. It could be implemented by any algebra 1 teacher while teaching a unit on linear equations. The activities focus on helping ELs build language skills within the math classroom. All activities are aligned with the 2007 Academic Standards for Mathematics as determined by the Minnesota Department of Education. Each activity includes an informational page that includes the rationale for its design, ideas for using it in a classroom, and ways to incorporate the activity into both formative and summative assessments.

This chapter laid out an overview of the entire project. The two main frameworks were explained and the reasoning for choosing both was discussed. Details about the specific audience were given as based on the 2018 statistics from the MN report card (MDE, 2020). A full description of the project was included which explained what kinds of activities were created as well as the technology used to create them. And finally, a timeline of completion was explained laying out the details of what steps were completed between May and August of 2020.

In Chapter 4 I will reflect on the finalized project and how it connects to the existing literature. I will explain my expectations for implementing the project and some of the limitations of the completed project. Additionally, I discuss how it benefits the teaching profession and some ideas for future projects.

CHAPTER FOUR

Conclusion

Introduction

My research question for this project is: *How can secondary mathematics teachers make language features in the mathematical register more comprehensible for English learners within a mathematics content classroom?* In this project I created eight supplemental activities for a mainstream algebra classroom designed to support beginning level English Learners (ELs). My goal was to create supporting activities that any algebra teacher could implement directly. Ideally, after implementing a couple of these activities, teachers will feel confident enough to modify the activity for a new topic within their curriculum. For each activity, I included an informational page which explains the rationale behind its design, some ideas for implementing it in a classroom, and ways to use it as an assessment. Each activity also includes a 'teacher version' with suggested answers and tips for using, and a 'student version' which is ready to print and hand out. To create the activities I used two frameworks, Backward Design (Wiggins & McTighe, 2011) and Mutually Adaptive Learning Paradigm (MALP) (Marshall & DeCapua, 2013). Backward Design is content focused. It required me to first identify the final learning target, second, design assessments, and lastly, design learning activities. This ensures that learning activities are content oriented and not only fun or entertaining (Wiggins & McTighe, 2011). MALP is a way of designing activities specifically to help ELs. The basic premise is to use a topic students are familiar with while teaching a new language skill, once the language skill is comfortable then it can be used with new content knowledge. The goal is to prevent students from struggling simultaneously with new content and new language structures. By first making the language structure understandable, students can then implement it using content specific material (Marshall & DeCapua, 2013).

This chapter provides a reflection of my completed project. First I will explain my major learnings from the design process, second I will connect my project to the existing literature. Next I will discuss the implications, limitations, and future steps. Finally I will explain how I will communicate this project to others and how it will benefit the profession.

Personal Learning and Growth

My first task when designing the project was to decide which Minnesota Academic Standards for mathematics I wanted to focus on. I settled on six standards on the topic of linear graphs and equations. Having taught this topic many times in my career I know that it is language heavy and many students, not just ELs, struggle with the language required in this topic. One of the resources I used for ideas when designing each activity is *The ELL Teachers' Toolbox* (Ferlazzo & Hull, 2018). While the activities are designed to teach language skills, I was pleasantly surprised at how many could be modified to fit a math classroom. While I designed eight activities, there are many more available that could be easily adapted for math. I also noticed that many of the activities require movement and student collaboration in a variety of ways. These are both topics that have been frequently covered in my professional development opportunities over the past couple of years. I was encouraged to find activities focussed on language skills which also use best practice teaching practices in their design.

A second surprise was realizing how well the language activities applied directly to some of the standards I was focusing on. I was expecting that the activities would be scaffolds helping students to eventually achieve the standard, but in some cases the activities are directly fulfilling some requirements of the standard. This mainly happened with standard 8.2.2.1: Represent linear functions with tables, verbal descriptions, symbols, equations and graphs; translate from one representation to another. (MDE, 2007) The standard itself requires students to connect verbal descriptions with multiple representations of lines. Many of the activities I created require students to either create or listen to a verbal description of a graphical representation of a line. This task is directly helping students translate between two representations of a line, exactly what the standard requires.

As I was designing activities, I was excited by how simple incorporating MALP (Marshall & DeCapua, 2013) became. Eventually I had a formula for designing: First, known topic + new language skill; second, repeat language skill + new content topic. I am excited to implement these activities in my own classroom in a few months. I feel that as an educator, I do have a solid ‘toolbox’ of ideas I can begin using to help my ELs from day one. I have been teaching math classes with ELs for nine years, and while I have found some ways of helping them, I have never explicitly focused on language to the extent that this project does. Moving forward after this experience, my classroom will have a much stronger emphasis on language and how it is used in mathematics.

Literature Review

In researching the language of mathematics, I was surprised to find multiple well known researchers such as Halliday (1978), Schleppegrell (2007), and others, stating that it is important for math teachers to explicitly teach how to use language within the context of mathematics. The other main takeaway I found was the impact teacher language use can have for building mathematical concepts (Hughes et al., 2016). Teacher language and precision in elementary school can impact how students perceive and understand mathematical concepts. Misconceptions can be reinforced or even taught because of imprecise teacher language (Hughes et al., 2016). As a result of these findings I have found myself being more careful with the language I use with my two year old daughter when talking about numbers and counting. These two ideas were a large part of my inspiration for this project. I set out to create activities that focus on the language of mathematics.

Traditionally, math classes are very lecture and worksheet oriented, my goal was to create activities that require students to use language with the math content. Although my ultimate goal is to help ELs in math classes, I do think that some of these activities would be beneficial for all students. In my experience, many students struggle with language in math, I have never had a student who was excited about word problems. I can see how using language focused activities will help students more confidently use the academic language of mathematics.

Implications

This project has allowed me to create something I have wanted to have for some time, language support materials for my EL students. As the creator of this project, I expect that I will be adapting and modifying these activities, and others, to fit my math classes. Having researched the importance of teaching language skills in a math classroom, I will be adding in language emphasis into my regular classroom lessons. Also, I will be better able to create scaffolded materials using Backward Design (Wiggins & McTighe, 2011) and MALP (Marshall & DeCapua, 2013) in order to support my beginning EL students.

For my school district, I hope that by seeing language supports designed for math classrooms and understanding the rationale of teaching language, that other teachers will also begin explicitly teaching how to use language in the context of math. Through the combination of this completed project and professional learning communities, the math department is well situated to implement supporting materials for ELs in all math classes.

Limitations

The major limitation of this project is that it is only a single unit of material and is typically taught about half-way through the curriculum. This project is not sufficient for the entire algebra curriculum, it would need to include many more topics. Also, the topic of focus, linear equations and graphs, is covered mid-way through most algebra courses. This means that teachers may struggle to provide support during the beginning of the course and not become comfortable with these activities until later on. This will in turn cause students to struggle as well. Ideally, these activities would be implemented from the beginning of the course so teachers could learn how to best organize their class period to incorporate them. While these activities can be modified and used during the beginning of the course, teachers may be uncomfortable modifying the activities if they have never used them in the original format. After using them with students, it will be much easier to modify them to fit other topics.

Future Projects

This project is designed for a single unit in an algebra class. Future projects include adapting these activities for all the other units in an algebra class. Also, these could be adapted for other math classes such as statistics, geometry, and computer coding. The eight activities I have included are not the only eight available. A wider variety of activities applied to more topics could be created. Beyond math, this same idea of providing language supports in content classrooms, could be implemented in other content areas as well. Science, social studies, art, shop, any content classroom could create activities that help ELs access the content by providing support with the language.

Communicating Results

In my current teaching position, I am one of multiple teachers who teach an algebra class. Additionally, the activities created can be adapted for topics in other mathematics classes. We have a shared google drive where resources for all classes are housed so all teachers have equal access to them. I will be uploading my project into the shared drive so all teachers have access. Also, I will be working in professional learning communities with other teachers who are teaching algebra as we implement these activities into our curriculum. Having worked in multiple buildings within my district, I will also be sharing this project with teachers at other buildings, especially those who are teaching algebra courses.

Benefit to Profession

Being a math teacher, I have often looked for ideas and activities to incorporate into my classroom. It is hard to find activities that are designed specifically to help ELs in a mathematics classroom. It takes time to modify activities to fit mathematic content and knowledge of ELs and language to design activities that support language while keeping content rigor high. In my experience, high school math teachers struggle to implement strategies because they require modification. Very few resources focused on EL language development in a math classroom are readily available. Additionally, teachers are often not adequately trained to design effective activities on their own. This project is starting to fill this gap by providing ready-to-use language activities designed for a mathematics classroom. It can function as a beginning tool for teachers to help them focus on teaching language skills in a math classroom.

Conclusion

This chapter explained my personal reflections after creating my supplemental curriculum project. I began by explaining the major take-aways from the literature that influenced my design process. Next I discussed the implications and limitations of this project. From there I talked about how I personally plan to implement these activities and continue creating and implementing more language activities into my own classroom. Finally, I explained how this project will be shared with my coworkers in the upcoming school year and how our professional learning communities can help facilitate its implementation in multiple classrooms. There are not many readily available language activities for mathematics classrooms. They are not included in textbooks or curriculum packages, by creating a product that is ready to use teachers can then modify it for a wider variety of topics they cover in the classroom.

While math teachers are skilled at breaking apart complex mathematical concepts, they are not trained linguists. Math teachers are also fluent in the language of mathematics and many are unable to identify why that language is baffling for students. These activities aim to help math teachers break apart the language of mathematics so that even their most beginning level ELs can access the math content without language being a barrier. With language supports in place, I hope to achieve Shleppegrell's (2007) goal of helping students become confident using the academic language of mathematics.

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