

TEACHING ACADEMIC VOCABULARY: AN EXPLORATION OF BEST
TEACHING PRACTICES

Teaching Academic Vocabulary in Math Classrooms to a Diverse Group of English
Language Learners: An Exploration of Best Teaching Practices.

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April, 2018

Submitted in partial fulfillment of the requirements for a Master of Arts in Education
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Dedicated to my wonderful husband and beautiful children for their unconditional love and support. Never forget that everything is possible if you put your mind to it.

I love you

Dedicado a mi querido esposo y hermosos hijos por todo su amor y apoyo incondicional durante este tiempo. Nunca olviden que todo es posible si se lo proponen.

Los amo mucho

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ABSTRACT

This curriculum development project consists of a detailed analysis of research based on journal articles, books, and other publications focused on the English language learners' language acquisition process, math academic language, and best teaching practices to facilitate their academic language learning. This research compiles the best teaching practices organized in three different sections: (1) Teacher Knowledge and Understanding, including second language acquisition, math academic language and vocabulary knowledge. (2) Teacher Planning and Organization, including planning techniques, classroom management and room organization. (3) Teacher Attitudes and Dispositions, including beliefs, attitudes, and awareness of student background knowledge.

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SECTION ONE

Introduction

In Ohio, the state's elementary and secondary public schools enrolled approximately 42,000 Limited English Proficient (LEP) students/English Language Learners (ELL) in the fall of (NCES, 2016). The terms "Limited English Proficient" and "English Language Learners" have been used interchangeably during the past years. English Language Learners refer to those students whose native or home language is other than English, and whose current limitations in the ability to understand, speak, read or write in English limits their effective participation in a school's educational program (ODE, 2014). For the purpose of this capstone project, I will use the term "English Language Learners".

In my school district, ELLs represent nearly 10% of the student population. This number represents 1,380 ELL students district-wide. These ELLs are a diverse group of students coming from 57 different countries and speaking 47 different languages from around the world. About 126 ELL students are enrolled at my high school (Facts at a Glance, 2017). These ELLs come with different backgrounds, various levels of schooling, and they bring a variety of English language skills. When they start high school, they are placed in classes based on their English knowledge and the OELPA assessment results (English Proficiency Test). They receive sheltered English, History, Science, Algebra and Geometry classes based on their academic achievement in content, previous background knowledge, years of schooling, past grades, and state tests results.

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The ESL department program and services in my district are consistent with the Ohio Department of Education standards. This program focuses on providing the resources and services to best support high academic achievement for ELLs. ESL teachers, mainstream teachers working in sheltered classes, and paraprofessional bilinguals provide research-based instruction techniques to ELLs to become English proficient and meet their social and emotional needs.

During the past three years, I have been working as paraprofessional bilingual providing language and content support to Algebra and Geometry sheltered classes. I have always enjoyed teaching math and I have a passion for working with ELLs. I feel I can relate to and empathize with their experience as an ELL myself, and I can see this relation in my interaction with them. I have been teaching math during group instruction, clarifying and answering questions, and providing various types of math support to my ELLs. Additionally, I am responsible for ESL study halls where I provide English language and math support to students who usually bring a lot of questions about homework and projects.

The exposure of working with ELLs, my passion for teaching math, and being a second language learner myself, brought me to the decision of pursuing first a TESOL endorsement and then a Master's degree. The education I have received for the past two years in my graduate courses has provided me with instructional techniques that I use in my daily work as a paraprofessional. It has allowed me to learn teaching strategies, gain a much deeper understanding of the second language acquisition process, and appreciate the time it takes to learn another language. Students have many questions on a variety of topics, such as the definitions of math vocabulary words, understanding of math

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problems, reading comprehension worksheets with dense English paragraphs, and lack of understanding of teacher's explanations.

During my work with students, I have noticed that ELLs sometimes do not ask teachers many questions in class settings. ELLs often stay silent when teachers ask questions and they refrain from participating in class because of fear of not understanding the question. They are unsure of how to structure their answers, and lack confidence in their growing English skills. Some ELLs have shared with me that they feel more comfortable with my explanations and the way I connect concepts and reasoning problems. I notice that being an ELL myself provides them a sense of familiarity and comfort. I believe my most valuable help comes from the fact that I understand how they are trying to learn when exposed to unfamiliar words or concepts and I can empathize with their experience.

In many of my interactions with the students, I notice that most of the questions they have center around understanding the meaning of math vocabulary words and math concepts. In some cases, students are well-versed in mathematics in their own language, yet struggle to do math using English. They are unable to transfer academic vocabulary and concepts from their home language to English and end up being placed in classes they have already completed in their home language. There is a need for learning academic language for the success of their English language proficiency. I observe that there is a need for a curriculum program, which can emphasize the teaching of academic language and math vocabulary words that should be based on teacher research.

Based on the observations described above, I developed this capstone project as a way to provide additional support to ELL and mainstream teachers in their work

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supporting the learning path of ELLs. Instructional techniques and other components need to be identified and shared with classroom teachers to facilitate successful outcomes for ELLs. The purpose of this curriculum development project is to research and summarize what research suggests are the best teaching practices to facilitate the learning of math academic language. The project was framed on the following questions:

- What are the best practices for teaching academic math language to ELLs?
- What is the best way to present these findings to math teachers in mainstream and sheltered Algebra and Geometry classrooms?

The method of delivery of this curriculum development project will be a “Best Practices Handbook” that consolidates the findings of the research and literature reviews including best practices about teaching academic math vocabulary to ELLs. This handbook will contain three sections:

1. Teacher Knowledge and Understanding, including second language acquisition, math academic language and vocabulary knowledge.
2. Teacher Planning and Organization, including planning techniques, classroom management and room organization.
3. Teacher Attitudes and Dispositions, including beliefs, attitudes, and awareness of student background knowledge.

After the conclusion of this capstone project, results will be shared with the ESL department at my school and any mainstream teacher who would like to learn the best teaching practices when exposing ELLs to new academic words in the math classroom. This capstone project is not only of significance to all ELLs and teachers, but also to me

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at the personal level because it will allow me to connect what research says with my experience as a second language learner moving to a new place, learning a new language, and embracing the American culture.

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SECTION TWO

Literature Review

English Language Learners

The fastest-growing student population in U.S. schools today are children of recent immigrants, half of whom do not speak English fluently and are thus labeled English Language Learners (ELLs) (Calderon, Slavin, & Sanchez, 2011). Although the federal government requires schools and school districts to provide services to ELLs, there are no consistent policies that must be followed in identifying, assessing, placing, or instructing them (Calderon, Slavin, & Sanchez, 2011). English language learners are a very diverse group of students who face the same academic challenge; they must learn the English language at the same time they are learning the academic content in all the different subject areas in an unfamiliar language.

According to Freeman and Freeman (2011), ELLs face challenges both outside of school as well as in school. These students must adapt not only to a new language but also to a new culture. As they do so, they are in most cases confronted by simultaneous challenges that could include living in poverty, dealing with religious persecution, and having less parental support in their learning (i.e., poor language proficiency, challenging work schedules, poor educational backgrounds, etc.). Despite all these challenges, some ELLs manage to learn a second language, adapt to a new culture and succeed in school.

Before a teacher can best know how to help ELLs, he or she must first understand the special attributes and characteristics ELLs have in common. Teachers must also understand the attributes and characteristics by which they vary. If one desires to

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optimally assist ELLs, it is important to understand each simultaneously as a unique individual and as part of a broader group. The Ohio Department of Education (ODE) presents important information prepared by Carol Striskovic, Linda Wait, and Jill Kramer (education specialists) that shares what educators need to know when teaching ELLs. In the sections that follow, I present what I deem to be the most important information about ELLs. I share important information, definitions, theories, and procedures that will help new teachers or teachers who are having their first experience working with ELLs to be better informed and prepared for working with students in this special group. All of this creates a solid professional knowledge-foundation upon which to build the recommendations that emerge from this curriculum development project.

Identifying Students as English Language Learners

The ODE establishes and implements statewide guidelines and procedures for the identification of ELLs. The first step in this process consists of administering a Home Language Survey at enrollment time. This survey identifies language backgrounds, other than English, spoken at home for all students enrolling in grades PreK-12. It is important to mention that place of birth is only a secondary factor in this identification process. English Language Learners may either be born outside or within the US. The student is then assessed for English Language Proficiency in reading, writing, listening and speaking skills by a qualified screener (ODE, 2014). Beyond this set of criteria, ELLs are a very diverse group of students.

Although this process is well defined and consistent, ELLs are quite different from one another. One important difference that must be recognized is that each ELL presents different levels of English proficiency. Some may be quite proficient and others

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less so. For that reason, the ODE classified the stages of language acquisition by ELLs, the different types of languages used for these ELLs, and the type of learners we can have in our classrooms.

These stages of language acquisition are closely aligned to the stages defined by Krashen and Terrel in their book *The Natural Approach* (Krashen & Terrel, 1983): (1) Pre-functional – Pre-production or “the silent period”. These students just listen and may not speak for weeks or months; don’t force them. Some will start using simple learned phrases and simple sentences. (2) Beginner –Students will develop a vocabulary of about 1,000 words; speak in one or two-word phrases, memorized chunks and simple sentences. This may last about 6 months. (3) High Beginner–Students will develop a vocabulary of about 3,000 words, use simple sentences, ask simple questions, read easy stories, and write simple sentences. (4) Intermediate–Now students have a 6,000-word vocabulary, use more complex sentences, and ask questions. They will still have grammar errors. (5) Advanced –It can take 4 – 10 years to achieve this. Students are able to cope in the classroom but will still need help with vocabulary, idioms, writing and content such as mathematics and social studies.

Differences in each ELL’s existing proficiency with English is a distinction of importance in successful support of ELLs. It can be used to promote a teacher’s decisions on how to balance the needs of individuals and the larger classroom group. It can also be a useful distinction when suggesting interventions that enable differentiation or adaptations to lessons designed for typical learners.

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Types of languages

To fully address the needs of ELLs as they strive to learn academic content and negotiate the challenges of schooling in an unfamiliar language, one must also consider how to support learning across the different forms of English or “types of language” used in communication. The ODE (ODE, 2014) suggests that classroom teachers need to consider not only the stages of language acquisition when working with ELL but also the difference between social and academic language. Based on research conducted by ELL experts such as Jim Cummins, it is important to differentiate between social and academic language when working with ELLs.

These two types of languages are: (1) Basic Interpersonal Communicative Skills (BICS), this is a social language that typically develops in one to three years. This is the day-to-day language needed to interact with other people. This language is context based and ELLs use BICS on the playground, in the cafeteria, on the bus and in other social settings. (2) Cognitive Academic Language Proficiency (CALP), this is academic language that usually takes between five and seven years to develop. This language includes general academic words and content specific words.

Students who have developed BICS but not CALP do not lack higher order thinking ability; they simply lack the language to succeed in school (ODE, 2014). This is especially apparent in the writings of our ELLs who are challenged with conventions of English writing, spelling, punctuation, and grammar. Even students in mainstream classrooms that can be considered advanced students still need support with vocabulary words and academic content. Thus, it is important for mainstream classroom teachers to take time to consult with ESL teachers and find out the student’s English proficiency

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level, the amount of formal schooling, the student's literacy in their first language, degree of acculturation into the USA, and level of family support in order to better serve ELLs.

Types of English Language Learners

All the concepts discussed above help a teacher develop the mental framework required to better understand or identify the type of English Language Learner that need support in the classroom. Teachers benefit in making decisions that support students when they are more fully aware of the student's background and past school history, and when they understand an ELL's specific profile as it relates to level of language proficiency and types of language. Knowledge of these critical characteristics help them develop appropriate teaching strategies and techniques to help ELLs acquire proficiency in both the English language and academic content areas.

Yvonne and David Freeman, authors of *Academic Language for English Language Learners and Struggling Readers* (2008) distinguish among three types of English Language Learners: (1) those newly arrived in the United States but well educated in their home country, who may succeed in school but face the challenges of learning English quickly enough to pass standardized or state assessments; (2) those who come with limited academic knowledge in their own countries due to limited access to education, and must learn how to read and write in English along with attaining and developing content area knowledge in English; (3) the last group are the long-term English learners who have been in the United States for an extended time, speak the social English language quite well but lack academic English.

An understanding of these types of learners is essential for pre-service, mainstream and ESL teachers in their day-to-day work as this eliminates misconceptions

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that ELLs are typically newly arrived to the US and come with limited or no education at all. Identification and classification of ELLs based on their English proficiency level and the understanding of the types of English language they speak are important concepts for teachers when developing a framework that meet the needs of ELLs. Similarly, understanding of how a second language is acquired is a critical component that needs to be incorporated as well. The following section will discuss what factors and conditions influence second language acquisition and how it will influence the way teachers plan and develop their instruction with ELLs.

Understanding Second Language Acquisition

Many people are introduced to a second language after they have achieved native competence in a first language (Fromkin, Rodman, & Hyams, 2009). It is extremely important for educators to understand the factors and conditions that influence second language acquisition. Knowledge of these theories enables teachers to make informed decisions about how best to teach second language learners (Freeman & Freeman, 2011). Significant research has been conducted by psycholinguists, neurolinguists, and sociolinguists that contributed to the development of current theories of second language acquisition. However, there is a difference of opinion and many viewpoints about this process.

Krashen's Monitor Model seems to have the most viable and evident impact in classroom practice and it has been widely accepted by educators because it is understandable and because teachers can see positive results in the classroom (Freeman & Freeman, 2011). Krashen's monitor model consists of five hypotheses: (1) the acquisition/learning hypothesis, (2) the natural order hypothesis, (3) the monitor

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hypothesis, (4) the input hypothesis, and (5) the affective filter hypothesis. Together, these five hypotheses empower teachers to understand how a second language is acquired and will help them to plan their lessons, activities and materials in their classrooms.

The acquisition/learning hypothesis is based on the belief that humans acquire a new language subconsciously as they receive messages they understand. According to this hypothesis, we can acquire a language in social contexts as people attempt to communicate with others. Acquisition allows us to speak, understand, read and write the language. Learning, on the other hand, is a conscious process that is associated with classroom instruction. Learning allows us to talk about the language or to pass a test or exam about the language. This is why many teens or adults who have studied a second language in high school or at the college level have never developed the ability to speak or understand the language they studied (Freeman & Freeman, 2011). Based on this theory, the optimal way a language is learned is through natural communication. As a second language teacher, the ideal is to create a situation wherein language is used in order to fulfill authentic purposes to help students to ‘acquire’ the language instead of just ‘learning’ it.

The natural order hypothesis, Krashen’s second hypothesis, states that language is acquired in a natural order. He points out that all learners of a particular language seem to acquire a language in the same order no matter what their first language could be. For example, Krashen talks about how the plural “s” morpheme added to a word like girl, “girls” comes earlier than the third person “s” added to the word “walk” in “He walks”. According to this hypothesis, teachers should be aware that certain structures of a

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language are easier to acquire than others and therefore language structures should be taught in an order that is conducive to learning.

The monitor hypothesis explains how acquisition and learning are used; the acquisition system initiates an utterance and the learning system ‘monitors’ the utterance to inspect and correct errors. Krashen states that monitoring can make some contribution to the accuracy of an utterance but its use should be limited. He suggests that the ‘monitor’ can sometimes act as a barrier as it forces the learner to slow down and focus more on accuracy as opposed to fluency. Teachers can help students become better monitor users. It does help to know the rules, but it is essential to know when to apply them and when to concentrate more on the meaning of the message (Freeman & Freeman, 2011).

The input hypothesis is considered the key to Krashen’s theory. He claims that people acquire language in only one way, when they received oral or written messages they understand, a concept also known as *comprehensible input*. This hypothesis highlights the importance of using the Target Language in the classroom. The goal of any language program is for learners to be able to communicate effectively. By providing as much comprehensible input as possible, especially in situations when learners are not exposed to the Target Language outside of the classroom, the teacher is able to create a more effective opportunity for language acquisition.

The affective filter hypothesis is the last hypothesis. This hypothesis does not impact acquisition but rather prevents input from reaching the language acquisition part of the brain. According to Krashen, the affective filter can be activated by many different variables including anxiety, self-confidence, motivation and stress. Even if a teacher

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provides comprehensible input, acquisition may not take place. It is important for teachers to be able to create a safe, welcoming environment in which students can learn. In both the ESL classroom and foreign language education, this may be especially important since in order to take in and produce language, learners need to feel that they are able to make mistakes and take risks.

Krashen's theory helps explain a number of common situations in which second language learners find themselves. The five-interrelated hypotheses constitute Krashen's Monitor Model of Second Language Acquisition and it can be summed up by this statement: "We acquire when we obtain comprehensible input in a low-anxiety situation, when we are presented with interesting messages, and when we understand these messages" (Freeman & Freeman, 2011 pg. 124)

English Academic Language and Math Academic Language

Krashen's model accurately describes what factors and conditions influenced the process of second language acquisition and how their five-interrelated hypothesis interact while acquiring a new language. However, the reality of ELLs in the classroom is that they are not only learning literacy skills to become proficient in English, but they are also learning the academic language behind the content needed to perform well in standardized tests and graduate from school.

According to Echeveria, Vogt, and Short (2017), one area where ELLs need support is developing academic language and literacy skills in English. Academic vocabulary is more difficult to learn than conversational language because it is more specific and sometimes abstract, making it difficult to grasp. Knowledge of this technical vocabulary is directly linked to content knowledge and it is essential that ELLs have

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explicit instruction about the academic vocabulary that is necessary for their success in school (Sibold, 2011).

What is Academic Language? Academic Language is a specialized language, both oral and written, use to facilitate communication and thinking about disciplinary content (Nagy and Townsend, 2012). Nagy and Townsend defined academic language as a specialized language because it needs to be able to convey abstract, technical, and a variety of ideas that are not typically examined in settings that are characterized by social and or casual conversation.

A much simpler definition of Academic Language is given by Echevarria, Vogt and Short (2017, pg. 12) as follows: “Academic language involves the use of high level vocabulary, more complex sentence structures and more sophisticated forms of expression than is generally found in everyday conversation. It is the type of language students need to discuss complex ideas, articulate a position, summarize material, and contrast points of view”. This type of language is used in all content areas included mathematics.

Is Math another language?

Mathematics is a language that people use to communicate, to solve problems, to engage in critical thinking, and to create tools. Mathematics shares many of the characteristics that define English as a language (Adams, 2003). Even though mathematics is considered a universal language, students who speak languages other than English may have difficulty doing mathematics in English. Sometimes the lack of familiarity with the problem’s context and lack of knowledge of math vocabulary may cause them trouble understanding exactly what operations to perform (Hoffert, 2009).

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According to Gutierrez (2002), mathematics is a universal language that requires the ability to understand a specific math content, often through repetitive practice and the capacity to process intangible information. Gutierrez (2002) suggested that because of the emphasis on seeing mathematics as a universal language, little attention is paid to students' cultural or linguistics background.

Based on Marzano and Pickering (2005), teaching specific terms in a specific way is probably the strongest action a teacher can take to ensure that students have the academic background knowledge they need to understand the content they will encounter in school. They stated that people's knowledge of any topic is condensed in the terms they know that are relevant to the topic. To illustrate this, think about understanding a math problem about finding a linear equation based on two points in a graph. Students who understand terms such as slope, coefficient, starting value, y-intercept, growth, changes in Y and X, will be better prepared to understand and solve the problem than students who lack understanding of these math terms. The more students understand these terms, the easier it is for them to understand information they may read or hear about the topic (Marzano & Pickering, 2005).

Berger (2013) shows a simple yet powerful example of language usage. In everyday English, for example, "or" implies a choice. Berger provides a great example using the words cake and ice cream. For example, if we tell a student you may have ice cream or cake for dessert, either ice cream or cake are permitted but not both. In contrast, the mathematical "or" tell us that at least one of two statements must be true. Our example, then implies that cake and ice cream are both available: one student may have

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ice cream, one may have cake; one may have both. This technical usage of the word “or” illustrates how a simple concept can create confusion among ELLs.

A deeper awareness of the importance that vocabulary plays in the math classroom is necessary in order for teachers to help students make connections between the various math concepts and the terminology associated with those concepts (Sprosty, 2009). The action research study of Sprosty found out that there is a correlation between mathematical vocabulary and problem solving. She concluded that the better students understand mathematical vocabulary, the more likely they are to succeed in mathematical applications and problem solving.

When students possess general knowledge of academic language used in a specific content area, it is easier for them to understand and learn new information related to such subject or content area. However, many of our ELLs come from environments that have not been academically advantaged and they enter our schools with a big gap on math content and academic math language. This knowledge gap plays a significant role in their academic achievement and success. Therefore, it is important to investigate and create a systematic instructional approach that shows how to teach this important academic math language to ELLs in order to facilitate their success in understanding math content and increase their academic achievement in math. As such, this curriculum development research will include simple yet important strategies and techniques to build the math academic language in ELLs.

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SECTION THREE

Presentation of Curriculum

I have a deep interest in learning how teachers can develop an instructional program that will allow them to effectively integrate Math academic content and English language concepts into ELL curriculum and instruction. I believe that teachers can employ simple yet powerful techniques and instructional strategies to make content Math concepts accessible in classrooms and help in the development of the student's skills in the new language. As such, the goal of this curriculum development research study is to identify the best teaching practices on math academic language for ELLs.

The framework presented below is a culmination of detailed analysis and research based on journal articles, books, and other publications focused on the English Language Learners language acquisition process, math academic language, and best teaching practices to facilitate their learning. Similarly, I have incorporated knowledge acquired during the Master of Arts in Education program, and my daily interactions and observations in the ELL classroom.

I searched a range of online databases including, Otterbein University Library, JSTOR, and OhioLink catalog. I took the year 2000 as a cutoff point and used the following descriptors: English Language Learners, Academic Math Language, and Best Teaching Practices. I also consulted official and well-known websites such as the Ohio Department of Education, Westerville City Schools, and Colorin Colorado (an educational service of the WETA, Washington DC Public Broadcasting Service affiliate).

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The literature reviewed for this project was not exhaustive yet represents a group of articles and sources that best fit the purpose of this curriculum development project.

My experience and observations working with ELLs has also influenced this project. In my role as an ESL Paraprofessional Bilingual at my school district, I have definitely observed how the lack of understanding of math academic language impacts ELLs. In addition to having to build their oral English skills, ELLs need to acquire reading and writing skills in English, while at the same time keeping up their learning in all content areas, including mathematics (Slavit & Ernst-Slavit, 2007).

Based on my research, it makes sense to compile these best teaching practices in three different groups: (1) Teacher Knowledge and Understanding, including second language acquisition, math academic language and vocabulary knowledge. (2) Teacher Planning and Organization, including planning techniques, classroom management and room organization. (3) Teacher Attitudes and Dispositions, including beliefs, attitudes, and awareness of student background knowledge.

Teacher Knowledge and Understanding

Based on research and my observations in the classroom, successful ELL teachers have a solid knowledge and understanding of second language acquisitions theories and the academic content area they teach. As such, I consider this to be the foundation for identifying and defining best teaching practices that focus on teaching math academic language.

The following research focuses on instructional strategies and support methods for teaching mathematics to ELLs. Jones, Hopper, Franz, Knott & Evitts (2008) describe in their research article “Mathematics: A second language” how mathematics can be

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defined as a second language and what are some of the instructional methods that result from this perspective. The researchers analyze how mathematics shares many of the characteristics that define English as a language. They agree with the idea that mathematics is a language that people use to communicate, to create art, to build tools and to solve problems and conclude that the language of mathematics should be taught too. They propose the use of the same methodologies of teaching English as second language to teach mathematics as a second language as well. This research among others emphasizes that the language used in math classrooms needs to be taught and learned as any other subject, specially by ELLs. They propose sheltered instruction as a beneficial strategy for teaching mathematics as a second language. Allowing students to meet in small groups, gives them the opportunity to speak with one another and formulate their own conclusions in a comfortable setting which is the key for their success. They see immersion as an excellent strategy to teach the language of mathematics.

Murrey (2008) analyzes the importance of differentiating instruction in Mathematics for the ELLs. The researcher mentions how important is for teachers to understand their students' level of language proficiency to be able to plan instruction. He presents four strategies for teaching mathematics to ELLs that will be covered in detail in the next section "Teacher Planning and Organization."

The research article by Bay-Williams and Livers (2009) states that providing appropriate language support is important for all students and essential to the success of ELLs and struggling readers. They emphasize that, in a mathematics classroom, the support includes the ongoing development of everyday vocabulary. They shared some considerations and strategies to support math vocabulary. Comprehensible input and

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culturally relevant context are used as strategies to get students engaged in the problem and understand its context and find it interesting. The researchers suggested that paying attention to vocabulary is essential to the development of both language and mathematical understanding. They mentioned some effective practices such as modeling when previewing vocabulary by using visuals, choral response and repetition and focus on the lesson's key words. As such, there is a need for identifying a list of basic math vocabulary words when teaching math content to ELLs.

Slavit and Ernst-Slavit research article discusses ways in which middle school mathematics teachers can assist their students and particularly ELLs when learning both mathematics and the skills needed to successfully participate in their classrooms. They discuss some of the specialized language needed to be able to “talk math” and some teaching strategies for learning and talking mathematics. A list of strategies for teaching mathematical vocabulary that support ELLs as they learn mathematics, “the math register”, and how to “talk math” are provided in this research article. Some of these strategies for teaching mathematical vocabulary are the following: (1) Introduce new vocabulary in a thoughtful and integrated manner. Teach vocabulary as not a separate activity but as part of the lesson. Use manipulatives, graphic organizers, charts, bulletin boards. (2) Identify and highlight key words with multiple meaning. For example, the word “table” can have many meanings such as “table of values” (for graphing functions), “times table” (for multiplication facts) and other non-mathematical uses of the word. (3) Preview and review. A technique that supports lesson introduction by using a handout, an outline of the lesson on the board or overhead, and a list key terms needed for the lesson. Finally, (4) Brainstorm the meaning and origin of technical terms to reveal potential

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connections between the meaning of the word, and the student's background. At this point, it seems as if Slavit and Ernst-Slavit (2007) make a compelling argument that all students need support to participate in mathematical conversations, and that mathematical content is not easily accessible when presented in a second language (Slavit & Ernst-Slavit, 2007)

Another research article that addresses the question of how to best serve students who are simultaneously learning English and academic content is answered by Carrier (2005). She identifies three key issues teachers should consider when understanding ELLs language and learning: (1) the amount of time required for developing academic English (five to seven years); (2) the two jobs of ELLs in the classroom: learning a new language while learning new academic content; and (3) the use of multiple modes of input and output because they have not developed their English language proficiency to a level where they can understand all the oral and written information they encounter in the content classroom. Carrier stated that we can help our ELLs by providing extra support in developing not only the content specific vocabulary but also the academic sentence structures needed to talk and write about concepts in the lesson. This helps integrate students into the classroom, instead of creating a less rigorous instruction for them, which denies them to grade level curriculum. Carrier suggested that content teachers should work together with ESL teachers and determine what are the major concepts in the curriculum that students must know to help bring the task down to a manageable size for ELLs. Carrier's final key emphasized the use of techniques that do not rely heavily in language to convey information such as manipulatives, realia, pictures, graphic organizers, multimedia, videos, hands-on activities, etc. These techniques reduce the use

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of language load because they display information with pictures, labels or short phrases. She concludes that understanding of these three keys issues when working with ELLs allows teachers to have a solid foundation for approaching all the information that is available to design effective instruction and help ELLs succeed in the content area.

Teacher Planning and Organization

While teacher knowledge and understanding provides a solid foundation for helping ELLs to acquire math academic language, teacher planning and organization is equally important as it helps teachers manage and organize the activities to better serve ELLs in gaining proficiency in English and math content.

Jones, Hopper, Franz, Knott, and Evitts (2008) research focuses on effective planning for teaching mathematics. They treat the mathematics classroom as a classroom for language acquisition and describe a simple four step process that addresses how to teach mathematics to ELLs with emphasis on comprehension. (1) Understanding the problem, including knowing the vocabulary, understanding the structure of the language, and having the ability to translate these words into mathematical language, which are all critical for ELLs success. (2) Devising the plan, providing ELLs the ability to define the words and successfully decode the relevant information so the reader is able to translate the text. (3) Carrying out the plan, “Sum up” all the information and discern meaning. (4) Looking back, asking to himself “what do those numbers mean?” and sharing with peers. The researchers concluded that allowing students to meet in small groups enables them to speak with one another quietly and formulate their own conclusions. For these researchers sheltered instruction is viewed as an effective approach to language instruction because it incorporates three key concepts: small-group collaborative

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learning; connecting and immersion. They see immersion as an excellent strategy for learning another language, concluding that it seems logical to teach the language of mathematics the same way.

In addition, Murrey (2008) described four principles that support academic language acquisition: (1) Comprehensible input, (2) Contextualized instruction, (3) A low-anxiety learning environment, and (4) Meaningful engagement in learning activities. For Murrey, mathematics teachers use comprehensible input as strategy when they are helping students understand what they are hearing and reading. Some of those strategies are for example speak a lower rate, repeat ideas and pause to check for understanding, using of gestures, real live-objects, graphic organizers and other visual models. The second principle is contextualized instruction, which means that students learn mathematics and associated academic language in a meaningful context by defining new vocabulary after they have learned the associated concept and can connect the term with the known concept. The third principle focuses on providing a safe environment classroom where cooperative learning is a strategy used to support student participation, facilitate scaffolding activities and reduces anxiety about using English since they can ask peers to clarify concepts. Murrey's last principle to support academic language focus on providing opportunities to ELLs to listen, speak, read and write about mathematics, giving them daily opportunities to discuss, defend, present and ask questions about mathematics. The researcher concluded that one goal of teaching mathematics should be to engage all students in meaningful problem-solving activities; construct knowledge that leads to greater understanding; and understand that students who are English language learners are learning the language of Mathematics while learning English. He concludes

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that, teachers are not only teaching Mathematics, they are also assisting in language acquisition, their classrooms are designed to provide access to every student and assure high standards and support while learning mathematics and English.

Research by Cady, Hodges, and Brown (2010) present specific instructional practices that target the needs that ELLs have in learning math concepts regardless of their cultural background. They group their strategies in two main categories: (1) strategies that support English Language acquisition and (2) strategies to promote low-anxiety classrooms. They believe that for language acquisition and learning to take place, students must feel safe and comfortable in their environment. Some of the strategies describe in the first group are: use of advanced organizers; some that can explain main ideas and unfamiliar words and those that compare and contrast ideas and concepts. Other strategies are those that help to develop student's vocabulary, such as identifying what words might cause confusion during a lesson. The use of visual cues, diagrams, props (realia) and photographs are also another strategy to develop student vocabulary. Finally, adjust teacher talk, using strategies that enhance clarity and reduce the complexity of the language are included in this research.

Another group of researchers that focus on teaching and applying strategies to help introduce new vocabulary are Slavit and Slavit (2007). Their strategies introduce new vocabulary in a thoughtful and integrated manner; identify and highlight key words with multiple meanings; preview and review a lesson; brainstorm the meaning and origin of technical terms; validate students' languages and cultures; cooperative learning and opportunities for interaction; take risks and make mistakes. They discussed the role of language in mathematical development and ways in which teachers of mathematics can

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facilitate the learning of content and language at the same time while using the above strategies to enrich the mathematical learning experience for all students, including English language learners. The researchers concluded that mathematical discourse is not easily accessible when presented in a second language and can become a complex endeavor for ELLs, because many words cannot be translated from English to their native languages.

Teacher Attitudes and Dispositions

This last group of best teaching practices are based on teachers' attitudes and dispositions. If bilingual students or ELLs do indeed use two languages as they learn mathematics, then it is necessary to explore what research in psycholinguistics and sociolinguistics might offer for understanding these practices. Moschkovich in "Using two languages when learning mathematics" (Moschokovich, 2007) reviews studies from these two different theoretical perspectives that differ in how they explain and how they explore language practices. He based his study in the sociolinguistic framework that stresses the social nature of language. Language is not only cognitive but also cultural, social, and takes place in a specific context. His research provides a complex view of code switching during conversations and arithmetic computation. His findings suggested that classroom instruction should allow bilinguals students to choose the language they prefer for carrying out arithmetic computation, either orally or in writing and code switching is not a deficiency or a sign of semi-linguism but a way to communicate mathematically.

Another group of scholars that focus in the role of teachers as teachers of ELLs are Calderon, Slavin and Sanchez (2011). They emphasize that the quality of instruction

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is what matters most in educating ELLs. They stated that as larger numbers of ELLs reach America's schools, k-12 general educators teachers are discovering the need to learn how to teach these students. They focus on identifying eight elements of effective instruction regardless of the language in which instruction is carried out. Some of these effective instructions are: vocabulary instruction, cooperative learning, and use of primary language during instruction. They stated that the teaching of vocabulary is one of the most effective modes of instruction when developing students' phonological awareness and reading comprehension. These researchers emphasized that explicit vocabulary instruction allows ELLs to have exposure to a word in multiple forms. Also, cooperative learning is seen as one of the effective instructions because it allows students to work in small groups and help one another to learn. In addition, they support the use of primary language during instruction as a way to show respect for the student first language and home culture. These activities give ELLs opportunities to discuss the content and use the language of the school in a safe context. They concluded that as larger number of ELLs and struggling readers reach America's middle and high schools, more and more of the nation's teachers are discovering that they need to learn how to teach these students effectively.

Gutierrez (2002) research study examines the teachers' work in three high schools suggesting that some of the strategies used by elementary and middle school teachers and teachers of ELLs are also successful with high school Latinos whose primarily language is not English. These strategies include having students work in small groups, allowing students to work in their primary language, supplementing textbook materials, and building in student's previous knowledge. Gutierrez states that when teachers have a

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solid knowledge of their students and respect their individual identities and specific needs, they are more likely to develop strategies that will support such students being active participants in the classroom. These teachers are able to judge accurately whether and when language is a significant factor in the learning of mathematics.

Another research article that supports and respects student's individual identities and home culture is by Torre-Velasquez and Lobo (2005). They describe and illustrate strategies for teaching culturally responsive mathematics to ELLs. They defined culturally responsive teaching as a dynamic form of teaching that builds on and supports students home culture. Torre-Velasquez and Lobo (2005) describe techniques used in the classroom that help students perceive and describe their world, their community, and themselves using mathematics and language, and these strategies help students connect their world, their peers and their teachers. Lobo uses these strategies to support the teaching of mathematics in ways that are meaningful for his ELL students.

Some of the strategies presented by the Tores-Velasquez and Lobo are the use of graphs. They used a tool called consensogram, where students collect data about themselves, identify themselves on the graph and think about what this data means in terms of describing the class as a group. These graphs will allow students to relate mathematics to real-life experiences. Another strategy is to use mathematics as a tool for developing a community of learners. Teachers should connect mathematics to things students know and they use those skills to teach them more about their culture and as a starting point for discussions on the importance of students' bilingualism. Teachers will learn more about their students and their families; while at the same time engaging students in a higher level of academic math vocabulary. Finally, these researchers

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proposed that math vocabulary should be taught explicitly. Teachers should teach both mathematics and English vocabulary explicitly and in ways that the students will not forget. They proposed multi-modal activities such as analogies, vocabulary games, using real graphs from newspapers, magazines, and the internet.

In conclusion, teaching academic language and math vocabulary to ELLs requires teachers to have a solid background knowledge of math and English content, a deep understanding of theories of second language acquisition, great planning skills but more importantly the right attitudes and values to respect student's diversity, culture, language, and values. I believe this is a critical component that will allow teachers to establish a deep connection with their students, and students to trust their teachers. This creates an atmosphere of common understanding, respect, and trust where learning from both teachers and students is maximized. It is my hope that this curriculum research project is a small step in that direction and that all the information and strategies presented in the handbook can be used by teachers to create such an atmosphere for their students.

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TEACHING PRACTICES

SECTION FOUR

Handbook



MATH ACADEMIC VOCABULARY FOR ELLS

An Exploration of Best Teaching Practices

This teacher handbook is a culmination of detailed analysis and research based on journal articles, books, and other publications focused on the English Language Learners language acquisition process, math academic language, and best teaching practices to facilitate their learning.

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Overview

The fastest-growing student population in U.S. schools today are children of recent immigrants, half of whom do not speak English fluently and are thus labeled English Language Learners (ELLs) (Calderon, Slavin, & Sanchez, 2011). Although the federal government requires schools and school districts to provide services to ELLs, it states no consistent policies that must be followed in identifying, assessing, placing, or instructing them (Calderon, Slavin, & Sanchez, 2011). English language learners are a very diverse group of students, but they all face the same academic challenge; they must learn the English language at the same time they are learning the academic content in all the different subject areas in an unfamiliar language.

In my school district, ELLs represent nearly 10% of the student population. This number represents nearly 1,500 ELL students district-wide. These ELLs are a diverse group of students coming from 57 different countries and speak 47 different languages from around the world. Over 100 ELL students are enrolled at my high school (Facts at a Glance, 2017). When they start high school, they are placed in classes based on their English knowledge and the OELPA assessment results (English Proficiency Test). They receive sheltered English, History, Science, Algebra and Geometry classes based on their academic achievement in content, previous background knowledge, years of schooling, past grades, and state tests results.

This teacher handbook presents and shares important definitions, instructional tips, and best teaching practices that will help first time teachers or teachers who are having their first experience working with ELLs to be better informed and prepared. The creation of this teacher handbook is the results of researching and summarizing what research states are the best teaching practices to facilitate the learning of math academic language while learning English.

English Language Learners

The Ohio Department of Education establishes and implements statewide guidelines and procedures for the identification of ELLs. The first step in this process consists of administering a Home Language Survey at enrollment time. This survey identifies language backgrounds other than English spoken at home for all students enrolling in grades Pre-K-12. It is important to mention that a student's "place of birth" is only a secondary factor in this identification process. English Language Learners may either be born outside the US or within it. The student is then assessed for English Language Proficiency in reading, writing, listening and speaking skills by qualified screener (ODE, 2014).

Stages of Language Acquisition

The Ohio Department of Education classifies the stages of language acquisition by ELLs as well as the different types of languages used for these ELLs and the type of learners we can have in our classrooms. These stages of language acquisition are closely aligned to the stages defined by Krashen and Terrel in their book *The Natural Approach* (Krashen & Terrel, 1983):

Pre-functional - Pre-production or "the silent period"

New students just listen. Some may not speak for weeks or months. Don't force them. Some will start using simple learned phrases and simple sentences.

Beginner

Students will develop a vocabulary of about 1,000 words; speak in one or two-word phrases, memorized chunks and simple sentences. This may last about 6 months.

High Beginner

Students will develop a vocabulary of about 3,000 words, use simple sentences, ask simple questions, read easy stories, and write simple sentences.

Intermediate

Now students have a 6,000-word vocabulary, use more complex sentences, and ask questions. They still have grammar errors.

Advanced

It can take 4 – 10 years to achieve this. Students are able to cope in the classroom but will still need help with vocabulary, idioms, writing and content such as mathematics and social studies.

Types of languages

The ODE (ODE, 2014) suggests that classroom teachers need to consider not only the stages of language acquisition when working with English learners but also the difference between social and academic language. Based on research conducted by ELL experts such as Jim Cummins, it is important to differentiate between social and academic language when working with ELLs. These two types of languages are:

BICS - Basic Interpersonal Communicative Skills

This is social language and develops in 1 to 3 years. This is the day-to-day language needed to interact with other people. This language is context based and ELLs use BICS on the playground, in the cafeteria, on the bus and in other social settings.

CALP - Cognitive Academic Language Proficiency

This is academic language and takes 5-7 years to develop. These are general academic words and content specific words. Academic language is decontextualized and often involves large and uncommon words.

Important definitions

Accommodations

Changes of language or written language to make comprehensible for ELLs.

Adaptations

Modifications in materials and instruction made for ELLs.

Background Knowledge

Also called prior knowledge, this term refers to the background experience and knowledge that students bring to the classroom.

Bilingual Paraprofessional

ESL staff who collaborate with licensed staff, support and assist ELLs with second language and second culture families as needed.

Comprehensible Input

It is language input that can be understood by listeners despite them not understanding all the words and structures in it. Students being able to understand the essence of what is being said or presented to them.

Co-teaching

A teaching approach whereby an ESL and general classroom teacher share responsibility for co-planning and co-delivering instruction in a general education classroom.

ELL

English Language Learners refer to those students whose native or home language is other than English, and whose current limitations in the ability to understand, speak, read or write in English limits their effective participation in a school's educational

programs. This term is often preferred over Limited English Proficiency (LEP) as it highlights accomplishments rather than deficits.

ESL Teacher

Develops students' social and academic English language skills (reading, writing, listening, and speaking) using State Standards. Requires a TESOL (Teachers of English to Students of Other Languages) endorsement to existing license.

Interpreter

"Interpreter" and "translator" are often used interchangeably, but they have different meanings. An interpreter conveys information from one language to another orally. A translator conveys information in the written form.

Mainstream

The placement of ELLs in regular education classes in which the language of instruction is the dominant language.

OELPA

Ohio English Language Proficiency Assessment (OELPA). Administered to all identified ELLs in Ohio. This test determines each student's level of English proficiency and is the basis for exit from an ESL program.

Parent Refusal

Parents decline ESL services for which children qualify. Students are placed in mainstream programs without ESL support. In Ohio, students remain eligible for accommodations on statewide tests and must take the OELPA test until exit from the ESL program.

Push-out

A teaching arrangement whereby a teacher or specialist takes small groups of students from the mainstream classroom for part of the school day to provide specialized support.

Push-in

A teaching arrangement whereby a teacher or specialist join the mainstream classroom to give specialized support to a small number of students or to help the general education/content teacher improve content instruction for ELLs.

Realia

Real life objects that are used as visuals in language instruction.

Scaffolding

The use of temporary supports that help ELLs comprehend information as they develop English language.

SIOP

Sheltered Instruction Observation Protocol. A program model for teaching grade-level content in a way that is understandable for ELL students while at the same time promoting their English language development.

TPR

Total Physical Response. Instruction that provides opportunities for students to develop language and conceptual understanding by physically doing an activity or engaging in the concept being taught.

Standards at a Glance

ELP Standards

The English Language (ELP) Standards ¹ developed for k-12 by the Ohio Department of Education highlights the necessary language skills and knowledge that ELLS require to be successful in schools and meet the college and career ready standards.

ELP consists of 10 standards that describe a set of language functions (what students do with language to accomplish content-specific tasks) and language forms (vocabulary, grammar, and discourse specific to a particular content area or discipline) that are required by English language learners as they develop competence in English language arts and literacy, mathematics, and science. Below are the ten ELP standards defined by the ODE:

1. Construct meaning from oral presentations and literary and informational text through grade-appropriate listening, reading, and viewing
2. Participate in grade-appropriate oral and written exchanges of information, ideas, and analyses, responding to peer, audience, or reader comments and questions
3. Speak and write about grade-appropriate complex literary and informational texts and topics
4. Construct grade-appropriate oral and written claims and support them with reasoning and evidence

¹ Source Ohio Department of Education: <http://education.ohio.gov/getattachment/Topics/Other-Resources/Limited-English-Proficiency/ELL-Guidelines/Ohio-English-Language-Proficiency-ELP-Standards/ELP-Content-Standards-20150824.pdf.aspx>

5. Conduct research and evaluate and communicate findings to answer questions or solve problems
6. Analyze and critique the arguments of others orally and in writing
7. Adapt language choices to purpose, task, and audience when speaking and writing
8. Determine the meaning of words and phrases in oral presentations and literary and informational text
9. Create clear and coherent grade-appropriate speech and text
10. Make accurate use of standard English to communicate in grade-appropriate speech and writing

The ELP Standards can also be framed in relation to narrower domains of listening, speaking, reading, and writing and also in relation to broader receptive, productive, and interactive modalities. (See mapping table)

Mathematics Standards

Mathematics content standards² define what students should understand and be able to do in their study of mathematics. The content standards are grade-specific but do not define the intervention methods or materials necessary to support students who are well below or well above grade-level expectations. It is also beyond the scope of the Standards to define the full range of supports appropriate for English language learners and for students with special needs.

² Source Ohio Department of Education: <http://education.ohio.gov/getattachment/Topics/Learning-in-Ohio/Mathematics/Ohio-s-Learning-Standards-in-Mathematics/Math-Standards.pdf.aspx>

The Standards for Mathematical practice describe varieties of expertise that mathematics educators at all levels should seek to develop in their students. There are eight standards for mathematical practice. These are included in the following section.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Mapping ELP Standards and Math Practices

Modalities	Domains	ELP Standards	Math Practices
Receptive Modalities	Listening and Reading	1. Construct meaning from oral presentations and literary and informational text through grade-appropriate listening, reading, and viewing	MP1 Make sense of problems and persevere in solving them.
		8. Determine the meaning of words and phrases in oral presentations and literary and informational text	MP1 Make sense of problems and persevere in solving them.
Productive Modalities	Speaking and Writing	3. Speak and write about grade-appropriate complex literacy and informational texts and topics	MP1 Make sense of problems and persevere in solving them. MP6 Attend to precision
		4. Construct grade-appropriate oral and written claims and support them with reasoning evidence	MP3 Construct viable arguments and critique reasoning of others MP6 Attend to precision
		7. Adapt language choices to purpose, task, and audience when speaking and writing	MP6 Attend to precision
Interactive Modalities	Listening, Speaking, Reading and Writing	2. Participate in grade-appropriate oral and written exchanges of information, ideas, and analysis, responding to peer, audience, or reader comments and questions	MP1 Make sense of problems and persevere in solving them MP6 Attend to precision
		5. Conduct research and evaluate and communicate findings to answer questions or solve problems	MP1 Make sense of problems and persevere in solving them
		6. Analyze and critique the arguments of others orally and in writing	MP1 Make sense of problems and persevere in solving them MP3 Construct viable arguments and critique reasoning of others

Table 1: Mapping ELP standards to Math Practices standards published by the Ohio Department of Education

Vocabulary List

Creating an instructional program that promotes vocabulary instruction as a strategy to teach academic language to ELL students is crucial to the success of their math content and academic language learning. Learning academic vocabulary requires more than just learning conversational language because this academic language is more specific and sometimes abstract, making it difficult to grasp by ELLs. Here is a list of some of the vocabulary words that I believe should be included in any vocabulary instructional program in the math classroom, especially before and during Algebra instruction. This list is organized in 4 levels and they are based on the book *Building Academic Vocabulary Teacher's manual* by Marzano and Pickering (2005).

Level 1	Level 2	Level 3	Level 4
Above	2-dimensional shape	3-dimensional shape	Absolute value
Addition	Acute angle	Addition of fractions	Acceleration
Area	Addend	Algebraic expression	Add radical expressions
Behind	Addition algorithm	Alternate interior	Addition
Below	Angle	angle	Algebraic function
Between	Angle unit	Angle bisector	Angle depression
Cardinal number	Area	Area model	Arc
Chance	Associative property	Array	Area
Circle	Bar graph	Axis of symmetry	Asymptote of function
Coin	Basic number	Circle formula	Binary system
Decrease	combinations	Circumference	Cartesian coordinates
Difference	Capacity	formula	Central angle
Direction	Centimeter	Combining like terms	Chord
Estimate	Circumference	Complementary	Circle
Foot	Classes of triangle	angle	Circular
(measurement)	Cluster	Composite number	Classes of functions

Level 1	Level 2	Level 3	Level 4
Graph	Common	Congruence	Combination
Greater than	denominator	Conjecture	Compound interest
Grouping	Common fractions	Constant difference	Conditional
Guess and check	Commutative	Constant rate of	Continuous
Height	property	change	Control group
Hour	Constant	Constant ratio	Correlation
In front	Corresponding	Convert	Cosine
Inch	angles	Coordinate	Curve
Increase	Corresponding sides	Counter example	Dependent
Inside	Cube	Counting	Dilation
Left	Cylinder	Cube number	Discrete
Length	Data	Cube root	Divide
Less than	Data collection	Cubic unit	Divide radical
Location	Decimal	Data	expressions
Measuring cup	Diagram	Deductive	Domain function
Minute	Different	Defining	Equivalent
Model	Distributive property	Dilation	Expected value
Money	Dividend	Distance	Exponent
Near	Divisibility	Enlarging	Exponential function
Number	Division	transformation	Factorial
Number line	Equation	Equal ratios	Finite graph
Numeral	Equilateral triangle	Equation	Fraction
Numeric pattern	Equivalent fractions	Experiment	Function notation
Ordinal number	Estimation	Exponent	Geometric function
Orientation	Even numbers	Exponential notation	Imaginary number
Outcome	Event likelihood	Fair chance	Isometry
Outside	Expanded notation	Frequency	Law of probability
Pattern	Extreme value	Graphic	Limit
Pound	Factors	representation of	Line equation
Prediction	Fraction	function	Line segment
Rectangle	Function	Growth rate	Line segment
Right	Geometric pattern	Input/output table	congruence

Level 1	Level 2	Level 3	Level 4
Ruler	Greatest common	Integer	Line segment similarity
Second (time)	factor	Intercept	Linear
Set	Growing pattern	Intercepting lines	Minimum/maximum of
Shape	Histogram	Irregular polygon	function
Similarity	Horizontal axis	Large sample	Monomial
Size	Identity pattern	Line symmetry	Multiply radical
Square	Improper fraction	Linear arithmetic	expressions
Subtraction	Inequality	sequence	Natural number
Sum	Intersection	Linear equation	Negative exponent
Table	Irrelevant	Mathematical	Parallel
Temperature	Isosceles triangle	expression	Pi
Time	Less common	Maximum	Polynomial
Triangle	multiple	Minimum	Postulate
Under	Line graph	Multiple	Powers
Volume	Linear pattern	Number property	Probability
Week	Mass	Odds	Proof
Whole number	Mean	Ordered pairs	Protractor
Width	Measurement	Parallel figures	Pythagorean theorem
Year	Median	Percent	Radical expression
Zero	Meter	Perimeter	Radius
	Metric system	Perpendicular	Range of function
Some words	Midpoint	Plane	Rational function
needed to	Mixed numbers	Polygon	Real numbers
understand math	Mode	Prime factor	Reciprocal
problems:	Multiple	Problem	Recursive
	Multiplication	Projection	Reflection
Analyze	Negative number	Proportional	Regression
Answer	Number of faces	Quadratic equation	Relative
Complete	Number pairs	Quadrilateral	Right triangle
Describe	Number sentence	Random	Roots and real numbers
Evaluate	Obtuse angle	Range	Rotation
Examine	Odd numbers	Rate	Sample

Level 1	Level 2	Level 3	Level 4
Explain	Order of operations	Rational number	Series
Find	Parallel lines	Rectangle	Similar
Graph	Parallelogram	Rectangular	Similar figures
Investigate	Part to whole	Recursive sequence	Speed
Mark	Pattern	Reflection	Standard
Observe	Percent	Root	Statistic
Resolve	Perimeter	Rotation symmetry	Strategy
Ruler	Perpendicular lines	Sample	Subtract
Solve	Pie chart	Scale	Summary
Study	Positive number	Scatter plot	Surface area
Survey	Prime factorization	Scientific notation	Systems of equations
	Prime number	Sequence	Systems of inequalities
	Prism	Similar	Tangent
	Probability	Similarity vs.	Term
	Process of elimination	congruence	Theorem
	Product	Simplification	Transversal
	Proof	Slope	Trigonometric
	Pyramid	Slope intercept formula	Two-way tables
	Quotient	Solid figure	Unit
	Rectangle	Solution	Vector
	Rectangle prism	Square number	Velocity
	Reduced form	Square root	Vertex
	Relative distance	Square units	
	Relevant information	Substitution	
	Remainder	Supplementary angle	
	Repeating pattern	Table representation	
	Restate a problem	Thermometer	
	Rhombus	Trapezoid formula	
	Right angle	Tree diagram model	
	Rotation	Triangle sides	
		Underestimation	

Level 1	Level 2	Level 3	Level 4
	Rounding	Unit size	
	Same size units	Variable	
	Sample	Vertex	
	Scale	Volume formula	
	Shape	Volume of cylinder, prism, and pyramid	
	Sphere	Work backward	
	Standard	Written representation	
	Subtraction		
	Surface area		
	Survey		
	Symbolic representations		
	Tallies		
	Time zone		
	Triangle formula		
	Unit		
	Unlike terms		
	Venn diagram		
	Verification		
	Vertical axis		
	Volume		

Instructional Strategies

The following tables include a series of teaching strategies and suggestions that represent the culmination of comprehensive research on how to integrate instructional strategies used during English instruction into the math content class in order to facilitate the teaching of mathematics academic and vocabulary content to ELLs. These recommended best practices and strategies have been summarized in the below charts based on the following categories:

1. **Teacher Knowledge and Understanding**, including second language acquisition, math academic language and vocabulary knowledge.
2. **Teacher Planning and Organization**, including planning techniques, classroom management and room organization.
3. **Teacher Attitudes and Dispositions**, including beliefs, attitudes, and awareness of student background knowledge.

Knowledge and Understanding	<ul style="list-style-type: none"> • Face your class when you are speaking to them • Use simple sentence structure and vocabulary • Minimize the use of idiomatic expressions • Model or demonstrate directions • Always speak in a normal tone (not louder) • Avoid overstressing correct pronunciation and grammar • Teach groups of words that are related together • Remember it can take two to seven years for a non-English speaker to acquire academic language
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Planning and Organization

- Simplify your language but not the concept when you are planning your lessons
- Announce and write objectives on the board
- State objective orally at the beginning of each lesson
- Review objectives at the end of each lesson
- Give students plenty of time to copy your notes
- Allow sufficient wait time or think time
- Write legibly, many ELLs cannot read cursive. Write in print
- Use the chalkboard or overhead projector to write important words and ideas
- Incorporate pictures and objects to teach new words and concepts
- Incorporate hands-on activities into each lesson
- Use objects like visuals displays, photos, and authentic materials such as newspapers and magazines
- Use manipulatives to promote hands-on activities and understanding of difficult concepts
- Use real objects (realia) to help students understand
- Use graphic organizers to simplify the language (timelines, diagrams and webs
- Label objects in the classroom in English
- Provide a list of directional words (write, read, underline, circle, match, add/subtract, trace, draw, cut)
- At the end of the lesson, summarize the main idea
- Use group assignments
- Reduce the number of test questions, simplify
- Design appropriate rubrics for assignments
- Allow students to demonstrate knowledge in drawings, posters, visual representations

Attitudes and Dispositions

- Learn the student's given name
- Never discourage parents from speaking with their student in their native language
- Never discourage student to speak their native language in the classroom. Establish common rules during instructional time
- Help student to feel part of the classroom
- Remember that some students have low levels of literacy and may not know the English alphabet
- Emphasize key words and phrases using intonation, repetition, and gestures
- Add elements of student's culture in your writings (problems)
- Make information comprehensible (comprehensible input)
- Encourage student to indicate when he/she does not understand you
- Employ daily routines in classroom activities
- Post a schedule in the classroom or provide a picture schedule
- Check frequently for comprehension (ask questions, think pair-share, etc.)
- Instead of asking students "do you understand?" ask students to reword or explain
- Avoid oral correction of language errors, instead model correct usage
- Consider giving ELL students a second chance to correct errors before grading

Helpful Resources and Websites

Colorin Colorado

<http://www.colorincolorado.org>

CPM Math Homework

<https://homework.cpm.org/cpm-homework/>

FluentU Educator Blog

<https://www.fluentu.com/blog/educator-english/esl-math/>

Free Rice

<http://freerice.com/category>

Kahoot

<https://kahoot.com>

Khan Academy

<https://www.khanacademy.org>

Ohio Department of Education

<https://education.ohio.gov>

Prodigy Math

<https://www.prodigygame.com>

SAT Free Practice

<http://www.satfreepractice.com>

Ten Marks

<https://www.tenmarks.com>

TEACHING ACADEMIC VOCABULARY: AN EXPLORATION OF BEST TEACHING PRACTICES

SECTION FIVE

Professional Outreach Plan

The outcome of this curriculum development project is a handbook titled “Math Academic Vocabulary for ELLs: An Exploration of Best Teaching Practices.” This handbook summarizes a set of best practices in teaching Mathematics academic language to ELLs and is based on a detailed analysis of well-known researchers, educational publications and personal experiences in English language acquisition process and mathematics content area development.

From day one, the goal of this project has been to investigate, acquire personal knowledge and understand what the best teaching practices are when teaching ELLs. These practices should not only help ELLs to acquire English as a second language but more importantly help them to develop their math academic language and be successful in math classes. Acquiring academic math vocabulary is a foundational requirement for ELLs to understand math content, solve math problems and be successful in the math classroom. I strongly believe that new ESL teachers, mainstream teachers and ELLs will benefit with the creation of a program that incorporates vocabulary instruction and best teaching practices as a core component of their curriculum. This in turn will benefit students, as appropriate implementation of these best teaching practices, will facilitate their learning and allow them to develop stronger math academic vocabulary and content.

As with many theories and best teaching strategies in the education field, teachers will face challenges and barriers to implementation in their daily work. Examples of these include: (1) Lack of implementation techniques and strategies for the English Language

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Proficiency (ELP) and Mathematics standards defined by the Ohio Department of Education. Both standards describe a set of language functions and language forms- what students do with the language- and define what students should understand and be able to do with the study of mathematics. These standards do not specify what to teach and how to do it which can be overwhelming for first time teachers and teachers who do not have experience working with ELLs. (2) Gaining support of school district administrators, curriculum and instruction officers and school principals to incorporate vocabulary instruction as part of the curriculum maps at the school district and/or building level. (3) Difficulty finding professional development days that include sessions that incorporate the latest instructional techniques about academic language and second language acquisition. (4) Finding the time in teachers' busy schedules to incorporate vocabulary instruction in their lesson plans. Teachers are not only responsible for instruction in the classroom but they also have many administrative responsibilities and tasks they need to comply with. (5) Finally, I believe the most important barrier is teachers' motivation which plays a critical role in the development of any vocabulary instruction program. Teachers that respect and value students' language and home culture create an atmosphere where they can learn from each other and establish trust and a deep connection. Teachers' attitudes and dispositions play an important role in students' success. I hope that teachers feel motivated enough to take on additional work added to their curriculum and lesson plans.

It is my desire to share this handbook with the ESL administrators, school administrators, middle school and high school math department chairs, ESL teachers, math content teachers and colleagues in my school district. I plan to disseminate both

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hard and electronic copies of this handbook to teachers and colleagues in my school district who are interested in learning more about this topic. My hope is that this curriculum development project can help teachers make a difference in their daily instruction and more importantly can help ELLs improve their English proficiency and feel that their home language, background knowledge, and culture is valued and appreciated.

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