



Math and English for Academic Purposes

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Introduction

Even though math is thought to be mostly numbers, there is a significant amount of language involved. Students do not have to know only the discipline-specific vocabulary, or jargon, associated with math, but they also have to understand other forms of language in and out of the classroom. For example, instructors will work problems out on the board while discussing the steps orally to go from one part of the problem to the next which may not align with what the teacher is writing on the board, so there is potentially a loss of comprehension on the student's part. Additionally, instructors will give instructions in class or give information on specific dates for exams, quizzes and homework which is sometimes given orally or written on the board. Asking questions during class and following transitions between activities can be another challenge for second language learners who struggle with language in a math class. Another aspect of language present in a math course is in the textbook. Students will often be assigned chapters or sections to read in order to prepare for an upcoming class. The textbook is written using the disciplinary language of math, which makes it difficult to follow especially because definitions of math words are often defined with other math jargon. With such rich language and classroom interaction, it is imperative to not overlook the subject of math when discussing English for Academic Purposes.

English for Math Class

Discipline Specific Language

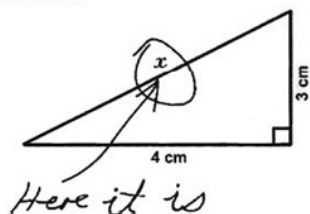
3. Find x .

Figure 1: Understanding jargon

Find x. The image in Figure 1 (Funny Stuff - Exam Answers, 2006) has been circulating the Internet for years as a funny joke. This, however, is not funny to English language learners enrolled in a math course without understanding the language of mathematics. The word *find* in math has a different meaning depending on the discipline-specific language of math. In order for a word to be considered learned, the learner must know the sounds that make up the word (phonetics/phonology), the meaning behind the word (semantics), and the use of the word (syntax). Often, a word like *find*, with a different meaning in math than in day-to-day use, can cause a second language learner to struggle to answer a question that would otherwise be straightforward. In fact, there are numerous words that are found in math and in other fields or day-to-day language that have a meaning specific to math, such as *evaluate*, *solve*, *identify*, *simplify*, *function*, *limit*, *variable*, *complex*, *degree*, *power*, *point*, *square*, *root*, or *radical*. Students must recognize these words with their new meanings – often not found in a translator – and apply them to the math they are learning. Therefore, students learning math must not only learn how to do the math itself, but also must learn the words in order to understand what the instructor is discussing or which directions to follow. For example, consider the following set of math problems.

1. *Evaluate the expression.* Let $x=0$, $(x+3)(x-5)$
2. *Solve.* $(x+3)(x-5)=0$

The first problem has the answer of -15 while the second has two answers, -3 and 5. If students do not know the difference between *evaluate* and *solve*, they would potentially lose points as they are very different instructions in math. The points lost may not be due to the student not understanding the math, but rather lost due to the student not understanding the concept of *evaluate*, which is allowing a variable to represent a number

and performing the indicated operations. Previewing chapters or having vocabulary lists can be a tremendous help to students learning math and the language of math, especially with examples the students can follow. Instructors can aid this process by creating vocabulary lists, or even adding definitions and examples, for second language students.

Application Problems

Another area where students struggle, especially second language learners, is with application problems (also called word or story problems). Application problems ask students to create an equation or expression from an English sentence consisting of words and numbers. In order for a student to successfully complete an application problem, there are three steps that students must master. The first step is to read the application problem for basic language comprehension. The second step is to understand the mapping between the words of English and the language of math. The third step is to understand the math concepts that are driving the problem. In the following problems, taken from Spector (2017), second language students may struggle with all three of these aspects.

1. Jane spent \$42 for shoes. This was \$14 less than twice what she spent for a blouse. How much was the blouse?
2. The sum of two consecutive numbers is 37. What are they?

In the first problem, the student must understand the English words *Jane*, *spent*, *blouse*, *less*, and *twice* in addition to the dollar amounts or what the dollar symbol means. In this particular problem the name and the article of clothing may be the only two areas that are challenging, but in other problems, where the language is more obscure or less frequent, this part of comprehending an application problem can cause difficulty. Once the student understands the language, it is important that the student can map the English to a mathematical expression or equation. The student must understand that the first sentence *Jane spent \$42* is the result and one side of the equation in addition to the sentence itself cueing an equation rather than an expression.

Understanding words like *less than* and knowing that, in this particular example, this means subtraction (-) rather than the less than symbol (<), is crucial in creating the equation. Furthermore, the student must

understand how the language *\$14 less than twice what she spent for a blouse* relates to the first sentence *Jane spent \$42*. What makes this particular problem challenging is the phrase *less than twice* which is difficult to parse whether the \$14 is written before or after the subtraction sign. Once the student has created an equation from the words, the student must be able to complete the math.

The second problem has fewer words but still requires substantial mathematical understanding on the student's part. The entire equation is in the first sentence of the problem. Students must understand the word *consecutive* and how to write that in math ($x, x+1$). The student also must map the word *is* to an equal sign (=). The last step, then, is to solve the equation created from the application problem.

Application problems are typically considered difficult not just by non-native English speakers learning math in an English environment, but also by native English speakers. These problems require students to stretch their knowledge base and apply what they have learned in a new manner. The second step, mapping the English to the math is incredibly difficult for most math students. The first step, having the basic language comprehension to read the problem, however, is typically only challenging to non-native speakers. This can be helped by students pre-reading the unit, asking the instructor or other students for clarification, or using a translator (in some cases). Although application problems are difficult, they are not the only difficult aspect in math classes for second language learners.

Following Directions

Understanding how to solve application problems and learning the discipline-specific vocabulary of math is only part of the puzzle. Students must also be able to follow the directions and steps in a lecture or class. Math instructors will often write while they talk, working out steps of math problems and examples on the board. Sometimes teachers write down the English steps next to the math, but it is often the responsibility of the student to write down the words with the numbers. This can be a two-pronged problem for non-native English speakers. The first part of the problem is following the pace of the class and understanding the words the instructor is saying. This can be challenging in that the second language student is learning new vocabulary at a (sometimes native-speaker's) quick speed and learning the new concepts in math simultaneously. The

second part of the problem is that the student may not know how to take adequate notes in English in a math class. Being that math class is thought to be number-heavy, students, even native English-speaking students, often think simply writing down the steps from the board is sufficient. Later, students return to their notes only to find that they cannot recall how they went from step 3 to step 4 or how they arrived at the final solution. Most math classes are partial-credit based meaning that students can earn credit for an incorrect answer if the work is correct. Not understanding the steps can unnecessarily cause the students to lose points.

Asking Questions

Second language students often have difficulty asking questions in class. To ask a math question, the student needs to know the correct math words and phrases. For example, if a student were given the following expression to factor, the student may have questions about completing the process.

$$\text{Factor. } 4x^4y^3 + 8x^2y^4 - 12x^3y$$

A student may ask any of the following questions when factoring the expression: *what is the greatest common factor? What is the lowest degree of the x-variable? What is the largest coefficient that I can factor out? Which term should I look at first?* The words and phrases, *greatest common factor, degree, variable, coefficient, factor, term,* are discipline specific. Without knowing these words and phrases, students are potentially left trying to understand the problem without being able to ask about it.

If students are missing the vocabulary, directions to work with math problems, instructions, and important dates, then they are not likely to have the minimal understanding needed to be able to ask a question during class. Instructors can help students by asking comprehension questions to second language learners to better understand if students are following the material. Comprehension questions can have various degrees of difficulty and can be asked privately. Checking for comprehension will give quick feedback to what the second language learner is acquiring from the lesson.

If students have a question, they may turn to the textbook, which is another major source for language. The math textbook is written in such a way that it is difficult to follow, even at lower levels of math, if the

student “does not speak math.” However, further examination of a math textbook will yield a well-organized hierarchy with language support. Chapters are broken down into sections with examples in each section. Jargon, discipline-specific words, are often highlighted in a manner that makes them easier to find, although not always easier to define. The authors typically use color or other fonts to offset important information. Students who can follow this hierarchy and break down the cues will be better served by the textbook. However, it may be up to the instructor to teach a second language learner how to access and understand the information in the textbook.

English for All Classes

Another situation where language can interfere is with instructions from class. Instructors will orally assign homework, give test information such as what is on the test or when the test is, and will discuss other information pertinent to the class. Students who cannot follow along may miss crucial information to their success in the class.

Related to listening to instructions, transitions may be difficult for second language learners to follow. Transitions between math problems and activities, or moving from one section to the next can challenge students who are learning English. If students are finding it difficult to follow the language of math, they may also struggle to see the boundaries between two activities. Some teachers will use explicit transition words and phrases while others will not. Second language learners can sometimes glean non-verbal cues from their classmates and the instructor, such as other students flipping pages or shifting in their seats or the instructor pausing and erasing the board, but these cues are not always consistent with transitions. It is most helpful when instructors use explicit transition language for second language learners to be able to track during class.

How Instructors Can Help

Instructors who have a second language learner in their class may find it best to talk to that student before or after class privately. In this short meeting, the instructor can check for comprehension, acquire feedback of how the student feels during class and how the student is tracking, and can show a personal interest in that student, thus potentially boosting confidence. Instructors can also address potential cultural differences,

such as working in groups, approaching the teacher due to power distance differences, and understanding homework expectations. Also during this short meeting, the instructor can address the pace of speaking during class or when speaking directly to the student. Often, even native speakers would benefit from their math instructor slowing down to a degree while lecturing.

Conclusion

Even in a math class there can be a language barrier. There is a substantial amount of language in the math class. From the word level, jargon, to the sentence level, asking questions, to the paragraph level, reading chapters and meeting with the instructor, language is everywhere in a math classroom.

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