Challenges That English Language Learners at College Level Encounter When Studying Mathematics

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Abstract

A number of students who are non-native speakers of English are expected to undertake the two-fold task of simultaneously learning a new language and content area. The issue becomes critical and challenging when these students have only started learning the language at a later stage of their educational journey, like in college level. They are supposed to study a mathematics course in English at the same time. The purpose of this pilot study is to identify the challenges that English Language Learners encounter when studying a content area of mathematics. It also aims to identify similarities between teaching Math and English, and finally examines the possibilities of collaboration between English and Mathematics teachers to support the learners. A pre-teaching knowledge assessment was run in class for a number of students, before start teaching mathematics. It aimed to explore what math vocabulary the students already knew before start learning the subject in English for the first time in their whole years of academic studies. The results of the assessment showed a lack of basic math vocabulary amongst the learners. On the other hand, a survey was conducted amongst both Faculty, math and English to collect their opinions about challenges that ELLs encounter, to explore the similarities between teaching math and English, and then to find out the possibilities of collaboration between both faculties to support the learners. The results suggest Faculty realizes that students encounter a challenge in learning English and math simultaneously, and they are willing to collaborate.

Keywords: Collaboration, Mathematics, English, Language, ELLs, IELTS, Limitations, Barriers, Challenges, Difficulties.

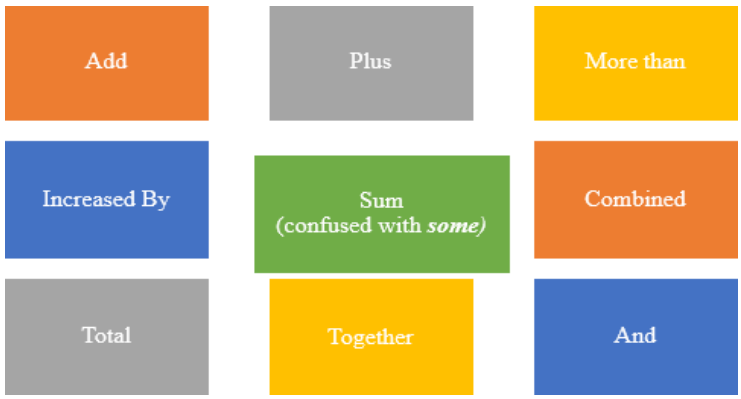
Introduction

English Language Learners at College *Foundations* level learn mathematics as well, which is mediated through English. The limitations of English language lead to limitations of learning mathematical concepts especially when ELLs are expected to be eventually able to understand and solve real-world exercises and problems. This paper argues that (1) ELLs encounter challenges when studying a subject content, (2) that teaching Math is similar to teaching English, and (3) that collaboration between teachers would support ELLs. A pilot study was conducted for that purpose. A group of non-native speakers of English who are students of College Foundations program is given a brief initial pre-teaching assessment. The aim was to find out whether they were able to identify math vocabulary, expressions, and symbols in English. The results will help the teacher well plan the assigned math course that these students will study during the semester. On the other hand, English and Math Faculty responded to an online survey. The purpose was to probe their opinions about the challenges that ELLs encounter when studying mathematics, and how to support them through a collaborative effort from all concerned teachers. The small-scale pilot study focused on four major issues:

- Identifying the challenges & difficulties that ELLs face at College Foundations level.
- Identifying the importance and benefits of collaboration between English and content teachers.
- Identifying barriers to collaboration
- Proposing ways of collaboration.

Literature review

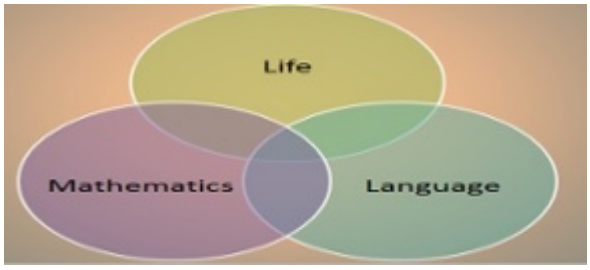
"Mathematics can be particularly challenging to ELL students because mathematical knowledge consists of three components: linguistic knowledge, conceptual knowledge, and procedural knowledge." (Moore-Harris, 2005). Learners come with a limited number of necessary mathematical vocabulary. They may get confused when they realize that the "addition" operation, for example, may appear in a variety of different terms.



They also discover that some terms do not always translate as should, like in the case of using "Some" and "Sum." The content course may also introduce examples, exercises, and word problems that may not be relevant to learners' lives. The students also find it difficult to understand what may appear as an abstract concept to them. According to Haynes (2009), "Problem solving is not just language but a thought process." Consider the following real-world problem:

A pancake recipe requires two and one quarter cups of milk to one cup of flour. If three and three quarter cups of milk are used, what quantity of flour will be needed, according to the recipe?

In this word problem, learners need to understand the meaning of a fractional amount, and how to mathematically write it, need to figure out the syntax, and above all they should know key vocabulary. They should also be able to create a relationship between different variables, and finally, come out with a way to solve it. Unfortunately, some English language learners may resort to what one may call a surface learning by reading an explanation of how to solve such a problem, and then "imitate" the solution by only manipulating or replacing the given numbers, which is a rote learning of math. There are three dimensions of word problems that students should pay attention to- the genre (language), mathematical structure, and personal experience (life). The three aspects are interrelated as shown in the figure below. (Bryant, 2014)



The culture differences may also not help the students to adopt the correct procedures when solving a math question. This matter may include, for example, reading and writing from right to left, mixing up between using commas and points, and being familiar with certain systems of measurement and not another such as Metric System. There is a misconception amongst some students and educators that Mathematics is just arithmetic. It is not! (Haynes, 2009). Teachers should be aware of the fact that the learners must acquire sufficient lingual abilities and skills in the language of the medium in a way that would qualify them to learn the subject matter. In the absence of such qualifications, the learners will be receiving a rote learning that has no meaning and does not relate to real life. Lack of English language knowledge may also result in low self-confidence. Texas State University System (TSUS) and Texas Education Agency (TEA) collaboratively produced The Teachers Guide to Teaching Mathematics for English Language Learners (2005).

The guide argues that ELLs sometimes have reservations about participating and interacting in class, asking questions, attempting a task, showing work, and explaining answers, due to limited vocabulary and language proficiency. There is then, a need for collaboration between English teachers and subject teachers to support these ELLs. The collaboration will help and support all the stakeholders. It will enable the learners to comprehend better the mathematical concepts that they are learning, and at the same time develop their language communication skills. It will give the subject teacher the opportunity to introduce more real-life word problems, which stands as a core learning objective. Finally, English teachers will be able to add more mathematical terms, words, and expressions to enrich their course. The collaboration should be seen as an easy process because there are so many commonalities between English and math. Both are learned through structures: Math through rules, and

English through Grammar. Both follow up a building-up process i.e. an accumulation of knowledge. Both are taught through visualizations and illustrations. Gough (2007) suggests that "mathematics is not a natural language but a formal language, artificially constructed, using our everyday natural language in teaching the mathematical language." (Leshem & Markovits, 2013). But, is the translation from English to mathematics similar to translation from English to French for example?
Consider the following question found in most mathematics courses:

Translate *the sentence into an equation.*
Use x as a variable
"Eight times the sum of a number and 6 equals 10".
The question starts with the term "Translate" which is a process taking place between two "*Languages*", yet this a different kind of translation, because mathematics language has its own nature. Barwell (2002) states that "Mathematical discourse has a number of distinctive features, including some aspects which are particular to mathematics classrooms." He describes these features as mathematics disclosures, and list them as the "mathematical vocabulary, the mathematics specialist syntax, the mathematical symbols, the specialized mathematics ways of talking, and finally the social dimension." It is the responsibility of the teachers to create situations in class where learners can practice translation to mathematics through these five features.

Method
Collins Dictionary defines a pilot study as a "small-scale experiment or set of observations undertaken to decide how and whether to launch a full-scale project." It stands as a crucial element of a good study design (Teijlingen and Hundley, 2001). (Crossman, 2016) argues that pilot studies are useful because they help the researcher to "identify or refine a research question, identify or refine a hypothesis or set of hypotheses, identify and evaluate a sample population, test research instruments like a survey or a questionnaire, and assess and decide upon research methods." This pilot small-scale study was conducted in one college only. The participants were merely a small population of Foundations students and their respective teachers. If it proved feasible and advantageous, then it would be extended it to a full-scale study to include much larger number of participants, and in more than one college. It was both, quantitative and qualitative. Quantitative, because it includes a survey and a questionnaire. On the other hand, it is a qualitative one, because it describes a problem that ELLs, and teachers of Math and English are trying to deal with. (Teijlingen and Hundley, 2001) argue that "One of the advantages of conducting a pilot study is that it may give advance warning about where the main research project could fail, where research protocols may not be followed, or whether proposed methods or instruments are inappropriate or too complicated". However, pilot studies have their own disadvantages and limitations. These include the possibility of making inaccurate predictions or assumptions on the basis of pilot data; problems arising from contamination; and problems related to funding. (Crossman, 2016). The participants of this pilot study will not be part of the full-scale study, and the data produced will not be used as well. This kind of arrangement will eliminate the possibility of contamination. It will also render a more valid and reliable study.

Study design

A) Pre-teaching assessment

High-school graduates, who are Arabic native speakers, join the Foundations program at the college before starting a specialized program. These newcomers have spent twelve years of schooling in a non-English medium. They arrive at college with a feeble English language if any, and so they will have to join an intensive English program. Alongside the intensive English course, they must learn two courses of mathematics in a non-native language. The Foundations program is a one-year duration, at the end of which learners sit for an IELTS, The International English Language Testing System to determine whether they have the ability to complete their course of study where the medium is English. They should score an overall band of 5 or more. Also, the learners will have to pass the Math One and Math Two successfully. As part of the pilot study, initial pre-teaching mathematics assessment was produced, but in English. The aim was to find out, and before start teaching the designated math course, what students knew about English math vocabulary, symbols, expressions, etc…

Since new knowledge and skill is dependent on pre-existing knowledge and skill, knowing what students know and can do when they come into the classroom or before they begin a new topic of study, can help us craft instructional activities that build off of student strengths and acknowledge and address their weaknesses.(The Simon initiative, 2008)

A small population of fifteen students was asked to take this test on the first day of their first college semester. There were no written instructions on the test paper as shown below, because they will simply be hard to understand and follow. Besides, this was like a chance for them to write what comes to their mind without being restricted to follow specific directions. The students were merely told to fill in the column on the right- hand with whatever they knew about each of the symbols, numbers or sentences that appeared in the left-hand column, but in English. They were given thirty minutes to complete this task.

1	+	
2	-	
3	÷	
4	**x**	
5	<	
6	≥	
7	=	
8	***One million ten thousand***	
9	***Seven thousand five hundred nine***	
10	**29**	
11	**1025**	
12	**3520**	
13	**3.5**	
14	**Give one even number**	
15	$\frac{1}{9}$	

Analysis of results of the pre-teaching assessment.
[Correct answers with spelling mistakes. were accepted]

	Percentage of correct/acceptable answers	Samples of answers and comments
+	**71%**	add, (plas), plus, (Give one and more one), (Give more number), (place), (plast), and, (pluse)
-	**57%**	Minus, (minas), (mines),(minic),(mince),(maines)
÷	**7%**	(divid)
X	**7%**	(time)
<	**7%**	(big number in right)
≥	**14%**	(big number in left)
=	**7%**	(same)
One million ten thousand	**0%**	(100100), (1,10,000)
Seven thousand five hundred nine	**42%**	(7059),(7500)
29	**78%**	(towinty nine),(two nine), (twenty nigh)
1025	**50%**	(ten twenty five)
3520	**43%**	(one thousand fivete tow)
3.5	**43%**	(three million five), (three boint five)
Give one even number	**0%**	The students who responded to this part gave odd numbers instead
$\frac{1}{9}$	**43%**	(one and nigh), (one on nine), (one ÷ nine)

The results of the pre-teaching initial assessment suggest that English Language Learners are not at the appropriate level of English. Consequently, they may not be able to learn a subject matter. Individual needs should be identified and any proposed learning plan must address these needs.

A) Teachers' Survey

Teachers of Mathematics and English for the Foundations level at the college, are a mixture of native and non-native speakers of English. However, all must teach and communicate with the students in English. This rule is set up to help the learners achieve the ultimate aim of developing their second language to the extent where they would able to continue their course of study in the new medium of teaching and learning. Teachers share the responsibility of making the transitional year between high school phase and the phase of specialization in the course of study, a successful one. Therefore, it was essential to this pilot study, to survey their opinions about the difficulties that ELLs encounter when studying English and math, any similarities in teaching the language and the subject matter, and aspects of collaboration among teachers. The main aim of this survey was to explore the possibilities of initiating a collaboration between English and Math teachers to support the Foundations students. **(**Wyse, 2012) states that "Conducting surveys is an unbiased approach to decision-making…and a survey results provide a snapshot of the attitudes and behaviors – including thoughts, opinions, and comments – about your target survey population." It was a four- question survey that would only take a few minutes to complete. (Shuttleworth, 2008) states that "You must keep your questionnaire as short as possible; people will either refuse to fill in a long questionnaire or get bored halfway through." Teachers were encouraged to respond because their feedback was valuable. The survey was conducted online to ensure privacy and render a non-intimidating circumstances.

In a non-intimidating survey environment, you will learn about what motivates survey respondents and what is important to them, and gather meaningful opinions, comments, and feedback. A non-intimidating survey environment is one that best suits the privacy needs of the survey respondent. Respondents are more likely to provide open and honest feedback in a more private survey method. Methods such as online surveys, paper surveys, or mobile surveys are more private and less intimidating than face-to-face survey interviews or telephone surveys. **(**Wyse, 2012)

Analysis of Survey results

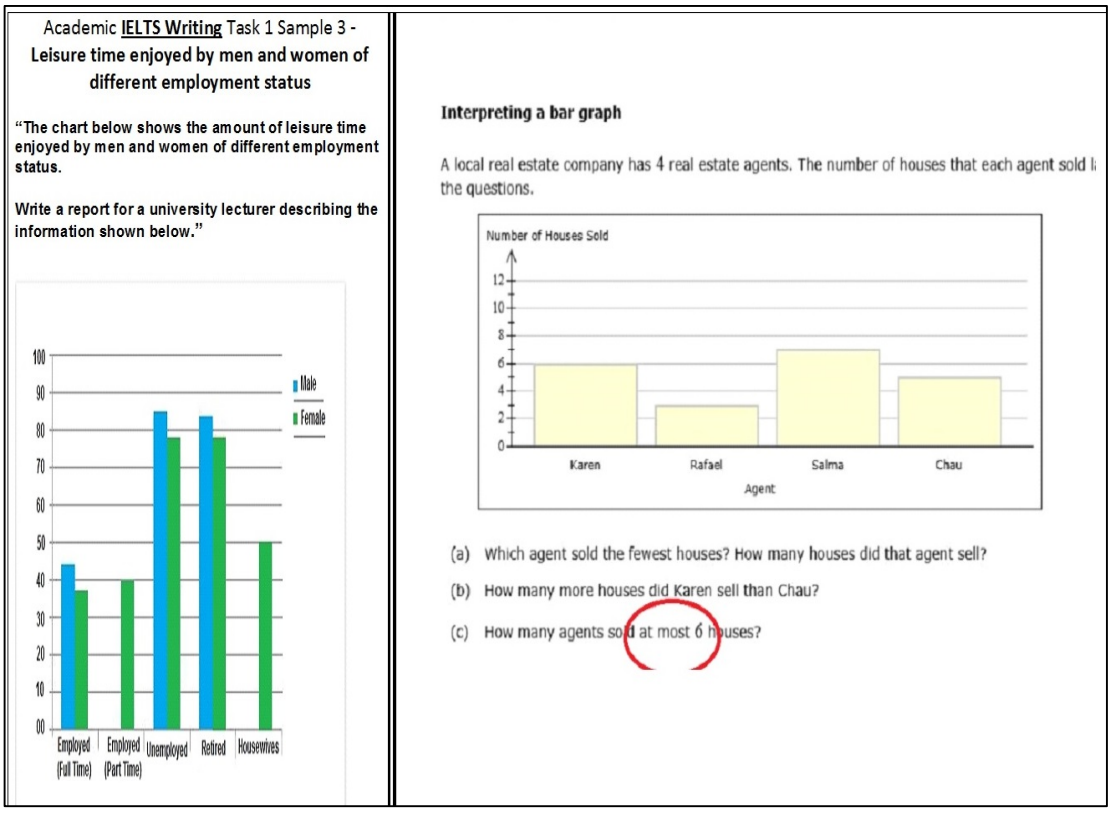
Twenty two teachers of English and math, out of total of forty one, responded to the survey. Here is a summary and analysis of responses to each question:

Q.1 Do you agree with the following statements?

	Agree	Neutral	Disagree	Total
Most of my foundations students have trouble learning a new language at college level.	72.73% 16	22.73% 5	4.55% 1	22
Most of my foundations students have trouble learning Math in a new language.	68.18% 15	31.82% 7	0.00% 0	22
Most of my foundations students have trouble dealing with the writing task of IELTS where they are required to analyze, interpret and discuss graphs, tables, and charts.	95.45% 21	4.55% 1	0.00% 0	22
English and Mathematics FND teachers share the responsibility of enabling the students to successfully learn both subjects.	68.18% 15	18.18% 4	13.64% 3	22
Some kind of collaboration between FND Math and English teachers may help our students perform better.	86.36% 19	9.09% 2	4.55% 1	22

The responses to the first statement indicate that learning English at the college level is not easy (Agree: 72.73%). The students did study the elementary level of English while they were at school. Was not sufficient? Should they be exposed to more advanced and intense English before joining college? There is a general opinion that young children find it easier to learn a second language than adults? Does it become difficult to pick up at an older age? (Schmid, 2016) conducted research that "does indeed suggest that our capacity to learn a language diminishes gradually over our

lives." (Weitz, 2011) argues that the little children minds "soak up foreign languages like a sponge." 68.18% agreed with the second statement. This rate is close to the first question result because learning math in a new language and at this age is a challenge for these ELLs. They still do not know the mathematical vocabulary, syntax, and symbols. Does the situation get better after the completion of the first math course? My teaching experience as a math teacher suggests that it does get better. The 95.45% agreement on the third statement does support the opinion that "Pupils are not adequately equipped with the critical thinking, graph literacy and reading skills to succeed in IELTS." (Pennington, 2016). The figure below shows a sample of a question in an English test, and the other one is an in a Math test. The first is the Academic IELTS* Writing task, where examinees are required to write a report for a university lecturer describing the information shown in a graph. They will have to read, interpret and analyze data. They should be able to compare similarities and differences, determine the significance and trends in the data. In the end, they will have to write a report describing all of the above findings. On the other hand, the Math test question is ALEKS* math course that is being taught at Foundations Level. Examinees are required to interpret the data and answer accordingly. It is clear that both questions demand both, an adequate level of English proficiency and mathematical knowledge and skill. It is an aspect where English and Math teachers can collaborate to support learners.



Q.2 Teaching Mathematics has been thought to be similar to teaching English because both are learned through structures (i.e. Rules in Math and Grammar in English). If you think there are other similarities in teaching Math and English, please describe them in a few words.

10 teachers responded to this question:

- I can't think of any apart from the formulaic structures that may apply to English language to an extent.
- Not really- just vocabulary is something that is shared. Math and grammar are not so parallel. Grammar has many exceptions and different kinds of restrictions.
- Sentence structure v/s equations
- They're quite different apart from in the teaching of structures but even then the approaches to teaching are probably different.
- Teaching structures
- Only in terms of learning structures. EFL uses every some of the same math language and symbols such as +. Otherwise it's very different.
- Practicing learned concepts is critical and necessary in both subjects. No practice/no progress. Imparting information through visual cues. Symbols and shapes in math vs. pictures and signs in English
- If both taught in English, then they share the same vocabulary
- I don't think that there are many similarities, but you students definitely need to learn some terminology in order to learn the math. I believe it is quite possible to learn math without having a sophisticated level of English.
- At the college, math is presented in English. If you're teaching a math lesson, you may have to teach an English question structure: Example: What percentage of ... How much?

Some teachers indicated other commonalities between English and Mathematics than learning structures, such as vocabulary, some symbols, and shapes.

Q.3 Based on your experience, which of the following mathematical skills and concepts may be helpful to foundations students? (Select one or more answers)

Answer Choices		Responses	
Reading numbers		75.00%	15
Recognizing and drawing shapes		40.00%	8
Counting numbers		45.00%	9
Reading and analyzing graphs and charts		100.00%	20
Performing operations (+,-, x, etc....)		50.00%	10
Reporting results		90.00%	18
Other (please specify):	Responses	10.00%	2
Total Respondents: 20			

The responses to question three, especially in the three choices of reading numbers, reading and analyzing graphs and charts, and reporting results, concur with the results of the statements in the first question.

Q.4Which of the following teaching methods and tools, may teachers of both English and Math collaboratively use to support learning of both subjects? (You may tick off more than one choice)

Answer Choices		Responses	
Share common vocabulary		100.00%	19
Use of hand gestures		21.05%	4
Use manipulatives		26.32%	5
Use charts and graphs		94.74%	18
Use sentence frames in Math classes		52.63%	10
Use mathematical language in English classes		78.95%	15
Other (please specify)	Responses	21.05%	4
Total Respondents: 19			

Sharing vocabulary seems to be the most effective tool that teachers can work on collaboratively. (Chung, 2012) states that "Vocabulary acquisition plays the most vital role in ELLs learning of the English language", and suggest that vocabulary knowledge would help the learners in closing the literacy achievement gap.

The 94.74% for the use of charts and graphs suggest that majority of teachers want to emphasize on the necessity of enabling the learners to develop critical thinking and analysis skills. It is also encouraging to see that 78.95% of teachers, most of which teach English, are willing to use mathematical language in their classes.

The four responses to the option "*Other*" are:

- *They need a preparatory class prior to ALEKS to learn the vocabulary of math*
- *The issue is time ... there is very little time to extend an already overburdened English curriculum*
- *To do this would require a Foundations re-organization. We also have much to prep students for, just for their English requirements. We have more hours, yes, but there is much to do for students who come knowing, in many cases, very little general English, let alone academic English. I posit this question: Are there any apps/websites/techniques that Math can borrow from English Foundations to better help your students (e.g. Kahoot, Socrative, etc.)?*
- *Awareness on both teams of what the other team is doing at any given time*
-

There is no doubt that the heavy teaching load does not allow for efficient collaboration between teachers. But, at least both faculty may start with sharing vocabulary. Perhaps the re-organization of Foundations program may allow for creating some kind of an integrated English and Math course.

Conclusion

College-Level English Language Learners at Foundations level encounter challenges when studying Mathematics. There is a necessity for collaboration between English & Math teachers to support these learners. This paper argued that (1) ELLs encounter challenges when studying a subject content, (2) that teaching Math is similar to teaching English, and (3) that collaboration between teachers would support ELLs. A pilot study was conducted for that purpose. A pre-teaching assessment was administered to a sample of learners, and a survey was run for both English and math teachers. The results of the assessment suggested that learners do have the appropriate level of English to study mathematics and that they will be challenged by the content area vocabulary, symbols, and syntax. About 50% of the teachers responded to the survey. Their responses showed there are similarities between teaching English and math. There was an indication that these teachers should collaborate amongst them, and that learners would benefit from collaboration. Ways and aspects of collaboration were suggested.

However, there may appear some barriers to collaboration such as:

- Absence of an integrated curriculum of Foundations English and Mathematics
- Lack of common learning outcomes

To overcome these two hinders, perhaps teachers need to be aware of the learning outcomes of each other's course, and keep these outcomes in the back of their minds when planning and teaching their subject matter. This is a kind of collaboration that may enhance the learning process with relevant examples.

- In-sufficient training for teachers in collaboration practices
- Heavy teaching load
- Limited resources

The outcomes of the pilot study are encouraging enough to go to large-scale research about the same topic with larger and different population of English language learners, teachers, and colleges.

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