English for Specific Purposes: A Math Preparation Course

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The most recently released numbers from the United States Department of Homeland Security (2012) records the total number of F1 visas at 1,514,783 in 2012. Most of these students choose to complete an intensive English program and then matriculate on to an institution of higher learning in the United States when they are finished with their English studies. Although the requirements for admittance are institution specific, there are some common areas that students have to demonstrate at least a basic proficiency before they are admitted. In addition to English, some areas include math, and science. Higher education institutions test prospective students for a demonstration of their abilities or rely on a third party to do so by using tests that are recognized as legitimate, such as the SAT, TOEFL, GRE, GMAT, and the ACT. The students that do not pass these exams or can not get their credits to transfer are required to take placement exams at the university where they seek admission. One of the first requirements that a recently admitted university student has to fulfill is to take a mathematics placement exam (MPE) in order to see what classes s/he needs to take to fulfill the prerequisites for taking math courses. All students must either take this math placement test or demonstrate, through official transcripts, that they already have taken the prerequisites courses for the upper level math courses. While it is fairly easy for an American student to demonstrate this, international students often can not get their credits to transfer and have to take a math placement exam. There is a distinct lack of preparation in most intensive English programs in preparing international students for the challenge of taking placement exams in English. Furthermore, the international student sometimes is not aware of how different these placement exams can be. For an intensive English program that wishes to aid students' future success at a university that operates in English, there is a need for a course that develops the ability of a student to express what they already know about math in their native language in English. While the area of content and language integrated instruction (CLIL) is already well established in the European context (Dalton-Puffer, Nikula, Smit, 2010), there is a great need for CLIL curriculum design and implementation in these specific areas at intensive English programs at American universities. This paper will present the research and development of such a CLIL course for the MPE at a large research based university.

Setting

The setting for this project is at an Intensive Language Center run by a public-private partnership at a large research oriented university in the United States. The partnership offers an academic program that "is accredited by the Commission on English Language Program Accreditation (CEA) and prepares international students for university study in the US. This academically rigorous program provides international students with high–quality English language instruction and academic

skills" (INTO CSU, 2014). There are three programs to choose from at this institution: Academic English (AE), General English (GE), and the Pathways program. The AE program is intended for students who wish to matriculate, but do not have the language skills yet to do so. The GE program is for students that wish to have an American cultural experience, or at the very least do not have an academic goal in mind for their language learning.

The Pathways program is a track that students can take which allows them to start concurrently taking classes at the university while continuing the finish their language prerequisites. These classes are mixed with students from the university and English language learners (ELLs) and are taught by professors with a specialization in Teaching English as a Second/Foreign Language (TESL/TEFL).

Needs Analysis

The impetus for this MPA class, conceived within an English for Specific Purposes (ESP) framework, originated from a conversation with the director of Pathways and English language programs and the Assistant Director of Advising at a large research university. Both informants identified a need for a preparatory course in mathematics for international students who intend to study at the university in the fields of engineering, science, and business once they have finished their intensive English program. In order to better understand the contextual needs, a needs analysis was then conducted according to a synthesis of methodologies (West, 1984; Courtney, 1988; Benesch, 1996; Chambers, 1980; Giménez, 1996). The areas of concern were triangulated by conducting interviews with a current calculus teacher, the Director of the Pathways program and English language programs, the Assistant Director of Advising, a math professor, and several students. An informal questionnaire (see Appendix A) was administered verbally to most of the informants and their responses were recorded on paper. See table 1 for a complete listing of all responses to the questionnaire.

The director of the Pathways program and English programs was our initial contact and she outlined the general areas of concern that the students in the Pathways program have after they leave the program. The Director of the Pathways program and English language programs (personal communication, October 1st, 2012) indicated that the students' areas of concern were the math placement exam (MPE) and expressing and understanding general and specific mathematics lexical items. She also gave a list of expert informants from the mathematics department whom should be contacted. The Assistant Director of Advising (personal communication, October 1st, 2012) confirmed what the information given by the Director of the Pathways program and English language programs. After gathering information from informants at the administrative level, an expert informant was contacted to understand the content specific areas of concerns.

Mathematics Placement Exams (MPE)

The MPE is a computer adaptive test that measures the ability of the test taker in three areas of mathematical knowledge. The three areas that are randomly selected from a test

bank are logarithms and exponential functions, trigonometry, and algebra.

Data Collection

A professor of mathematics was consulted as an expert, in both the field of mathematics and as a current teacher of ELLs. The professor (personal communication, October 3rd, 2012) was asked questions to assess areas that students struggled with (see Appendix A). The professor's responses were recorded by the interviewer.

A student who intended to take the MPE was also interviewed. This student (personal communication, October 10th, 2012) was interviewed to determine the areas of concern from his/her perspective. This interview was conducted informally and a questionnaire was not used with this informant in writing. Instead the student, who was studying to take the MPE at the time of the interview, was asked to list the areas that he was concerned about in regards to the MPE and generally taking math courses. After the student listed some of her/his concerns, the student was also given the first lab report, which is assigned to students taking calculus 160, received from the math professor, and asked to read the instructions. The student was also instructed to underline any lexical items that he/she did not understand. The informant was informally tested on his/her reading comprehension of the introduction.

A student who had taken the MPE was also interviewed as the final part of the needs analysis. This student also indicated that vocabulary was an issue, but that he was under prepared for using the calculator, the TI 83, that was required on the MPE and in classes. This student also indicated that it took a while to get used to having to explain the problem solving process instead of just giving the answer, which is the expected way in his culture.

Results

As a result of the informant interviews, it was determined that vocabulary should be the largest portion of the ESP course as it was biggest obstacle to the student's success. For instance, it was apparent that students could understand what the lab report was asking him to do, but this was only after some clarifications with the native speaking interlocutor.

The professor pointed out that she had observed that international students lacked in several areas: interacting with classmates during in class and out of class group work, interacting with the teacher during office hours, understanding technical and sub-technical vocabulary, general comprehension for math word problems, and being able to explain how the students arrived at an answer. Table 1 has a summation of all the information garnered from informants.

Proposed Solution: Course Design

The nature of this project would be classified as English for Specific Academic Purposes as defined by Jordan (1997) because it is concerned with a specific set of academic skills that are content specific, in this case, the field of mathematics. However, this class can also be classified under a larger umbrella term of CLIL which is defined as "an educational approach where subjects such as geography or biology are taught through the medium of a foreign language" (Dalton-Puffer,

Nikula, & Smit, 2010, p. 11). The most important part of this kind of classroom is that it is "neither exclusively language learning nor subject learning" (Dalton-Puffer, Nikula, & Smit, 2010, p. 12). In other words, the course would not focus on solely math or solely language. It would be an even distribution of the two. Since the focus of the course is the MPE, the sequence moves from simpler to more complex mathematics topics that are covered on the MPE. In other words, algebra first and logarithms and exponential functions last. Furthermore, the order is the same as they are presented when the students are taking the MPE.

A task-based syllabus was chosen because of the nature course, which is to take a test which is comprised of a series of tasks to solve. A task is defined as "an activity which requires learners to use language, with emphasis on meaning, to attain an objective" (Nation & Macalister, 2009, p. 80). Solving a math problem in English constitutes a task that focuses on meaning and that can be divided into different skills and sub-skills. Each section of the math review materials that the math department gives out to study for the MPE is a slightly different kind of task that the students need to learn to solve. Furthermore, some sections even have word problems that must be decoded before the math task can be completed. After deciding the form of the course, objectives for the course can be set.

First, the main objective of the course is to increase the mathematical lexicon of the students. Based on our interviews with student informants, they would understand and be able to explain the mathematics concepts shown to them once they were given the vocabulary needed to do so. In other words, the students are operating in Version B of the TOPRA model where they are "processing for word meaning, word form, and form-meaning mapping"(Barcroft, 2012, p. 28) and the processing power dedicated to each area is constantly shifting based on the individual students. This made vocabulary the most important part of the course to be integrated into the in class tasks. However, as Barcroft (2012) noted, it is important not to require the production of target words to quickly for maximal retention. As a result, math sections are often presented by the teacher to expose target words to the students. Then the students would work on solving the math problem, which does not require that the students use the word for the idea they are working with, to help solidify the understanding the word in context. For example, students often have done the math they are review, like polynomial manipulation, so the concept is not new so most of the students' processing power can go towards form processing and mapping. This method was employed more frequently later in the course as the content became less familiar to the students, i.e., logarithms and functions are not as fresh in students' minds if they even learned them at all in their country.

Furthermore, students also need the ability to read word problems and extract the math information from it to create expressions or equations. It is one aspect to know the technical vocabulary of math, but it is incomplete without the semi-technical and general vocabulary that is commonly used in

math problems. It is very common in American math classes to have to read or hear word problems and extract the proper information to create an equation to solve. This task is generally difficult for native English speakers, but especially for ELLs. Compounding this area is the use of non-technical words that are very low frequency. The classic example of this category of word is *buoy*. If a math problem has a context of the ocean, then there is an assumption on the part of the creator of the problem that the student will already have an awareness of ocean related lexical items. It was therefore also necessary to work on the ability to guess the meaning of a word from the context of the math problem.

The secondary objective was to increase the academic skills required to complete the mathematics courses at CSU. An adjunct professor teaching calculus 160 in the math department indicated that they noticed many of the ELLs in their classroom had a hard time working in groups to solve in depth problems and that they often would only give the solution to the problem, which is a problem in American universities because they often require that a student show their work to get full credit for solving the problem. These two goals formed the largest *threads* that would run throughout the entire course.

In order to achieve the course objectives, foci were set from classroom tasks. A primary focus of in-class tasks is to understand what the problem is that needs to be solved, which includes understanding the context. It is important to understand the context of the math problem because it will help guide the intuition of the students as to whether or not their answers make sense in the given context. For example, if a problem is about time to complete a small gardening task and the units are given in minutes and hours, it should cause some concern if the answer that the student ends with an answer in years. By dissecting and solving math word problems, the two goals were accomplished simultaneously.

The secondary focus of the tasks in class was to foster academic study skills in the students. Math does not rely on higher order thinking skills for the most part and many times, there is a problem and a student either understands it and can solve it or not. While this is not new for many students, having to explain how they arrived at the answer is. As a result, most classes involve group work that reinforces the need to practice doing the problems and then explaining the problem solving process. When a student teaches something, it reinforces the learning process and it is acquired faster by that student. Part of the needs analysis informed the need for international students to work in groups. By working in groups and explaining how a problem was solved, the students are being prepared to enter math courses at the university which is the goal of completing the MPE successfully. This is an example of a *thread* (Nation & Macalister, 2010) that runs throughout the whole course in order to develop the abilities and skills they will need during the MPE and in subsequent classes.

Materials

The use of corpora and concordancers has been established as a useful tool when creating activities and even courses

(Flowerdew, 1993a; Allison & Tauroza, 1995; Stevens, 1991; Thurstin & Candlin, 1998). For this project, the needs analysis showed a need for creating a corpus of technical and semi-technical words for international mathematics students. There are a variety of different ways in which a corpus can be utilized to aid in the development of many aspects of a course, from the overall design and flow of the course to giving authenticity to the content of the classroom tasks. The design of the general corpus included texts from various sources that relate to mathematics and the academic environment of which the students are expected to be involved in. The resources for this corpus included syllabi from relevant courses, lab reports, tests samples, and transcripts of relevant lectures, academic assignments, and online math tutorials.

The majority of the math corpus came from the Khan Academy website (https://www.khanacademy.org/), which is a website that seeks to provide a college education for free on the Internet through the use of video presentations. Using the Khan academy, students can start learning the basics of math, simple arithmetic, and continue to the most complex concepts of math, like differential equations and linear algebra. This website was chosen because it simulates a lecture setting that students will encounter in American universities, and it provided more data than could be gathered from observing and transcribing lectures by hand. Using the transcript function on the website, about thirty three separate corpora were created based on the different content areas in math. The subject areas include calculus, algebra, trigonometry, logarithms, and geometry. When all of the sub categories of math were combined, a unified corpus of approximately 1.4 million words was created. For reasons of materials development and ease of use by the students, the corpora were kept as the separate files to allow students to look at specific topics of interest. For instance, if a student is confused about a term that they encounter in a future trigonometry class, they can look only at the trigonometry corpus and not be burdened by too much irrelevant data. This allowed the course to target specific areas of mathematics for lexical development.

As for the corpora analysis, two programs were used: lextutor.ca and AntConc. First, each content area was looked at using both Antconc and www.Lextutor.ca to analyze the frequency data. The technical and semi-technical words were collected and they populated the vocabulary list to be taught during that section of the course. Any words that appeared in the corpora that were also part of the K2000 word list were removed. Since the intended audience of this course is either a Pathways or conditionally admitted CSU student, it was expected that they should all already be familiar with the K2000 word list and to some extent the academic word list. The remaining words were sorted according to how they were used. The focus quickly became the nouns and verbs, some of which are common but used in a way that the students were not accustomed to. For instance, verbs commonly indicate operators in math problems and therefore need to be taught in a math context. For example, a math problem where people are *leaving* a

restaurant represents subtraction or a large group that *breaks into* smaller groups indicates division. Nouns comprised the largest portion of the vocabulary list, both technical and general, such as *tenant*, *buoy*, *nurses*, and *ripple*.

Other materials for the course came from different sources including the Math Department, math related websites, and a GRE prep book.

The math department materials were used because they represent precisely what is expected of the students to know before the test. These materials were the most useful in setting benchmarks and syllabus design for what should be included in the course. However, they are lacking in that they do not properly prepare the students for the multiple choice nature of the MPE and they contain very little in the way of word problems. Generally, the study materials contain section explanations and some sample problems and solutions to those kinds of problems. The student is presented with an equation to solve and the solution is provided. Another reason for not using these materials in the classroom is that the language that is used in these materials makes them inaccessible to ELLs. They were distributed to the students to use as study materials while at home because the students, for the most part, are able to solve the equations presented to them. What they are lacking is the ability to explain what they have done in English. Therefore, the PDFs were a better tool for homework and used as such.

The corpora were also used to generate a variety of different vocabulary activities that are commonly used in more normal ESL settings. However, the typical vocabulary exercises quickly proved to be not very effective because of how different the subject-matter is. Using the vocabulary lists and the concordancer, the students were able to look at how the words on the list are used throughout the lectures which was more beneficial for building their intuition about the vocabulary, as well as show them the different ways that they are used, which are not always uniform.

Student Assessment

Gimenez (1996) notes that process oriented assessment and EAP courses are perfect for each other for a couple of reasons. Generally, there are greater time constraints placed on ESP courses and therefore require a tightening of what is normally accomplished in a classroom. Oftentimes, it is the assessment that is subject to the most trimming. Since the objective of this course is a workshop in nature, the decision was made to not have formal assessments be part of the course, at least when dealing with the students' grades. This decision was made because the focus on the class is process oriented and how well each student does on the MPE is the real grade for the class. In other words, the goal of the class is to better equip the students to undertake and explain the process involved with interpreting and solving math problems. It is for this reason that course contained many informal assessment measures used on a daily basis. Informal assessments that were used include creating their own math problem within certain parameters, drawing a dictated picture, and giving mini presentations about

topics that were discussed. Watching the presentation of the groups will give the teacher the information needed to make on-line adjustments to the course. This means that any time the students are producing in class; it is an informal assessment of their progress.

The development of this test is based on the Bachman & Palmer (1996) model which includes information about test takers, task types, the TLU domain, and construct definition. There are two parts to the proposed test. The first part is a vocabulary section, which includes isolated vocabulary terms and a vocabulary in context section. The second part of the test is a question formation and hedging section regarding interacting with the teacher during office hours.

The impact of this test will occur at two levels: micro and macro (Bachman & Palmer, 1996). The micro-level impact will affect the students and what they need to focus on while attending the ESP course. Since this course is designed as a supplement to the students' Pathways courses, the test in the course will serve as a formative tool for the students to recognize what areas they should spend more time studying. The macro-level wash back will have two levels of impact: an immediate and a delayed (Bachman & Palmer, 1996). The results of the test will inform the teacher to the current needs of the students so that the course can evolve accordingly, if there is an area that is consistently weak for a majority of the students. The delayed impact will manifest in the form of curriculum and syllabus change for future iterations of the course. Finally, the test scores will be used by the teacher as one data point to determine the grade for the class; and the test taker will use the scores to determine if they are ready to take the Math Placement Exam at CSU.

The test is syllabus based and criterion referenced test, which is defined as "a test or other type of assessment designed to provide a measure of performance that is interpretable in terms of a clearly defined and delimited domain of learning tasks" (Miller, Linn, & Gronlund, 2008, p. 40). Since the goal of the ESP course is to prepare the students to succeed in future math courses, this test is an achievement based design. One of the vocabulary sections is a fixed choice assessment, and the other is a restricted response question. The question formation and hedging section is also a restricted response.

There are two formal tests in the class, one in the middle and one and the end. The one in the middle is a type of formative test to make sure that there is vocabulary retention on the part of the students. This test is strictly multiple-choice because there is a binary of knowing and recognizing the math lexicon or not. This format was also chosen because it is hard to put technical math lexical items into context without having them actually do a math problem, which they get enough practice with in in-class activities.

The final test at the end is there for two reasons. First, it would help guide future versions of the class. How well or poorly the students did on the test will highlight areas that need to be adjusted in the curriculum or lesson plans. Second, it will boost the

students' confidence in their ability to understand and therefore solve math problems in English. Motivation can play a big part in how well or poorly a student does, especially for high stakes tests. If the student is confident in their abilities, many affective variables can be mitigated if not eliminated. The test is comprised of three tasks: two vocabulary sections and a question formation and hedging section. The input for all of the sections is visual, in the target language, and in real time. The first vocabulary section is a set multiple choice items testing knowledge of technical mathematics vocabulary. This section is designed to check recognition and ability to define basic math related lexical items which were derived from the Khan Academy Corpus. The input for this section is a single word, a phrase, or a sentence. The expected response for this section is either the correct word for the given definition or the correct definition for the word or example. The relationship between the input and the expected response is narrow, non-reciprocal, and direct. The scoring for this section will be binary 0-1.

The second vocabulary section requires the test taker to comprehend and analyze words in context from a short mathematics reading passage. The input for this section is a short reading passage followed by a set of items. The relationship between the input and the expected response is narrow, non-reciprocal, and direct. The scoring for this section allows for a total of one point for each question. The test taker can receive partial credit if the answer is not completely accurate.

Initially there was a third task relating to question formation and hedging, but after six weeks working with the students, it became apparent that they would not need extra attention in these areas. Although academic etiquette and norms of American universities were discussed, there was no need to test this area and the task was removed.

Conclusion

The process of developing a class has a beginning but should not have an end. After completion of the course, revisions should be made so that the next iterations corrects mistakes or adds improvements to the way things are done. The only end that a course should ever experience is a lack of need for the course and therefore there are no students to take the course. Even when a curriculum is excellent, there is still a need for constant readjustment to accommodate the needs of every new cohort of students that takes the course. Lesson plans should be guidelines for how to navigate through a lesson but should never be inflexible as too not allow any modifications. As campuses become more international, there will be a greater demand for ESP courses from a variety of different fields. This paper highlighted some of the important dimensions to consider when developing ESP courses which should be applied to other content areas. While it is not an easy task to understand and weight needs, design curriculum to match those needs, and understand all the constraints, it can be done with time, consideration, and data.

References

Allison, D. & Tauroza, S. (1995). The effect of discourse organization on lecture comprehension. *English for Specific Purposes, 14*(2), 157-173.

Bachman, L., & Palmer, A. (1996). *Language testing in practice.* New York: Oxford University Press.

Barcroft, J. (2012) *Input-Based Incremental Vocabulary Instruction*. Virginia: TESOL International Association.

Benesch, S. (1996). Needs analysis and curriculum development in EAP: an example of a critical approach. *TESOL Quarterly*, *30*(4), 723-738.

Chambers, F. (1980). A re-evaluation of needs analysis in ESP. *The ESP Journal*, 1(1), 25-33.

Courtney, M. (1988). Some initial considerations for course design. *English for Specific Purposes*, 7, 195-203.

Dalton-Puffer, C., Nikula, T., Smit, U. (2010). *Language use and language learning in CLIL classrooms.* Amsterdam: John Benjamins Pub. Co.

Dubin, F., & Olshtain, E. (1986). *Course design: developing programs and materials for language learning.* Cambridge [Cambridgeshire]: Cambridge University Press.

Echevarria, J., Vogt, M. (2008). *Making content comprehensible for English learners: The SIOP® model.* 3rd ed. Boston: Pearson.

Flowerdew, J. (1986). Cognitive style and specific-purpose course design. *English for Specific Purposes*, 5(2)

Flowerdew, J. (1993a). Concordancing as a tool in course design. *System*, *21*(2), 231-244.

Flowerdew, J. (1993b). Content-based language instruction in a tertiary setting. *English for Specific Purposes*, *12*, 121-138.

Giménez, J. (1996). Process Assessment in ESP: Input, throughput and output. *English for Specific Purposes, 15*(3), 233-241.

INTO CSU (2014). *Program Information*. Retrieved from http://www.intohigher.com/us/en-us/the-universities/into-colorado-state-university/studying/our-programs/programs/academic-english.aspx

Jordan, R. R. (1997). *English for academic purposes: a guide and resource book for teachers*. Cambridge [England]: Cambridge University Press.

Jones, C. (1991). An integrated model for ESP syllabus design. *English for Specific Purposes*, *10*, 155-172.

Long, M. H. (2005). *Second language needs analysis.* Cambridge, UK: Cambridge University Press.

Miller, M. D., Linn, R., & Gronlund, N. (2008). *Measurement and assessment in teaching*. (10th Edition). Upper Saddle River, NJ: Merrill, Prentice Hall.

Nation, I., Macalister, J. (2009). *Language Curriculum Design.* Hoboken: Taylor & Francis.

Nation, I. & Newton, J. (2009). *Teaching ESL/EFL Listening and Speaking.* Routledge

Read, J. (2000). *Assessing Vocabulary*. New York: Cambridge University Press.

Reiss, J. (2012). *120 content strategies for English language learners: teaching for academic success in secondary school.* 2nd ed. Boston, MA: Pearson/Allyn and Bacon.

Stevens, V. (1991). Classroom concordancing: vocabulary materials derived from relevant, authentic texts. *English for Specific Purpose*, *10*, 35-46.

Thurstun, J. & Candlin, C. (1998). Concordancing and the teaching of the vocabulary of academic English. *English for Specific Purposes*, *17*(3), 267-280.

United States Department of Homeland Security. (2012). *Yearbook of Immigration Statistics*. Retrieved from https://www.dhs.gov/yearbook-immigration-statistics-2012-nonimmigrant-admissions

West, L. (1984). Needs assessment in occupation-specific VESL or how to decide what to teach. *The ESP Journal*, *3*, 143-152.