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Original Article

Exploring Translanguaging to Teach Undergraduate Math to ELF Students

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Abstract - *Teaching mathematics in the English language to EFL students while they are developing basic English language skills is a challenge for the faculty members of General Studies Department at Yanbu Industrial College (YIC), Saudi Arabia. This action research explores the experience of 158 female Saudi Foundation Year students when they studied post-secondary core math curriculum in English for the first time. The analysis involves different views on mathematics curriculum and identifying improvements in math language comprehension via translanguaging. It also includes a recognition of the facilitation translanguaging had on student's learning capabilities and achievement level.*

Keywords - *Translanguaging, Foundation year program, Bilingual, Mathematics, Framework.*

1. Background

English Language Learners (ELLs) represent the fastest-growing section of the student body in the Kingdom of Saudi Arabia. As a result, there has been a tremendous increase in the number of Saudi students enrolling in US colleges and universities; from less than five thousand students before 2005 to more than a hundred thousand from 2013 to 2014. [1] The medium of instruction in the education system up to grade 12 is Arabic, as it is the first language of most of the students. The majority of the schools in Saudi Arabia use Arabic medium of instruction for most content subjects while English is taught as a separate core subject. However, at the tertiary level due to the requirement to reach a global outlook and to increase student employability, the medium of instruction is switched to English for most of the courses.

During the Foundation Year at YIC, post-secondary students receive an immersion of 20 weekly hours of English along with four hours of Mathematics before joining their desired baccalaureate program. Moreover, this is their first experience of studying Math in the English Language with a teacher who may not share a common first language with them. According to Moe Eli et.al. [2] a sixteen-year-old student requires B2 Common European Framework of Reference for Languages (CEFR) Level to understand information, instructions and directions provided in math classrooms. However, a high school graduate walks into YIC's Foundation Year Program with an A1/A2 CEFR level and is expected to accomplish a B1 CEFR level by the end of the two-semester program. Thus, students with low CEFR levels are challenged by a higher CEFR level math curriculum. Hence, juggling with the high language demands of math curriculum while attaining English language skills simultaneously is a critical issue affecting both students and teachers. As a result, the mathematics classroom interaction in Foundation Year courses is fraught with stress. Teachers struggle to teach a difficult subject, mathematics, in an even more challenging language, English while the students try to comprehend a new language, English, while also comprehending mathematics at the same time. There is undoubtedly a communication gap between teacher and student. Hence, the educators, despite the restriction, occasionally deliberately or deliberately employ code-switching or translanguaging to clarify mathematical concepts. [3] Therefore, the purpose of this study is to highlight the language issues related to teaching and learning of mathematics.

2. Overview of the Action Research

Globally, most of the research on problems faced by English as Foreign Language (EFL) students in learning mathematics has been conducted on primary or secondary-level courses for teachers and students. However, Barton et.al. [4] emphasized the association between language competency and students' postsecondary performance and discovered that the consequences of a lack of language skills extend beyond elementary and secondary institutions. In Saudi Arabia as nearly all students born in Arab countries since 2000 formed the first-generation of EFLs here. In the USA, a student whose parents did not attend college or

obtain a college degree, leaving them without college counseling from the family, are referred as first-generation students. Thus, in comparison, the Foundation Year students in KSA, without any advice from home regarding English language learning, are comparable to first-generation students in USA. [5]

Factors like non -English speaking parents and Arabic language as mother tongue must be considered while teaching a foreign language such as English. The first part of this research article describes the context of Math education in terms of teachers' work to implement the new Foundation Year math curriculum at YIC and the problems faced by students. The second part presents data drawn from the survey results of 158 female students who studied their first core math course in English language. Survey results showed that understanding the experience of math students is important for teachers as it helps in designing effective teaching strategies and methodologies. Data also elaborates on the nature of experiences that added more value to their learning and the effectiveness of methodologies to change their math skills over time. The last part presents the research findings and recommendations for math teachers to improve students' learning in the math classroom.

3. Literature Review

There are many methods that experts have employed in math classes to teach ELL students. Studies have shown a strong correlation between English proficiency and mathematical performance. [3,6,7] The language used to express advanced math concepts is generally not used in everyday life and neither can it be acquired through ordinary conversation. [8] Tertiary-level math language uses words like matrices, improper integrals, coordinate system etc., which can be learned in an academic environment only. Mathematical terminologies and their associated concepts, oral or written instructions on how to complete problems, and the basic language used in a teacher's explanation of a concept contribute to the difficulties faced by EFL learners. Math is one of "the critical areas in which ELLs have language-associated learning difficulties." [9]

The following notions outlined by Moschkovich should be the cornerstones of math classes for EFL learners. [10]

- Use students' languages as an asset rather than as a limitation.
- Focus on more than the vocabulary and urge the emerging bilinguals to engage in mathematical discussions as they learn English.

Barwell posits that the set of instructions should be designed in such a manner that they support all students regardless of their language proficiency level. The question is not whether the students can improve their vocabulary but rather how the teacher's instructions can best support students in learning both vocabulary and mathematics. Learning and deciphering mathematical concepts and notations are not easy tasks for many students. For instance, students may fail to comprehend the content in a textbook or may be unable to understand the instructions given by the teacher. The difficulty of comprehending mathematical language may further get amplified for students who need to overcome language barrier. This at times results in offering non-challenging math content to EFL /ELL students. [11]

NASEM emphasizes the importance of prior STEM knowledge in relation to class placement as "children are not typically assessed for their content knowledge when entering U.S. schools. Instead, their identification and course placement, at least at the secondary level, is typically determined by their level of English proficiency." [12]

According to Umansky, offering low track math courses to students due to lack of language proficiency deprives them of opportunities to learn rigorous math. Hence, it can be surmised that the incompetence of target language severely impacts their performance in math courses. To undo this negative cycle, rigorous mathematical concepts should not be held from EFL students until they achieve proficiency in the English language. This suggestion is based on the fact that EFL students are capable of solving higher order math problems and exercising rigorous thinking abilities if a tool to bridge this gap is developed or implemented. [13]

Moreover, AlAdnani A and Elyas propose that for pedagogical reasons, the tutor must use code switching to Arabic to facilitate students' learning and performance. [14]

Tai also illustrates how translanguaging practices can be deployed as an inclusive pedagogy in the English medium instruction of science and mathematics to engage linguistically and culturally diverse students for content and language learning in the classroom. He further proposes the enactment of inclusive practices involving translanguaging where the teacher seeks out available multilingual resources and strategically selects accurate resources to implement inclusive practices in the classroom with English as the medium of instruction. [15]

Translanguaging, first used in 1994 by a Welsh teacher to educate his multilingual students, was described as employing students' language abilities to integrate two languages during the learning phase and was characterized as the speaker's "full linguistic repertory". [16] Unlike code-switching, translanguaging uses the whole lexicon rather than just a word. [17] Similarly, Dual Language educational programs which help students develop high levels of language proficiency and literacy provide English learners with more opportunities to reach higher level of academic achievement than any other type of program. [18-22]

Meta-analysis conducted by Sharma and Sharma provided evidence for successfully teaching mathematics to ELLs of year 1-10 through Dual-Language Program, Curriculum Integration, Teacher Professional Development, and Cognitively Fused Interventions. It highlighted the benefits of interventions that focused on utilizing students' native language for developing their mathematical skills and reported that the most successful intervention for teaching mathematics to ELLs involved Dual Language Program. [23] This action research confirms the effectiveness of Translanguaging and usage of native language as a resource at tertiary level and concurs with Sharma and Sharma's meta-analysis from school level.

4. Materials and Methods

The study explored teaching and learning math in the Foundation Year math classrooms of Yanbu Industrial College, Saudi Arabia. It must be clarified here that students joining the Foundation Year Program have completed high school in Arabic language and get their first exposure to mathematics in English language during this program. The work environment values students' success rates and the administrative monitoring requires teachers to maintain a record of student progress.

The old course plan for Math 010 consisted of five modules, covered in a semester, and followed Precalculus: Mathematics for Calculus by Stewart et al. (2017) as a textbook. With a broad range of topics and a single semester of teaching time, the course presented a challenge to the teachers on how to cover the range of topics in a way that led to success and fulfilled the requirements of baccalaureate programs. Although the textbook used for teaching this course covered all the intended learning outcomes, student achievement was below the targeted level. As shown in Table 1, around 30% of the 25 Baccalaureate Program faculty members polled believed that students who completed the Foundation Year had appropriate mathematics knowledge and skills to thrive in bachelor programs. Survey results also pinpointed some deficiencies in the Foundation Year math courses, addressing them could enhance higher-order thinking skills in students.

Table 1. Students have adequate mathematical knowledge and skills

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Not Applicable
Percentage of Faculty Members	12%	24%	36%	28%	0%	0%

Based on these findings, the new mathematics study plan was implemented in 2021, which consisted of eight modules. This plan spanned over two semesters and used Algebra and Trigonometry by Ron Larson as the textbook for the new Foundation Year Math courses. The idea was that focusing on eight modules repeated over two semesters would give the students a better understanding of the topics. The two new courses of 4-credit hours each were introduced in place of a 5-credit hour math course. The new courses included more topics than the previous math course and gave the faculty members time to distinguish between the English Language Learners (ELL) and English as Foreign Language (EFL) students while focusing on culturally responsive teaching. Special emphasis could thus be placed on acquiring academic language for mathematical discussions and lesson comprehension by the students.

The following goals were established for the teachers to accomplish during instruction.

1. Identify the needs of ELL and EFL students in learning mathematics.
2. Identify the capabilities and skills of students to maximize learning in class.
3. Use the native language of students as a resource.
4. Allocate cognitively challenging tasks to enhance knowledge base.
5. Encourage students to participate in mathematical discussions to improve their English language skills.

The goal of implementing this new core math curriculum was to meet the needs of the degree programs while remaining loyal to the demanding spirit of the assessment objectives. This further necessitated not offering any accommodation to facilitate students with low proficiency in English.

Most of the Foundation Year students can solve numerical questions with more convenience than the word problem, yet they are unable to explain their thought process for solving the numerical problem. This can be because the language of mathematics is also different in different cultures. For example, in the American system, numbers are separated by a comma as 9,456 but in Arab countries, a comma is used to represent a decimal. Similar differences exist in other cultures as well. For example, negative numbers in Mexico are written with a bar on top while in the UK and USA, a bar on top of the number is used to express a repeating decimal. Task allocation thus becomes a political act in an EFL class, as it exposes students to challenging mathematical problems which might conflict with their language and cultural embodiment of math concepts. [23] Most EFL students might be good at problem solving but the teacher insists on simple questions because it is assumed that evolving bilinguals cannot comprehend the English embedded in mathematical word problems and as a result EFL students never achieve their grade level math abilities. It is not just an issue that you are dealing with students who feel math is not for them, but also a struggle against the belief that there is something inherent in mathematics that shuts people out. So, what do the teachers do in the classroom to help students see their future in math?

5. Framework for Analysis of Word Problems

Providing easy tasks or text-less question statements is not the only way to help struggling EFL students. Instead, the teachers can reduce the language demands without diminishing the opportunities to learn quality mathematics. Identifying and removing the unnecessary segments of the statement and breaking down the word problem in multiple steps can help reduce the demands of the heavy text. However, this must not reduce the mathematical demands of the task. Otherwise, the usage of visuals and simulations can also make the comprehension of text easier for the students without making any changes to the statement. [24]

Math content taught in the Foundation Year Math courses contains word problems and most of the students do not have the English proficiency level compatible with the course requirement. Although some students are proficient in mathematics, they are unable to demonstrate math knowledge properly due to complex sentences and difficult problem statements. Incorporating translanguaging pedagogy into an instructional plan has helped a lot in this course as being co-learners teachers are willing to learn from students, their language and culture, rather than being the sole knowledge provider.

According to Oliveira, we can make mathematical problems accessible to students by analyzing each clause of a word problem. [25] Following five questions based on Huang and Normandia's analysis were implemented during translanguaging in a Foundation Year Math class at YIC. [26]

1. What is the student asked to perform?
2. What relevant information is presented in the word problem?
3. What mathematical concepts are presented in the information?
4. What mathematical procedures can students use to solve the problem?
5. What additional language demands exist in the problem?

Table 2 illustrates a word problem by adapting the Framework for Analyzing Word Problems as presented by Oliveria by adding translanguaging components during Foundation Year math class. [25]

Q) A soccer player passes the ball from a point that is 18 yards from the end line and 12 yards from the sideline. A teammate who is 42 yards from the same end line and 50 yards from the same sideline, receives the pass (see Figure 1). How long is the pass?

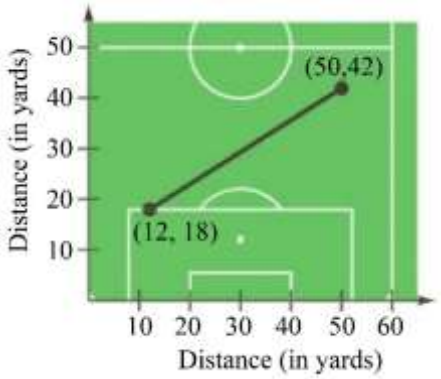

Fig. 1 Soccer field

Table 2. How to analyze word problem (Oliveira, 2012)

	Information provided in English	**Information in native language**	**Mathematical concept in a language of choice**	**Mathematical procedure to be used**
Clause 1	A soccer player passes the ball from a point that is 18 yards from the end line and 12 yards from the sideline	يقوم لاعب كرة القدم بتمرير الكرة من نقطة تبعد 18 ياردة من خط النهاية و 12 ياردة من الخط الجانبي	Locate the position of the player in $\boldsymbol{xy}$-plane	Graphic representation
Clause 2	A team mate who is 42 yards from the same end line and 50 yards from the same sideline receives the pass	زميل في الفريق على بعد 42 ياردة من نفس خط النهاية و 50 ياردة من نفس الخط الجانبي ، يتلقى التمريرة.	Locate the position of the second player in the $\boldsymbol{xy}$-plane	Graphic representation
Clause 3	See figure	انظر للصورة	Relate the statement with the given picture	Identify the picture as the $\boldsymbol{xy}$-plane. Find $(\boldsymbol{x_1}, \boldsymbol{y_1})$ and $(\boldsymbol{x_2}, \boldsymbol{y_2})$.
Clause 4	How long is the pass?	ما هي المسافة؟	Calculate the distance	$\boldsymbol{d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}}$

Students need guidance in identifying and filling up this table. Thus, students can use any language they like, as this tool is for them to understand the language and information conveyed by the word problem.

6. Results

Learning mathematics is normally perceived as a difficult task by students. [27] Many students struggle in math assessments simply because they do not understand the statement of the question. This is especially common among bilingual pupils who are learning the assessment language. Comprehension of textbook content or the instructions given during lectures depends on their reading and listening skills. On the other hand, some students find difficulty in comprehending instructions for assessments. This study explores the impact of mathematics teaching and learning at Yanbu English Language Institute in Saudi Arabia, where students are introduced to foundation-level English and Math courses in English before enrolling in bachelor programs. Participating group consisted of 158 Saudi female students who were studying Math 001 and English 001 concurrently. To assess the impact of the learning experience, pre and post examinations were administered at the mid and end of the semester. The results show that students' performance rose from 51% to over 70%, even though the complexity level of Mathematical concepts increased towards the conclusion of the semester. However, it must be noted that the post semester survey (Table 3) illustrated that nearly 50% of the students felt comfortable with the course content while approximately 20% considered that some advanced topics should be added to the curriculum. Though more than 60% of students believed that the math course improved their English language skills and helped them become better learners, yet nearly half of them were unable to comprehend the requirements of statement-based assessment. Similarly, the survey results showed that approximately 34% of students thought the math teacher's instructions in English were sufficient to comprehend the question statement, but more than a quarter of students thought the language of friends and classmates, which in this case was Arabic, was the best way to understand mathematics (see Figure 2).

Table 3. Post semester survey

	Yes	**No**	**Maybe**
Have your English skills improved through the Math course?	**64.6%**	**11.4%**	**24.1%**
Has the Math course helped you become a better learner?	**62.7%**	**9.5%**	**27.8%**
Do the words in the question statement help you understand what is required of you?	**52.5%**	**20.3%**	**27.2%**

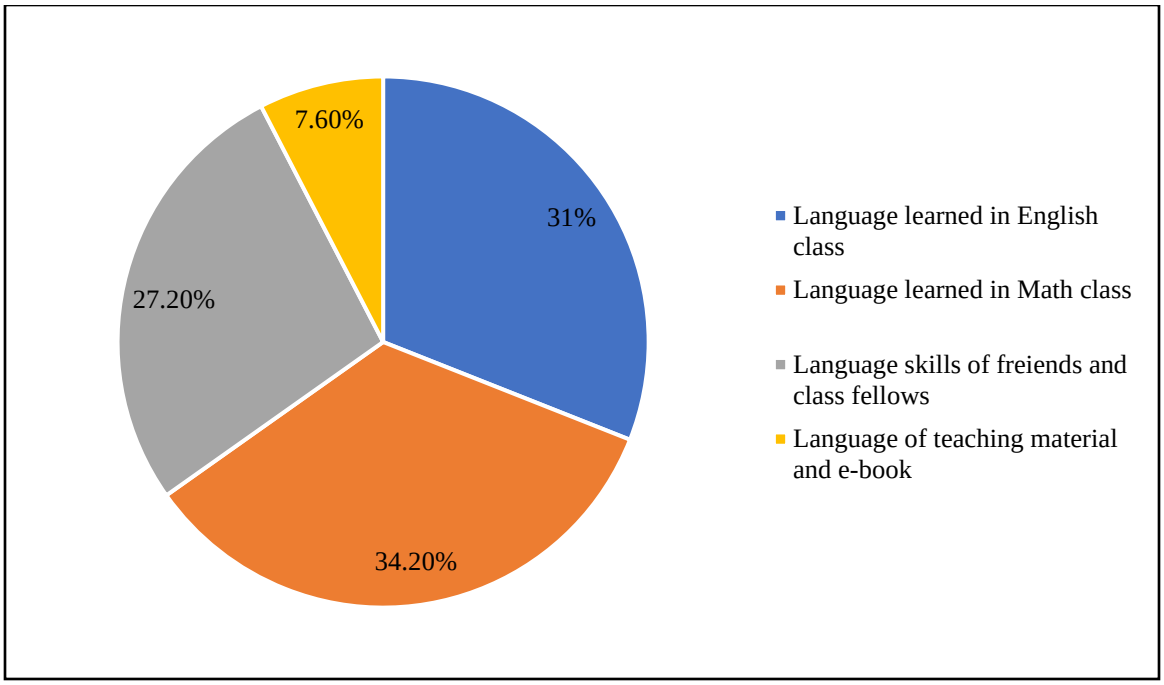

Fig. 2 What helps students the most in understanding the math language?

The intention of developing this core math concept curriculum was to respond to the demands of the baccalaureate programs while avoiding unnecessarily demanding math content with quick coverage of content in class. Throughout the semester, four modules were taught with two exit assessments for each module along with a mid-semester and final assessment. Repeated learning and assessment of the content was expected to provide the students a chance to develop confidence with the course content. Teaching pace was adjusted according to the learner's' needs in different ILOs and faculty members were instructed to revisit topics with low student achievement level. However, the inability of 25% students to comprehend the set of instructions provided during math class in English language indicates the need for intervention in Arabic language during delivering the math content. In this context of teaching core math curriculum, hearing students' voices helped the teachers understand what the pupils value the most in their classroom environment. The survey finding that more than 60% of students recognized their math skills to be better than before and considered themselves as better learners shows the effectiveness of proposed methodologies in this study.

Most successful teaching interventions related to math education for English language learners involve Dual Language Programmes which can be (i) asset-based pedagogy, [28] (ii) Dual language two-way immersion programme, [29] and (iii) Representations, Oral Language and Engagement in Mathematics (RoleM) Learning activities. [30] In other words, the effectiveness of math comprehension for EFL students is dependent on the extent to which an organization's policies allow teachers to experiment with language boundaries.

7. Limitations

This study has a tremendous potential to explore multivariate analysis and gender-based dichotomies in student achievement levels, however, there were certain limitations of the research plan and the researcher. Firstly, it is needed to replicate this research over extended numbers of teaching semesters. Although a single semester's results endorse the success of translanguaging in math class, however further cross-sectional analysis with a fresh sample of students in each semester is required over a longer timeframe to assess the effectiveness of translanguaging in achieving the intended learning outcomes.

Secondly, the participants of the study, consisting of 158 females, were the direct students of the researcher and a co-teacher. It would have been more accurate if the data had been collected from a diverse pool of tutor-researchers' classrooms containing students of both genders.

Thirdly, although 60% of the students believed that their English language skills have improved through the math course, but this research is missing on how employing translanguaging in math class affects the students' performance in their English

courses. This should go a long way toward demonstrating that language concerns in mathematics teaching and learning are essential for evaluating the effectiveness of the Foundation Year Program and warrant additional examination.

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Ethics approval

Permission to conduct the study was granted by the Department of General Studies at Yanbu Industrial College.

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