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Mathematics Through a Linguistic Lens: The impact of English Language Proficiency in Solving Mathematical Word Problems Among Secondary ESL Students

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ABSTRACT

Background: This study delves into the intricate relationship between English language proficiency and the aptitude for solving Mathematical word problems among secondary ESL students in Qatar. Recognizing the nuanced nature of mathematical word problems, the research underscores the impediments posed by language barriers, impacting students' comprehension and communication in the realm of Mathematics. **Methods:** To investigate this relationship, two primary data collection instruments were employed: the "English Language Proficiency Test" assessed overall language proficiency, including listening, speaking, reading, and writing skills, while the "Math Word Problem-Solving Ability Test" measured students' competence in comprehending and solving Mathematical word problems. Data analysis, conducted through Pearson's correlation coefficient and linear regression analysis in SPSS, incorporated descriptive statistics to provide a comprehensive overview of data distribution. **Results:** The results revealed a robust positive correlation between English language proficiency and Math word problem-solving ability. Descriptive statistics offered insights into data distribution, and linear regression analysis illustrated the predictive relationship, demonstrating how changes in English proficiency predict corresponding shifts in Math problem-solving scores. **Conclusion:** The findings underscore the critical importance of addressing language-related challenges in Mathematics education for ESL students. Recommendations include explicit vocabulary instruction, effective modelling, the use of visual aids, fostering collaborative discussions, and adjustments to language complexity in mathematical problems. By deepening our understanding of the interplay between English language proficiency and Math problem-solving, educators can tailor instructional strategies to enhance the overall educational experience for ESL secondary students in Qatar, fostering improved comprehension and success in Math word problem-solving ability.

Keywords: English Language Proficiency; Math Word Problems; ESL (English as a Second Language); Secondary Students; Math Word Problem-Solving Abilities (MWPS)

Background

ESL students' academic success, particularly in subjects like mathematics, relies heavily on their English language proficiency. Math word problem-solving poses a significant challenge for ESL students due to word complexity and difficulty. Lager's (2004) study highlighted language-related challenges, categorizing them into obstacles to understanding the algebraic task and obstacles to communicating the correct response. Linguistic barriers make it challenging to evaluate and analyze problems accurately, hindering effective problem-solving techniques. Liton's (2016) study at Jazan University in Saudi Arabia revealed negative attitudes toward learning English due to cross-cultural issues, lack of motivation, and flaws in the curriculum. Understanding how English language proficiency influences math word problem-solving is crucial for educators to create targeted instructional strategies and enhance students' Mathematical performance.

Liton (2016) emphasizes the importance of this research in comprehending the relationship between bolstering English foundations and supporting students in their specializations. This research aims to provide new perspectives on the connection between Math problem-solving skills and English language proficiency. It also explores the effects of teaching and evaluating Mathematics in a second language, offering potential fresh approaches for engaging a larger number of students (Zerafa, 2016). The research investigates how English language proficiency affects ESL students' approaches to Mathematics, considering the difficulties they face in understanding Math word problems, analyzing Mathematical language, and communicating solutions. The study also explores how contextual and cultural factors influence students' problem-solving approaches. In addition to examining challenges, the research evaluates instructional support for ESL secondary students, focusing on methods teachers use to overcome language barriers. The goal is to identify effective methodologies that enhance students' problem-solving aptitude, ultimately improving the overall educational experience for ESL secondary mathematics learners. Importantly, these inquiries are specifically tailored to the context of Qatar.

Problem Statement

Some learners are unable to interpret MWPs, especially when they cannot visualize the concepts (Moleko & Mosimege, 2020). Some learners experience difficulty in terms of understanding the questions and this inhibits them from converting the word problems into mathematical equations (Sepeng & Sigola, 2013). Learners rely on keywords to solve the MWPs and this often leads to incorrect translations (Salemeh & Etchells, 2016). Research has investigated the teaching-learning of mathematics online (Upadhyay & Mohammed, 2022) and examined the teacher's perceptions of flipped classroom approach towards digital literacy skills trying to help in promoting teaching-learning mathematics (Eriyagama & Mohammed, 2024), however not examined the techniques of Math word problems. Previous local research findings have found that students are generally weak in solving Math word problems, especially in problems that required skills in choosing the various Mathematical techniques they have learned in previous years. Too often, students see the knowledge taught by teachers as Mathematical procedures and they fail to apply the importance of such knowledge to their daily lives. Several research investigated two main areas, namely students' performance in solving Mathematics word problems and the relationship between English competency and the ability to do Mathematics. (Pungut & Shahrill, 2014). Studying these issues can help us understand the connection between Mathematical ability and English language proficiency and can also help us develop strategies for helping ESL Secondary students become more proficient in solving Mathematical problems.

Objectives of the Study

General Objectives

To investigate the impact of English language proficiency level in solving Math word problems among ESL secondary school students in Qatar.

Specific Objectives

1. To find out the students' English language proficiency level among secondary school students in Qatar.
2. To analyse the correlation between English proficiency and the ability to solve Math word problems among secondary school students in Qatar.

Literature Review

Research in education examines the intricate link between English language proficiency and Math word problem-solving among ESL secondary students. Diverse studies have delved into this subject, highlighting challenges, and proposing solutions. Recent work, a longitudinal study by Powell *et al*. (2022), explores relationships among word problem-solving, language processing, and calculation abilities in second graders. Low English proficiency consistently impedes ESL students, particularly those struggling with language processing and reading comprehension (Lei, 2021). A comprehensive literature review discusses major findings and developments in this field. The term "problems" and its variants were explored by Pearce *et al*., (2013), indicating the historical discussion of word problems in professional literature. Difficulties understanding these problems can lead to errors in Mathematical operations during high-stakes assessments, affecting students with Mathematics difficulty (MD) and dual-language learners (DLLs) (Nguyen *et al.*, 2015; Swanson, Lussier & Orosco, 2015). Math word problems, laden with specialized vocabulary and terminology, pose challenges for ESL students. Mulwa's study (2015) underscores these challenges, suggesting explicit vocabulary instruction and bilingual support. Students' propensity to seek advice from peers and the complexity of Mathematical language contribute to these challenges. The relationship between Mathematical performance and English proficiency is complex. While some studies (Nguyen *et al.*, 2015) find a strong correlation, others (Cummins, 2008; Pongsakdi *et al*., 2020) argue that Math performance is not solely determined by English language proficiency. Cognitive skills, teaching strategies, and past Mathematical knowledge also influence students' ability to solve puzzles. English Language proficiency remains crucial for ESL students in mastering Mathematics. Cultural and contextual backgrounds impact problem-solving approaches, necessitating culturally sensitive instruction (Martin, 2011). Collaborative problem-solving, culturally appropriate examples, and real-world contexts enhance students' engagement and comprehension of Math word problems (Abdulrahim & Orosco, 2020). Teachers play a vital role, with visual aids, manipulatives, and scaffolding strategies proving effective (Williams & Lockley, 2012; Arthur *et al*., 2017). Students stress the importance of differentiated instruction and explicit language support.

In summary, ESL secondary students' Math problem-solving is significantly influenced by English language proficiency, encompassing vocabulary, comprehension, and cultural factors. Targeted instructional support, considering efficient strategies and addressing language barriers, is crucial for improving math performance. Ongoing research is essential to identify precise instructional strategies that can better support ESL students in enhancing their Math problem-solving skills and overall academic success.

Theoretical Framework

This study explores the impact of English language proficiency on Math word problem-solving among ESL secondary school students using two key theoretical frameworks: Sociocultural Theory (Vygotsky & Cole, 1978) and Language Acquisition Theory (Cummins, 2008). Sociocultural Theory emphasizes the role of social interaction and cultural context in cognitive development. It posits that ESL students' language proficiency influences their ability to use language as a tool for effective problem-solving in Mathematics. The framework underscores the dynamic interaction between language, culture, and cognition, suggesting the potential for enhancing proficiency through reshaping social interactions in schools. Language Acquisition Theory, drawing from Krashen's Input Hypothesis and Cummins' BICS and CALP framework, views language acquisition as involving both

everyday conversational skills (BICS) and academic language skills (CALP). The theory highlights the challenge ESL students face in developing CALP, impacting their comprehension and solution of Math word problems. It emphasizes the explicit development of academic language skills, including Mathematical vocabulary and syntax. These theoretical frameworks provide a comprehensive lens for understanding the intricate relationship between ESL students' English language proficiency and Math word problem-solving. They offer insights into how language development, cultural context, and social interactions shape students' problem-solving capacity. Leveraging these frameworks, researchers can explore specific difficulties faced by ESL students, identify effective teaching techniques, and inform educational policies supporting the concurrent growth of Mathematical and English language proficiency (Vygotsky & Cole, 1978; Cummins, 2008).

Conceptual Framework

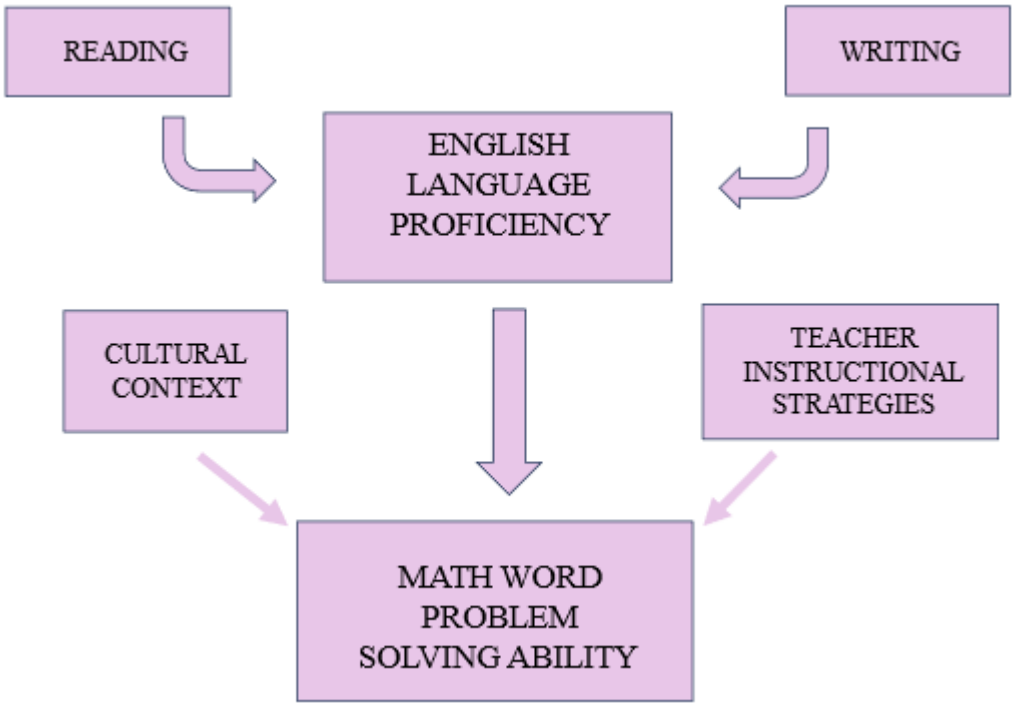

Fig 1: Conceptual Framework

In this conceptual model:

Independent Variable (IV): English Language Proficiency: This variable represents the proficiency level of ESL secondary students in Qatar. It was assessed through standardized English language tests or other proficiency measures.

Dependent Variable (DV): Math Word Problem Solving Ability: This variable represents ESL secondary students' ability to solve math word problems. It includes comprehending problem statements, applying problem-solving strategies, and effective communication of solutions.

Moderating Variables:

(a)Cultural Context (CC):

- Moderating variable reflecting the influence of cultural background.

- Expected to moderate the relationship between ELP and MWPS.

(b)Teacher Instructional Strategies (TIS):

- Moderating variable representing methods used by teachers to support ESL students.

- Expected to moderate the relationship between ELP and MWPS.

In short, the model explores the direct relationship between English language proficiency and Math Word Problem-Solving ability among ESL secondary students in Qatar. Cultural context and teacher instructional strategies are introduced as moderating variables, influencing the strength or nature of the relationship between ELP and MWPS.

Methods

The impact of English language proficiency on Math Word Problem-Solving ability among ESL secondary students in an international school in Qatar was done to gather some solution-oriented approaches. The following approaches can be adopted based on the findings from this study:

Research Design

A quantitative correlational research design was employed to examine the relationship between English language proficiency and Math word problem-solving ability among ESL secondary school students in Qatar. This design allowed for assessing the strength and direction of the correlation between the variables. The main purpose of the above study is to identify students' difficulties in learning Math in English for the ESL secondary school learners and to implement strategies to overcome the barriers.
The main process of the research was conducted by the researcher as follows,

-Test on English language proficiency

-Test on math worded problem-solving ability

Sample Selection

A representative sample of ESL secondary students was randomly selected from an international school in Qatar. The school, exclusively for girls, provides a high-quality international education with a UK-based curriculum, supplemented by comprehensive programs in Arabic, Islamic education, and Qatar history. The student body comprises 1,622 individuals from various nationalities and cultures, with approximately 80% being Qatari.

Sampling Design

The participants for this study on English proficiency and Mathematics problem-solving skills were drawn from grades 9 to 12. The selection process involved choosing two sections out of five in grade 9, two out of three in grade 10, and two out of three in both grades 11 and 12. In total, 160 students were included in the study. By adopting a random sampling approach, this study sought to ensure a fair and unbiased representation of ESL secondary school students across different grades in the international school.

Table 1: Student Demographics

S. No	Grade	Section	No. of participants
1	9	A	22
2	9	B	20
3	10	A	23
4	10	C	20
5	11	B	24
6	11	C	24
7	12	A	13
8	12	B	14
		Total	160

Data Collection Instruments

Quantitative data for this study were gathered through a meticulously designed English Language Proficiency Test and Math Word Problem-Solving Ability Test tailored for ESL secondary school students. The English Language Proficiency Test, collaboratively developed by the researcher and

supervisor, focused on reading, and writing skills for non-native speakers. It aimed to precisely assess language proficiency in line with research objectives. The Math Word Problem-Solving Ability Test, validated by three expert math teachers, comprised age-appropriate assessments aligned with the curriculum. The English test provided a comprehensive evaluation of language proficiency, emphasizing reading and writing skills relevant to the study. The Math test measured students' ability to comprehend, apply problem-solving strategies, and communicate solutions within Mathematical word problems, ensuring alignment with the curriculum and undergoing rigorous validation.

In summary, these thoughtfully designed instruments, a standardized English Language Proficiency Test, and a validated Math Word Problem-Solving Ability Test formed the robust foundation for collecting quantitative data. They played a crucial role in analyzing the intricate relationship between English language proficiency and Math Word Problem-Solving ability among ESL secondary school students.

Data Collection Procedure

Data was gathered to evaluate how English proficiency affects math problem-solving in ESL secondary students in Qatar. Rigorous standardized tests were conducted, overseen by the researcher and math teachers, with meticulous record-keeping and quality checks. Collaboration with experts ensured test validity and alignment with intended skills. This thorough methodology ensures reliable data for analyzing the correlation between English proficiency and math problem-solving in Qatari ESL students.

Data Analysis

The collected data underwent analysis using appropriate statistical techniques, specifically employing Pearson’s correlation coefficient. This statistical method was chosen to assess the strength and direction of the relationship between English language proficiency and Math Word Problem-Solving ability of ESL secondary school students in Qatar. The analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software. The data presentation involved the use of figures and tables, presenting information in terms of frequencies, percentages, mean, and standard deviation. Descriptive statistical scores, such as arithmetic mean, standard deviation, variance, skewness, and kurtosis, were computed to provide a comprehensive overview of the data's distribution and characteristics. In addition to Pearson’s correlation coefficient, linear regression analysis was applied to explore the predictive relationship between English language proficiency and Math Word Problem-Solving ability. This allowed for an investigation into how changes in English language proficiency might predict corresponding changes in math word problem-solving scores. The presentation of data was enhanced through figures and tables, facilitating a clearer understanding of data patterns. Pearson’s correlation coefficient was utilized not only to identify significant relationships between English proficiency and Mathematics problem-solving skills but also to measure the strength of the observed linear association between these two variables.

Results

The table below presents the descriptive statistics, Product Moment Correlation Coefficient (PMCC) which refers to the Pearson correlation coefficient, which is commonly denoted as "r" and measures the strength and direction of a linear relationship between the two variables English proficiency level and math problem-solving ability among ESL (English as a Second Language) secondary school students in Qatar.

Table 2: Descriptive Statistics

Descriptive Statistics									
	N	Mean		Std Deviation	Variance	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Math Word problem solving ability	168	67.46	1.56	20.25	410.23	-0.459	0.187	-0.499	0.373
English Language Proficiency	168	72.89	0.88	11.35	128.88	-0.384	0.187	0.12	0.373
Valid N (listwise)	168								

Table 3: Correlation/Regression

Correlations			
	Pearson Correlation	Sig.(2-tailed)	N
Math Word Problem Solving	1	0	168
English Language Proficiency	0.47**	0	
** Correlation is significant at the 0.01 level (2-tailed)			

Regression (Model Summary)				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.47[a]	0.22	0.217	17.93
a. Predictors:(Constant), English Language Proficiency				

Table 4: Testing the Significance of the Regression Model

ANOVA					
Model	Sum of Squares	df	Mean Square	F	Sig
1 **Regression**	15157.553	1	15157.553	47.162	0.000[b]
Residual	53351.363	166	321.394		
Total	68508.915	167			
a. Dependent variable: Math Word problem Solving Ability b. Predictors:(Constant), English Language Proficiency					

Table 5: Coefficients

Coefficients[a]					
Model	Unstandardized Coefficients		Unstandardized Coefficients Beta		
	B	Std. Error		t	Sig
1 **Constant**	6.29	9.01		0.7	0.486
English Language Proficiency	0.84	0.12	0.47	6.87	0
a. Dependent variable: Math Word problem Solving Ability					

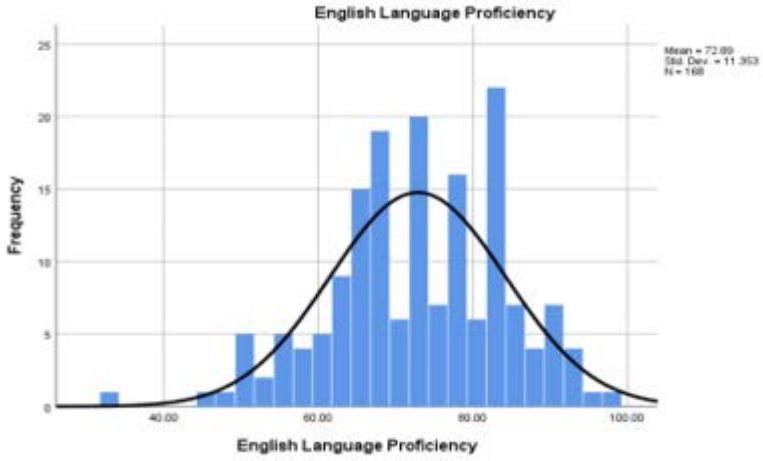

Figure 2: English Language Proficiency

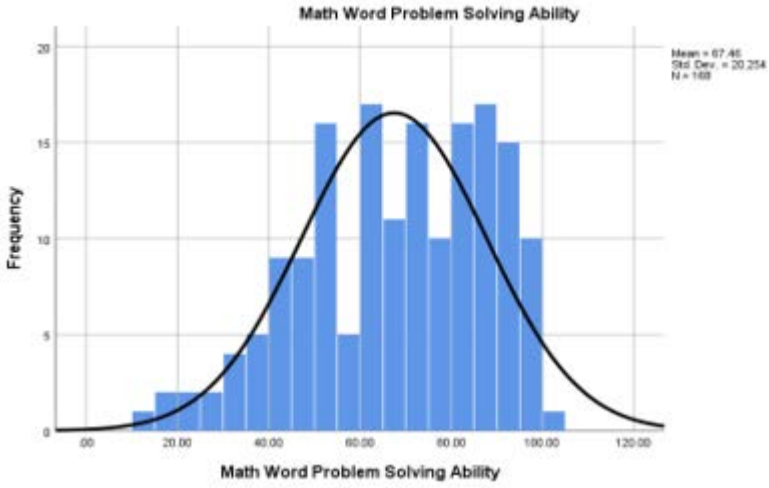

Figure 3: Math Word Problem Solving Ability

Pearson Correlation

There is a 0.47 correlation between the ability to solve math word problems and English language proficiency. The two variables appear to have a moderately positive correlation, according to this. The correlation shows strong confidence in the observed relationship and is statistically significant at the 0.01 (2-tailed) level. We need to remember that correlation does not imply causation. The correlation between English Language Proficiency and Math Word Problem Solving Ability may be due to a third variable, such as cognitive ability. Regression Model Summary indicates, R Square value of 0.22, English Language Proficiency, the predictor variable, accounts for 22% of the variance in Math Word Problem Solving. The R Square value is marginally modified by the adjusted R Square, which takes the number of predictors in the model into account (0.217). ANOVA indicates that it is significant ($F = 47.162$, $p < 0.01$). This suggests that the predictor variable, English Language Proficiency, has a major role in predicting the ability to solve math word problems. Co-efficient results show that at zero English language proficiency, the estimated constant value for the Math Word Problem Solving Ability is 6.29. Also, the English Language Proficiency coefficient stands at 0.84 indicating that Math Word Problem Solving Ability is expected to increase by 0.84 units for every unit increase in English Language Proficiency. At a significance threshold of 0, the English Language Proficiency t-value is 6.87. This suggests that there exists a statistically significant correlation between English language proficiency and Math Word Problem Solving ability.

Discussions

The study uncovers a significant positive correlation between English language proficiency and the ability to solve Math word problems among ESL secondary students. The regression model highlights English Language Proficiency as a substantial predictor, emphasizing its crucial role in enhancing Math problem-solving skills. This finding has important implications for educators and policymakers, suggesting the need for targeted interventions and support systems to improve Math problem-solving skills among students with lower language proficiency (Fatmanissa & Novianti, 2022).

Teachers are identified as key contributors, playing a pivotal role in supporting ESL students by integrating language development and Mathematical reasoning in instructional strategies. To address challenges related to math word problems, teachers are encouraged to provide explicit vocabulary instruction, model problem-solving techniques, and foster collaborative discussions to strengthen students' comprehension and communication skills. The study recommends allowing students to articulate their thoughts using various forms, such as Mathematical language, drawings, and natural language, to enhance comprehension and mathematical thinking skills. ESL secondary school students are advised to actively engage in language learning activities, regularly practice Math word problems, and seek clarification when language barriers arise. Promoting self-regulated learning strategies, including goal setting and reflection on problem-solving processes, empowers students to take ownership of their learning and overcome language challenges. Creating a collaborative and supportive learning environment is deemed essential, with collaboration among teachers, students, and parents fostering a comprehensive approach to language and Math instruction. The study suggests potential solutions for improving Math Word Problem-Solving ability among ESL secondary students in Qatar, including implementing language-focused Math instruction, offering professional development for teachers, providing targeted interventions for students with limited language proficiency, and incorporating culturally relevant math word problems reflecting students' experiences and backgrounds. These solutions aim to address identified challenges and promote the academic success of ESL secondary students in Qatar (Hamdan & Amayreh, 2007).

Modifications to the Teaching Methods

To support ESL secondary school students in improving their math word problem-solving abilities, it is important to make certain modifications to the language used in math word problems. Here are some potential modifications that can help alleviate language barriers and enhance comprehension:

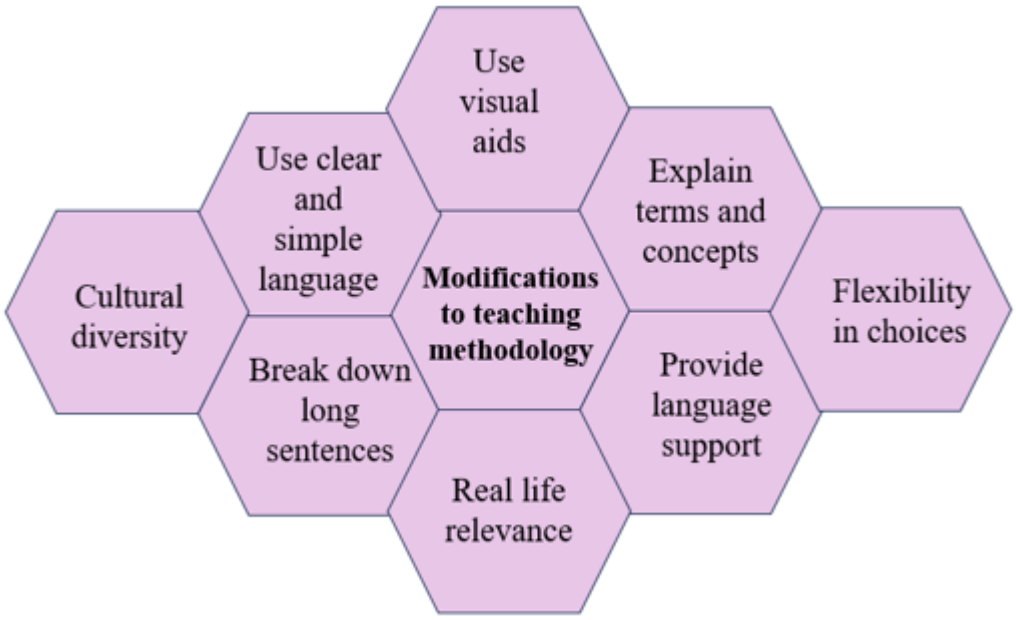

Figure 4: Modifications to Teaching Methodology

These modifications to the language of math word problems can help ESL secondary school students overcome language barriers, improve comprehension, and enhance their math problem-solving abilities. Implementing these strategies in the classroom can create a more inclusive and supportive learning environment for ESL students, enabling them to succeed in math problem-solving tasks.

Limitations & Future Directions for Research

In acknowledging study limitations, it is crucial to highlight the potential constraint of generalizability due to the focus on a specific school in Qatar. The concentration on correlation and regression analyses, while insightful for understanding associations, falls short of establishing causation, underscoring the challenge in determining the exact direction of influence between variables. For future research, addressing these limitations becomes imperative. Longitudinal studies could provide a more in-depth exploration of the enduring impact of English language proficiency on math word problem-solving abilities over an extended period. The inclusion of qualitative research methods, such as interviews and observations, could offer richer insights into the challenges faced by ESL secondary school students, shedding light on effective strategies employed by teachers to support their learning journeys. Moreover, broadening the research scope to encompass diverse educational settings would enhance the external validity of findings. Exploring specific instructional strategies and considering student perspectives could contribute to a more comprehensive understanding of the intricate dynamics at play in the intersection of language proficiency and math problem-solving abilities. By venturing into these areas, future research endeavours have the potential to provide nuanced insights and evidence-based recommendations for educators and policymakers aiming to enhance the academic success of ESL secondary school students in mathematics.

Conclusion

In summary, this study has illuminated the positive correlation between English language proficiency and math word problem-solving skills among ESL secondary school students in Qatar. It highlights the indispensable roles of both teachers and students in achieving this positive impact. Teachers are pivotal in supporting ESL students by employing instructional strategies that seamlessly integrate language development with mathematical reasoning. Through explicit vocabulary instruction, effective modelling, problem-solving techniques, and fostering collaborative discussions, teachers can significantly enhance students' understanding of math word problems and their ability to articulate solutions. Simultaneously, ESL students play a crucial role in their own learning journey. Actively participating in language learning activities, regular practice of math word problems, and seeking clarification when language barriers arise are essential steps for students to overcome challenges and enhance their math problem-solving skills.

The creation of a collaborative and supportive learning environment emerges as a key factor in assisting ESL secondary school students. Collaboration among teachers, students, and parents facilitates a holistic approach to language and math instruction. Regular communication with parents, involving them in students' learning progress, and providing resources for continued language development at home further contribute to the overall improvement of students' language and math skills. To further enhance math word problem-solving abilities among ESL students, the study recommends specific modifications. These include adjusting the language complexity of math problems, clarifying vocabulary and terminology, contextualizing problems, providing language supports, and encouraging the use of multiple representations. These modifications aim to alleviate language barriers, enhance comprehension, and ultimately contribute to a more successful learning experience for ESL secondary school students.

Declarations

Ethics Approval and Consent to Participate: In the data collection process, consent was obtained from the participants.

Conflicts of interest: Not applicable.

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