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Language Challenges in Mathematics Courses for Non-Native English-speaking Students: A Literature Review

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Abstract. This review was particularly relevant as it took place at a time when the number of Saudi students in the United Kingdom (UK) and most other developed countries had increased dramatically. Such growth called for an understanding of the language difficulties these students were likely to face in coping with the discursive features of mathematics courses. This review responded to this need and provided important information for educators. Existing knowledge was accessed to determine the relationship between language and mathematical learning and helping non-native English-speaking students. A specific detailed methodology was used to select the chosen studies including four criteria: topic, research base, reliability and validity, and research question. Their findings would enable stakeholders and mathematics teachers to anticipate the language problems for these mathematics students. The study suggested strategies for mathematics teachers that support non-native English-speaking students and made several recommendations for mathematics teachers to improve the experience for such students. It is clear that all students who are non-native English speakers need support to participate in mathematical conversations, and the strategies provided will help to enrich the mathematical learning experience for these students.

Keywords: mathematics education, linguistic challenges, non-native English-speaking students, language and mathematics, learning support

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1. Introduction

Large numbers of students fail mathematics examinations solely because they are unable to understand some of the words on the question papers (Backhouse, 1999; Fatmanissa & Novianti, 2022). Gillam et al. (2016) assessed the impact of language impairments on mathematical ability and identified multiple problems in mathematics classrooms. These include students not realising when they have failed to understand information, lacking the ability to begin a classroom conversation, and failing to ask questions. All these issues can impede the teaching and learning of mathematics. Therefore, a student learning mathematics should have the ability to create, store, and retrieve a mathematical schema. Four linguistic competencies are needed: an ability to use vocabularies and forms of syntax with disparate meanings in mathematics and general contexts, the ability to move between these contexts in their usage of words, reading comprehension, and a knowledge of the formal language and symbols required to solve mathematics problems. Research indicates certain language impairments can prevent students from acquiring mathematical skills such as understanding the place value principle, spoken number sequences, and calculation. There may, however, be less of an impact on their understanding of the logical principles underpinning simple arithmetic (Donlan et al., 2007).

Arguably, mathematics is a unique language with distinct phrases, vocabularies, symbols and an unusual method for reading comprehension. This often causes problems and leads to confusion. The concepts employed in mathematics are frequently complicated and the words used are imbued with meanings that are entirely at odds with their everyday usage (Gillam et al., 2016). Examples of such words include “similar”, “root”, “power”, “odd”, and “ring”. Difficulties with the language are one of the principal reasons why a large number of students perform poorly in mathematics; this is particularly acute for bilingual and multilingual students. Therefore, it is not surprising that students proficient in the English language are more likely to excel in mathematics (Recca & Lasaten, 2016).

Existing research, however, has yielded mixed findings regarding the relationship between mathematical proficiency and language proficiency, with some studies suggesting that the two forms of proficiency depend on each other (Holton et al., 1999, cited in Albert, 2001) and others suggesting they are independent skills (Chomsky, 1975). The following literature review therefore strives to clarify the issues for students whose native language differs from that used to present the mathematical problems with which they are faced.

As stated in Abdullah (2019), a recently published report by the Agency of the Ministry of Education for Scholarship Affairs revealed that 92,997 Saudi students are currently studying abroad. This includes 52,038 scholarship students, 18,560 employees on a study scholarship, 13,049 self-funded students, and 9,350 dependents of scholarship students (Abdullah, 2019). The total number of students studying globally is as follows: the United States (US) has the most students with 51,083, followed by the UK with 14,614, Australia with 6,694, Germany with 1,929, Ireland with 1,162, France with 743, the Netherlands with

404, China with 382, Austria with 339, and Japan with 319, while there are 15,328 students dispersed in other countries (Abdullah, 2019).

Given the recent increase in the number of Saudi students studying abroad with their families, this review will enable administrators and teachers to anticipate problems, employ the right strategies, and design alternative plans that will help ease their predicament.

1.1 Background

The review began in response to understand the difficulties experienced by Saudi students in mathematics at primary, middle, and secondary schools – and some students at university level – due to a lack of proficiency in English, which is not their first language. It was initiated by two separate incidents in examinations that drew attention to the fact some students were experiencing difficulties comprehending particular questions solely owing to their language.

This was followed up by talking to twenty Saudi students studying at primary schools in the UK. They were found to be proficient in mathematics when studying in their language because they understood the lecture extremely well. They mentioned some of the strategies the teachers in the UK used to support them in understanding mathematics. Such instances indicated that language-related difficulties in learning mathematics merited further research. It was clear that it is important to first access existing knowledge and survey literature in this field to establish what is already known.

1.2 The Study Objectives

In order to understand the language difficulties students were likely to face in coping with the discursive features of mathematics courses, the research objectives were as follows:

(a) To access existing knowledge and perform a survey of literature to highlight the relationship between language and mathematical learning and help non-native English-speaking students;
(b) To enable administrators and mathematics teachers to anticipate language problems and mathematics for these students;
(c) To identify strategies for mathematics teachers that support non-native English-speaking students in mathematics education;
(d) To make useful recommendations for mathematics teachers, so they can produce guidelines for the design of language support programmes; and
(e) To encourage teachers and researchers with an interest in language and mathematics to continue exploring this issue.

1.3 Research Questions

The research was based on the following questions:

(a) When we access existing knowledge and conduct a literature survey, what can we find to explore the relationship between language and mathematical learning to help non-native English-speaking students?
(b) What can we draw from the literature about strategies mathematics that teachers can use to support non-native English-speaking students when learning mathematics?

(c) What are the recommendations extracted from these findings to stakeholders and teachers to help non-native English-speaking students when learning mathematics?

2. Theoretical Framework

This section presents the theoretical framework for the research. It is divided into four main aspects as follows:

2.1 Why does the relationship between language and mathematical learning merit particular attention?

There are numerous reasons as to why it is important to pay particular attention to mathematics education. First, mathematics texts are frequently difficult for students, who must expend considerable effort in processing them. With the aim of imparting information, such texts often contain abstract and dense concepts, and employ language and terminology that students will probably not have encountered in everyday usage (Palinscar, 2013). Their technical and explanatory nature means that the language skills required by students need to be highly sophisticated. This includes a knowledge of specialist vocabulary, interpreting scientific symbols and diagrams, identifying and comprehending the ways in which science texts are commonly organised, employing inductive and deductive reasoning to extract the core ideas, and knowing how to identify causal relationships (Barton & Jordan, 2001).

For students studying mathematics, whether this is at primary, secondary or tertiary in different level, an essential attribute is a sophisticated level of reading proficiency and language skills. This is particularly the case for multilingual or bilingual students who are having to learn mathematics in a second language. Fang (2006) contends that the particular linguistic features that render science texts more abstract and denser can often lead to difficulties in understanding, especially for students whose first language is not English. Moreover, the number of such students is growing in line with increasing migration and mobility, and approximately 50% of the global population are now believed to use two or more languages or dialects in their lives (Ansaldo et al., 2008). This provides a strong justification for focusing on the learning of mathematics among non-native English-speaking students (Barwell, et al., 2007; Rhodes & Feder, 2014).

2.2 Review of the Theoretical Literature on the Relationship between Mathematical Learning and Language

Driscoll (1983) and Pirie (1998) contend that language is the means by which mathematical symbols are interpreted, while Brown (1997) and Setati (2005) assert that language is the medium used to convey mathematical ideas. Similarly, Rotman (1993, cited in Ernest, 1994) argues that mathematics is a practice that employs written language to formulate, record, and validate the knowledge it produces. Both Ernest (1994) and Lerman (2001) assert that language fulfils an essential function in creating, acquiring, communicating, creating, and justifying mathematical knowledge, and indeed, knowledge per se.

Barwell et al. (2007) state that students studying mathematics who are using a second language face the dual challenge of not only learning mathematical concepts but also the language through which such concepts are conveyed.

Douady (1997) highlights two aspects associated with a knowledge of mathematics. The first requires the acquisition of specific concepts and theorems that enable the learner to solve problems and understand information, and to generate novel questions. The second aspect requires an ability to identify concepts and theorems as fundamental components of a body of knowledge that is both socially and scientifically recognised. This includes an ability to formulate definitions, and to state and prove theorems that form part of this corpus.

The model suggested by Clark (1975) asserts that the conceptual development of the student is facilitated by language, and is a product of their experiences, which are derived through instruction and discussion. The model highlights the diverse roles played by language in teaching mathematics. As various mathematical concepts are learnt, various linguistic activities fulfil different functions. Therefore, to cope with the range of linguistic activities needed to learn mathematics, students need to have a high level of proficiency in both their first and second languages.

Durán (1989) outlines a number of factors that impact the performance of those learning the English language in certain content-based areas. These include a lack of familiarity with the particular linguistic structures employed in questions, a failure to identify vocabulary expressions, and the literal misinterpretations of items. With respect to testing Ell students, Tippeconnic and Faircloth (2002) highlighted the importance of language alongside cultural characteristics.

2.3 Review of Empirical Literature

Employing an experimental design, Barbu and Beal (2010) examined the effect of linguistic complexity on the ability to solve mathematical word problems among a sample of 41 English students from three middle schools in Tucson, Arizona. The study materials consisted of booklets that contained eight mathematical word problems, the difficulty of which ranged from easy-math easy-English to hard-math hard-English. The results were consistent with 17 predictions derived from cognitive load theory. Performance on problems written in more complex language was lower than performance in the same problems written in simple language. The problems that caused most problems were those that were both linguistically and mathematically complex. This could be attributed to the extra cognitive demands placed on students with respect to understanding the text. Additionally, students' perceptions of the difficulty of mathematical problems were strongly influenced by the extent to which items were linguistically difficult.

Eduardo and Saul (2013) performed an analysis of quantitative data gathered from the first (2002) and second (2004) phases of the Educational Longitudinal Study (ELS)(2002). Their aim was to examine the association between performance in 12th grade mathematics of Latina/o secondary school students and their proficiency in English language as well as mathematics course-taking measures. The results indicated that there was a robust relationship between mathematics achievement and the provision of support to enhance students' proficiency in both mathematics and English.

Focusing on a sample of 118 students from the Faculty of Science and Technology, University Kebangsaan, in Malaysia, Rambley et al. (2013) also examined the relationship between mathematics achievement and English proficiency. Data were gathered from the assessment of a course taught at the university which comprised four subjective questions at varying levels of difficulty The results suggested that a strong mastery of English was required to achieve excellent results in mathematics. This is reflected in the fact that students who obtained lower grades were less proficient in English.

Kagasi (2014) conducted a study to assess how the use of manipulative learning resources impacted students' ability to learn number recognition. Data were gathered by administering pre-tests and post-tests to a sample of 792 students in 30 preschools, and questionnaires to a sample of 60 teachers in these schools. The results indicated that teachers' attitudes towards the use of manipulatives impacted how often they used such resources in their classrooms. Moreover, the use of manipulative instructional resources enhanced students' ability to learn number recognition.

Cekiso, et al. (2015) investigated the effect of proficiency in English language on the academic performance of learners in natural science, economic and management science (EMS), and mathematics. Participants comprised a purposive sample of 215 Grade 8 students. The criteria employed to measure their performance in each subject were end-of-year results. The results revealed no significant relationship between English language proficiency and the academic performance of students in mathematics and EMS, but a weak relationship between English language proficiency and academic performance in natural science. The researchers concluded that there was no relationship between the language proficiency needed to succeed academically in mathematics and EMS and the current structures of the English language subject presented to them.

Buba and Umar (2015) examined how students' academic performances in financial accounting was affected by their proficiency in mathematics and English. The sample comprised 451 business education students enrolled at six universities in the northern states of Nigeria. The achievement test used by the researchers consisted of problems derived from Financial Accounting textbooks and the contents of lectures. The results indicated that academic achievement was impacted by gender differences, and that there was a positive relationship between academic performance in financial accounting and proficiency in mathematics and English.

Kontas (2016) investigated the extent to which the use of manipulatives affected the academic achievement of secondary school students in mathematics and their attitudes towards this subject. The sample comprised 48 seventh grade students who were divided into an experimental group and a control group. Data were gathered using an attitude scale for mathematics and a mathematics achievement test. The results indicated that there were significant differences in academic achievement scores between the two groups on the post-tests. Specifically, the achievement scores of the experimental group increased substantially as a result of using manipulatives. Additionally, attitudes towards mathematics were significantly more positive in the experimental group.

2.4 Strategies for Supporting English Language Learners

When taking his children to a primary school in the UK, the second author observed mathematics teachers employing a range of methods to support students who were not native English speakers; these methods were due to empirical experience. They included use of the home language, word origins, collaborative learning, visual aids/diagrams/manipulatives, and strategies for journal writing. It was therefore decided to review these strategies to determine their relative benefits in assisting English language students.

2.4.1 Word origins

Languages that have similar roots also contain words that exhibit similarities in sound and appearance. To furnish non-native speakers with enough information to know where they should concentrate their reading activities, it is important to provide regular visual cues when verbally communicating concepts. This will also help non-native speakers of English to gradually develop English language abilities in the domain of study, thus serving as a means of connection between the two languages (Fatmanissa & Novianti, 2022).

Using the origins of words can also enable them to form associations between different mathematical terms. Rubenstein (2000) asserts that teaching students the origins of a word will provide them with insights into what the word means and how it is constructed. Consequently, students are more likely to remember it. For instance, although trigonometry sounds like a novel term when it is disassembled into its constituent parts, these can be connected to established concepts such as tri- for three, -gon for form, and metr- for measurement (Shatnawi 2008) When students realise that the word relates to triangles and measurements, they are able to make greater sense of it, particularly if they are already familiar with these three concepts (Benjamin, 2011).

2.4.2 Home language

An essential method employed to foster the development of mathematical skills among English language students is to recognise and promote the use of native languages in the mathematics classroom. Such languages should therefore be viewed as a valuable resource rather than an impediment, in the same way that variations in mathematical approaches are acknowledged and valued (Moschkovich, 2010; Planas & Setati-Phakeng, 2014).

Research has indicated that mathematical vocabulary develops faster when students are able to use their native language (Xi & Yeping, 2008). Indeed, both mathematical learning and language development can be facilitated by the use of specific techniques derived from students' native languages. A notable example in this regard is a mathematical word bank, where students are provided with the translations of mathematical words in their native language (Lee at al., 2011). This can also enhance their relationships with their parents, who are now able to understand the language employed in their children's homework, not only in mathematics but also in other academic subjects (Lee et al., 2011).

In addition to making use of students' home languages, it is also essential to utilise English words that are familiar to students. This makes sense as prior to developing proficiency in an academic language, including mathematics, English language students initially become proficient in the use of everyday, spoken English (Lee et al., 2011). Using such terms will therefore serve as a bridge to understanding more complex academic English terms. To illustrate, Lee et al. (2011) used the word "difference" to facilitate students' comprehension of the term "subtraction".

2.4.3 Visual aids/diagrams/manipulatives

For students whose language skills do not equal their mathematical ability, it can be useful to apply visual techniques as a form of scaffolding (Altieri, 2009; Lee et al., 2011; Nguyen & Cortes, 2013). For instance, if students lack the ability to ask questions in English or do not feel sufficiently confident to approach their teachers, visual aids such as diagrams and posters can help them find answers to their questions (Nguyen & Cortes, 2013). To facilitate their understanding of word problems, they can also be provided with physical items such as props (Brown et al., 2009; Nguyen & Cortes, 2013). Moreover, the use of visual aids and manipulatives can also serve to place mathematics within a particular context. This is useful because English language students often find it difficult to understand the abstract nature of academic mathematical language (Lee et al., 2011; Moschkovich, 2002). Indeed, the use of manipulatives can be extremely helpful in enabling all students to deal with the abstract nature of mathematical language (Altieri, 2009; Nguyen & Cortes, 2013). For English language students, such aids help reduce the language load as they can learn mathematics by observing and physically handling resources (Nguyen & Cortes, 2013).

2.4.4 Collaborative learning

A powerful resource for all students, particularly English language students in mathematics, is that of collaborative learning. Working in conjunction with a partner provides English language students with the opportunities to engage with others and receive vital support, which is invaluable for learning (Brown et al., 2009). Through collaboration, they can ask questions and make errors in a safe environment in which they can be provided with instant and direct feedback. Moreover, students' language development is enhanced by taking part in genuine interaction and conversation. This works particularly well when they are paired with a student with a high level of proficiency in the English language. Therefore, to nurture the mathematical understanding and development of English language learners, it is advisable to employ a versatile grouping strategy strategically which is designed to meet the different needs of each student (Ngyuen & Cortes, 2013).

2.4.5 Journal writing

Winsor (2007) reported that journal writing simultaneously assists English language students in both learning mathematics and the nature of the mathematical language used. For instance, while writing in the language with which they feel most at ease, students were also asked to write down mathematical terms in English. This helped them link these English terms with mathematical terms with which they were already familiar. A vital element in making journal entries is the skill of evaluation. For instance, as each week came to an end, students used a simple three-point rubric to assess the work of their peers. This involved swapping journals with their peer partner, scoring specific journal entries, and then providing a written justification as to why they gave these particular scores. Employing the same rubric, the writer of the journal then read and reacted to the evaluation. Winsor (2007) argues that this has a number of benefits for students. First, writing about the mathematics compelled students to think about what they did or did not understand and then write those thoughts down. Second, they became more adept at mathematical communication. Even though earlier diary entries lacked sophistication and students often resorted to non-mathematical ideas to convey their thoughts, their entries exhibited greater mathematical precision over time. Moreover, students made greater use of English in their writing. Students worked hard on their journal entries because they were aware that these would be read by their peers, and that they would be asking each other questions when there were points in the evaluation they did not agree with or understand. Because students had to explain the rationale for their evaluation, such discussions were usually mathematical in content.

An alternative yet straightforward writing technique is to combine writing with problem solving. For instance, for take-home problem-solving assignments, students were asked to fold a piece of paper vertically down the centre (Rubenstein & Thompson, 2002). On the left-hand side, they wrote down their approach to solving the mathematical problem while on the right-hand side they explained the thinking behind this process. Rubenstein and Thompson (2002) reported that even though students initially found such assignments to be extremely time-consuming, it also enhanced their understanding, especially among English language students.

3. Methods

This section describes the research methodology employed, the search and retrieval of studies. This section also includes a description of the procedures undertaken by researchers in applying the research tools, and inclusion and exclusion criteria.

3.1 Search and retrieval of studies

The current literature review implemented a systematic approach to provide a better understanding of the language difficulties these students (non-native English speakers) are likely to face in coping with the discursive features of mathematics courses. This review responded to this need and provides important information for educators. The process of systematic review is characterized by some criteria that are used to narrow the scope of a review (Higgins & Green, 2009). These criteria are the standards for judging the weight of evidence in the studies included in this review. Table 1 explains the inclusion criteria in detail:

Table 1: Literature Inclusion Criteria

Criteria	Description
Topic	The primary inclusion criterion was that the study should focus on the access of existing knowledge and conduct a literature survey to highlight the relationship between language and mathematical learning and to help non-native English-speaking students.
Research Base	Literature should include only connecting language and mathematics learning, linguistic challenges, learning support, mathematics education, non-native English-speaking students.
Reliability & Validity	The outcomes of literature studies must be valid and reliable according to the type of the study and publication indexed.
Research Questions	A coding scheme was developed in relation to the research questions.

The databases used in the search process included ProQuest, EBSCO Host, ScienceDirect, Springer, Scopus, Wiley Interscience, Journal Storage (JSTOR), Educational Resources Information Center (ERIC), and WOS. This study only reviewed research articles written in English which were published between 2000 and 2022.

The main key search term was devised on the basis of the main research areas: Language challenges in mathematics courses for non-native English-speaking students. When conducting the search, the main search term was developed as follows: TITLE-ABS-KEY through ProQuest, EBSCO Host, ScienceDirect, Springer, Scopus, Wiley Interscience, Journal Storage (JSTOR), Educational Resources Information Center (ERIC), and WOS. Using the chosen search strategies, a total of 780 results were found.

Choosing to focus purely on journal articles published in English reduced the likelihood that complicated or ambiguous translations would be needed. Subsequently, publications from the 22-year period in question (2000-2022) were examined. The country or region in which the articles were published was not considered for exclusion purposes.

All articles that were incomplete were excluded. In addition, publications that did not satisfy the criteria for language challenges in mathematics courses for non-native English-speaking students were excluded. Subsequently, to verify that each of the articles satisfied the selection criteria and objectives of the study, a thorough review of their titles, abstracts, methodologies, results, and discussions was conducted. At this stage in the process, 758 publications were excluded as they did not focus on the subject of mathematics or they did not involve language challenges in mathematics courses for non-native English-speaking students. As a result, 22 publications were selected to be included in the ultimate stage of the review procedure.

3.2 Inclusion and exclusion criteria

Subsequent to collecting all the results from the selected sources, various selection criteria were applied, including the timeline, type of document, language and topic area, to screen publications that had no relevance to the current study. In the process of choosing which publications would be included or excluded, it is important to define the relevant criteria clearly to guarantee that the chosen publications have relevance to the main objective of the research. Table 1 presents the criteria determining which articles would be included or excluded in the current review study, as well as the research findings. It was identified that 22 publications had relevance; therefore, the full-text articles of these studies were acquired.

Six faculty researchers with experience in the field conducted the coding process which involved reading and then categorising the AIME publications according to the established coding scheme. The kappa coefficient among the coding results of the respective researchers was determined to be 0.90, thus indicating that they were highly consistent (Lavrakas, 2008).

4. Discussion

This review was carried out in light of the rapid increase in the number of Saudi students choosing to study overseas in the UK and the corresponding increase in the number of students now studying at schools and university, especially on mathematics courses. As revealed by Abdullah (2019), a report published recently by the Agency of the Ministry of Education for Scholarship Affairs stated that 92,997 Saudi students are now studying abroad, 14,000 of whom have chosen to study in the UK. The aim of this review was therefore to enable stakeholders, administrators and teachers to predict potential problems, employ the correct strategies, and develop effective plans to address such problems.

The first stage in this process was to review extant knowledge in this area. This revealed that a large body of researchers (e.g., Barbu & Beal, 2010; Buba & Umar, 2015; Eduardo & Saul, 2013; Kagasi, 2014; Kontas, 2016; Middle et al., 2015; Rambley et al., 2013) had highlighted language as having a substantial impact on learning mathematics at pre-school, primary school, middle school, secondary school, and university levels. The relationship between mathematics and English is intrinsically linked to the fact that language is a fundamental component in the communication of academic material. Indeed, when English was employed as the language of instruction, almost all studies identified a strong relationship between English and mathematical problem solving. The only exception was a study by Cekiso, et al. (2015) who identified no relationship between the language proficiency needed to succeed academically in mathematics and the current structures of the English language subject with which they were presented.

The current researchers challenge this conclusion as they contend language has an essential role to play in learning mathematics. For instance, it is used by teachers to implement mathematical procedures and explain mathematical concepts. Furthermore, a specialist technical vocabulary (addition, subtraction, addend, sum) is employed when solving mathematics problems. Those researching mathematical learning have also revealed that using language to convey and reflect on their ideas can enhance and deepen students' understanding of mathematics (e.g., Barwell et al., 2007; Brown, 1997; Clark's proposed model, 1975; Douady, 1997; Driscoll, 1983; Durán, 1989; Ernest, 1994; Lerman, 2001; Pirie, 1998; Rotman, 1993; Setati, 2005).

It was observed by the researchers that the second author's children encountered similar barriers to learning mathematics whilst studying at primary schools in the UK. One such obstacle was unfamiliar or poorly understood vocabulary. For instance, confusion often arose because mathematical terms such as "even", "odd", and "function" have a different meaning from that employed in everyday language. There was also confusion as to whether a variety of mathematical terms such as "add, "and", "plus", "sum", and "combine" can be used to denote the same mathematical operation. For instance, usage of the word "left" – as in "How many are left?" – can also cause confusion as its everyday use is as a marker of direction. Another difficulty lies in the use of "sum" and "whole", which have nonmathematical homonyms (some and hole) in everyday usage.

A second barrier was an insufficient understanding of syntax and grammar. For instance, mathematics questions are often couched in language that renders the problems obscure or hard to understand. For instance, a typical question might be the following: "Steve bought four bags of oranges with eight oranges in each bag. How many oranges did he buy?" The difficulty created here for someone less proficient in English is the use of both the past and present tense of the irregular verb "to buy".

Another typical problem may be formulated as follows: Sara gave a total of 12 treats to her cats. She gave her large cat two more treats than she gave her small cat. How many treats did she give to each cat? In this example, students need to understand or work out the meanings of the words "total' and "treats". In addition, they have to comprehend words that denote a mathematical relationship, e.g., "more… than", as well as inferring that Lisa has only two cats. The researchers contend that English language students often find it difficult to comprehend and thus solve word problems, which worsens as they progress through school owing to the increasing linguistic and conceptual complexity of such problems. Difficulties in understanding mathematical instructions and participating in mathematical discussions are therefore founded on problems with grammar, syntax, and vocabulary.

In terms of strategies to support English language students in mathematics, a notable method employed by UK teachers when teaching Saudi students is to focus on word origins. Even though similarities exist in the sounds and appearances of words from languages with similar roots, these are usually not marked enough to help students learn mathematics in a language with which they are unfamiliar. However, conventions that often transcend languages and cultural boundaries were those such as numerical order and the use of certain numerical symbols. This indicates the importance of clarity when using verbal communication in a classroom presentation that provides students with information additional to the written mathematics. The similarities between languages and cultures that are enshrined in numerical order and symbolic representation can therefore be extremely useful to both teachers and students. For both written and verbal communication, visually depicted numerical indicators such as chapter and section numbers can therefore help provide clarity. Although a large number of teachers do this, often routinely, it is important to ensure it is not forgotten. Furthermore, because language difficulties mean students may sometimes lose track of verbal communication, it is essential to ensure they know where to locate information in their written materials. For instance, when verbally explaining mathematical concepts, non-native speakers can be provided with information on where to concentrate their subsequent reading activities through the use of frequent visual cues such as section numbers on white/blackboards and presentation slides. This will help non-native speakers gradually develop their English language skills in this particular domain, thereby serving as a link between the two languages (Fatmanissa & Novianti, 2022).

An alternative technique is to make use of home language, which should be considered a resource to support students' learning and not an impediment (Moschkovich, 2010; Planas & Setati-Phakeng, 2014). The subject of language is acknowledged as essential for building mathematical knowledge within the classroom. Students will be required to understand the core and linguistic assumptions underpinning school mathematics to enhance educational performance and outcomes in this subject. Furthermore, they will be required to engage and actively participate in classroom activities such as intellectually demanding tasks, group work, and reporting results or findings. These make enormous demands on the ability of students to engage meaningfully with these components of learning. Therefore, in line with the findings of other researchers (e.g., Lee et al., 2011; Xi & Yeping, 2008), it is argued that to enable students to better understand and resolve these mathematical problems, they should be supported in using their home language within classroom settings.

Another useful approach is to use visual strategies which will serve as scaffolding for students whose mathematical ability is not matched by their aptitude in language (Altieri, 2009; Lee et al., 2011; Nguyen & Cortes, 2013). In line with the findings of Nguyen and Cortes (2013), such strategies entail presenting information in the form of photos, illustrations, graphs, diagrams, icons, symbols, and other visual models to help students interpret and understand complex data. The second author identified five key visual learning skills employed by mathematics teachers of their own children in UK schools, namely recognition, observation, interpretation, perception, and self-expression. The authors believe that implementing these skills through dedicated strategies is essential to help students understand mathematics.

Examples of strategies employed by mathematics teachers in UK schools are presented in this section. The first was sketching out new concepts: this involved students sketching out a novel mathematics concept and was considered an extremely powerful visual learning strategy. The researchers contended that students can only understand abstract mathematical concepts if they could see how they work, and they often solve problems using visual models. Such models ranged from drawings and solving word problems to tallies used to mark quantities. The second is creating charts and graphs: this strategy supports students in viewing and comprehending data relationships using strong tools such as bar graphs. For instance, in the 'Lemonade for Sale' story, a group of children created a lemonade stand in order to raise money so that they could repair their clubhouse. They recorded the number of cups sold each day on a chart. This gave them a strong visual indicator of the days on which they sold the most or fewest cups, forming the basis for subsequent decisions. Such an approach aligns with the findings of Nguyen and Cortes (2013) who stated that that the use of visual aids, such as diagrams and posters, enables answers to be sought by students who lack the confidence to ask their teachers or are unable to ask questions in English.

Another strategy was collaborative learning, which was a learning method that uses social interaction as a means of knowledge building. The second author heard his children say that they are able to work alongside a partner, especially when this was a peer who had a higher degree of proficiency in the English language, as they felt they support their mathematical understanding and development. The vital message to those teaching mathematics to non-native English speakers is that collaboration is an essential component of group work, as this is where students support each other's learning. They can resolve areas of confusion or answer particular mathematics questions in a manner other students can grasp. In line with the findings of several researchers (e.g., Brown et al., 2009; Nguyen & Cortes, 2013), this is beneficial for both non-native English speakers, who receive an answer to their question, and native English speakers, who will remember the concept having taught it to someone else.

Regarding the final strategy, journal writing, the second author observed that mathematics teachers integrated both writing and problem solving when teaching his children in UK primary schools. For instance, he noticed that his children exhibited a substantial improvement in mathematical problem-solving using the paper-folding strategy described earlier in this chapter. This aligns with the work of several researchers (e.g., Rubenstein & Thompson, 2002; Winsor, 2007) who found that writing journals assisted English language students in learning both mathematics and mathematical language at the same time.

It is useful to note that mathematics teachers in the UK use these strategies to help students understand the content of their mathematics lessons. Such support is vital for developing a basic comprehension of mathematical concepts; however, it may not give them sufficient linguistic support to talk about the strategies they employ, which could deepen their understanding. For instance, if a student creates a two-column chart with drawings that make a distinction between polygons and non-polygons, this will help their understanding of this concept. However, they may not have understood the linguistic components of the lesson enough to advance their learning of polygons in future lessons. In short, to develop a strong understanding of mathematical concepts, it is essential to possess the language to discuss them.

As stated earlier in this review, the conceptual understanding of students is deepened by engaging in classroom discussions about mathematics. These are essential in developing both content and language, creating an environment in which English language students can determine meaning through everyday interactions within the classroom. Regrettably, non-native English-speaking students will not benefit from such discussions and will lag behind their peers if the language they need in order to participate in such discussions is not made clear.

Teachers need to concentrate on mathematical concepts and their associated academic language. They need to be mindful of the linguistic demands placed on students and ways to address them explicitly during teaching for non-native English-speaking students to become fully involved.

5. Conclusion

The main objective of this study was to access existing knowledge and perform a survey of literature to highlight the relationship between language and mathematical learning and to help non-native English-speaking students, through determining strategies for mathematics teachers that support non-native English-speaking students in mathematics education. Therefore, it has highlighted the gap in knowledge regarding the relationship between the teaching of mathematics and a student's English proficiency and language background. This study is especially important given the dramatic increase taking place in the number of Saudi students in the UK and many other developed countries. It is essential to comprehend the language problems these students will face when having to deal with the discursive elements of mathematics courses.

The results showed that when English was employed as the language of instruction, almost all studies identified a strong relationship between English and mathematical problem solving. The only exception was a study by Cekiso et al. (2015) who identified no relationship between the language proficiency needed to succeed academically in mathematics and the current structures of the English language subject with which they were presented. In addition, home language, word origins, collaborative learning, visual aids/diagrams/manipulatives, and journal writing are useful techniques that will increase the understanding of students and enable them to acquire knowledge so that they can perform to an optimal level in mathematics. It is therefore essential to be aware that non-native English speakers require assistance if they are to participate fully in mathematical discussions. The strategies outlined will serve to enhance the learning experiences of these students.

6. Recommendations

Based on the literature review, the study offers the following recommendations: Firstly, teachers, academic leadership staff, and educationalists need to be cognisant of the association between students' mathematical achievement and their proficiency in the language of instruction. Secondly, teachers and educationalists should gain enough knowledge to adjust the design of their teaching in order to meet the needs of individual students and attain the set objectives. It is important to modify the complexity of mathematical word problems so that they are aligned to students' level of linguistic proficiency. Thirdly, home language, word origins, collaborative learning, visual aids/diagrams/manipulatives, and journal writing are useful techniques that will increase the understanding of students and enable them to acquire knowledge so that they can perform to an optimal level in mathematics. Fourthly, the use of manipulative resources will help elevate students' understanding to an advanced level. This is because it provides them with concrete objects to handle as a means of enhancing mathematical learning. Fifthly, the stakeholders in Saudi Arabia and UK should take advantage of this review to help current and future students. Finally, it is important that schools, university and departmental administrative bodies consider tracking the language challenges in mathematics courses for non-native English-speaking students, to better assist students.

7. Suggestions

The following suggestions are made to assist non-native speakers requiring assistance when learning mathematics: Firstly, further studies need to be conducted to identify the disadvantages of each strategy in teaching mathematics. Secondly, further studies need to be conducted to identify the effect of other strategies, on teaching mathematics, when teaching non-native English-speaking students. Finally, this study focused on teaching mathematics, but another study could focus on other areas of the education field.

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