The Intersections of English-Language Proficiency, Use of Technology, and Teaching and Learning Mathematics in Undergraduate Courses in the UAE

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Abstract. There is an undeniable link between student language proficiency and mathematical performance. In institutions such as ours in the UAE, the medium of instruction is English, which poses a further layer of complexity for Emirati students in developing mathematical skills. How can math teachers overcome these difficulties? Previous research indicated that explicit vocabulary instruction, mnemonic strategies, and gamification strategies, including the use of technology for teaching and learning, were proven effective in overcoming poor math performance in the mathematical classroom. We consulted an experienced mathematician who shed light on strategies to help students to overcome their mathematics phobia and predisposed negative connotations to mathematics as a science. We suggest that the use of technology, strategic methods of explicit language teaching, storytelling, and gamification could increase student motivation and performance in mathematics. Furthermore, mathematical instruction should move from scientific pedagogy from facts and specific principles to a language-focused, technology-infused pedagogy to support students whose mother tongue is not English. We conclude that there is a paucity of research on interdisciplinary approaches to teaching mathematics, and it warrants further investigation by mathematicians, language teachers, and technology experts in interdisciplinary studies rather than in separate sciences.

Keywords: language proficiency, technology, mathematics

1 Introduction

English has been increasingly used as a medium of instruction in higher education programs in the United Arab Emirates (UAE). This poses a challenge for local students and their teachers. Daleure (2011) reported that Emirati students have underdeveloped reading skills in English and Arabic in her research on blended learning in the UAE. The researcher reported that learners come to higher education unprepared for English as a medium of instruction. Teaching and learning mathematics are simply not just

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performing calculations, but also showing students mathematical ways of communication (Planas et al., 2018). The link between literacy and mathematics has ample evidence in research (Purpura et al., 2017). In addition, recent statistical studies have shown that students with higher language proficiency outperform students with lower language proficiency in mathematical exams (Erath et al., 2018; Greisen et al., 2021; Hartanto et al., 2018; Xu et al., 2022).

Another factor reported to impact mathematics instruction significantly is the use of technology, which has become a key driving force for innovation in all spheres of human life, including education (Dinges et al., 2018). Teachers use a variety of technology as a delivery mode of instruction as well as a toolset to support their teaching and foster student learning (Halepoto & Lohar, 2022; Wang, 2021). Research findings also indicate that mathematics students have positive attitudes toward using digital tools in class (Eyyam & Yaratan, 2014; Murphy, 2016; Talib et al., 2018). Moreover, the use of technology in teaching and learning mathematics enhances both instructor-student and student-student interactions, promotes student collaboration, supports accuracy of student mathematical computation, and fosters student self-confidence in their abilities to learn mathematical concepts, which, in its turn, assists in development of student mathematical competences and higher-order thinking (Murphy, 2016).

The crisscrossing of the use of technology, student English-language proficiency, and mathematical pedagogy is discussed further. First, we present themes in the literature about the use of technology and the role English proficiency plays in the mathematics classroom. Gaps in the literature are identified. Next, we offer expertly trailed methods from a math specialist. Finally, we suggest that technology-infused pedagogy that supports learners who are not native speakers of English might improve student mathematics-learning outcomes.

2 Literature Review

The literature review presents recent research results on the link between student English-language proficiency and learning mathematics. In addition, findings of empirical studies about the use of technology to support teaching and learning mathematics are discussed. Many educators express their concerns that students who are not native speakers of English often become invisible in mathematics classrooms because they lack English-language proficiency to communicate their mathematical reasoning. For example, Nikula et al. (2020) have found that using mathematical diagrams can help students make sense of mathematics and facilitate their mathematical communication and language development. "In this manner, diagrams promote student agency and mathematical authority" (p. 80). Moreover, Erath et al. (2018) emphasize that the language of explaining, or the discursive practice of explaining, should be a learning goal in mathematics classrooms to optimize learning.

Fuchs et al. (2018) investigated mathematical word problems as a form of text comprehension and the role of language in learning mathematics. They found that language is significant in forecasting individual differences in word problem outcomes in mathematics. The researchers suggest that when teaching word problems, the focus should not be only on calculation skills, as is often the case. Instead, they recommend applying an approach to teaching mathematics, like teaching reading comprehension, with a focus on vocabulary and syntactic composition.

Based on their study results, Planas et al. (2018) argue that research on mathematics and language encompasses three main possible foci: (1) the language of the learner – the linguistic skills a learner brings to the classroom; (2) the language of the teacher – the linguistic skills teachers have in the classroom; and (3) the language of mathematics – a set of linguistic features of the texts within mathematics. According to the researchers, students "need to learn 'the language of mathematics,' which requires access to and use of other languages and discourses of the classroom" (p. 200).

Early literacy skills and early mathematics may be predictive of each other. Purpura et al. (2017) claim that mathematical skills are a measure of another skill, such as a deeper knowledge of language in general. Moreover, Tennison (2018) emphasizes that language support from a bilingual teaching assistant and access to recorded lessons that allow students to learn at their own pace help non-native English speakers to grasp mathematics in the English-medium class. Language support in terms of mathematical vocabulary learning has also been highlighted in the study conducted by Riccomini et al. (2015). These researchers argue that vocabulary learning is essential for mathematical proficiency.

Next, Denfield et al. (2014) claim that English proficiency is a statistically significant predictor of mathematics scores. Specifically, higher proficiency in English results in higher mathematics scores; however, as the grade level increases, this tendency reduces. In addition, grade level moderates the influence of English proficiency on mathematics scores.

Moreover, current research shows that having high English-language proficiency is not the only significant variable that is likely to impact learning mathematics in the modern English-mediated class. It is quite challenging to imagine today's instruction without the use of a variety of hardware and software. Integration of technology in teaching and learning has been proven beneficial because "…high-quality professional development, digital standards-based content, and personalized learning plans can increase student achievement, engagement, and critical-thinking skills, and provide students with access to learning opportunities otherwise difficult to attain." (Nebbergall & Hambrick, 2012). However, one cannot use technology to enhance teaching and learning without being "on good terms" with the digital tools.

Specifically, Sprenger and Schwaninger (2021) claim that "user acceptance is a pre-requisite for technology effectiveness." (p. 1) In a quantitative study, the scholars examined student acceptance of the use of four types of technology: e-lectures, classroom response system, classroom chat, and mobile virtual reality (VR). Based on students' feedback collected twice, before and after the use of each digital tool, the acceptance of the classroom response system was the highest one. The second most-accepted technology was e-lectures, followed by classroom chat. The least accepted digital tool was mobile VR. The students specified that "the setup of the mobile VR sequences took too much time—technical issues for some few students detained the entire class" (p. 13). Another barrier to the mobile VR acceptance increase could be students' underwhelming because of the simplicity of the mobile VR modules offered.

Another study, conducted by Prifti (2022), measured student satisfaction in a blended course. The researcher focused on identifying Learning-Management-System (LMS) factors that might affect student self-efficacy and influence their overall course satisfaction. Study results indicate that LMS self-efficacy positively impacts learner satisfaction. Specifically, LMS content, its accessibility, and components that foster student critical thinking (quizzes with open- and closed-ended questions, diverse assignments, and case studies) are the factors that are likely to enhance LMS self-efficacy and increase blended-course effectiveness.

Recent research findings also reveal that instructors and students should acquire the necessary skills to use technology in class to benefit both teaching and learning (Buentello-Montoya et al., 2021; Herbst et al., 2022; Papadakis et al., 2021). In addition, instructors' paying specific attention to the number of digital tools they intend to use in one course as well as their variety, is emphasized in recent studies. For example, in a mixed-method study, Wang (2021) analyzed the implemented multimedia distance-learning environment at an entry-level mathematics university classroom and its resulting consequences on student mathematics learning and assessment performance. The scholar used *Moodle, Zoom,* and *Campuswire* as delivery-mode digital tools. Research findings indicate that students prefer using a smaller variety of technology in one course because it is challenging to manage a range of digital tools to complete one task or project. Wang (2021) also pointed out that *Moodle* was the most used platform for her teaching "because of its clarity and functionality" (p. 28).

Findings of the reviewed research on the use of technology in mathematics class show that diverse digital tools are to be part of everyday instruction. The use of technology in mathematics classes has been proven to support teaching and enhance student learning. However, researchers also reason that teachers should be cautious when deciding which available digital tools are the most appropriate to use for a target activity, task, or project. In addition, scholars emphasize that a wider variety of technology used in one course does not imply a better quality of instruction and/or higher student achievement. Therefore, these multiple factors should be considered when planning a technology-supported activity, task, project, or entire course. Moreover, when the language of mathematics instruction is English, and mathematics students are English-language learners, this should also be considered. Explicit vocabulary instruction, mnemonic strategies, and gamification strategies, including technology, were proven effective in mathematics teaching and learning.

3 Gaps in the Literature

Little attention has been given to subjects taught in English in the Middle East (Alhassan et al., 2021). Similarly, the mechanisms by which mathematics and language proficiency are related and how these connections may differ over time need further investigation (Purpura et al., 2017). According to Planas et al. (2018), there is also a gap in research on how language competences may be influenced by using innovative technology that enables new discourse practices in mathematics instruction. Similarly, more empirical research is needed regarding the efficacy of instructional technology for teaching vocabulary specific to mathematics to low achievers (Riccomini et al., 2015). There is also a lack of research on the use of emerging digital tools for teaching certain mathematical concepts. Moreover, educators are in a constant and intensive search for the best ways to integrate technology in their teaching as well as in independent student-learning activities. Finally, the impact of using different digital tools on student learning outcomes must also be investigated thoroughly (Rodriguez, 2020; Thurm & Barzel, 2022).

4 Expertly Trialed Methods

Many efforts have been made in the last years by mathematicians, experimenting with numerous techniques in learning mathematics to engage students who major in different subjects. In educational courses, learners study philosophy, history, culture, music, language, and other liberal arts courses, exploring tangible ideas. However, in mathematics, teachers need to make the abstract concrete. What are the ways they do this? A mathematician expert with more than 35 years of teaching experience (one of the chapter's authors) starts his class by asking an attention-grabbing question, such as "How long will it take you to climb a 2-km-tall building vertically, like a spider-man?" In the lesson, he aims to include fascinating ideas and exciting concepts to grab student attention and, hopefully, get them on good terms with mathematics and even have fun when dealing with mathematical tasks. According to this expert, concepts such as infinity, certainty, uncertainty, fractals, or chaos should be taught in between liberal arts and science pedagogy. By doing this, the mathematician implies that science pedagogy should not focus on just presenting formulae without providing proper context, meaningful to his students. This approach helps to avoid presenting mathematics to the students scientifically. Including stories, anecdotes, visuals, and other teaching strategies and techniques in everyday instruction may foster student engagement in learning mathematical concepts. Formal definitions, statements, lemmata, corollaries, propositions, and theorems are unattractive to non-mathematics majors. A fascinating journey into the science of numbers and figures begins by illustrating techniques to develop ways to formulate questions that arise from real-life observations. This enables students to find the beauty in mathematics by looking for patterns and generalizations and making conjectures based on their observations. Here is one of the word problems suggested by the mathematician expert as an example: "You are meeting seven friends. In total, you are a group of eight people. If each of you shakes hands with everybody, how many handshakes are there in total?". This question creates some fun in the classroom while students try to get the correct answer.

Next, the students are encouraged to look for a mathematical pattern. The following technique is applied to find the pattern. If there are only two people in the group, and you name them *A* and *B,* there is obviously only one handshake (*A–B*). If there are three people in the group, *A, B, C,* there are three handshakes (*A–B, B–C,* and *A–C*). If there are four people in the group, *A, B, C, D,* there are six handshakes (*A–B, A–C, A–D, B–C, B–D,* and *C–D*). Have you seen a pattern yet? (See Table 1)

Table 1. Number of handshakes with no apparent pattern.

Number of people	Number of handshakes
2	1
3	3
4	6

Not yet? How about now? (See Table 2)

Table 2. Number of handshakes with a pattern.

Number of people	Number of handshakes
2	1=2*1/2
3	3=3*2/2
4	6=4*3/2

In other words, if there are five people, the number of handshakes will be: *5*4/2=10.* To answer the original question about the number of handshakes for a group of eight friends, the answer will be *8*7/2=28.* This way, students create a new formula: the number of handshakes amongst a number of people (n) is $n(n-1)/2$. This activity, known as the *Handshake Problem*, has been proven to involve even the least interested and/or motivated-to-do calculations students.

In addition, educators should never forget that when a student hates or dislikes mathematics, this feeling might be lifelong. Even just mentioning the word *mathematics* can cause issues in class! So, using simple everyday English when explaining mathematical concepts to the students and sharing captivating real-life stories with them could make learning mathematics more enjoyable. Here is where appropriate English-language competences come to the fore. For instance, when talking to students about the history of numbers, how people started counting using their fingers, *one, two, …*, and because this was the natural way to count, the {*1, 2, 3, ...*} is called the set of natural numbers and is denoted by *N.* Amazingly, this is the reason we have a decimal system today because we have ten fingers and ten digits, namely *0, 1, 2, 3, 4, 5, 6, 7, 8, 9,* where each finger corresponds to a specific digit. Students love this story, and it reduces the phobia of using numbers from the early lessons as they view all the sets of numbers (*integer, rational, real, imaginary, and complex*) as a manageable range. Another supportive technique would be adding a fairy tale to calculations, telling the students that "… during a quiet night, I was walking alone in the desert, and I met a creature from another planet. He had one eye in the middle of his forehead, and four fingers on each of his two hands…". Next, he would ask students: "What numeric system do you think the extraterrestrial creature uses on his planet? Binary, decimal, or another one?"

The answer, of course, is "octadic" because the creature had eight fingers on his two hands.

Ongoing mathematics class observation shows that the use of everyday language helps the teacher to introduce mathematical concepts and contexts in a motivating manner. It also assists in developing student mathematical skills by using those in real-life examples; it acts as a bridge for mastering problem-solving skills. Thus, the beginning of mathematical learning is based on creating a connection between the use of a language and physical objects. As children grow up, the use of the language fosters their "acquaintance" and "friendship" with the symbolic nature of numerals. In other words, English and mathematics create a perfect partnership since mathematics embraces the content and boosts students' cognitive skills and logical and creative thinking. At the same time, English supports verbal communication, which teachers desperately need to be able to explain the complexity of mathematics to students.

From the perspective of an English-language instructor, mathematical terms must be explicitly taught in addition to other definitions of words and how to use them correctly in a mathematical context. For example, the word *plus* means "addition"; however, so do *total, together, sum,* and *add*. What a nightmare for students of other languages! To overcome these vocabulary challenges, students should be encouraged to support each other in their mother tongue. When it comes to word problems, visual cues, graphic representations, and realia can help students to grasp a mathematical problem. Furthermore, reading a mathematical problem several times by using different lingual expressions meaning the same concepts (for example, we can use *difference, minus,* or *take away*) and discussing what that means might be more effective than just focusing on keywords in the word problem. Krick-Morales (2006) provided a good example that illustrates what is stated above. "Maria has *24* marbles, which is *8* fewer than Paolo has. How many marbles does Paolo have?" (para. 3) If teachers focus on keywords, the expression *fewer than* might confuse students because they might have been taught that *fewer than* means to subtract. However, it is not the case in this word problem. Mathematics teachers, therefore, should also focus on the context in which keywords are used.

The second variable impacting mathematics teaching and learning, the use of technology in the classroom, provides additional opportunities for learners to interact with mathematical concepts. Students can discover more aspects of mathematical objects by playing games and using simulations. For example, the use of *Kahoot* (www.kahoot.com), a digital quiz-based learning platform to incorporate gamification in teaching and learning mathematics, affords creating multiple-choice, multiple-answer, type-an-answer, and puzzle questions that help students both to learn new mathematical concepts and to review their already obtained knowledge. In addition, using *Kahoot* in class makes students active learners, which is likely to foster their learning outcomes. For instance, when teaching an equation of straight lines, the mathematician expert divides students into two groups to create a competitive environment and enable their peer support. Specifically, he assigns two distinct points of a straight line to one group and asks them to find the correct straight line passing through the given points. At the same time, another group performs the same task using different data (i.e., different points). Both groups work hard to find the correct answer first because they want to win the game. The number of members in a group may vary from three to five depending on the overall number of students in the classroom. Students can play the *Kahoot* game on their laptops or smartphones. The mathematician guides students through every step to ensure that each student has accessed the *Kahoot* web page and entered the pin for the game he provided. Our expert's classroom observation data indicate that students like group participation more when they are taught a new mathematical notion. This is because when students are introduced to a new mathematical concept, they have opportunities to interact and collaborate using the English language, request support from their peers, and develop an answer as a group.

The mathematics expert's experience indicates that using the classic/individual *Kahoot* play mode is more beneficial for student achievement during in-class reviews of already-learned concepts before a benchmark assessment. For instance, the expert usually includes multiple-choice and jumble questions in applied mathematics final review class. He uses multiple-choice questions to review fundamental mathematical terms. In the case of statistical concepts, jumble questions are used. Moreover, these students insist on the classic/individual *Kahoot* play mode before benchmark assessments to assess their current mathematical competences and identify gaps in their knowledge before formal assessment. *Kahoot's* competitive features help students to engage in in-game activities and focus on winning.

Another example of the beneficial use of technology for mathematics learning is *Desmos* (www.desmos.com), a web-based graphing calculator. For example, if a student wants to graph a complicated function, such as $f(x) = \frac{2^x + x^2}{x - 2}$, with a couple of clicks, the student will see Fig. 1.

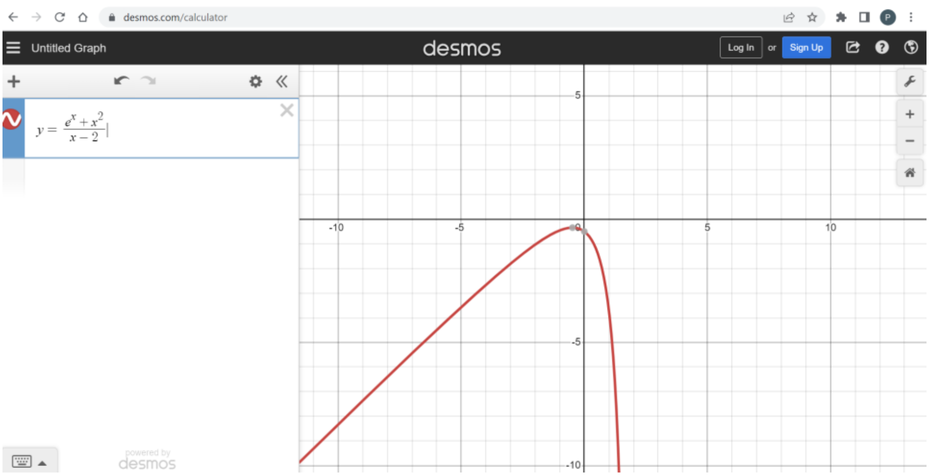

Fig. 1. Mathematical complicated calculations in Desmos.

Students can easily change the domain of the function to "play" with it to find maxima or minima points, *x*- or *y*-intercepts, or use any of the numerable features that the application provides. They can also simply find the intersection point(s) of the above curve with another curve so they can easily solve simultaneous equations. For example, the intersection point(s) of the above function with the additional function $y = tanx$ is needed. Then, the result will show as it is in Fig. 2.

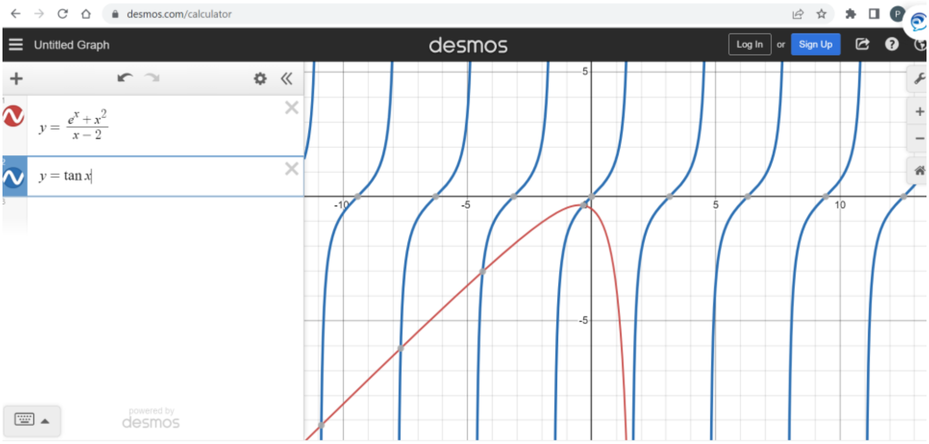

Fig. 2. Display in Desmos with more than one graphed function.

Other digital tools to enhance mathematics learning include applications where a derivative, an integral, or other mathematical objects can be calculated with a click of a button, suggesting, if the user wishes, the steps for the solution. A well-known website to do these calculations is *Symbolab* (symbolab.com), see Fig. 3.

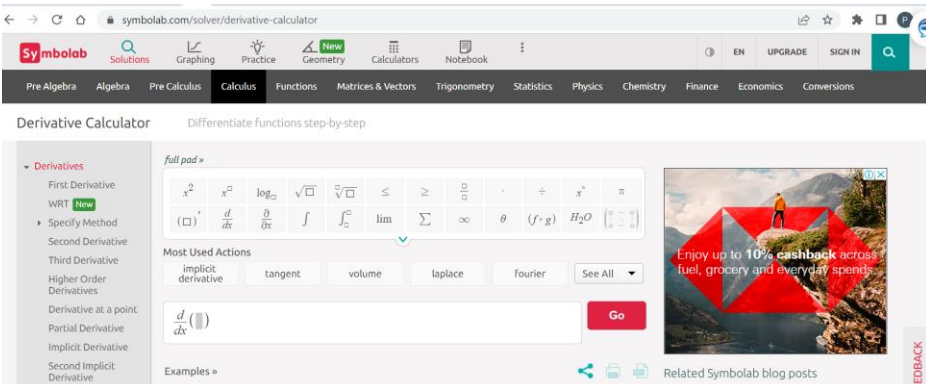

Fig. 3. Symbolab website view.

The above digital tools were chosen to provide examples because they belong to open-source software. This means that no instructor or student may have any restrictions on their usage. As such, they can be deployed to spark student interest in learning mathematics and increase their motivation and performance (Zakaria & Khalid, 2016). Moreover, Talib et al. (2018) claim that mathematics students involved in using technology for learning purposes can work at higher levels of generalization and abstraction.

5 Conclusion

Recent research studies highlight the link between language proficiency and mathematical performance and the benefits of using technology to support both mathematics and language learners. When the medium of instruction in a mathematics classroom is English, there is a further layer of complexity in acquiring mathematical skills. However, teachers can overcome these challenges by applying tried and tested strategies. These include (1) teaching mathematical concepts through explicit vocabulary instruction, (2) providing mathematical tasks meaningful to students, (3) suggesting equations within real-life contexts and storytelling, (4) adding gamification elements in classroom activities by giving students applicable tasks and deploying gamification software; this implies that both teachers and students are technology-savvy enough to apply digital tools successfully, and (5) using software to create mathematical diagrams and solve equations.

Such strategies can be effective in overcoming poor mathematical performance in the classroom. Moreover, using those strategies will help students overcome their phobia and predisposed negative connotations to mathematics as a science. The authors suggest that math instruction should move from scientific pedagogy with its facts and specific formulae to a language-focused, technology-infused pedagogy to support non-native English-speaking students. More research on interdisciplinary approaches to teaching mathematics is needed to warrant further investigation by mathematicians, language teachers, and technology experts in cooperation rather than in separate areas of study.

References

1. Alhassan, A., Ali, N. A., & Ali, H. I. H.: EFL students' challenges in English-medium business programmes: Perspectives from students and content teachers. Cogent Education, 8(1), 1–15 (2021).
2. Buentello-Montoya, D. A., Lomelí-Plascencia, M. G., & Medina-Herrera, L. M.: The role of reality enhancing technologies in teaching and learning of mathematics. Computers & Electrical Engineering, 94(0), 107287 (2021).
3. Daleure, G.: Maximizing the effectiveness of classroom teaching with second language business students: The power punch of blended learning. International Council for Business Schools and Programs Annual Conference Proceedings 1(3), 1–11 (2011).
4. Denfield L. H., Nistor N., & Baltes B.: Examining the relationship between mathematics scores and English language proficiency. Journal of Educational Research and Practice, 4(1), 11–29 (2014).
5. Dinges, M., Biegelbauer, P., & Wilhelmer, D.: The tower of Babylon in the governance of research, technology and innovation: Participatory foresight as a method of policy coordination. Futures: The Journal of Policy, Planning and Futures Studies, 100(0), 34–44 (2018).

6. Erath, K., Prediger, S., Quasthoff, U., & Heller, V.: Discourse competence as important part of academic language proficiency in mathematics classrooms: The case of explaining to learn and learning to explain. Educational Studies in Mathematics, 99(2), 161–179 (2018).
7. Eyyam, R., & Yaratan, H.: Impact of use of technology in mathematics lessons on student achievement and attitudes. Social Behavior and Personality: An International Journal, 42(0), S31–S42 (2014).
8. Fuchs, L. S., Gilbert, J. K., Fuchs, D., Seethaler, P. M., & N. Martin, B.: Text comprehension and oral language as predictors of word-problem solving: Insights into word-problem solving as a form of text comprehension. Scientific Studies of Reading, 22(2), 152–166 (2018).
9. Greisen, M., Georges, C., Hornung, C., Sonnleitner, P., & Schiltz, C.: Learning mathematics with shackles: How lower reading comprehension in the language of mathematics instruction accounts for lower mathematics achievement in speakers of different home languages. Acta Psychologica, 221, 103456 (2021).
10. Halepoto, A., & Lohar, S. A.: Effectiveness of mobile assisted language learning (MALL): Perception of university teachers in Nawabshah Pakistan. The American Journal of Humanities and Social Sciences Research (The AJHSSR), 5(1), 1–5 (2022).
11. Hartanto, A., Yang, H., & Yang, S.: Bilingualism positively predicts mathematical competence: Evidence from two large-scale studies. Learning and Individual Differences, 61, 216–227 (2018).
12. Herbst, P., Shultz, M., Bardelli, E., Boileau, N., & Milewski, A.: How can teaching simulations help us study at scale the tensions mathematics teachers have to manage when considering policy recommendations? Educational Studies in Mathematics, 110(1), 1–21 (2022).
13. Krick-Morales, B.: Reading and understanding written mathematics problems. Colorín Colorado. (2006).
14. Murphy, D.: A literature review: The effect of implementing technology in a high school mathematics classroom. International Journal of Research in Education and Science, 2(2), 295–299 (2016).
15. Nebbergall, A., & Hambrick, K.: Integration of technology in teaching and learning: Comprehensive initiatives enhance student engagement and learning. ICF International (NJ1) (2012).
16. Nikula, J., Neumayer DePiper, J., & Driscoll, M.: Making mathematical thinking visible. Educational Leadership, 77–81 (2020).
17. Papadakis, S., Vaiopoulou, J., Sifaki, E., Stamovlasis, D., Kalogiannakis, M., & Vassilakis, K.: Factors that hinder in-service teachers from incorporating educational robotics into their daily or future teaching practice. CSEDU 2(0), 55–63 (2021).
18. Planas, N., Morgan, C., & Schütte, M.: Mathematics education and language: Lessons and directions from two decades of research. In Dreyfus, T., Artigue, M., Potari, D., Prediger, S. & Ruthven, K. (Eds.), Developing research in mathematics education. Twenty years of communication, cooperation and collaboration in Europe. New York, NY: Routledge. (2018).
19. Prifti, R.: Self–efficacy and student satisfaction in the context of blended learning courses. Open Learning: The Journal of Open, Distance and e-Learning, 37(2), 111–125 (2022).
20. Purpura, D. J., Logan, J. A., Hassinger-Das, B., & Napoli, A. R.: Why do early mathematics skills predict later reading? The role of mathematical language. Developmental Psychology, 53(9), 1633 (2017).

21. Riccomini, P. J., Smith, G. W., Hughes, E. M., & Fries, K. M.: The language of mathematics: The importance of teaching and learning mathematical vocabulary. Reading & Writing Quarterly, 31(3), 235–252 (2015).
22. Rodriguez, M.: A systematic review of technological impact on mathematics literacy in the postsecondary classrooms. Higher Education Studies, 10(4), 54–61 (2020).
23. Sprenger, D. A., & Schwaninger, A.: Technology acceptance of four digital learning technologies (classroom response system, classroom chat, e-lectures, and mobile virtual reality) after three months' usage. International Journal of Educational Technology in Higher Education, 18(1), 1–17 (2021).
24. Talib, C. A., Aliyu, H., Zawadzki, R., & Ali, M.: Developing student's computational thinking through graphic calculator in STEAM education. In AIP Conference Proceedings, 2184(0), 030003 (2019).
25. Tennison, J.: Methods of supporting English learners in mathematics classes. Master's Thesis, California State University (2018).
26. Thurm, D., & Barzel, B.: Teaching mathematics with technology: A multidimensional analysis of teacher beliefs. Educational Studies in Mathematics,109, 41–63 (2022).
27. Wang, H.: What works and what does not: A reflective practice on an online mathematics class. Mathematics Teaching-Research Journal, 13(1), 16–30 (2021).
28. Xu, C., Lafay, A., Douglas , H., Burr, S. D. L., LeFevre, J-A., Osana, H., Skwarchuk, S-L., Wylie, J., Simms, V., & Maloney, E.: The role of mathematical language skills in arithmetic fluency and word-problem solving for first- and second-language learners. Journal of Educational Psychology, 114(3), 513–539 (2022).
29. Zakaria, N. A., & Khalid, F.: The benefits and constraints of the use of information and communication technology (ICT) in teaching mathematics. Creative Education, 7, 1537–1544 (2016).