Enablers and obstacles in teaching and learning of mathematics: A systematic review in LUMAT journal

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This paper presents results of a systematic review of papers published at the LUMAT journal on the current issues positively and negatively affecting teaching and learning in mathematics, in concurrence with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The analysis also offers insight into the most studied topics in mathematics education research, including key demographic and methodological characteristics such as year of publication, participants, education level, research methodologies, and research focus. Data was gathered from the studies published in the LUMAT: International Journal on Math, Science and Technology Education, starting from its first volume in 2013. So far, 225 articles were published in this journal, with 133 studies written in English and 51 studies related to mathematics. Although earlier studies support the notion that mathematics education is mostly traditional, this review suggests current research has thorough and positive outcomes, such that mathematics educators are likely to implement non-traditional approaches, encouraging student engagement, peer collaboration, and mathematical discourse. Certainly, in such learning environments, students tend to feel more motivated and less anxious about learning mathematics. They may also be more active and responsible in their learning, collaborate with peers, and get into mathematical discussions. Yet, there are also a number of difficulties and obstacles highlighted both in teaching and learning of mathematics. The findings might inspire several instructional implications for mathematics educators, curriculum developers, and researchers. Recommendations are given to add into what the existing literature claims and offer greater empirical evidence to support the verdicts.

Keywords: mathematics education, mathematics learning, mathematics teaching, systematic review, PRISMA

ARTICLE DETAILS

LUMAT Special Issue
Vol 10 No 2 (2022), 33–55

Pages: 23
References: 85

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https://doi.org/10.31129/LUMAT.10.2.1627

1 Introduction

How do you remember being taught mathematics at school? If you were in school some decades ago, you could think of sitting in a row, watching the teacher quietly while s/he is solving a number of questions on the board, and then doing similar exercises (Rossi, 2015) until s/he thinks that the targeted learning outcomes are attained. How about nowadays? Is it still the same way? Definitely, with the increased knowledge of how students learn (Bransford, Brown, & Cocking, 2002), the recognition of ineffectiveness of traditional pedagogies (Hazari, Sonnert, Sadler, & Shanahan, 2010), and the availability of new educational technologies, this kind of structured and teacher-centered approaches are not common nor desired practices in mathematics education (Milner-Bolotin, 2012). These days, learners are expected to be capable of more than applying arithmetic skills, but rather taking responsibility in learning process and possessing 21st century skills such as mathematical reasoning, critical thinking, and problem solving (Larmer, Mergendoller & Boss, 2015). Correspondingly, teachers are no longer expected to be transmitting knowledge, but rather acting as facilitator and engaging students in mathematical discourse structured around well-designed authentic activities (Markham, Lamer & Ravitz, 2006).

Especially, since the beginning of 1980s, problem solving has become an essential part of mathematics teaching and learning (Schoenfeld, 1985). According to Polya (1962), the term 'problem solving' refers to "finding a way out of a difficulty, a way around an obstacle, attaining an aim which was not immediately attainable" (p. v). More clearly, Mayer and Wittrock (2006) explain it as "when you are faced with a problem and you are not aware of any obvious solution method, you must engage in a form of cognitive processing called problem solving. Problem solving is cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver" (p. 287). Here, it is important to note that the attribute "problem" is determined by the solver, more than the task itself, such that what might be a challenging problem for one solver can be just a routine exercise for other (Polya, 1962). It is commonly acknowledged that solving problems, especially open-ended problems through classroom discussion, helps students share strategies, insights, and observations with each other, engaging them in a quality mathematical discourse (Boud, Keogh & Walker, 1985), deepening their mathematical thinking, enhancing creativity (Pehkonen, 2001), and promoting diverse and flexible thinking, as well as positively influencing attitudes and self-efficacy in mathematics learning (Lester & Kehle, 2003).

More recently, project-based learning has taken the attention of educators and education researchers. In particular, it is, similar to problem solving, an active learning methodology which "engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks" (Markham, Lamer & Ravitz, 2006, p. 4). It has been documented that when students learn mathematics through project-based learning, they are more capable of using mathematical knowledge in daily life situations (Drake & Long, 2009), remember the content longer (Wirkala & Kuhn, 2011), and have increased motivation toward learning mathematics (Larmer, Mergendoller & Boss, 2015). Beyond that, lately, in consent with unifying instruction, research on STEM (Science, Technology, Engineering and Mathematics) and STEAM (Science, Technology, Engineering, Art and Mathematics) education have spread comprehensively (Çiftçi, Topçu, & Foulk, 2020). Mainly, STEM and STEAM are interdisciplinary approaches that integrate the development of academic knowledge and skills beyond the specificities of the separate disciplines (Monkeviciene, Autukeviciene, Kaminskiene & Monkevicius, 2020). There is a growing body of research showing that incorporating mathematics education with other subject matters in a real, integral, and meaningful context evidently provides an effective platform for rich learning experiences (Brenneman, Lange & Nayfeld, 2019; García-Holgado, Camacho, & García-Peñalvo, 2019; Lawson, Cook, Dorn, & Pariso, 2018).

In brief, in the last decades, with the shift from structured and teacher centered pedagogies to advanced and learner-centric pedagogies, there was a significant transformation by what means mathematics was taught in schools. Yet, along with all this transformation, students still perceive mathematics as a difficult subject matter (Fritz, Haase & Rasanen, 2019) and still several students do not achieve well in mathematics (Sun, 2018). The literature highlights numerous challenges related to both inner and external conditions of a learner. In particular, the inner conditions include cognitive, affective, and motivational factors (Op't Eynde, De Corte & Verschaffel, 2006), such as lack of interest, poor motivation, negative attitudes about learning mathematics, and negative beliefs about their ability and potential (Walker, Smith & Hamidova, 2013). Likewise, the external conditions include teacher factors, such as teachers' poor experience, subject knowledge, qualification (Holzberger, Philipp, & Kunter, 2013), as well as negative attitudes, interest, motivation (King-Sears and Baker, 2014), and efficacy beliefs about teaching (Woodcock & Reupert, 2016). In addition, the external factors consist of contextual factors, including under-resourced and large sized classes (Chiwiye, 2013), and negative attitudes of family members, friends, and society (Boaler, 2015).

If, as Pólya (1962) stated, mathematics is about inquiry, reasoning, and understanding how things fit together, then what could be added into mathematics instruction to help students deepen their mathematical thinking and sense making? How can mathematics learning happen in a concrete and playful way? How can students experience mathematics through creating, designing, and connecting mathematical ideas? Which learning environments can inspire students to build their own mathematical thinking?

This study aims to provide a portrait of research on mathematics education, highlighting multiple aspects of studies published in the LUMAT: International Journal on Math, Science and Technology Education, starting from its first volume in 2013 so far. Specifically, the study aims to answer the following research questions:

1. What are the most studied topics in mathematics education research?
2. What are the enablers and obstacles in mathematics teaching?
3. What are the enablers and obstacles in mathematics learning?

2 Methodology

In this study, a systematic review was conducted on all the published papers in the LUMAT: International Journal on Math, Science and Technology Education, starting from its first volume at 2013 to volume 9 no 2 in 2021. While traditional literature reviews provide a review of knowledge on a general topic without applying a scientific methodology, a systematic review implies "a complete, objective and reproducible" (Linares-Espinós et al., 2018, p.502) synthesis of a clearly defined topic to answer particular research questions in a transparent (Gough, Oliver & Thomas, 2012), standardized, and systematic way (Higgins et al., 2021). Systematic review consists of identifying, selecting, analyzing, and synthesizing information derived from published studies, with explicit inclusion and exclusion criteria (Møller & Myles, 2016). To ensure credibility, consistency, and transparency, the researcher followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and the four-phase flow diagram, addressing all the sections of a systematic review (Moher, Liberati, Tetzlaff, & Altman, 2009).

2.1 Eligibility criteria

The eligible studies in this review consist of all the articles published in this journal, since its first volume, including studies written in English and related to mathematics learning and teaching. So far, 225 articles were published in this journal, with 133 studies written in English (59.1%) and 51 studies related to mathematics field (22.7%).

2.2 Information sources

In June 2021, the researcher visited the website of the LUMAT: International Journal on Math, Science and Technology Education and accessed all the journal's papers in the archives, as it is an open access journal.

2.3 Search and study selection

The search was done manually by the researcher, as the search option in the journal website was filtering the studies only by title or author. The researcher examined all the papers volume by volume, first identifying the publications in English, then screening the papers by the title, abstract, and keywords for the limiters 'math', 'mathematics education', 'mathematics learning' and 'mathematics teaching'. Figure 1 illustrates the flow of the study selection process, including identification, screening, eligibility, and included studies. The retained papers are marked with an asterisk in the references list and summarized in the Appendix.

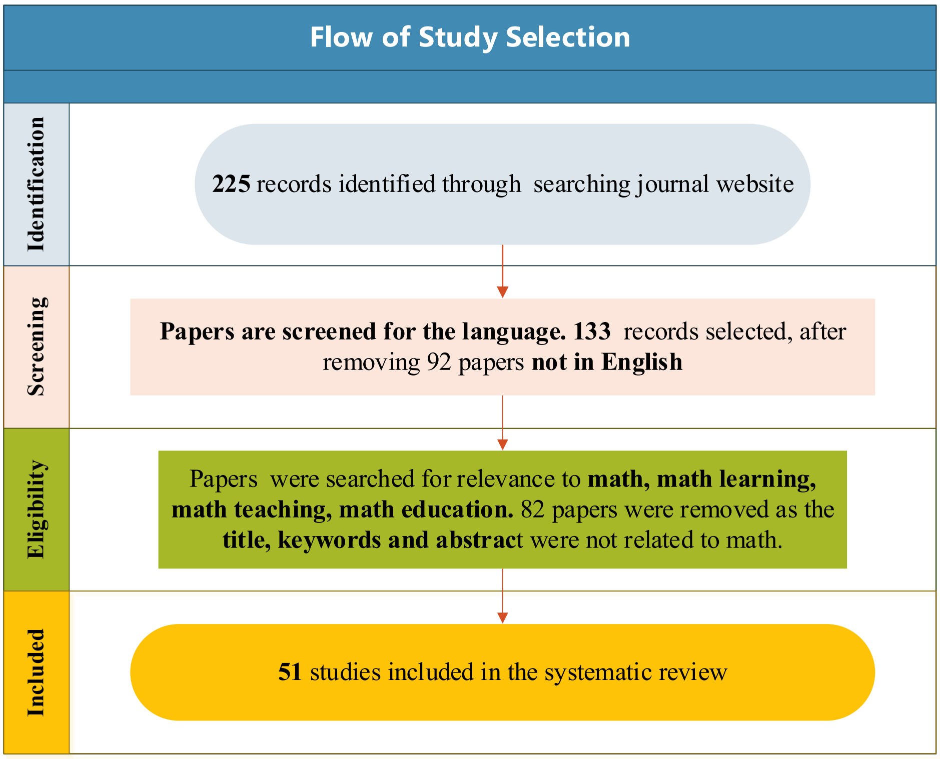

Figure 1. Flow of the study selection

2.4 Data extraction process

Data were extracted from the published papers about publication year, participants, education level, research methods, and research focus. Prior to extracting the data, the researcher established a coding protocol to analyze the data systematically. The variables and the codes are listed in Table 1.

Table 1. Data items and codes

Year of Publication	Participants	Level of Education	Research Method	Research Focus
1. 2013 2. 2014 3. 2015 4. 2016 5. 2017 6. 2018 7. 2019 8. 2020 9. 2021	1. K-12 students 2. Undergraduate students 3. Graduate students 4. K-12 teachers 5. Pre-service teachers 6. Faculty members 7. Parents 8. Principles 9. Others	1. Higher education 2. Secondary education (grades 10-12) 3. Primary education (KG, grades 1-9) 4. All 5. Others	1. Qualitative (e.g. case study, historical study, grounded study) 2. Quantitative (e.g. survey, experimental, correlational) 3. Mixed (e.g. explanatory, exploratory, multiphase) 4. Conceptual (e.g. systematic review, reflection paper, opinion paper) 5. Others	1. Math teachers and teaching 2. Math learners and learning 3. Policy and curriculum 4. STEM education 5. Others

3 Results and Discussion

3.1 What are the most studied topics in mathematics education research?

The analysis of most studied topics in mathematics education included examining key demographic and methodological characteristics, including year of publication participants, level of education, research method, and research focus. With regard to publication years (Figure 2), the results reveal that starting from the year 2013 so far, a total of 225 articles were published in this journal (in 2013 n=43, 19.1%, in 2014 n= 25, 11.1%, in 2015 n=78, 34.7%, in 2016 n=6, 2.7%, in 2017 n=4, 1.8%, in 2018 n=15, 6.7%, in 2019 n=22, 9.8%, in 2020 n=14, 6.2%, and in 2021 n=18, 8%), with the highest number of publications in the year of 2015. In particular, 133 studies (59.1%) were written in English (in 2013 n=20, 15%, in 2014 n=2, 1.5%, in 2015 n=45, 33.8%, in 2016 n=3, 2.3%, in 2017 n=3, 2.3%, in 2018 n=12, 9%, in 2019 n=21, 15.8%, in 2020 n=13, 9.8%, and in 2021 n=14, 10.5%), with the highest number of publications in the year of 2015 as well. Among these studies, 51 studies (38.4%) were related to mathematics (in 2013 *n*=2, 3.9%, in 2015 *n*=13, 25.5%, in 2017 *n*=1, 1.9%, in 2018 *n*= 5, 9.8%, in 2019 *n*=14, 27.5%, in 2020 *n*=9, 17.6%, and in 2021 *n*=7, 13.7%), with the highest number of publications in the year of 2019, and no publication in the years of 2014 and 2016.

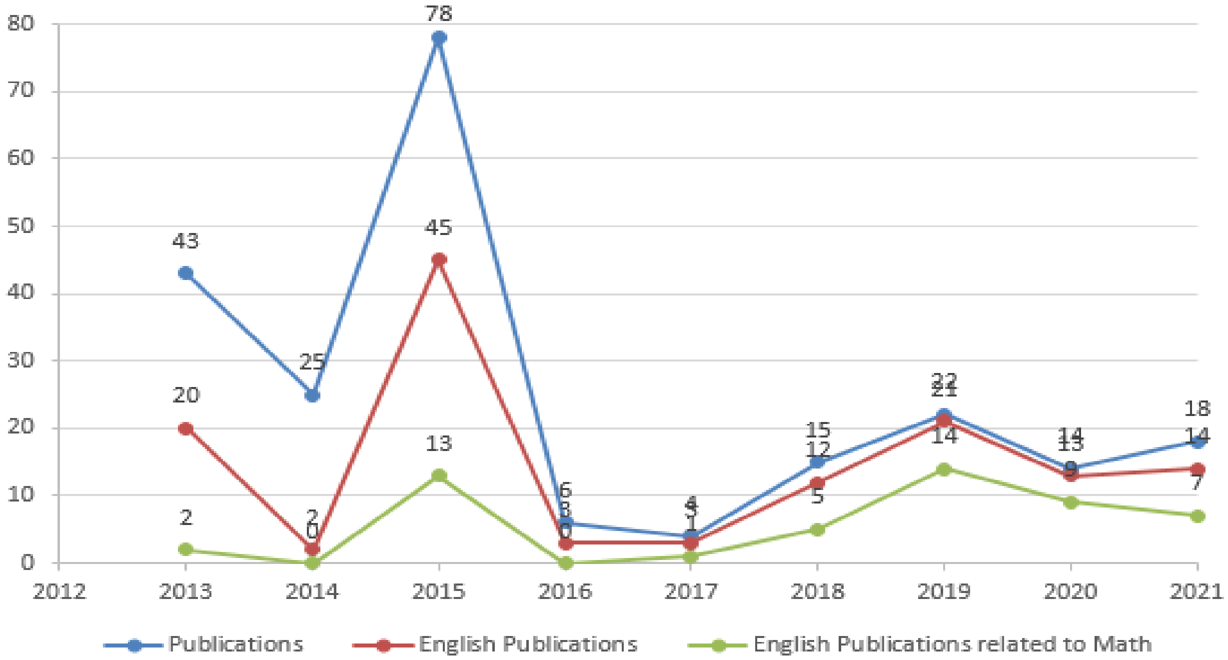

Figure 2. Publication Year

Regarding participants (Figure 3), in most of the studies the data was gathered from teachers (*n*=28, 54.9%), in particular from K-12 teachers (*n*=15,29.4%), pre-service teachers (*n*=10, 19.6%), and faculty members (*n*=3, 5.9%). In addition, information was also collected from students (*n*=19, 37.2%), specifically from K-12 students (*n*=15, 29.4%), and undergraduate students (*n*=4, 7.8%), with no focus on graduate students. In few cases, information were extracted from published materials (*n*=8, 15.7%), as well as principles (*n*=2, 3.9%) and parents (*n*=1, 1.9%).

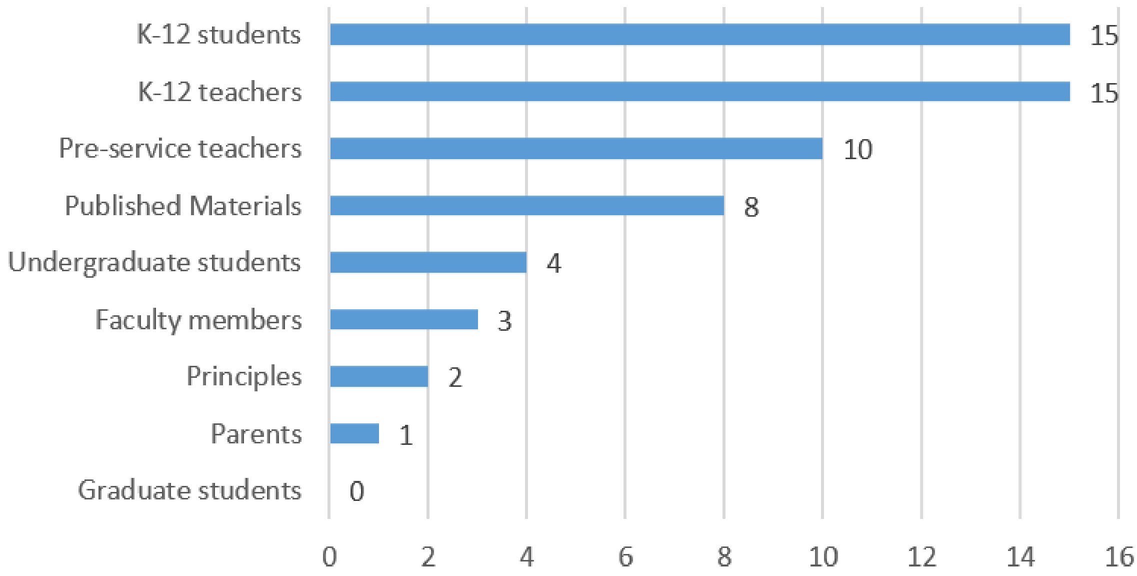

Figure 3. Participants

Concerning level of education, the results show that in most of the studies a strong focus was on primary education which includes kindergarten and grades 1 to 9 (*n*=23, 45.1%) followed by higher education (*n*=15, 29.4%) and secondary education including grades 10 to 12 (*n*=10, 19.6%). Moreover, a few studies included all levels of education (*n*=6, 11.8%).

In terms of research methods, qualitative analysis was the most widely- used research methodology (*n*=22, 43.1%), followed by mixed (*n*=13, 25.5%), quantitative (*n*=9, 17.6%), and conceptual analysis (*n*=7, 13.7%). Lastly, in terms of research focus, in most of the studies the focus was highly on mathematics teachers and teaching (*n*=25, 49%), followed by mathematics learners and learning (*n*=20, 39.2%), and STEM education (*n*=5, 9.8%), with no emphasis on educational policy or curriculum.

3.2 What are the enablers and obstacles in mathematics teaching?

Across the fifty-one studies analyzed here, half of the research on mathematics education were related to internal and external factors positively or negatively affecting mathematics teaching. Overall, one of the main overarching themes identified from this analysis was that well-designed professional development activities and quality teacher training programs have a great impact on teachers' and pre-service teachers' knowledge, competence, and self-efficacy in teaching. Mostly, when there is a mutual trust among teachers and experts, a good teacher-expert collaboration and quality discussions, teachers tend to form a habit of personal reflection on their professional learning and look for solutions to make changes in their mathematics teaching (Namsone, Čakāne & France, 2015).

In this aspect, a study by Kuzle (2019) and Hannula (2019) show that after receiving a professional training about problem solving, pre-service teachers evidently improved their mathematical content knowledge and problem-solving competence. Likewise, a study conducted by Heikkinen, Hästö, Kangas and Leinonen (2015) reveal that after a one-day, on-site professional training event, most of the teachers started questioning and challenging their attitudes towards mathematics teaching. On the other hand, some teachers were still resilient to change their traditional teaching methods due to external factors such as “lack of time, equipment and ready-to-use materials” and “lack of colleague support who share their vision” (p. 914). In addition, there were a number of internal factors, such as “lack of self-confidence in changing teaching methods” and “fear of failure as a teacher” (p. 915). In like manner, a study conducted by Wadanambi and Leung (2019) suggest that “contextual factors such as examination-oriented expectations, time constraints and previous learning experiences” have a significant impact on teachers’ actual teaching practices. In this aspect, it is highly important that teacher education programs focus not only on enhancing teachers’ instructional preparedness but also on preparing them affectively with high levels of efficacy and confidence in teaching (Ekstam, Linnanmäki & Aunio, 2017).

Another interesting outcome of this review is that problem solving appears to be one of the most commonly used method for teaching mathematics. Such as, a study by Koponen (2015) support the proposition that although implementing problem solving might be challenging and time consuming, it is an essential part of developing students’ mathematical thinking and problem solving skills. Especially, for an effective problem solving experience, it is highly recommended that instructors select problems for clear and pre-determined goals, ask students share their point of views with each other, and provide them appropriate guidance while working on finding the proper solution. Here, it is worth noting that while providing guidance, the type, number, and quality of teacher guidance have a great impact on students’ problem solutions (Kojo, Laine & Näveri, 2018). In particular, if a teacher provides too much help or reveals the solution, this ruins the problem solution process and turns an original problem into a standard task. Hence, research suggest that teachers learn how to properly guide their students with variety of probing and guiding questions. For example, teachers can ask probing questions (e.g. How did you solve this?) to lead students to explain their mathematical thinking and ideas. Next, they can ask guiding questions (e.g. Why do you think it is not valid?) to leads students to think about the problem in a different way or to justify their solution. Moreover, teachers can ask factual questions (e.g. How many solutions have you found?) to motivate students to progress in their thinking process. Likewise, a study conducted by Luoto (2020) show that when a teacher balances between dialogic and authoritative speech, giving all students equitable chances of practice, students get active and participate in more productive mathematical discourse. However, when a teacher holds on authoritative approach, seeing discussions as useless and believing that students need strict procedural guidance, students have very limited classroom discourse where the participation happens mostly with short answers.

Similarly, in a study on problem solving with a STEM/STEAM focus, White and Delaney (2021) found that when teachers implement real-world project-based or problem-based learning, where students are in the center of their learning and learn by doing, students achieve higher learning outcomes, and develop positive attitude towards science and mathematics learning. As for research on problem solving, the findings are relatively straightforward, highlighting the importance of problem solving in enhancing students' mathematics learning; it becomes highly important for mathematics educators to have a clear understanding on how they can enhance students' problem-solving proficiency. In light of this, Chapman's (2015) study suggests that it requires more than knowing how to solve a problem. Particularly, in addition to being proficient in problem solving, mathematics educators need to understand "what a student knows, can do, and is disposed to do" and "how and what it means to help students to become better problem solvers", as well as "nature and impact of productive and unproductive affective factors and beliefs" (Chapman, 2015, p.31).

Finally, in addition to the above mentioned aspects, the results of this systematic analysis suggest that, in most of the studies analyzed here, mathematics educators were likely to possess positive characteristics, such as being "a life-long learner, patient, soft, friendly, calm, joyful, self-confident, knowing, and able to withstand hard use when needed" (Portaankorva-Koivisto & Grevholm, 2019, p.107). In addition, in most of the studies, mathematics teachers were reported to be implementing non-traditional teaching approaches including cooperative learning, deductive approach, inductive approach, and integrative approach. According to a study conducted by Cardino and Ortega-Dela (2020), mathematics teachers were mostly applying cooperative learning, followed by demonstration and repetitive exercise. The researchers suggested teachers to use think-pair-share, round table activities, and jigsaw discussions for enhancing cooperative learning in mathematics education. For inductive approach, they suggested using observation, generalization, testing, and verification. Furthermore, for integrative teaching, the researchers advised mathematics teachers to foster students' creativity, use age appropriate materials, and generate new interdisciplinary ways for presenting old topics.

3.3 What are the enablers and obstacles in mathematics learning?

Regarding research on mathematics learning, the analyzed studies can be broadly consolidated into four key aspects, as learning mathematics via technology, impact of cognitive and affective variables on mathematics learning, influence of non-traditional pedagogies on mathematical discourse, and issues related to STEM learning. To start with, as regards to usage of technology in mathematics learning, in a study, Milner-Bolotin, Fisher and MacDonald (2013) examined the implementation of technology-enhanced pedagogy in different learning settings and suggested that classroom response systems (clickers) evidently improve student engagement, reduce anxiety, and enhance students' conceptual understanding in mathematics. Next, a study by Kuzle (2015a), on what learners could gain while working on geometry with a dynamic geometry software, revealed that with the use of software students could go beyond memorization. Indeed, they engaged in solving a wide variety of open-ended problems, which helped them apply the theoretical facts into practical situations and increase their mathematical understanding. In a further study, Kuzle (2015b) examined problem solver's cognitive and metacognitive behaviors while using the same dynamic geometry software. The findings suggest that the use of software supported the learner to engage in a variety of cognitive and metacognitive behaviors, such as gathering information, exploring, conjecturing, generating precise visual inputs, and finding possible solutions. In addition, the feedback provided by the software was assisted the problem solver to make effective decisions and actions. Lastly, in a study, Kaarakka, Helkala, Valmari and Joutsenlahti (2019) examined the impact of an online tool, called MathCheck, on students' level of conceptual understanding. Briefly, what made this tool potent was that it was checking the problem solution step by step and providing detailed feedback to the problem solver, more than an incorrect/correct verdict. Overall, the findings support the proposition that using technology helps students in independent studying and enhance a deeper conceptual understanding in mathematics learning.

Next, regarding research on cognitive and affective aspects, a study by Nyman and Sumpter (2019) revealed that students possess both intrinsic and extrinsic motivation for learning mathematics. Indeed, there is a high association between students' intrinsic and extrinsic motivation such that they are intertwined and hard to separate. In another study, Viholainen, Tossavainen, Viitala, and Johansson (2019) examined the challenges students face with respect to mathematics proof and proving. The results show that even though students were highly motivated to learn proof and proving, there were a number of factors hindering their proving skills, such as fear of making mistakes, lack of experience, low self-efficacy, and lack of knowledge about mathematical content. In this aspect, a study by Viitala (2015) suggest that even though in the existing education system students' educational motivation, positive self-image and self-confidence do not have an influence on their mathematics grades, it is essential that educators consider "taking responsibility of own learning, expressing mathematical thinking and applying mathematics in different environments" as a part of the assessment criteria (p. 148).

As for research on implementation of non-traditional pedagogies in mathematics learning, in a study, Rossi (2015) examined the impact of constructive teaching and technology on mathematics learning, and found that with non-traditional approaches it is possible to challenge and change students' poor engagement and negative attitudes towards mathematics learning. In a similar vein, Ambrus and Barczi-Veres (2015) investigated traditional versus student-centered learning environments, and found that working in groups on open-ended math problems enhance collaboration and communication among students as well as improving their problem solving skills. In particular, when students worked in teams, they used more mathematical language to explain their ideas to each other. Specially, slow learners had more time to understand the given task and participated more actively in the problem solving process. However, in spite of being an effective learning tool, cooperative learning was reported to be time-consuming, causing a noisy environment, and disruptive for students who prefer to work alone. With a similar context, Viro and Joutsenlahti (2020) investigated the impact of project-based learning on students' level of mathematics attainment, and proposed that problem-based learning significantly improves students' grades in mathematics. Yet, the researcher also pointed out that the group formation is a critical issue in problem-based learning setting such that "a hard-working group can support and inspire a pupil to work and learn more, but on the other hand, a strong group may encourage a pupil to be a passenger" (p. 129). In addition, when a student has most of his/her group members a lot weak, s/he may feel them as burden in his or her learning. Indeed, in an interesting research, Cardino and Ortega-Dela (2020) examined how students' learning styles influence their academic performance, and found that most of the students had a combination of dependent, collaborative and independent learning styles, and among these learning styles, although most of the students were collaborative, only independent learning style had a significant impact on improving academic performance.

In a study, Mason (2015) suggest that being stuck is a math problem could enhance learning about mathematics and mathematical thinking, as it opens the ways for inspiration and mindfulness. In this aspect, a study conducted by Laine, Ahtee, Näveri, Pehkonen, and Hannula (2018) focused on how students' mathematics learning was challenged when their teachers requested them to write down their thinking while solving problems. Based on the results, it was evident that deep questioning activated students' mathematical thinking, especially writing about their own thinking helped them "to remember and confirm new mathematical understanding" (p. 102). Hence, the researchers suggested that well-designed problem solving tasks, games, and class discussions are of high importance as they create a motivating context for learning and promote sharing of ideas, making sense and reasoning. Certainly, a study by Mononen and Aunio (2013) also suggest that when learners solve more problems and get more acquainted with mathematic topics, they performed better in exams, especially in problems related to numbers, listing, and arithmetic. Furthermore, from a different aspect, Alfaro Viquez and Joutsenlahti (2020) examined the impact of languaging exercises on promoting understanding in mathematics. Particularly, during the languaging exercises, students were given opportunities to participate in the construction of their knowledge by using a combination of symbolic, natural, and pictorial languages. The results showed that using different languages enhanced "the acquisition of skills necessary to be mathematically proficient and are a useful tool for revealing students' mathematical thinking and misconceptions" (p. 229). Likewise, a study by Luoto (2020) suggest that students' participation in mathematics discourse improve their mathematics learning.

As a final overarching aspect, in terms of research on STEM learning, Tomperi et al. (2020) investigated factors affecting students' attitudes towards learning mathematics and science. The results indicated that although female students realized the importance of science and mathematics for their future, male students were more interested in career opportunities in the industry. Another interesting finding was that students who experienced innovative and student-centered teaching approaches were more motivated and less anxious about learning science and mathematics. Moreover, in a study, Cabello, Martinez, Armijo, and Maldonado (2021) investigated possible strengths and weaknesses of STEAM learning. Briefly, the study highlighted the strengths as promoting students' interests, engagement and motivation for learning processes. Especially, working with diverse materials and having enriched experiences mostly supported by technology allowed students to view scientific work as an exciting endeavor. On the other hand, the main difficulty was reported as teachers' management of student emotions and behavior, suggesting that "keeping class time within the average attention span and closely monitoring of children's fatigue may help prevent episodes of disruptive behavior" (p. 50). Lastly, a study by Milner-Bolotin and Marotto (2018) focused on the effect of parental engagement on students' STEM learning. The results highlighted the fact that although parents have a positive impact on students' STEM engagement and achievement, due limited STEM knowledge and language issues, some parents have difficult time in supporting their children in their STEM journey. In this manner, "creating family-oriented STEM resources" and offering "school-related projects, homework assignments, out-of-school science clubs and visits to science centres" are found to be assisting and motivating parents to engage in STEM learning with their children. (p. 53). In a follow up study, Marotto and Milner-Bolotin (2018) also suggested that "school-family, parent-teacher, and parent-child interactions" are important networks of communication in promoting STEM education (p. 81).

4 Conclusion and Suggestions

As a portrait of research on mathematics education, this systematic review highlights multiple aspects of studies published in the LUMAT: International Journal on Math, Science and Technology Education, starting from its first volume in 2013 so far. Searches were rigorously conducted on 225 existing studies and 51 articles were identified, analyzed and synthesized to examine issues positively or negatively affecting teaching and learning in mathematics. Moreover, the analysis offers insight into the most studied topics in mathematics education research, including key demographic and methodological characteristics such as year of publication, participants, level of education, research methodologies, and focus.

Briefly, in terms of the most studied topics, the results show that although in the year of 2015 the journal had the highest number of publications, the studies related to mathematics education was mostly published in 2019. In respect of participants, data were mostly extracted from teachers, followed by students, with very few information gathered from principles and parents. Regarding level of education, several studies were related to primary mathematics education and higher education, yet studies at kindergarten level was very limited. Moreover, as regards of research methodologies, qualitative analysis was the most widely-used research method, followed by mixed, quantitative and conceptual analysis. Furthermore, in terms of research focus, most of the studies focused on mathematics teachers and teaching, followed by mathematics learners and learning, however no special emphasis was given to educational policies or mathematics curriculum.

Regarding issues affecting mathematics teaching and learning, the results reveal that most of the existing studies have thorough and positive outcomes. In brief, research on mathematics teaching supports the notion that well-designed and good quality professional development programs positively influence teachers' and pre-service teachers' knowledge, competence, and self-efficacy in teaching. Interestingly, in many studies, mathematics educators were reported to be implementing non-traditional approaches in their teaching, including cooperative learning, problem-based learning, project-based learning, and experiential learning. In particular, teachers were paying attention to encouraging student engagement, peer collaboration, and mathematical discourse. Certainly, in such positive and inspiring learning environments, students were found to be more motivated and less anxious about learning mathematics. Indeed, they were active and responsible in constructing their mathematical understanding, such that they were collaborating with their peers, using mathematical language to share their ideas, and getting into discussions and deep questioning. In that aspect, the results give signals that having a student-centered approach in mathematics education with open-ended problems, think-pair-share activities, Socrative questioning, as well as interactive games, online tools, and challenging tasks that include observation, testing and verification could be of high importance in promoting students' mathematical thinking, conceptual understanding, and academic performance. This claim can be validated with further empirical investigation and studies using experimental designs to inspire the instructional implications for mathematics educators, curriculum developers, and researchers.

Definitely, there are also a number of difficulties and obstacles highlighted in the existing research in mathematics teaching and learning. For instance, although commonly non-traditional teaching approaches were reported to be having positive impact on student learning, they were also found to be causing a noisy environment, being time-consuming and disruptive especially for students who prefer to work independently. As for collaborative work, results suggest that while some group formations were supportive and inspirational in nature, some others were highly unproductive, turning even hard working students into passive observers. Here, research underlines the importance of the type, number, and quality of teacher guidance in such learning contexts, where too much help ruins the problem solution process, making an original problem just a standard exercise. Equally, it is important to consider teachers' monitoring and management abilities, to keep the class time within student attention span and prevent disruptive behavior. Indeed, not every teacher is a fan of student-centric pedagogies. In particular, research show that some teachers were resilient to change their teaching approaches as they had limiting exam-oriented expectations, time constraints and previous learning experiences. Next, some teachers stated having lack of self-confidence in making a change and fear of failure as a teacher. In that aspect, it is possible to recommend that teacher education programs and in-service activities should not only emphasize a number of theoretical aspects on instructional preparedness but also enhance educators' practical experiences and develop self-efficacy and confidence in teaching.

5 Limitations and Implications for Future Studies

This systematic review is limited to the analysis of the papers published in this journal. A broader dataset in terms of number of journals, language, and research context would greatly improve the understanding of enablers and challenges in mathematics learning and hence support the development of mathematics education. Certainly, what is gathered in one study may not be the same or similar to what is gathered in other, as every research endeavor has its own characteristics. In order to add to what the existing literature claims and offer greater empirical evidence to support the verdicts, further studies can be conducted in mathematics education particularly by means of different settings and characteristics.

Furthermore, while this review provides insights into what exists in the current literature, future studies can focus on specific issues to deepen our understanding of mathematics education. For instance, more research is needed on affective variables such as teachers' and students' educational motivation, attitudes and self-confidence, as well as the influence of parents' and friends' attitudes toward mathematics learning. Next, research can be conducted on the relatively unexplored field of high-performing or gifted students in mathematics, such as examining how to enrich the current educational materials and expand on the standard goals so high achievers and gifted learners get more opportunities to benefit from the formal mathematics curriculum. Furthermore, as research underlines the fact that traditional examinations are not correct ways for measuring the twenty-first-century skills (Bell, 2010), more research is needed to investigate the validity of authentic assessments, such as portfolios, self-assessment, team work, and peer evaluations (Erdogan & Bozeman, 2015). Finally, whilst research on STEM and STEAM education is still in its infancy, further studies can be conducted to gather a more nuanced understanding of how to integrate these disciplines in mathematics education, especially starting in the early years.

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