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Mathematics Teachers' Pedagogy through Technology: A Systematic Literature Review

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Abstract. Mathematics teachers' pedagogy (MTP) is an integral part of classroom instructional mediation through technology or manipulatives. This article describes a logical literature analysis for the MTP and technology with GeoGebra (GG). The findings reveal the intervention impact of MTP with GG and other technologies such as matrix laboratory (MATLAB); an interactive whiteboard (IWB) and computer algebra system (CAS); wxMaxima, which is a CAS; information and communication technologies (ICT); concrete materials as well as other resources in developing students' performances in mathematics which were generally effective too. The systematic literature review (SLR) explored findings from current research between January 2011 and October 2020. Quality assessment screening of the papers was done and alongside further elimination of repeated documents from the analysis, twenty-eight publications met the refinement and inclusion/exclusion criteria out of 110 papers. The modified preferred reporting items for systematic reviews and meta-analyses (PRISMA) outline exemplifies the literature review accordingly. The authors observed, accomplished, and discussed the significance of the SLR. This was followed by the constraints, upcoming directions for MTP with technology and GG, and the MTP consequences for education and research.

Keywords: GeoGebra; Mathematics education; Mathematics teachers' pedagogy; Systematic literature review; Technology

1. Introduction

Mathematics is a study of topics such as quantity or numerals, change, shapes, and space. Mathematics tries to find out designs or patterns and use them to convey new conjectures. Thus, it is essential in many fields, such as medicine, natural sciences, engineering, finance, social sciences, and many more. Mathematics has several valuable advantages to our minds if we go into its study. The development of mental thinking/reasoning accelerates our minds and analytical thinking as well as being useful for practical use and day-to-day activities. Usman (2019) stressed that mathematics is the rational language for conveying concepts, structures, capacities, dimensions, other modifications, and vitality in the teaching procedure and clarifying the difficulties of modern society in the professional, commercial, academic, economic and engineering fields for lifelong learning. Without mathematics there is no science, no modern technology, and no national development (Usman, 2019). Furthermore, Chinyere (2016) argues that there is no course of study in our institutions of learning that does not require the knowledge of mathematics; hence its role in science and technology cannot be overemphasised. Mathematics teachers' pedagogy (MTP) in this situation discusses what instructors can do to uphold the best quality practice that may meet the necessary targets of the 21st century. Thus, teachers need to be able to develop strategies on how they can improve effectiveness in their teaching, what scientific training can elevate their levels of competence, and what teachers' content knowledge and what approaches may yield desirable outcomes for students (Warner & Kaur, 2017).

The TPACK framework proposes that excellent instruction requires a good understanding of the intricate relationships among the three key foundations of information: technology, pedagogy, and content; and reports in what manner they play out in indefinite settings (Mishra et al., 2011). Thus, for successful design in technology integration, schoolteachers must understand more than the technical aspects of technology; they need to comprehend its constraints and benefits both for demonstrating subject matter and distinguishing relevant teaching styles (Mishra et al., 2011). Recently, the TPACK framework has been recommended as an incorporated context for teacher knowledge for successful technology assimilation. Built on Shulman's pedagogical content knowledge (PCK), Mishra et al. (2011) added 'technological' (T), thereby creating TPACK (technological, pedagogical and content knowledge) in 2005. Thus, TPACK is essential for implementing technology and effective instruction. Effective instruction involves teachers' knowing how to operate knowledge and the use of technology in instruction. The TPACK structure comprises three basic components, namely content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK) (Luo et al., 2018).

Furthermore, technology integration (TI) focuses on new knowledge or what can transform modern technology, such as GeoGebra (GG), to have a constructive impact on the students' learning because of the excellence and richness of the lesson materials offered by teachers through the incorporation of technology. Ogbonnaya and Mushipe (2020) stressed that TI, like GG with mathematics training, corresponds to the constructivist philosophy of understanding through knowledge as a dynamic procedure and that society can study via investigation and functioning involvement in the education development. However, in the teaching/learning of mathematics, numerous classroom modification activities are done through designing and developing lesson plans with the aid of supportive innovation that can lead to success in mathematics learning (Za'ba et al., 2020). Thus, what precise abilities and limitations do these tools have and do they bring positive changes to the classroom setting and nurture the progress of students' learning? Accordingly, Za'ba et al. (2020) point out that the achievement of technology integration into teaching/learning transpires when teachers are capable of using technological devices to support them in acquiring information, exploring and incorporating the information, and expressing it proficiently to students. Pfeiffer (2017) argues that many instructors and students have open entry to appropriate software while computers are obtainable both in homes and schools, integrating technology into the daily teaching/learning of mathematics. Also, GG is freely available, and teachers/students can access it through smartphones or computers and can copy it online. Students can even use it in their free time on computers or smartphones (Pfeiffer, 2017). Further, GG or other software through TI can support students' learning activity and challenge the traditional approach of teaching/learning.

Abidin et al. (2019) stressed that a systematic literature review (SLR) is a technique to classify, choose and assess study subject matter appropriate to the research problem. In reviewing a paper, three phases are necessary: preparing the review, performing the review, and informing the review (Abidin et al., 2019). Moreover, there are some challenges associated with SLR that include the need for training, difficulty in synthesising results, formulating the study design, lack of funding, and being time-consuming. Thus, Abidin et al. (2019) argue that the technique in the SLR should comprise setting a question, carrying out a search, recognising the right type of research, and obtaining information from the articles. Subsequently, the conclusions of the review should be brief, and the outline of the assessment should be made known. The information should include the mediation and the pattern result of all the paper evaluations (Abidin et al., 2019).

Consequently, in the PRISMA framework, the existing pieces of evidence are synthesised in the findings. There is always categorisation of the outcomes. SLR has an established protocol for searching strategies and reporting. Duplicate records' removal from the documents is paramount. SLR provides reasons for including or excluding studies and is explicitly informed by the research questions. Data extraction is on current and relevant studies related to the topic of discussion. Finally, included studies only were assessed as to the quality of the review.

In the findings, the sections are used to explain the entire content of the research in ascending order: Purpose of the Review, Methodology, Results and Discussion (Study of Mathematics Teachers' Pedagogy with Technology, Study of Mathematics Teachers' Pedagogy and GeoGebra and a summary of twenty-eight review papers), Limitations, Future Recommendations, Conclusion, Research Implication and References.

2. Goal of the Review

The objectives are to map out the existing understanding of the problem. This systematic review (SR) is an integrative and retrospective scientific investigation which intends to answer research questions clearly formulated through a systematic and explicit process. The following research questions were formulated and used to guide the procedure of the SLR, namely (i) What are the findings of the studies in MTP and technology intervention? and (ii) What are the previous studies in MTP and GG intervention?

Based on these research questions, the following objectives were set: (i) to provide an introductory overview of the process; to highlight key standards that can be used to prepare, conduct, and report on SLR; present resources; add values; address the knowledge gap; synthesise multiple studies; and give the best estimate of any true effect. (ii) The study aims to review papers on the effect of MTP using technology and GG as well as offering more descriptions in the field and making recommendations for future development.

In this phase, the planning is according to the PRISMA framework and the questions posed in the research. Thus, the inquiry sequence and the reporting pattern are explained below:

3. Methodology

SLR is a technique of sorting and blending result findings that fit precise standards to solve a specific problem (Piper, 2013). It is a process of developing a clear question that utilises logical and specific approaches towards classifying, selecting and crucially assessing or calculating significant investigation, and of collecting and examining the information from the findings for the review. SLR tries to classify, evaluate, and create realistic support that convenes pre-stipulated appropriateness measures to resolve a provided investigation issue. A meta-evaluation is a statistical review of the information presented from several sources or findings that seeks to enquire or respond to the identical problem (Piper, 2013). Li et al. (2020) argue that performing systematic reviews to investigate the significance of and developments in particular subjects is common in learning research. For instance, investigators analyse the historical progress of study in mathematics education as well as patterns studied with technology used in mathematics education (Li et al., 2020).

Consequently, in the current research, a modified PRISMA statement template is used for the methodological procedure to gather, examine, and produce all the related information in the earlier studies to offer the state of the research. Thus, the PRISMA information facilitates the investigator to enrich the coverage of the assessment paper (Khan & Qureshi, 2020) and build on the indicated purposes of the research finding. Figure 1 below shows the literature inclusion and exclusion at every phase:

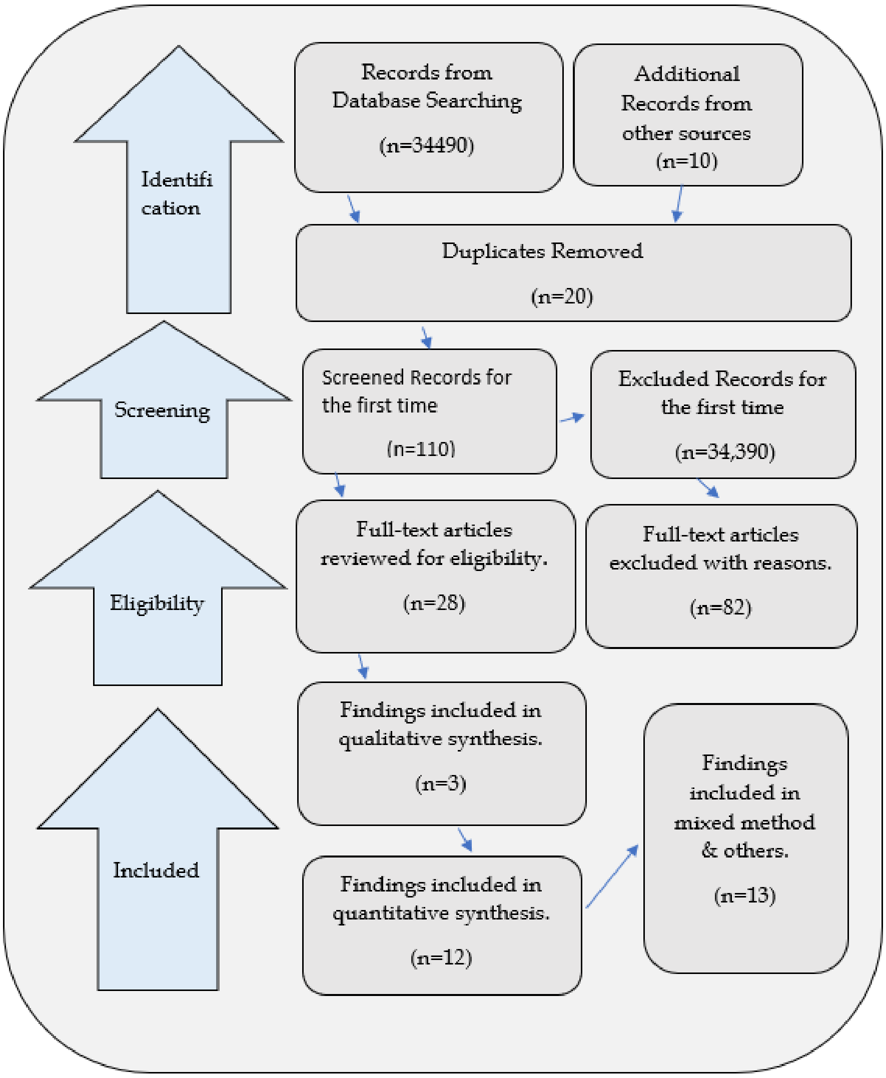

Figure 1: A summary of literature inclusion and exclusion

3.1 Search Strategies

For this systematic search, a search strategy was developed to identify relevant literature: Pedagogy OR MTP AND GG OR Technology in Mathematics Education. These search strategies used five databases: IEEE XPLORE, ScienceDirect or Elsevier, Scopus, Springer Link, and Taylor & Francis Online. In addition, tools such as Google Scholar and Web of Science were used in the belief that they are the leading databases that comprise bibliographic documents with full-text publishing structures in a variety of disciplines and, specifically for educational multidisciplinary research. All searches spanned from databases 01-01--2011 until 18-10-2020 and included journals, reviews and conferences published in English only.

3.2 Selection Criteria
The search focused mainly on mapping existing literature on pedagogy (MTP) or with technology (GG) in the field of social sciences. The examination was then restricted to the subject sections, to social sciences, art, and humanity, multidisciplinary and technology with over 34,500 papers. The exploration period was 2011-2020. All articles prior to 2011 were excluded from the examination. The exploration concentrated on all nations globally. Thus, a total 34,390 research articles was excluded at this stage. There were 110 records extracted at this stage.

3.3 Quality Assessment
The research is centred on new investigation articles and conference documents. For upholding the integrity of the review, all duplicates were verified comprehensively. The abstracts of the articles were checked meticulously for the evaluation and purification of the articles to certify the excellence and significance of educational information contained in the analysis procedure. A thorough assessment of all inquiry articles was held at a subsequent phase. The following rejection measure was to regulate the documents published in the English language only. There were 10 in other languages and these have been eliminated from the research. Also, refinement of 50 papers was done and these were excluded. Furthermore, after the filtration of duplicate records, 20 more articles were removed from the study. A total of 28 articles were selected after assessing each article on the inclusion and extraction criteria.

3.4 Data Extraction
The findings have been limited to conferences, journal articles and review papers from 2011 until 2020 and are accessible in the English Language. A total of 110 papers were found while conducting the review. These papers were examined to detect the objectives of the study. The keywords related to GeoGebra and other technological interventions as used in the previous findings, among others, include the following: (i) GeoGebra assisted students effectively in solving the properties of straight-line graph problems (Mudaly & Fletcher, 2019). (ii) The outcomes of the post-test indicate that 70-75% of students answered the questions correctly with the intervention of the GG software (Aizikovitsh-Udi & Radakovic, 2012). (iii) The statistical assessment demonstrates that the students' knowledge attainment in investigating drawing and graph functions improved with GG (Takači, Stankov, & Milanovic, 2015). (iv) Nineteen of the candidates enjoyed significant educational success and seven had less success through GG software in the past (İpek et al., 2014). (v) Good practice with technology uses enhanced exploration, inquiry and collaboration among learners (Bray & Tangney, 2017).

The writers then encapsulated the content into a table for the stage of informing the review. Subsequently, the writers eliminated the papers corresponding to the criteria; 28 papers were found to be reviewed in depth. The review of the results and discussion is presented below.

4. Results and Discussion

Primarily, in the twenty-eight papers evaluated, seventeen conducted the study on secondary/high/college school students, four on primary/elementary school students, and seven on university students. Thus, this information shows that there is a limited amount of research at the primary and university levels. Moreover, only four out of twenty-eight researchers used the TPACK framework in their findings. The researchers incorporated other relevant pedagogies related to technology or ICT as well as information in the instruction and studying of calculation at all levels of education (Costică, 2015). Other writers from the review used a computer algebra system (CAS) that focused on the symbolic manipulation of doing mathematics (Marshall et al., 2012). CAS is a specific kind of mathematical software platform that can control and influence mathematical representations with a conceptual variable quantity. The main goal of a CAS is to systematise monotonous and occasionally challenging algebraic manipulation tasks. Thus, many teachers said that the role of symbolism in classrooms ought to be transformed (Özgün-Koca, 2010).

Currently, in the findings, and also in the previous study, there are various approaches to technology use that include interactive whiteboard (IWB) (Ayub et al., 2012), MATLAB (Beauchamp & Kennewell, 2013), and wxMAXIMA (Costică, 2015). Most of the papers reported the use of pedagogy or technology or mathematics software for intervention purposes. The roles of these tools in the education and understanding of mathematics bring changes to pupils' learning and encourage an increase of students' discoveries (Yong et al., 2019). Moreover, it enables students to gain access to a variety of unusual solution sets, and to experiment and construct with geometrical tools to make assumptions and clarifications. Graphics or visuals facilitate knowledge access and improve students' attitude to the issues of a subject traditionally regarded as being difficult (Ayub et al., 2012; Beauchamp & Kennewell, 2013; Costică, 2015).

However, in the elementary-school mathematics classroom, it is necessary for the use of augmented reality to adopt the curriculum subject (Radu et al., 2016). Computer-assisted instruction (CAI) has a significant effect on the teaching/learning of mathematics (Young, 2017). Thus, good practice through technology-enhanced exploration, inquiry and collaboration is required (Bray & Tangney, 2017).

Table 1: Study of mathematics teachers' pedagogy with technology

Citation	Instrument MTP &Technology	Results
Lye, 2013	TPACK; education technology; ICT in education	There is a need for improvement in PCK as aspects of learning skills
Kaarakka et al., 2019	MathCheck; pedagogy; mathematics; education	MathCheck encouragement
Al-Abdullatif & Alsaeed, 2019	Visible learning ICT integration; mathematics classrooms; technology-enhanced (TI)	Around Saudi Arabia, there is a need for re-evaluating their instructors' outcomes on learner's knowledge through TI
Young, 2017	Calculators; meta-evaluation; Technology; computer-assisted instruction; mathematics achievement	Statistically important moderator of the effects on mathematics through technology enhancement
Kalloo, Mohan, & Kinshuk, 2016	Learning game design pedagogy; competition design; mathematics games; major games; event model lenses	In studying sport design there is a need for the insertion of pedagogical concepts into the new requirement.
Yong et al., 2019	Digital event-centred learning; educational games; COTS; mathematics; tutors, parents, and undergraduates	Students should explore Digital Game-Based Learning (DGBL) on their own
Zualkernan, 2015	Gender-variations; growing countries; online-learning; equipment-enhanced learning; mathematics	With or without the use of technology, as observed there is no considerable disparity in performance among female and male children for class II and class V proficiency
Radu et al., 2016	Fundamental classroom instruction; teachers' augmented reality; prototyping; mathematics	In the elementary-school math classroom, there are few opportunities for adopting the curriculum subjects
Kurvinen et al., 2019	Teacher feedback: technology-enhanced learning	The programme constructed and executed at the University of Turku called Ville to improve teachers' confidence
Bray & Tangney, 2017	Technology-enhanced learning; mathematics education; secondary education, SLR	Excellent preparation with technology uses improved inquiry, exploration, and co-operation, whereby the teacher functions as a mediator of knowledge

Akkaya, 2016	Mathematics instruction; intermediate school mathematics pre-service instructors; technology (TPCK)	Pre-service tutors to have guidance on TPACK and re-evaluated in the context of TPACK to primary mathematics tutors
Beauchamp & Kennewell, 2013	IWB; transition; instrumentation; affordance; instructor's role; tutor learning	A knowledgeable instructor and learners can devise the IWB system to accelerate successful learning by the students
Saralar, Işiksal-Bostan, & Akyüz, 2018	Collaborative learning; constructivism; mathematics; function; problem-solving	Delivers results on TPACK. The pre-service teachers use dynamic geometry as observed through their planning artefacts and evaluation with TPACK structure
McCulloch et al., 2018	Enhancing teaching; pedagogical issues; learning/teaching plans; secondary education	Teachers should gain access to a range of various technology instruments and be prepared to use the knowledge they need at their college
Chen & Jang, 2014	Stages of concern; TPACK; TI; career development; Taiwan	Investigate the interrelatedness among instructor concerns and their learning formation (TPACK)
Bano et al., 2018	Science education; mathematics education; pedagogy; mobile learning	Examining the relationship between mobile learning and these pedagogies through SLR
da Silva Figueira-Sampaio et al., 2013	Mathematics; K-12 schools; solid materials; coaching systems	Schoolteachers use tangible resources for teaching mathematics and materials are valuable and attractive
Backfisch et al., 2020	Learning technology; capability research; specialised knowledge; anticipation-value theory; teaching mathematics	Motivational values with instructors' role for learning technologies perform a vital status in incorporating technology into mathematics instruction
Kivkovich, 2015	Teaching strategies; geometry; mediation; mathematics; pupils' attitudes	Teachers can utilise tools for comprehensive and feature intermediated learning by dialogic communication. These include spoken and non-verbal aspects
Marshall et al., 2012	Post-secondary education applications in subject areas; improving classroom teaching; human-computer interface	Using CAS largely to have students' discover and imagine mathematical notions

Ayub et al., 2012	Great approach; calculus; wxMaxima; surface approach; CAI	wxMaxima as a teaching aid may develop mathematics at the Malaysia secondary school stage
Costică, 2015	Computing technology; the geometric representations. competition; tetrahedron; parallelepiped	Creates cognition, develops a suitable behaviour, and uses pedagogical practice, the AEL lesson packs and special software such as GG, MATLAB, and Maple

Re-examining teachers' effect on learners' skill and development through technology (Al-Abdullatif & Alsaeed, 2019), inserting pedagogical theories into learning game design and exploring digital game-based learning (DGBL) are paramount (Kalloo et al., 2016). Thus, the design and implementation of a platform such as Ville (Kurvinen et al., 2019) and feedback in the use of MathCheck improve teachers' confidence, provide encouragement and offer opportunities for adopting the curriculum subjects in schools (Kaarakka et al., 2019).

Training through TPACK for primary mathematics teachers may improve best practices (Akkaya, 2016). Evaluating the TPACK of pre-service teachers using a dynamic geometry environment can enhance learning (Akkaya, 2016). Assessing the interrelationship among educator concerns and their familiarity formation (TPACK) found that, out of 26 participants, 19 have high levels of academic success (Chen & Jang, 2014).

Similarly, the role of teachers in orchestrating the IWB environment to simplify efficient learning by the students, software such as GG, MATLAB and Maple, creates cognition to the learners, using CAS to visualise and explore mathematical concepts and wxMaxima could serve as useful teaching aids (Ayub et al., 2012; Beauchamp & Kennewell, 2013; Costică, 2015).

Moreover, teachers use concrete materials for teaching mathematics, which is useful and attractive for teachers to use tools for complete and quality mediated learning (Da Silva Figueira-Sampaio et al., 2013). Motivational beliefs and teachers' role are key factors in adding technology into mathematics instruction (Backfisch et al., 2020). Besides, it is paramount that teachers have to get and use different technology instruments at their school (McCulloch et al., 2018). Zualkernan (2015) stressed that, in the developing countries, in technology-enhanced leaning of mathematics, with or without the e-learning, there is no substantial difference in implementation between male and female children for grade II and grade V numeracy (Zualkernan, 2015).

Consequently, technology enhancement moderates effects on mathematics, Good practice with technology uses enhanced exploration, inquiry and collaboration as well as examining the relationship between mobile learning and pedagogies (Bano et al., 2018).

Table 2: Study of mathematics teachers' pedagogy and GeoGebra

Citation	Instrument (MTP)&GG	Results
Khoza & Biyela, 2019	Content; GG; knowledge; mathematics; pedagogy; technology	The solution to the decolonisation of education can be done using pedagogical information to generate a realistic curriculum
Mudaly & Fletcher, 2019	iPad technology; mathematics teaching; linear functions; GG software manipulation	A positive outlook by participants towards the use of the GG app in collaborative learning
Aliyev, 2011	Using ICT in teaching geometry in mathematics classroom	The existence of four and three-way relationship inscribed to one and constrained about other triangles and Apollonius (red) circle and its generating blue tangent circles are developed
Aizikovitsh-Udi & Radakovic, 2012	GG; high order thinking; critical thinking; Bayes' theorem	The marks of the post-test illustrate that 70%-75% of students were able to solve the questions correctly with the help of the software.
Takači, Stankov, & Milanovic, 2015	Collaborative learning; constructivism; mathematics; function; problem solving	The statistical analysis proves that the students' learning achievement in examining functions and drawing their graphs is better when they use GG
İpek et al., 2014	Mathematics instruction; geometry education; CAS; computer-assisted geometry education; TPACK; GG	Nineteen participants have high academic success while seven have less and only one contributor had previously heard about GG software

Therefore, GG is user-friendly and free software that promotes high-order thinking. Critical thinking may help students to solve the questions correctly with the help of the software, it encourages collaborative learning, construction of knowledge, problem solving, and helps students' learning achievement (Misrom et al., 2020; Mudaly & Fletcher, 2019) in examining functions and drawing a better graph with the use of GG as well as in TPACK (Takači et al., 2015) and mathematics instruction with CAS (İpek et al., 2014).

Moreover, the software can be used in teaching linear functions in a collaborative learning environment with a positive outcome from the students. Thus, it generates a realistic curriculum from the solution to the decolonisation of education (Khoza & Biyela, 2019). Besides, the content knowledge of mathematics pedagogy, and the use of ICT in the teaching of geometry in the mathematics classroom and specifically in solving four triangles inscribed to one and circumscribed about other triangles and Apollonius (red) circle and its generating tangent (blue) circles are achieved (Aliyev, 2011).

In this assessment, numerous sources from conferences peer-reviews and journals that support the findings are included. There were twelve quantitative, three qualitative, six mixed-method, three review and five empirical studies that investigated the pedagogy or MTP with GG. A summary of the reviewed articles is illustrated in Table 3 below:

Table 3: An outline of the 28 reviewed studies

Researcher & year	Country	Research type	Method
Aizikovitsh-Udi & Radakovic (2012)	Israel	Social and Behavioural Sciences	Quantitative
Akkaya (2016)	Turkey	Eurasia Journal of MSTE	Mixed method
Al-Abdullatif & Alsaeed (2019)	Saudi	Cogent Education	Quantitative
Aliyev (2011)	Azerbaijan	Inter Conference on ICT	Empirical
Ayub et al. (2012)	Malaysia	Social and Behavioural Sciences	Quantitative
Backfisch et al. (2020)	Germany	Learning and Instruction	Quantitative
Bano et al.(2018)	Australia	Computers & Education	SLR
Beauchamp & Kennewell (2013)	UK	Educ Inf Technology	Empirical
Bray & Tangney (2017)	Ireland	Computers & Education	SLR
Chen & Jang (2014)	Taiwan	Computers in Human Behaviour	Quantitative
Costica, (2015)	Romania	Social and Behavioural Sciences	Quantitative
Figueira-Sampaio et al. (2013)	Brazil	Social and Behavioural Sciences	Quantitative
İpek et al.(2014)	Turkey	Social and Behavioural Sciences	Mixed method
Kaarakka et al. (2019)	Finland	LUMAT	Quantitative
Kalloo et al. (2016)	Trinidad Tobago	Inter Conference on ALT	Empirical
Khoza & Biyela (2019	South African	Education and Info Technologies	Mixed method
Kivkovich (2015)	Romania	Social and Behavioural Sciences	Mixed method
Kurvinen et al. (2019)	Finland	MIPRO, IEEE	Mixed method
Lye (2013)	Malaysia	Social and Behavioural Sciences	Mixed method
Marshall et al. (2012)	Canada	Computers & Education	Quantitative
McCulloch et al. (2018)	USA	Computers & Education	Qualitative
Mudaly& Fletcher (2019)	South Africa	Prob of Educ in the 21st Century	Qualitative
Radu et al. (2016)	Georgia	IEEE Virtual Reality	Empirical
Saralar et al. (2018)	Turkey	International Journal for TME	Qualitative
Takaci et al. (2015)	Serbia	Computers & Education	Mixed method
Yong et al (2019)	Malaysia	Peer-review IEEE	Quantitative
Young (2017)	USA	Educational Research Journal	Review
Zualkernan (2015)	UAE	IEEE GHTC	Quantitative

5. Limitations

The nominated investigations cover an array of nations. Thus, in this research, there are a limited number of research studies in primary schools (3) and universities (8) as compared to high/secondary schools (17). Several studies were performed in one or more frameworks (Daoud et al., 2020) and others were done in the same situation, but adopted different learning principles (Daoud et al., 2020). Figure 2 summarises the scenario by country/territory:

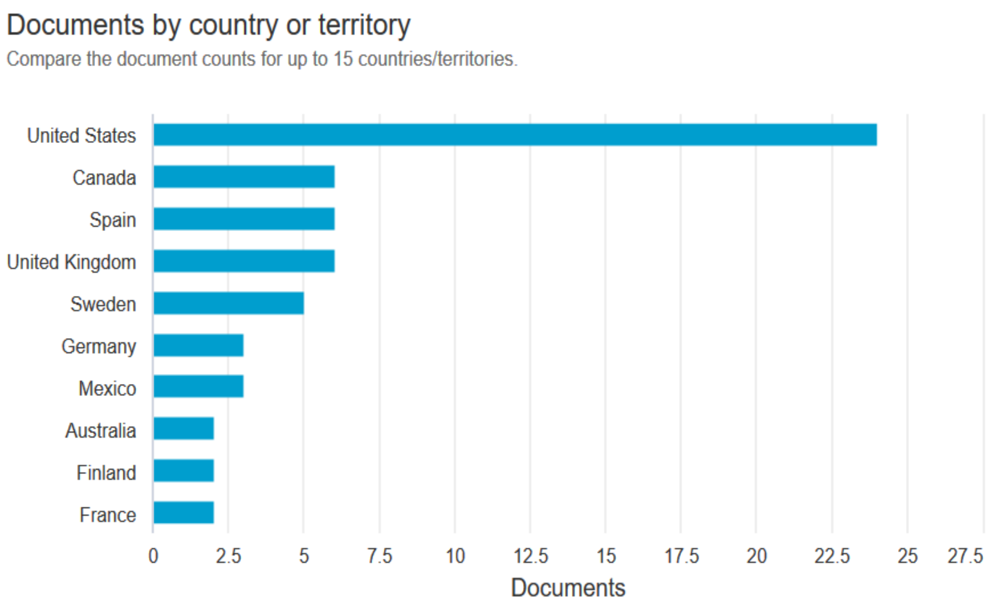

Figure 2: Documents by country or territory

The USA, Canada, Spain, the UK, and Sweden remained the most studied individual countries and in one database South Africa met the inclusion criteria. Thus, there were no findings that coincided with the inclusion provisions from Africa according to some data bases used. Figure 3 below indicates documents by citations.

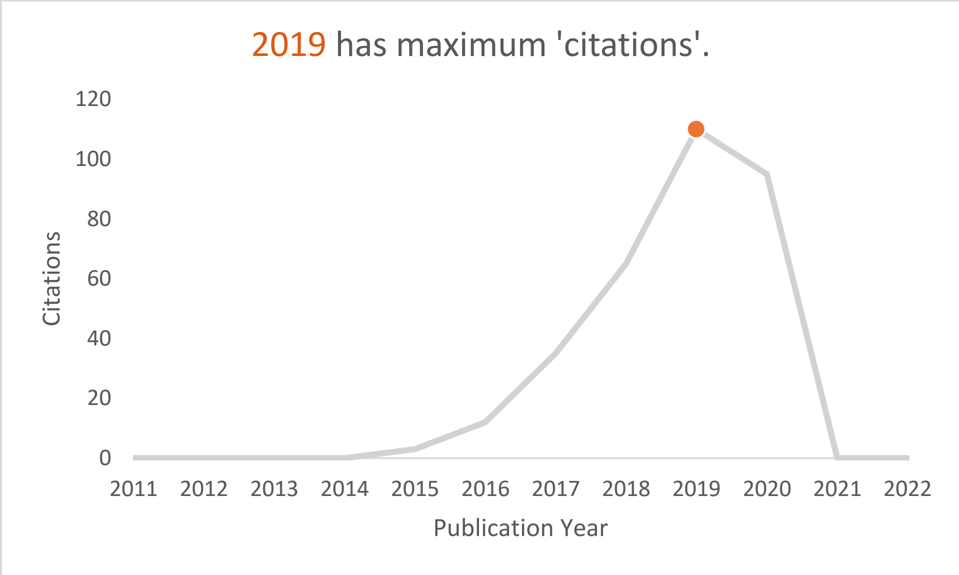

Figure 3: Documents by citations

Consequently, the articles within the review identified and reported information on the aspects of documents by citation, subject area, and by year. Mathematics has only 5.1% while social sciences had 51.9%. This indicates the need for more article writers in the field of mathematics as illustrated in Figure 4 below:

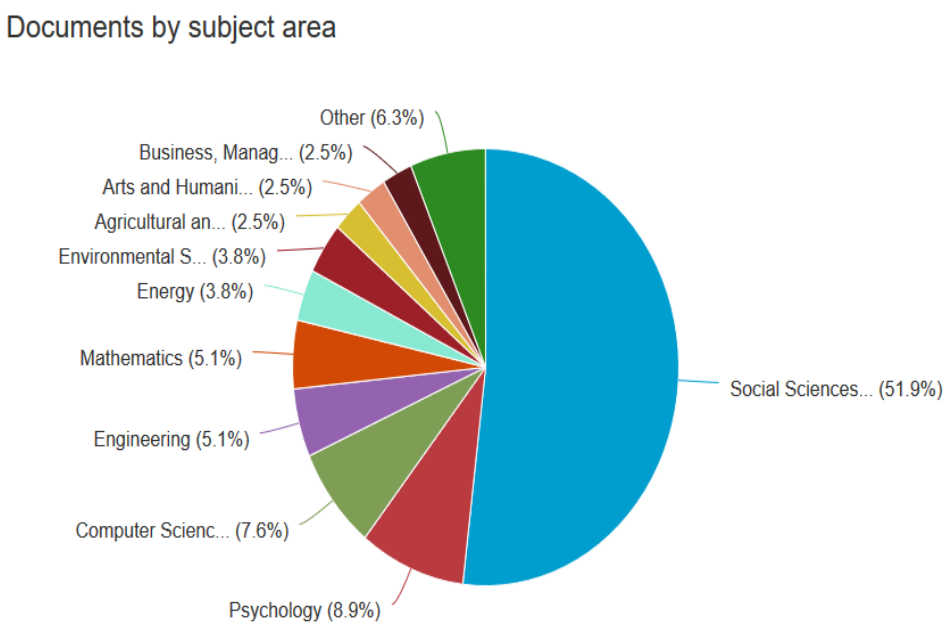

Figure 4: Documents by subject area

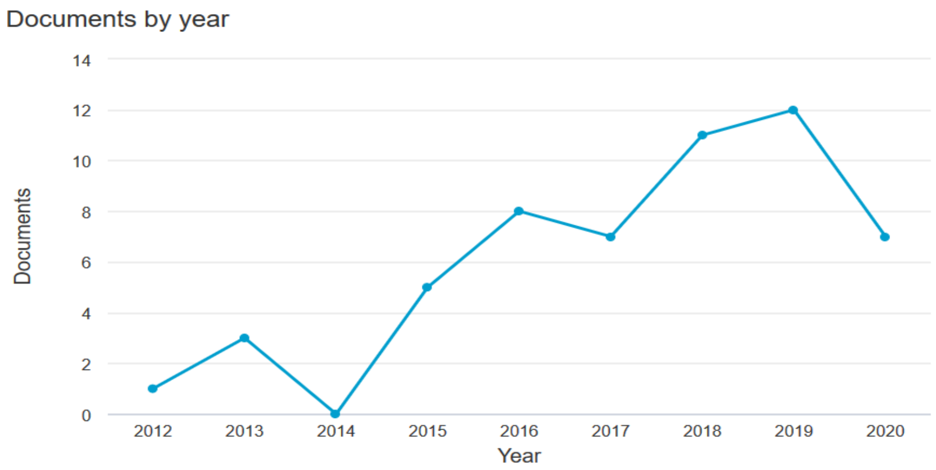

Figure 5: Documents by year

Moreover, documents by year indicate 2011 no records, 2012 only 1, 2014 no documents, 2015 with five papers, 2016 with eight papers, 2019 with the highest of twelve articles, and 2020 with seven publications. Thus, this information reveals that there are generally few writers per year in this field of studies.

6. Future Recommendations

The current systematic review reveals that the research studies conducted in the area of MTP and GG focus on instructional materials that include MATLAB, IWB, wxMaxima and others with specification on primary, high schools/colleges, and universities through technology intervention and manipulatives.

Consequently, attention to other learning areas such as Solving 3×3 simultaneous equations with GG, complex numbers, and algebraic proofs are paramount. The use of alternative strategies such as TPACK and GG could develop the quality and discovery in MTP.

7. Conclusion

This review aimed to evaluate the MTP through TI. A modified PRISMA framework (data extraction, quality assessment, selection criteria, and search strategies) was used to demonstrate the entire scenario in the literature review, and 28 out of 110 papers met the criteria. Data extraction was restricted to journals, review papers and conferences in English language only from previous studies. Results of the discussion outcome related to MTP with technology and MTP with GG showed a positive outcome. The summary of the reviewed articles illustrated justification of the research methodology assessment findings. Thus, the objectives of the review, some limitations and future direction were discussed. The use of various interventions, such as an interactive whiteboard (IWB), the dynamic geometry software (DGS), the CAS, GG and other pedagogies shape and promote the learning of mathematics. Moreover, most of the writers focus on secondary schools and colleges with few on primary schools and universities. Hence, documents by country, citations, subject area, and by year indicate areas of weakness and that there are limited researches on those areas of study. Thus, potential suggestions were made with respect to GG and MTP.

8. Research Implications

The implication of MTP to educational practice and research is dynamic and significant to the learners' logical thinking ability and may foster a good understanding of content knowledge. MTP is a catalyst that sustains best practice through critical thinking, technology, communication, and confidence. Pedagogy is a vibrant and flexible phenomenon that promotes awareness and gives support to students. The MTP is a stimulus for the development and evaluation of teacher preparation programmes. Also, MTP enhances teamwork and interest for the students to learn as peers and alleviate learning obstacles. Multiple representations in MTP through technology (GG) help in addressing students' learning misconceptions. Encouragement for MTP in the teaching processes may nurture the attainment of a well-established knowledge base. Research into MTP demonstrates the shift and assimilation of knowledge, both in theory and practice, and needs to be further investigated and conducted.

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