Commemorating One-Year of the COVID-19 Pandemic: Indonesian and International Issues of Secondary and Tertiary Mathematics Learning

Robert Soesanto (robert.soesanto@uph.edu)
Pelita Harapan University: Universitas Pelita Harapan https://orcid.org/0000-0003-3664-3633
Kurnia Putri Sepdikasari Dirgantoro
Pelita Harapan University: Universitas Pelita Harapan

Systematic Review

Keywords: COVID-19 pandemic, pandemic learning, mathematics learning issue, tertiary education

Posted Date: April 16th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-407435/v1

Abstract

A year into the COVID-19 crisis has revealed massive and substantial changes in the world of education. Educators have had to quickly develop effective online learning environments for their students. This study focuses specifically on mathematics learning issues during this first pandemic year. A systematic literature study using a scope review approach was conducted to capture issues on a national and international scale in the context of secondary and tertiary education. Through the identification of national and international articles from various reputable journals, it was evident that there was little research that specifically explored learning mathematics online during the pandemic although several issues were found related to students' mathematics competencies, aspects of learning, and affective domains. These findings will hopefully stimulate researchers to bridge the still large research gap related to the causality of implementing mathematics learning in times of crisis in order to contribute to developing pedagogical strategies to improve students' mathematics performance and attitudes.

1. Introduction

The COVID-19 pandemic has marked a year since the World Health Organization (WHO) declared it a global emergency by the end of January 2020 and a pandemic on March 11, 2020 (WHO, 2020). The situation affected massive and substantial transitions in the field of education. Rigorous health protocols pragmatically applied to all segments of society required learning processes and activities to shift online. This required advancements in learning technologies to provide environments in which students felt comfortable with the idea of technology-based learning (Warren et al., 2020). It certainly presented challenges for educators, both teachers in the context of the school (Grypp & Luebeck, 2015; Sun & Xie, 2020) and also lecturers in the context of tertiary education (Quinn & Aarão, 2020; Wahyudi et al., 2020).

The ability of an educator to be creative is an essential factor in constructing authentic and engaging online learning experiences. For instance, one of the elements that aids in significant learning is optimizing video as a learning media (Grypp & Luebeck, 2015). Educators can utilize video to engage students during online learning and improve quality through multimedia learning strategies (Mayer, 2012) that include trimming long presentations into a sequence of shorter videos and personalising videos in a conversational style (Lage et al., 2000; Schultz et al., 2014). No less critical an element in learning is the discussion between educators and students regarding students' engagement (Sun & Xie, 2020). In terms of the physical distancing caused by online learning, educators must construct encouraging online forum discussions to help achieve learning outcomes (Tsai et al., 2015; Alexander, 2018).

Online learning can be broadly defined as a learning experience through the internet, where teachers and students are not dependent on a physical location (Singh & Thurman, 2019). This kind of independence becomes an obstacle in learning mathematics during a pandemic (Bakker & Wagner, 2020). A salient point related to this phenomenon is how much more students struggle with comprehending math concepts in an online setting. Entirely online mathematics courses are more likely to cause difficulties for students than other disciplines (Trenholm et al., 2019; Quinn & Aarão, 2020). This argument is in line with

Trenholm et al. (2019) that mathematics learning is more challenging to teach fully online than face-to-face. The pandemic has caused pedagogical transformations as all educational components have had to shift to a fully online context.

Before the pandemic had such an enormous impact on mathematics learning, the term “online learning” was typically synonymous with blended learning (Marinagi & Skourlas, 2013; Clark et al., 2016) which is defined as a combination of two parts: asynchronous internet technology outside of the classroom and synchronous face-to-face facilitated in-class group learning activities (Borba et al., 2016; Quinn & Aarão, 2020). Furthermore, with blended learning, some aspects of face-to-face mathematics activities are enhanced by technology-based skills (Garrison & Vaughan, 2008). Several research studies addressing the online learning implementation of mathematics before the pandemic occurred focused on students’ creative thinking ability (Shen & Lai, 2018; Wahyudi et al., 2020), students’ mathematics achievement (Lo & Hew, 2018), and students’ cognitive engagement (Guo et al., 2014; Clark, 2015).

As the pandemic struck, adjustments to blended learning became necessary. The synchronous activities usually implemented directly in the classroom could no longer occur. Educators were given the opportunity to fine-tune synchronous face-to-face activities by interacting with students through various online platforms (Dhawan, 2020). This adjustment certainly offers numerous challenges during mathematics online or blended learning in the pandemic era. Both educators and students need to strive to build an effective online math learning atmosphere amidst network technical problems and gadgets’ availability (Bakker & Wagner, 2020). Therefore, in the context of the struggling situation, this learning environment can be mentioned with the term “pandemic learning” (Rahiem, 2021).

Despite physical distancing as a consequence of the pandemic’s threat to humanity (Poon & Peiris, 2020), the fundamental and undeniable aspects of the learning process remain the students’ existence and role as learners. Schleicher (2020) depicts that learning out of school has undoubtedly placed greater demands on students’ autonomy. Students from university and all other school levels are perceived as autonomous learners who are responsible for deciding their own learning techniques and monitoring their learning process (Al Ghazali, 2020). By searching information from various online resources, students are able to gain the necessary understanding and knowledge to solve problems given by teachers or lecturers. These circumstances may benefit educators as facilitators to build up online discussions through several platforms according to the pieces of information gathered by students (Kelly et al., 2020).

In contrast, the online environment tends to provide less guidance for students and may be detrimental when they learn mathematics. The provision of minimal guidance from teachers coupled with students’ lack of computer literacy can raise their mathematics anxiety, and these situations can hinder the mathematics learning process (Macmull & Ashkenazi, 2019; Wong, 2020). Another problem that arises is related to mathematics assessment modifications, which undoubtedly add extra work for educators and challenges for students as they undergo new forms of assessment that are not as usual (Adedoyin & Soykan, 2020). Several studies also portray the further effect of mathematics anxiety on students’ math

performance and learning behavior (Chang & Beilock, 2016; Luttenberger et al., 2018). Obviously, it is not only mathematics anxiety that potentially arises due to online learning during a pandemic.

Every student's limitations and difficulties provide an opportunity for researchers to discover learning goals or highlights related to mathematics learning during the COVID-19 outbreak. Several preliminary studies have investigated the issue of math learning before the pandemic hit. A longitudinal analysis conducted by Camilli & Kim (2018) maps three domains of students' academic achievement, and one of them is mathematical thinking. Another study conducted by Takele (2020) focuses on implementing active learning methods to accommodate some problem-solving in mathematics classes. Students' learning difficulties in mathematics education are still relevant in this decade (Chinn, 2016). Today, we focus on gathering and highlighting the many studies related to online mathematics learning during this first year of the COVID-19 pandemic.

2. Methodology

This study implemented the concept of a systematic literature review (SLR) as a way of synthesizing research findings to address the research question as well as to uncover areas in which more research is needed (Snyder, 2019). A scoping review approach was conducted to identify the conceptual types of potential evidence or research gaps (Xiao & Watson, 2019). This study performed eight steps of review divided into three components, as displayed in Fig. 1.

2.1 Planning the Review

The pandemic has triggered a shifting paradigm in mathematics learning. Therefore, there is an urgency and a need to highlight this issue so as to learn from it. The formulation of the problem was thoroughly discussed to ensure that the research questions were not too broad (Cronin et al., 2008) in order to avoid an unmanageable review. Hence, this paper focused on studies that examined mathematics learning during the pandemic for one year from March 2020 to March 2021. In addition, the selected research subjects were students, not educators. Online learning is closely related to students as autonomous learners. Based on this, the researchers only chose studies that involved secondary or tertiary students. The reason is that the secondary or tertiary students are considered to have skills in managing their own learning (Zimmerman, 2015; Gunawan et al., 2019). Primary students, on the other hand, are mostly dependent on parental intervention during online learning (Abuhammad, 2020; Dong et al., 2020; Garbe et al., 2020), which has the potential to create biased evidence. The researchers strictly focused on searching for students as the sole learner participants.

Furthermore, the review protocol was constructed based on the inclusion criteria associated with the scope of the review. These criteria included the articles' form (neither proceedings nor book chapters), the publication year, the journals' reputation, the articles' language, the focus of the research problems, and the full-text availability of the articles. Only two articles' languages would be included: international

articles (English language) and national articles (Indonesian language). A flow diagram of the methodology of the review protocol is shown in Fig. 2.

2.2 Conducting the Review

In this stage, with the inclusion criteria set, and the researchers began to search the literature. The study included papers, written in English or Indonesian, that discussed online mathematics learning problems and focused on students as learners in the context of secondary and tertiary education. Any studies in the form of proceedings were excluded. Science Direct and Google Scholar were chosen as the search databases as they included articles in Indonesian and were international scope. In order to ensure a high-quality literature review, the researchers excluded articles that were not confirmed as from an international journal with a ranking between Q1 and Q4. For Indonesian articles, the researchers excluded articles that were not confirmed as nationally accredited journals based on the research ministry's standards (known as Sinta accreditation), from Sinta 1 to Sinta 3.

Based on the research question, numerous studies which had a publication date between March 2020 and March 2021 were examined. The publication date limitation was administered to build a critical appraisal of the recent literature on students' challenges with learning mathematics online due to the pandemic. In identifying literature, the researchers started with the broad keyword "online mathematics learning" to find potentially relevant articles in English. Additional keywords were also used, such as "online mathematics learning", "blended mathematics learning", and "pandemic mathematics learning". For Indonesian articles, the researchers applied the keywords "pembelajaran matematika online", "pembelajaran matematika pandemi" and "pembelajaran matematika daring" which have similar meanings as the English keywords. The selection of broad keywords was deliberately made because being exhaustive was more important than being precise during the initial stage of conducting the review (Wanden-Berghe & Sanz-Valero, 2012).

After the inclusion screening process, the review was continued using the quality assessment procedure. At this stage, two researchers conducted parallel independent work (Xiao & Watson, 2019). Both researchers discussed and communicated all distinctions by carefully reading full-text articles to check each study against the accuracy criteria. The work of full-text review also offered an opportunity for a final check of the inclusion criteria.

2.3 Reporting the Review

In this final stage, the researchers presented the findings from the review. The report about the results from the literature identification, inclusion screening, and assessment quality would be presented before the findings. According to the findings, all novel or unexpected results were highlighted to open opportunities and direction for further research (Okoli, 2015).

3. Result And Discussion

3.1 International Issues of Online Mathematics Learning during the Pandemic

In the initial stage, the researchers searched the Science Direct database using the keywords mentioned above. Then, the search was refined based on the publication year, the article type (research articles), and the subject area (Social Sciences/Education). The total number of articles found was 693. After reviewing the first ten pages of search results which consisted of 25 papers for each page, 14 potentially relevant articles remained. The literature identification was repeated with the same parameters in Google Scholar. There were 124 results divided into five pages. After reviewing all pages, 54 potentially relevant articles were left. Hence, the researchers had a total of 68 articles which were ready to be filtered based on the inclusion criteria. Table 1 displays the complete review process for the total amount of papers included.

It is surprising that the researchers found so few studies about online mathematics learning during the pandemic. A total of 17 out of 22 eligible articles were rejected through the back-and-forth discussion and consideration between the reviewers. The reason behind the rejection was because of the time in which the research was conducted. All 17 articles highlight the implementation of online learning models in mathematics learning (with the terms: blended learning, flipped learning, ICT-based learning) but were not conducted during the COVID-19 era. Indeed, this finding provides a vast opportunity for researchers all over the world to consider conducting studies that focus on online mathematics learning during the pandemic.

It is essential to realize that the conditions of online mathematics learning before and during the pandemic are two different things. Before the pandemic, online mathematics learning was defined as merging digital technology and face-to-face pedagogical methods (Gaol & Hutagalung, 2020). It means that direct interaction between educators and students is still able to occur. Verbal communication can be established without worrying about the disruption of the internet network. On the other hand, online mathematics learning during the pandemic requires educators and students to be detached by distance. Learning activities are also entirely tied to the internet (Schleicher, 2020). Face-to-face activities must be substituted by a synchronous model. This massive transformation certainly offers a lesson for educators and researchers to more comprehensively observe the effects on students' mathematics learning (Bakker & Wagner, 2020).

The researchers only discovered three articles that focused on the international issue of online mathematics learning during the pandemic. Unfortunately, one article was declined after rigorous examination because it included teacher and school leader perceptions about the implementation of blended learning during the pandemic. The first article is the mixed-methods study from Mulenga & Marbán (2020) that investigated prospective teachers' online learning mathematics activities in Zambia during the COVID-19 pandemic. The study was conducted using a cluster analysis approach and found that students in the cluster where there was a technology-rich environment exhibited excellent online learning skills for mathematics. The findings recommended a new series of investigations on how to

implement an advanced pedagogic design integrated with digital technology, especially for students who are lacking in using online platforms.

The second article is research using an experimental design with pre-test and post-test from Uzunboylu et al. (2020), which investigated mathematics achievement and online authentic learning self-efficacy. This quantitative study used the Moodle LMS with three different learning methods (blended, online, and traditional) based on an authentic learning approach. A series of statistical tests revealed that blended learning methods during the pandemic can bring positive scores on students' mathematics achievement and online authentic learning self-efficacy. It opens the way for further studies that the authentic learning approach theory's implementation and evaluation must be given more place in developing academic skills in different mathematics courses.

The lack of the number of articles found does not mean that no investigations have been conducted related to the study during the first year of the pandemic. In fact, the researchers found several studies during the literature identification process that focused on digital technology but they were on a general level. There are still few studies in reputable journals that look specifically at mathematics learning during pandemics.

3.2 Indonesian Issues of Online Mathematics Learning during the Pandemic

Similar to international issues, the researchers started with literature identification to obtain numerous Indonesian studies from the Google Scholar database. The identification revealed 352 papers after reviewing the first ten pages in the database with related keywords as previously. Then, all the papers were filtered based on the inclusion criteria and 28 potentially relevant articles remained. Those relevant articles were then rigorously discussed until the researchers settled on the eligible articles presented in detail in Table 2.

A total of 13 eligible articles were reduced to nine following comprehensive discussions between the reviewers. Four articles were eliminated due to a mismatch in the research subject (1 article), study fields (2 articles), and research period (1 article). Through the findings from the nine eligible articles, the researchers discovered various issues conducted in accordance with pandemic mathematics learning. Different aspects of the students' perspective were covered. In terms of the cognitive aspect, several studies focused on viewing students' mathematics competencies, namely problem-solving (Kusmaharti & Yustitia, 2020), mathematical communication (Sari et al., 2020), conceptual understanding (Anugrahana, 2021), and mathematical reasoning (Sugandi & Bernard, 2020). Other studies revealed common purposes related to mathematics learning outcomes (Sari et al., 2020) and learning difficulties (Anugrahana, 2021) during the pandemic.

The pandemic has also pushed educators to develop tangible learning tools for maximizing students' mathematics performance. There is evidence that research and development (R & D) design is emerging as educators' embrace online pedagogical strategies. A study conducted by Maskar & Dewi (2020)

discusses a learning tool integrated with Geogebra for calculus students in realistic mathematics learning content. In terms of affective aspects, several studies focused on learning motivation (Fitriyani et al., 2020), self-regulated learning (Kusuma, 2020), and students' attitudes (Wulandari & Nugroho, 2020). It is an undeniable fact that not all educators conduct online mathematics learning processes in a rich-technology environment. There is a possibility that some educators may struggle in delivering mathematics content to students in remote areas where they lack available gadgets or good internet connections. A case study conducted by Apsari et al. (2020) provides an alternative for mathematics distance learning through the use of a straightforward group chat in delivering math content in remote areas. A brief taxonomy displayed in Fig. 3 highlights the pandemic mathematics learning issues on both the Indonesian and international scale.

The pandemic period emphasizes the need for educators to make decisions about how to encourage students to continue their learning at a distance (Bakker & Wagner, 2020). The researchers found evidence of the efforts of educators to foster motivation, self-regulated learning, and self-efficacy. Moreover, fostering students' independence and autonomy should be achieved (Al Ghazali, 2020). Specifically, for online mathematics learning, educators should focus on the elements of the students as learners in the current situations in order to prepare for effective learning in any possible future crises (Bakker & Wagner, 2020). The dependency of online learning on technological facilities is a big challenge for all education components to deal with (Adedoyin & Soykan, 2020). This literature review reveals that there are still opportunities to dig deeper into students' math competencies or affective domains. To highlight topics for further studies (Okoli, 2015), the researchers tabulated all the findings and recommendations based on the Indonesian and international eligible articles. The tabulation is presented in Table 3 to help all readers consider future recommendations.

4. Conclusion

The COVID-19 pandemic as a time of crisis should give researchers plenty of opportunities to contribute more to the field of online mathematics learning. The lack of specific research that examines students' dimensions of mathematics learning during the pandemic will hopefully stimulate many researchers to look more broadly and deeply at the various impact and causalities affecting students' mathematics learning performances. Studies on the affective domains also need to be enriched so that researchers can provide insights to students, educators, or institutions on various practical understandings of mathematics education.

A year of the pandemic has passed. Governments in various countries have been active in distributing vaccines to their citizens. However, this does not mean that in the near future, learning will return entirely face-to-face. The fact that some schools and universities are starting to re-open does not guarantee that all students will return to classroom. Strict health protocols still have to be implemented. Moreover, news media reports about coronavirus mutations and the impact they cause, makes it less likely that any return

normal will be soon. Therefore, further research is necessary to develop significant learning about mathematics and serve as a solid anchor for mathematics learning in other emergency situations in the future.

Declarations

Availability of data and material

Not applicable

Funding

Not applicable

Acknowledgments

We expressed our gratitude to Sheryl Taylor as a proofreader in ensuring the quality of the substance and the consistency of the grammar in this paper.

References

Abuhammad, S. (2020). Barriers to distance learning during the covid-19 outbreak: A qualitative review from parents' perspective. *Heliyon*, *6*(11), 1–5. https://doi.org/https://doi.org/10.1016/j.heliyon.2020.e05482

Adedoyin, O. B., & Soykan, E. (2020). Covid-19 pandemic and online learning: The challenges and opportunities. *Interactive Learning Environments*, *28*(1), 1–13. https://doi.org/10.1080/10494820.2020.1813180

Al Ghazali, F. (2020). Challenges and opportunities of fostering learner autonomy and self-access learning during the covid-19 pandemic. *Studies in Self-Access Learning Journal*, *11*(3), 114–127. https://doi.org/https://doi.org/10.37237/110302

Alexander, M. M. (2018). The flipped classroom: Engaging the student in active learning. *Journal of Legal Studies Education*, *35*(2), 277–300. https://doi.org/10.1111/jlse.12078

Anugrahana, A. (2021). Analisis kemampuan pemahaman kognitif dan kesulitan belajar matematika konsep "logika" dengan model pembelajaran daring. *Scholaria: Jurnal Pendidikan Dan Kebudayaan*, *11*(1), 37–46. https://doi.org/10.24246/j.js.2021.v11.i1.p37-46

Apsari, R. A., Sripatmi, S., Sariyasa, S., Maulyda, M. A., & Salsabila, N. H. (2020). Pembelajaran matematika dengan media obrolan kelompok multi-arah sebagai alternatif kelas jarak jauh. *Jurnal Elemen*, *6*(2), 318–332. https://doi.org/10.29408/jel.v6i2.2179

Bakker, A., & Wagner, D. (2020). Pandemic : lessons for today and tomorrow ? *Educational Studies in Mathematics*, *104*(1), 1–4. https://doi.org/10.1007/s10649-020-09946-3

Borba, M. C., Askar, P., Engelbrecht, J., Gadanidis, G., Llinares, S., & Sánchez, M. (2016). Blended learning, e-learning and mobile learning in mathematics education. *ZDM*, *48*(5), 589–610. https://doi.org/https://doi.org/10.1007/s11858-016-0798-4

Camilli, G., & Kim, S. (2018). Longitudinal analysis of early mathematics learning. *Educational Measurement: Issues and Practice*, *37*(3), 4–10. https://doi.org/https://doi.org/10.1111/emip.12180

Chang, H., & Beilock, S. L. (2016). The math anxiety-math performance link and its relation to individual and environmental factors: A review of current behavioral and psychophysiological research. *Current Opinion in Behavioral Sciences*, *10*, 33–38. https://doi.org/10.1016/j.cobeha.2016.04.011

Chinn, S. (2016). Commentaries challenges in teaching mathematics: Perspectives from students ' learning difficulties. *Journal of Numerical Cognition*, *2*(1), 53–56. https://doi.org/https://doi.org/10.5964/jnc.v2i1.26

Clark, K. (2015). The effects of the flipped model of instruction on student engagement and performance in the secondary mathematics classroom. *The Journal of Educators Online*, *12*(1), 91–115. https://doi.org/https://doi.org/10.9743/jeo.2015.1.5

Clark, R. M., Kaw, A., & Besterfield-sacre, M. (2016). Comparing the effectiveness of blended, semi-flipped, and flipped formats in an engineering numerical methods course. *Advances in Engineering Education*, *5*(3), 1–38. https://advances.asee.org/wp-content/uploads/vol05/issue03/Papers/AEE-19-Flipping-Kaw.pdf

Cronin, P., Ryan, F., & Coughlan, M. (2008). Undertaking a literature review: A step-by-step approach. *British Journal of Nursing*, *17*(1), 38–43. https://doi.org/https://doi.org/10.12968/bjon.2008.17.1.28059

Dhawan, S. (2020). Online learning: A panacea in the time of covid-19 crisis. *Journal of Educational Technology Systems*, *49*(1), 5–22. https://doi.org/https://doi.org/10.1177/0047239520934018

Dong, C., Cao, S., & Li, H. (2020). Young children's online learning during covid-19 pandemic: Chinese parents' beliefs and attitudes. *Children and Youth Services Review*, *118*, 1–9. https://doi.org/https://doi.org/10.1016/j.childyouth.2020.105440

Fitriyani, Y., Fauzi, I., & Sari, M. Z. (2020). Motivasi belajar mahasiswa pada pembelajaran daring selama pandemik covid-19. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, *7*(1), 121–132. https://doi.org/10.23917/ppd.v7i1.10973

Gaol, F. L., & Hutagalung, F. (2020). The trends of blended learning in South East Asia. *Education and Information Technologies*, *25*(2), 659–663. https://doi.org/10.1007/s10639-020-10140-4

Garbe, A., Ogurlu, U., Logan, N., & Cook, P. (2020). Covid-19 and remote learning: Experiences of parents with children during the pandemic. *American Journal of Qualitative Research*, *4*(3), 45–65. https://doi.org/https://doi.org/10.29333/ajqr/8471

Garrison, D., & Vaughan, N. (2008). *Blended learning in higher education: Framework, principles, and guidelines*. San Francisco, CA: John Wiley & Sons, Inc.

Grypp, L., & Luebeck, J. (2015). Rotating solids and flipping instruction. *Mathematics Teacher*, *109*(3), 186–193. https://doi.org/https://doi.org/10.5951/mathteacher.109.3.0186

Gunawan, Prawoto, A., & Sumarmo, U. (2019). Mathematical Reasoning and Self Regulated Learning According to Student's Cognitive Stage. *JIML: Journal of Innovative Mathematics Learning*, *2*(1), 39–52. https://doi.org/https://doi.org/10.22460/jiml.v2i1.p39-52

Guo, P. J., Kim, J., & Rubin, R. (2014). How video production affects student engagement: An empirical study of MOOC videos. *Proceedings of the First ACM Conference on Learning Scale Conference*, 41–50.

Kelly, A., Johnston, N., & Matthews, S. (2020). Online self-access learning support during the covid-19 pandemic: An Australian university case study. *Studies in Self-Access Learning Journal*, *11*(3), 187–198. https://doi.org/10.37237/110307

Kusmaharti, D., & Yustitia, V. (2020). Efektivitas online larning terhadap kemampuan pemecahan masalah matematika mahasiswa. *Journal of Medives: Journal of Mathematics Education IKIP Veteran Semarang*, *4*(2), 311–318. https://doi.org/10.31331/medivesveteran.v4i2.1199

Kusuma, D. A. (2020). Dampak penerapan pembelajaran daring terhadap kemandirian belajar (self-regulated learning) mahasiswa pada mata kuliah Geometri selama pembelajaran jarak jauh di masa pandemi covid-19. *Teorema: Teori Dan Riset Matematika*, *5*(2), 169. https://doi.org/10.25157/teorema.v5i2.3504

Lage, M. J., Platt, G. J., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *Journal of Economic Education*, *31*(1), 30–43. https://doi.org/10.1080/00220480009596759

Lo, C. K., & Hew, K. F. (2018). A comparison of flipped learning with gamification, traditional learning, and online independent study: The effects on students' mathematics achievement and cognitive engagement. *Interactive Learning Environments*, *28*(4), 464–481. https://doi.org/10.1080/10494820.2018.1541910

Luttenberger, S., Wimmer, S., & Paechter, M. (2018). Spotlight on math anxiety. *Psychology Research and Behavior Management*, *11*, 311–322. https://doi.org/10.2147/PRBM.S141421

Macmull, M. S., & Ashkenazi, S. (2019). Math anxiety: The relationship between parenting style and math self-efficacy. *Frontiers in Psychology*, *10*, 1–12. https://doi.org/10.3389/fpsyg.2019.01721

Marinagi, C., & Skourlas, C. (2013). Blended learning in personalized assistive learning environments. *International Journal of Mobile and Blended Learning*, *5*(2), 39–59. https://doi.org/https://doi.org/10.4018/jmbl.2013040103

Maskar, S., & Dewi, P. S. (2020). Praktikalitas dan efektifitas bahan ajar kalkulus berbasis daring berbantuan Geogebra. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *4*(2), 888–899. https://doi.org/10.31004/cendekia.v4i2.326

Mayer, R. E. (2012). Cognitive theory of multimedia learning. In *The Cambridge handbook of multimedia learning* (pp. 31–48). New York, NY: Cambridge University Press. https://doi.org/https://doi.org/10.1017/CBO9780511816819.004

Mulenga, E. M., & Marbán, J. M. (2020). Prospective Teachers ' Online Learning Mathematics Activities in The Age of COVID-19 : A Cluster Analysis Approach. *EURASIA: Journal of Mathematics, Science and Technology Education*, *16*(9), 1–9. https://doi.org/https://doi.org/10.29333/ejmste/8345

Okoli, C. (2015). A guide to conducting a standalone systematic literature review. *Communications of the Association for Information Systems*, *37*(43), 879–910. https://doi.org/https://doi.org/10.17705/1cais.03743

Poon, L. L., & Peiris, M. (2020). Emergence of a novel human coronavirus threatening human health. *Nature Medicine*, *26*(3), 317–319. https://doi.org/https://doi.org/10.1038/s41591-020-0796-5

Quinn, D., & Aarão, J. (2020). Blended learning in first year engineering mathematics. *ZDM - Mathematics Education*, *52*(5), 927–941. https://doi.org/10.1007/s11858-020-01160-y

Rahiem, M. D. H. (2021). Indonesian university students' likes and dislikes about emergency remote learning during the COVID-19 pandemic. *Asian Journal of University Education, 17*(1), 1-18. https://doi.org/10.24191/ajue.v17i1.11525

Sari, N. W., Dewi, M. N., & Kartini, H. R. (2020). Analisis kemampuan komunikasi matematis dalam meningkatkan hasil belajar mahasiswa pada pembelaran online matematika kimia. *Jurnal Pendidikan Matematika Universitas Lampung*, *8*(2), 68–76. https://doi.org/10.23960/mtk/v8i2.pp68-76

Schleicher, A. (2020). The impact of covid-19 on education: Insights from education at a glance 2020. In *OECD Journal: Economic Studies*. Paris: OECD Publishing. https://www.oecd.org/education/the-impact-of-covid-19-on-education-insights-education-at-a-glance-2020.pdf

Schultz, D., Duffield, S., Rasmussen, S. C., & Wageman, J. (2014). Effects of the flipped classroom model on student performance for advanced placement high school chemistry students. *Journal of Chemical Education*, *91*(9), 1334–1339. https://doi.org/10.1021/ed400868x

Shen, T., & Lai, J. (2018). Instructional design of creating creative and imaginative works. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(4), 1509–1517.

https://doi.org/https://doi.org/10.29333/ejmste/84836

Singh, V., & Thurman, A. (2019). How many ways can we define online learning? A systematic literature review of definitions of online learning (1988-2018). *American Journal of Distance Education*, *33*(4), 289–306. https://doi.org/10.1080/08923647.2019.1663082

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Sugandi, A. I., & Bernard, M. (2020). Efektivitas pembelajaran daring berbasis masalah berbantuan Geogebra terhadap kemampuan penalaran matematis di era covid-19. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *9*(4), 993–1004. https://doi.org/https://doi.org/10.24127/ajpm.v9i4.3133

Sun, Z., & Xie, K. (2020). How do students prepare in the pre-class setting of a flipped undergraduate math course? A latent profile analysis of learning behavior and the impact of achievement goals. *Internet and Higher Education*, *46*, 1–13. https://doi.org/10.1016/j.iheduc.2020.100731

Takele, M. (2020). Practices and challenges of active learning methods in mathematics classes of upper primary schools. *Journal of Education and Practice*, *11*(13), 26–40. https://doi.org/https://doi.org/10.7176/jep/11-13-04

Trenholm, S., Peschke, J., & Chinnappan, M. (2019). A review of fully online undergraduate mathematics instruction through the lens of large-scale research (2000-2015). *Primus*, *29*(10), 1080–1100. https://doi.org/10.1080/10511970.2018.1472685

Tsai, C. W., Shen, P. Di, & Lu, Y. J. (2015). The effects of problem-based learning with flipped classroom on elementary students' computing skills: A case study of the production of Ebooks. *International Journal of Information and Communication Technology Education*, *11*(2), 32–40. https://doi.org/10.4018/ijicte.2015040103

Uzunboylu, H., Tezer, M., & Yildiz, E. P. (2020). The effects of the authentic learning approach with a course management system (moodle) on students' mathematics success and online authentic learning self-efficacy. *Educational Research and Reviews*, *15*(11), 679–689. https://doi.org/10.5897/ERR2020.4087

Wahyudi, W., Waluya, S. B., Suyitno, H., & Isnarto, I. (2020). The impact of 3CM model within blended learning to enhance students' creative thinking ability. *Journal of Technology and Science Education*, *10*(1), 32–46. https://doi.org/10.3926/jotse.588

Wanden-Berghe, C., & Sanz-Valero, J. (2012). Systematic reviews in nutrition: Standardized methodology. *British Journal of Nutrition*, *107*(S2), S3–S7. https://doi.org/https://doi.org/10.1017/s0007114512001432

Warren, L., Reilly, D., Herdan, A., & Lin, Y. (2020). Self-efficacy, performance and the role of blended learning. *Journal of Applied Research in Higher Education*, *13*(1), 98–111. https://doi.org/10.1108/JARHE-08-2019-0210

WHO. (2020). *Coronavirus disease (COVID-19) pandemic*. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/

Wong, R. (2020). When no one can go to school: Does online learning meet students' basic learning needs? *Interactive Learning Environments*, *28*(2), 1–17. https://doi.org/10.1080/10494820.2020.1789672

Wulandari, E., & Nugroho, W. (2020). Sikap siswa terhadap video pembelajaran jarak jauh materi statistika pada media sosial Youtube. *Edumatica: Jurnal Pendidikan Matematika*, *10*(2), 1–9. https://online-journal.unja.ac.id/edumatica/article/view/10584

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. *Journal of Planning Education and Research*, *39*(1), 93–112. https://doi.org/10.1177/0739456X17723971

Zimmerman, B. J. (2015). Self-regulated learning: Theories, measures, and outcomes. *International Encyclopedia of the Social & Behavioral Sciences*, 541–546. https://doi.org/https://doi.org/10.1016/b978-0-08-097086-8.26060-1

Tables

Table 1. Review Process for International Papers

Identification	
Total papers identified through database searching	n = 68
Screening	
Papers excluded with reasons: Book chapter or conference proceeding (n = 21)	n = 43
Did not meet publication year requirement (n = 3)	
From non-reputable journals based on Scimago Journal Rank (n = 10)	
Did not focus on students as learners (n = 8)	
Did not focus on mathematics learning (n = 1)	
Eligibility	
Full-text articles assessed for eligibility	n = 25
Full-text articles excluded with reasons:	n = 22
Were not conducted during the pandemic period (n = 17)	
Non-mathematics research (n = 1)	
Did not focus on students as learners (n = 1)	
Did not provide full-text (n = 1)	
Focused on primary education (n = 2)	
Inclusion	
Studies included Paper excluded through a comprehensive discussion (n = 1)	n = 3
Total amount of international studies included	n = 2

Table 2. Review Process for Indonesian Papers

Identification	
Total papers identified through database searching	n = 352
Screening	
Papers excluded with reasons:	n = 324
Book chapter or conference proceeding (n = 101)	
Did not meet publication year requirement (n = 91)	
From non or low-reputable journals based on Sinta Journal Rank (n = 117)	
Did not focus on students as learners (n = 10)	
Did not focus on mathematics learning (n = 5)	
Eligibility	
Full-text articles assessed for eligibility	n = 28
Full-text articles excluded with reasons:	n = 15
Were not conducted during the pandemic period (n = 2)	
Non-mathematics research (n = 3)	
Did not focus on students as learners (n = 2)	
Did not provide full-text (n = 2)	
Focused on primary education (n = 3)	
Failed in proper methodology (n = 3)	
Inclusion	
Studies included	n = 13
Paper excluded through a comprehensive discussion (n = 4)	
Total amount of international studies included	n = 9

Table 3. Data Tabulation of Future Recommendations

International Articles		
Author	Research Findings	Future Recommendation
(Mulenga & Marbán, 2020)	• Cluster analysis results revealed that online learning mathematics activities have significant mean differences in clustering. • Cluster with a rich-technology environment exhibited excellent online learning skills for mathematics.	• For the university management that a comprehensive and advanced pedagogic design should be implemented to render lessons through virtual classrooms
(Uzunboylu et al., 2020)	• The mathematics achievement test scores and online authentic learning self-efficacy scores of the students who had blended learning were higher than online and traditional learning.	• The implementation and evaluation of the authentic learning approach theory must be given more place in developing academic skills in different mathematics courses.
Indonesian Articles		
(Sari et al., 2020)	• Student learning outcomes were not determined by the achievement of mathematical communication skills in chemistry mathematics courses. • Some mathematical concepts require direct explanation during online learning, so that understanding the material becomes a challenge for students.	• Further research is needed on the treatment, especially in the interaction process in online learning both among students and between students and learning materials.
(Kusmaharti & Yustitia, 2020)	• Mathematics during online learning was effectively implemented amid the COVID-19 pandemic. Students' problem-solving abilities demonstrated that they met the minimum completion criteria and their response to learning was in the positive category.	• Educators should prepare online learning tools well to maximize the capacity of learners in solving problems.
(Anugrahana, 2021)	• According to Bloom's Taxonomy, the analysis of students' cognitive abilities was measured by tests that met the standard of cognitive dimensions, but student completion results were still below 50%.	• Need to develop further mathematical logic learning that is more innovatively integrated with ICT.
(Sugandi & Bernard, 2020)	• The implementation of Geogebra-assisted problem-based model was more effective than both problem-based and conventional models of mathematical reasoning abilities.	• For further research, problem-based learning combined with Geogebra can be applied to develop other mathematical thinking skills.
(Fitriyani et al., 2020)	• Eight students' motivation indicators showed an overall percentage of 80.27% that fall into the good category. It stated that during the	• To analyze and develop student learning motivation in online learning in the future,

	COVID-19 pandemic, students might strive to have high learning motivation.	as related to pedagogic strategies and the availability of learning infrastructures.
(Kusuma, 2020)	• The implementation of online learning during a pandemic positively impacted students' self-regulated learning in Geometry courses.	• Further study should review the impact of online learning on the students' mathematical resilience during the crisis period.
(Apsari et al., 2020)	• Online mathematics learning could be performed using simple, cost-effective applications while still paying attention to quality to get good results. • This study showed that facilities and internet access limitations could be mediated with the use of simple applications such as group chat media, as long as communication is multi-directional. Hence, students can still actively learn maximally.	• The findings are expected to provide an alternative for educators and students who face limited device facilities and internet access.

Figures

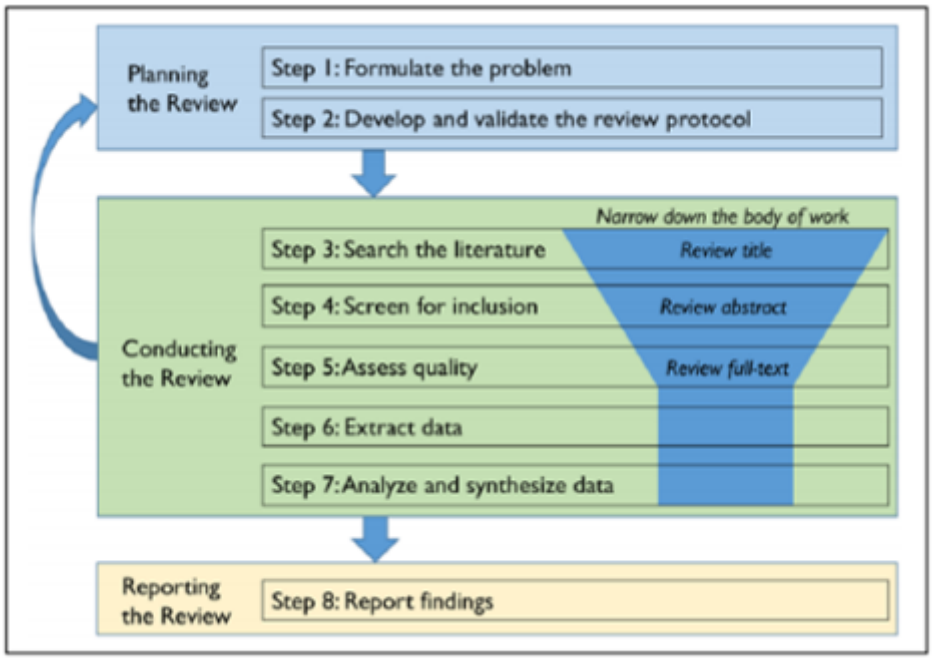

Figure 1

Process of Systematic Literature Review

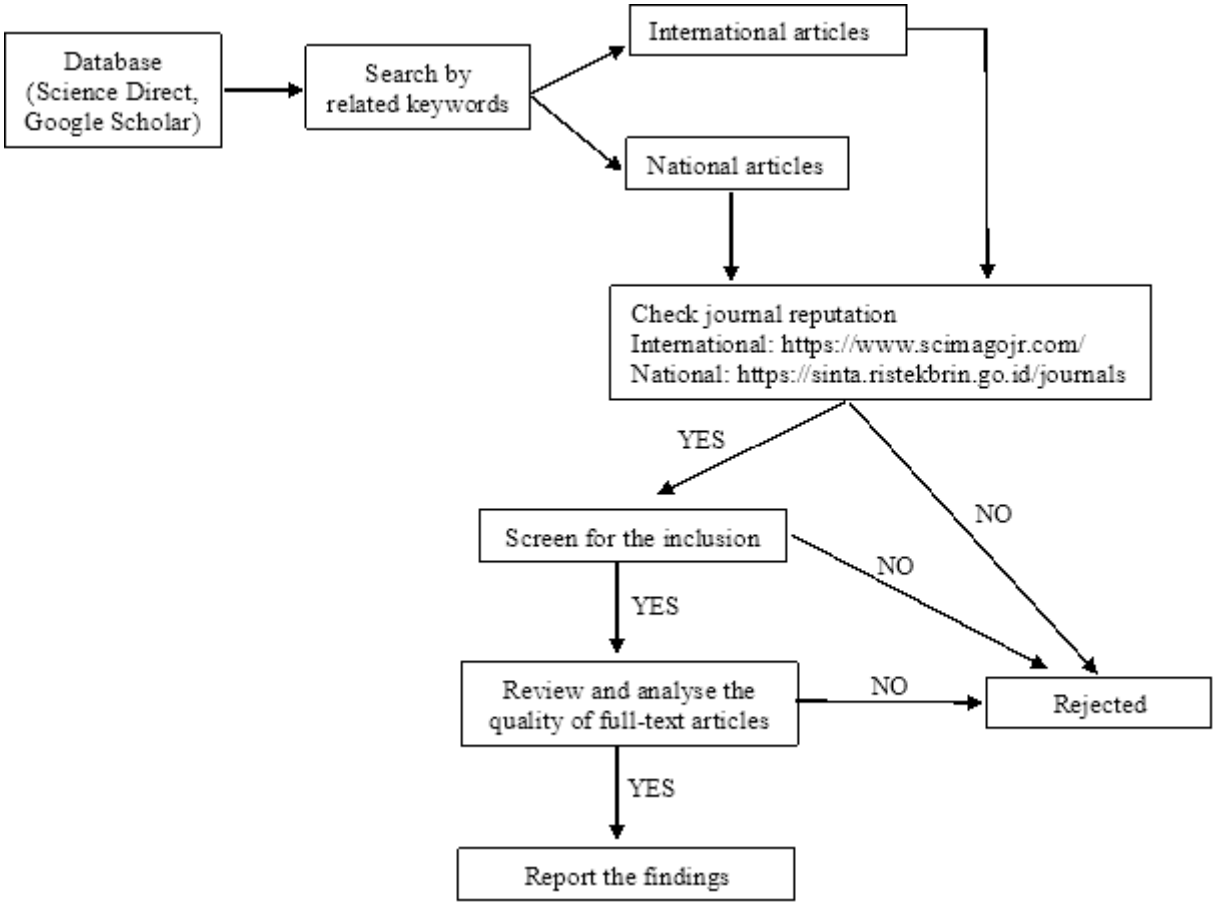

Figure 2

Flow Diagram of the Systematic Literature Review Methodology

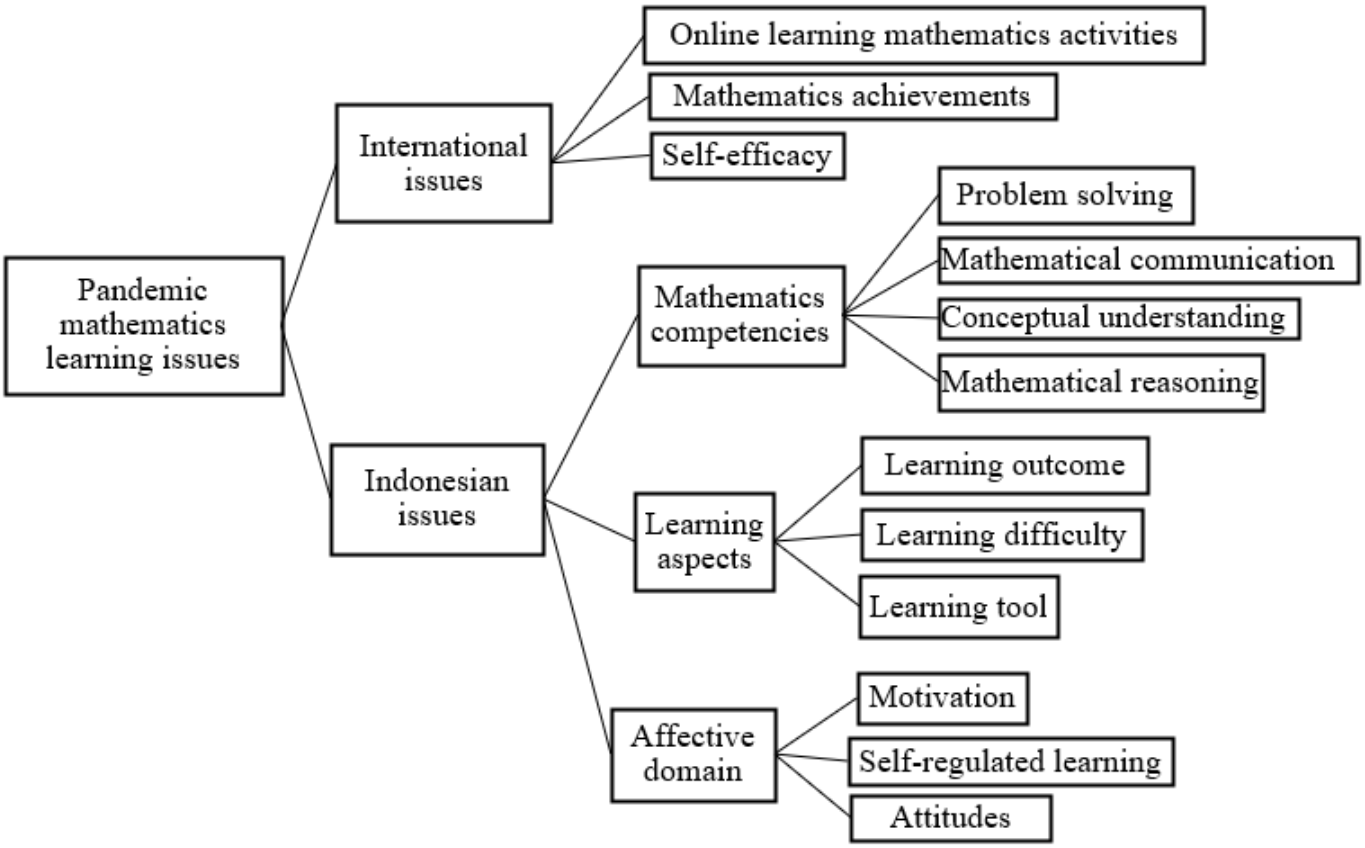

Figure 3

Taxonomy of Pandemic Mathematics Learning Issues