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Research Article

MASSIVE OPEN ONLINE COURSE IN MATHEMATICS: PERSPECTIVES ON COUNTRY, PUBLICATION TRENDS, RESEARCH APPROACHES, PARTICIPANTS, AND CONTENT ELEMENT

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Abstract
Massive Open Online Courses (MOOCs) have emerged as powerful tools that bridge vast learning resources with diverse global learners, particularly gaining prominence during and after the COVID-19 pandemic. While numerous studies have investigated the general application of MOOCs, limited research has specifically focused on their distribution and utilization within the field of mathematics education, especially in the post-pandemic context. This study aims to fill that gap by conducting a systematic literature review on MOOCs in mathematics, using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure a rigorous and replicable review process. At the identification stage, 2,349,886 articles were initially retrieved. After a comprehensive screening process based on inclusion and exclusion criteria, 78,191 articles were considered relevant. From this pool, 12 articles specifically addressed MOOCs in mathematics. However, only 6 articles met all the eligibility criteria for in-depth analysis. The findings reveal several key insights: (1) mathematics MOOCs are underrepresented in research, particularly in the context of school education; (2) research output on mathematics MOOCs has declined post-pandemic; (3) quantitative research methods dominate the field, limiting deeper qualitative insights; and (4) African countries remain significantly underrepresented in terms of both production and study of MOOCs in mathematics. This study contributes novel insights to the literature by highlighting geographic and methodological research gaps. It suggests that future research should explore mathematics MOOCs in school contexts, particularly using mixed-method approaches, and focus on understudied regions like Africa to promote equitable digital education access and innovation.

Keywords: Mathematics, MOOC, PRISMA, Systematic Literature Review

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INTRODUCTION

The rapid advancement of digital technology has significantly influenced 21st-century education, with one of the most transformative innovations being Massive Open Online Courses (MOOCs) (Ossiannilsson et al., 2016; Sanchez-Gordon & Luján-Mora, 2021; Hidayat et al., 2024). MOOCs provide open access to learning materials and courses, offering flexibility for students to expand their knowledge particularly in disciplines such as mathematics without the constraints of time or location (Ossiannilsson et al., 2016a; Magro et al., 2017; Taranto et al., 2021a). This flexibility allows learners to engage in self-paced learning and revisit concepts as needed. Educators increasingly utilize MOOCs as supplementary tools to provide additional resources, enrich instructional materials, and foster independent learning among students (Gulatee & Nilsook, 2016; Hew & Cheung, 2014; Salsabila et al., 2020; Hizon et al., 2024).

In the Indonesian educational context, however, the adoption of MOOCs especially in mathematics learning remains relatively limited. This is partly due to perceptions that MOOCs often overlook essential didactic and pedagogical principles, which are central to effective mathematics instruction (Magro et al., 2017; Tømte, 2019; Gonda et al., 2020a). Moreover, the lack of alignment between MOOC content and local curricula, along with insufficient contextualization for students' cultural and educational backgrounds, presents additional challenges to their effective integration into the classroom (Ma & Lee, 2018). Nonetheless, with appropriate adaptation and localization, MOOCs hold the potential to become valuable and innovative learning tools that complement traditional mathematics education in Indonesia.

Mathematics, as a subject, often presents intrinsic difficulties for learners, particularly in relation to abstract concepts, symbolic reasoning, and logical structure (Sudirman et al., 2021; Yaniawati et al., 2023). Students commonly struggle to relate mathematical theory to practical applications, which hinders their ability to think critically and solve problems effectively (Syutaridho et al., 2023; Herliana et al., 2024). These challenges are exacerbated when instructional materials fail to integrate sound pedagogical strategies, such as scaffolding, conceptual visualization, and contextual learning. While MOOCs have shown potential in increasing student engagement and improving learning outcomes (Azizul & Din, 2016; Boaler et al., 2018; Hung et al., 2018; Qin et al., 2019; Riazy et al., 2020), their effectiveness in fostering deep mathematical thinking skills including reasoning, abstraction, and problem-solving has not been sufficiently explored.

Although a growing body of research supports the effectiveness of MOOCs in mathematics education, several significant gaps remain. First, most existing studies focus on the general outcomes of MOOC implementation, such as student satisfaction or learning engagement, without delving deeply into how MOOCs contribute to the development of specific mathematical thinking competencies. Second, previous research tends to examine MOOC integration within specific institutional or national contexts, limiting the generalizability of findings across diverse educational systems. Third, the literature lacks a systematic mapping of how MOOCs in mathematics are distributed based on various critical dimensions such as geographic origin, research methodology, participant demographics, and content focus. This makes it difficult to obtain a comprehensive overview of current trends and underexplored areas in the field. Lastly, little attention has been paid to how MOOCs address pedagogical alignment with curriculum standards or accommodate learner diversity, particularly in developing countries like Indonesia.

In response to these gaps, this study aims to conduct a comprehensive analysis of the distribution and characteristics of MOOCs in mathematics education. By examining published studies and MOOC developments across multiple dimensions, this research seeks to uncover patterns and areas that require further investigation. The specific research questions addressed in this study include: 1) How is the distribution of MOOCs in mathematics learning based on country?; 2) How is the distribution of MOOC publications in mathematics over the past five years?; 3) How is the distribution of MOOCs in mathematics viewed from the aspect of the research approach?; 4) How is the distribution of MOOCs in mathematics viewed by the participants involved?; 5) How is the distribution of MOOCs in mathematics viewed from the content elements?. By addressing these questions, the study not only aims to map the current state of research on MOOCs in mathematics education but also to inform educators, researchers, and policymakers about the potentials and challenges of integrating MOOCs to enhance mathematical understanding and thinking skills especially in diverse educational settings like Indonesia.

RESEARCH METHOD

This research design used a systematic literature review (SLR). SLR was used because it was able to describe a topic in depth, especially the distribution of the research reviewed from several aspects (Albadarin et al., 2024; Ardwiyanti et al., 2021; Nugroho et al., 2024; Pahmi et al., 2022; Zuhri et al., 2023). The topic referred to in this study was MOOC, while the distribution referred to aspects of the research question, such as which countries had implemented MOOC, research trends each year, elements of mathematical content discussed, research methods used, and participants targeted in the study. The focus of this study was the analysis of Scopus or Web of Science (WoS) indexed articles published in the last five years. The selection of this year range was intended to find out the latest developments in MOOC, especially after the COVID-19 pandemic. Preferred reporting items for systematic reviews and meta-analysis (PRISMA) was used to assist the process of sorting articles in this study. PRISMA was used because it was able to sort systematically and use strict inclusion criteria. This process then produced quality articles that were ready to be analyzed (Mohamed et al., 2021; Pahmi et al., 2022). To strengthen confidence in the articles obtained, this study asked for the help of three external reviewers to assess and approve the articles obtained.

Systematic Review Process

Identification

In this step, researchers and external reviewers conducted searches on several well-known websites, such as ScienceDirect, SpringerLink, ProQuest, and ERIC, as the main databases and used searches on Google Scholar as an additional database. The keywords used were MOOC, massive online open course, mathematics, mathematics education, and mathematics instruction. The search was conducted during the period from July 15 to August 14, 2024. Based on the search results, around 2.349.886 articles related to mathematics education were found. We conducted the search from July 15 to August 14, 2024. Complete details regarding the number of articles obtained from each website can be seen in Figure 1.

Screening

The second step in PRISMA was screening. At this stage, researchers, together with external reviewers, screened the titles and abstracts of all articles found in the previous step. The focus of the criteria at the screening stage was to ensure that there were no duplicate articles, that the year of publication was in the range of 2020 to 2024, that the articles were in English, and that there were no articles of the thesis, book, book chapter, or systematic review types. In this step, articles that were not open-access were also excluded. Therefore, quite a lot of articles were issued at this step. Based on the screening results, information was obtained that there were 78.191 articles that met the criteria.

Eligibility

The next PRISMA stage was eligibility. At this stage, the researcher used mathematics, mathematics education, and mathematics instruction as inclusion criteria for each article. In other words, only MOOCs or massive online open course articles that contained the inclusion criteria were analyzed in the next stage. Based on the results of the analysis, information was obtained that there were 12 articles that met the inclusion criteria. These 12 articles were then further analyzed in the next stage.

Inclusion

At the inclusion stage, researchers used several inclusion criteria, such as articles published in journals or proceedings indexed by Scopus or Web of Science (WoS) and containing the necessary information to answer the research questions. Based on these criteria, it was found that six articles were excluded, leaving only about six articles to be used as sources to answer the research questions. It was important to note that there were quite a lot of articles containing MOOCs in mathematics, but not all of them met the established criteria. The researcher also wanted to confirm that there was 1 article (Taranto et al., 2021) that reached almost 27 countries, so even though only 6 articles were analyzed in this study, the reach of the countries that were the research locations was quite large. A summary of the number of articles during the PRISMA process can be seen in Figure 1.

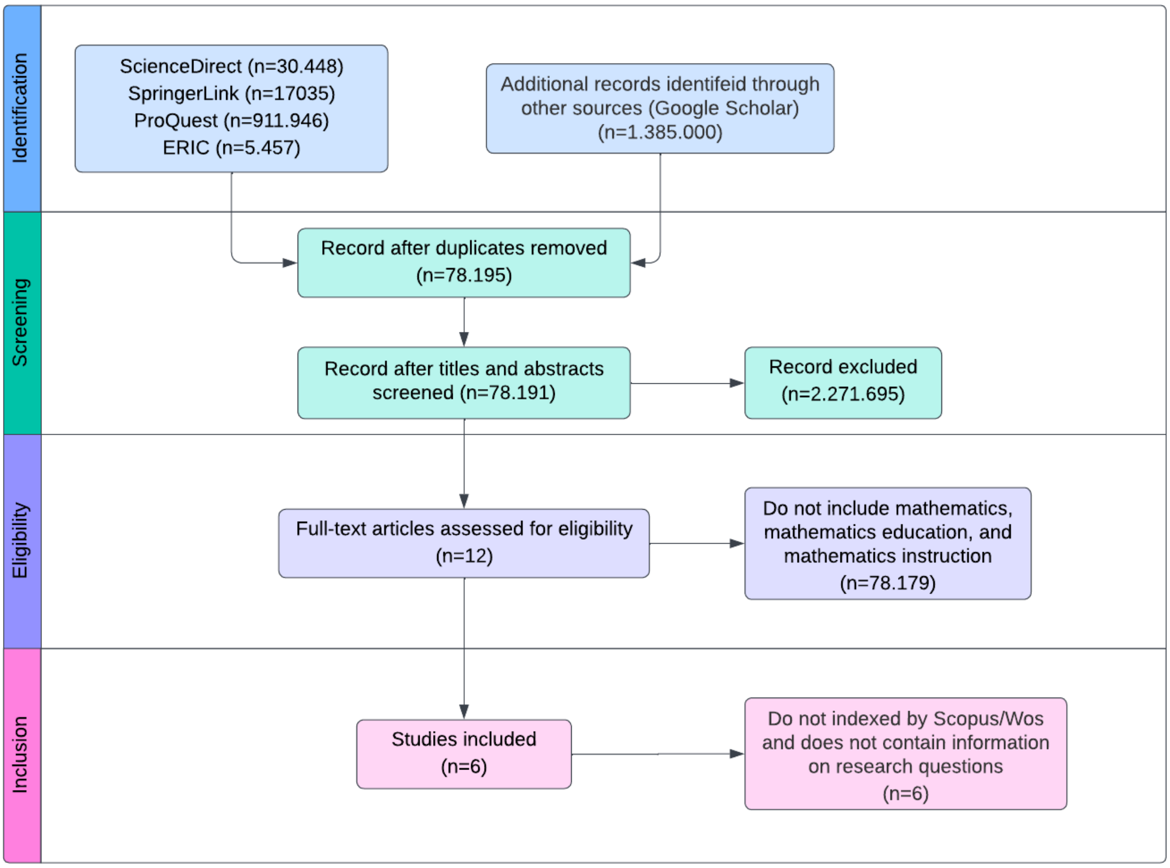

Figure 1. PRISMA results

RESULTS AND DISCUSSION

Based on the previous PRISMA results, it was found that there were six articles (Gonda et al., 2020; Hollebrands & Lee, 2020; Taranto et al., 2021; Vagaeva et al., 2021; Yıldırım, 2022; Yuniwati et al., 2021) that met the inclusion criteria until the final stage (See Table 1).

Table 1. Six articles that meet the criteria

No.	Publication Articles
1	Gonda, D., Ďuriš, V., Pavlovičová, G., & Tirpáková, A. (2020). Analysis of factors influencing students' access to mathematics education in the form of MOOC. Mathematics, 8(8), 1–12. https://doi.org/10.3390/MATH8081229
2	Hollebrands, K. F., & Lee, H. S. (2020). Effective design of massive open online courses for mathematics teachers to support their professional learning. ZDM-Mathematics Education, 52(5), 859–875. https://doi.org/10.1007/s11858-020-01142-0
3	Taranto, E., Jablonski, S., Recio, T., Mercat, C., Cunha, E., Lázaro, C., Ludwig, M., & Mammana, M. F. (2021). Professional development in mathematics education—Evaluation of a MOOC on outdoor mathematics. Mathematics, 9(22), 1–30. https://doi.org/10.3390/math9222975
4	Vagaeva, O. A., Galimullina, N. M., Liksina, E. V., Efremkina, I. N., & Lomakin, D. E. (2021). Role of MOOCs in teaching Mathematics to students majoring in Engineering. Journal of Physics: Conference Series, 1889(2), 1–6. https://doi.org/10.1088/1742-6596/1889/2/022043
5	Yıldırım, B. (2022). MOOCs in STEM education: Teacher preparation and views. Technology, Knowledge and Learning, 27(3), 663–688. https://doi.org/10.1007/s10758-020-09481-3
6	Yuniwati, I., Yustita, A. D., Hardiyanti, S. A., & Suardinata, I. W. (2021). Development of attitude assessment instrument in engineering mathematics 1 course to assess discussion on MOOC platform. Journal of Physics: Conference Series, 1918(4), 1–7. https://doi.org/10.1088/1742-6596/1918/4/042079

Based on the analysis of the six previous articles, it was found that the practice of MOOCs in mathematics research reached several countries. It was noted that 33 countries had become research targets. One study (Taranto et al., 2021) included teacher participants from 27 countries. The distribution of these countries can be seen in Figure 2. The map in red shows countries that have implemented MOOCs in mathematics.

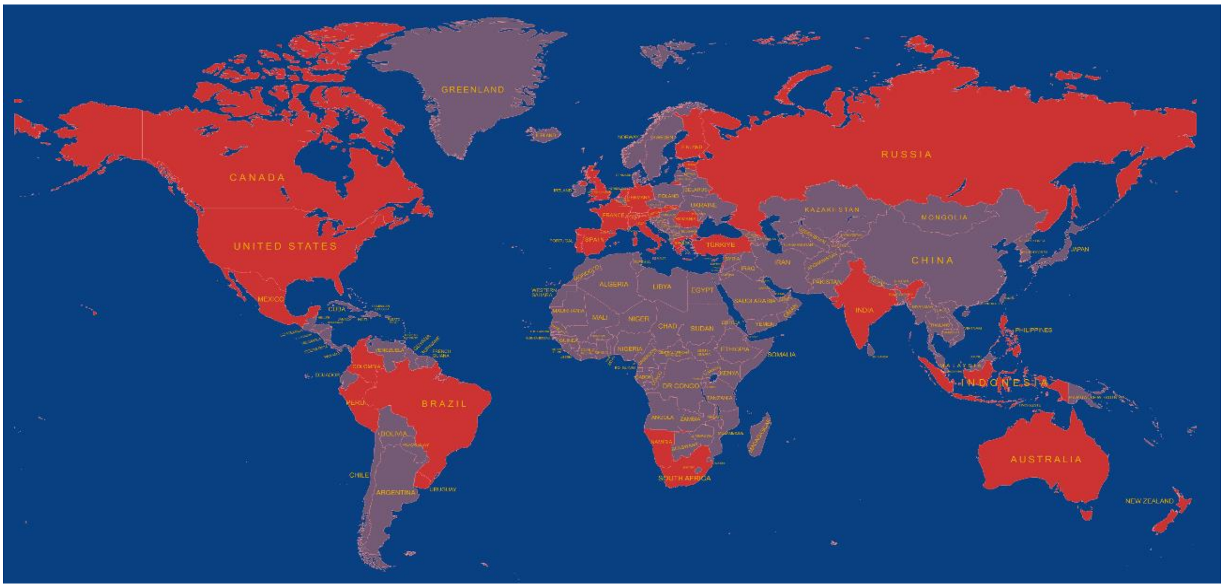

Figure 2. MOOC in mathematics by country

Based on the map (Figure 2), it can be seen that countries in various continents such as North America (Canada, United States), South America (Brazil), Europe, Asia (including Russia, India, and China), Africa, and Australia have become targets or locations for MOOC-related research in mathematics. This reflects that the implementation of MOOC in mathematics has a global scope, covering various countries worldwide. In addition, countries that have not implemented MOOC in mathematics learning on this map are marked in purple. Some regions that have not been involved include most countries in Africa, the Middle East, Southeast Asia (except Indonesia), several countries in Eastern Europe, and Central America such as Mexico and countries in the Caribbean. In addition, regions such as Oceania (except Australia and New Zealand) and several countries in South America have also not been involved in MOOC mathematics research.

The results of the analysis of the six previous articles showed that there had been a decrease in the number of publications related to MOOCs in mathematics. Evidently, in 2020, there were three articles discussing MOOCs. In 2021, there were two articles about MOOCs, while in 2022, only one article discussed MOOCs. In fact, in 2023 and 2024, there were no articles discussing MOOCs based on the inclusion criteria used in this study. In simple terms, the distribution of publications related to MOOCs in mathematics can be seen in Figure 3.

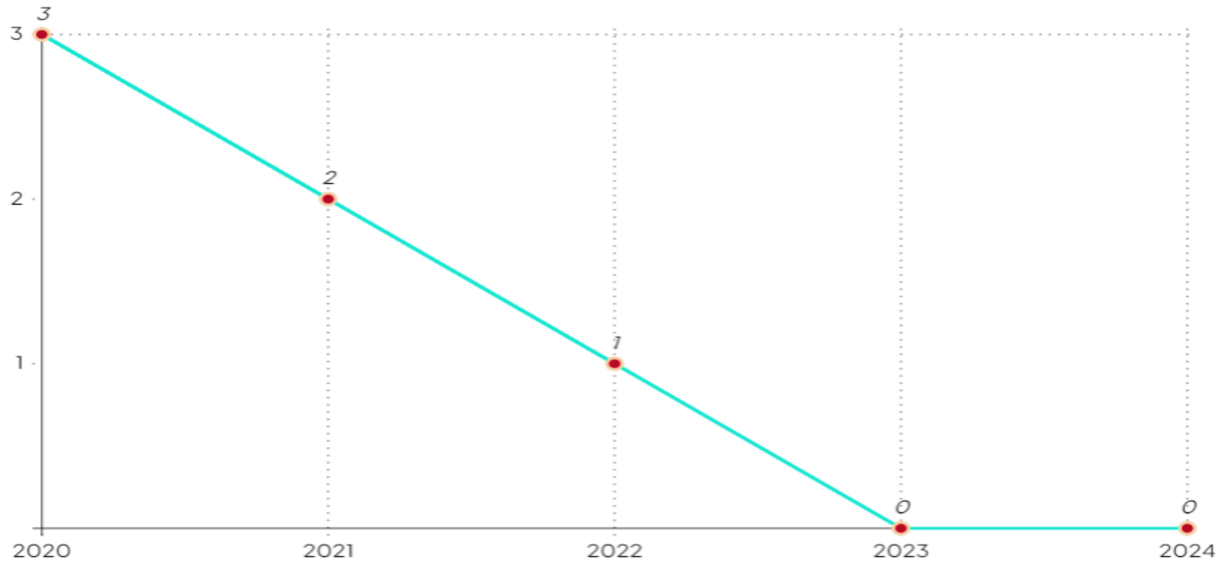

Figure 3. MOOC in mathematics by year of publication

This downward trend could indicate several things, such as a possible decline in researchers' interest or focus on MOOCs in mathematics, or perhaps a shift in research trends to other areas that are considered more relevant or important at this time. In addition, this lack of publications could be due to certain challenges in the implementation and research of MOOCs in the context of mathematics learning, such as difficulties in measuring their effectiveness, technological constraints, or changes in educational needs during the period. This phenomenon could be a signal that more studies and innovations are needed to revitalize or re-evaluate the role of MOOCs in mathematics education in the future.

In general, research approaches were divided into three types: qualitative, quantitative, and mixed-method. Based on the results of the analysis of the six previous articles, it was found that four articles used a quantitative approach, one article used a qualitative approach, and one other article used a mixed-method approach. The percentage of MOOC distribution in mathematics reviewed from the aspect of the research approach used could be seen in Figure 4.

Figure 4. MOOC in mathematics by methodology

Figure 5 shows the distribution of MOOCs in mathematics in terms of the participants involved. Figure 5 provided information that three articles used engineering students as participants and three other articles used teachers as participants. This indicated that all participants from the previous six articles were adults.

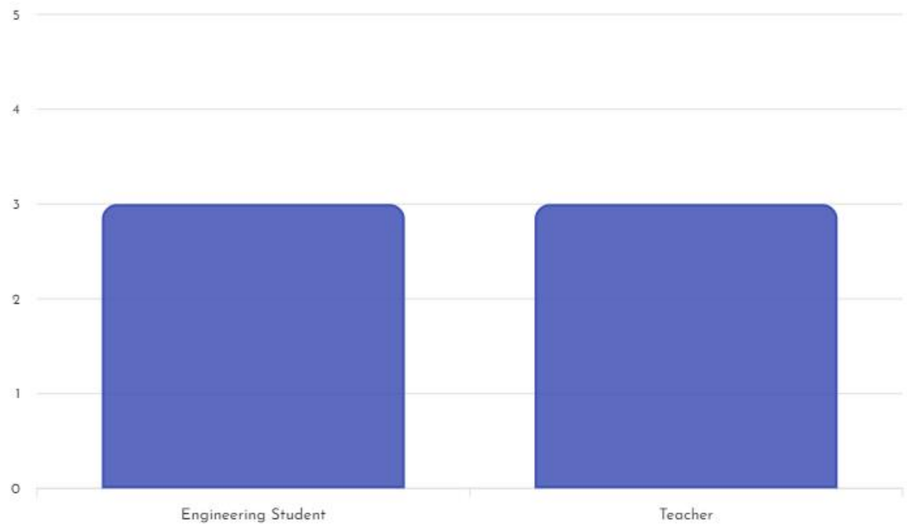

Figure 5. MOOC in mathematics by participants

The dominance of quantitative approaches may be due to the desire to obtain measurable and statistically comparable results, which are often considered more objective in assessing the effectiveness of MOOCs in the context of mathematics learning. On the other hand, the minimal use of qualitative and mixed approaches indicates that aspects of MOOC participants' experiences, perceptions, and interactions in mathematics have not been explored in depth. Qualitative and mixed approaches have the potential to provide more comprehensive insights into how learners interact with materials, technology, and learning methods in MOOCs. Therefore, there is an opportunity for researchers to develop further research using qualitative or mixed approaches to enrich the understanding of the implementation of MOOCs in mathematics education.

Based on the results of the analysis of the six previous articles, it was found that not all elements of mathematics subject content were topics discussed in mathematics learning or lectures. There was only one article (Hollebrands & Lee, 2020) that discussed statistics, which is included in the data analysis and probability content element. The other five articles discussed mathematics topics in general. In simple terms, the distribution can be seen in Figure 6.

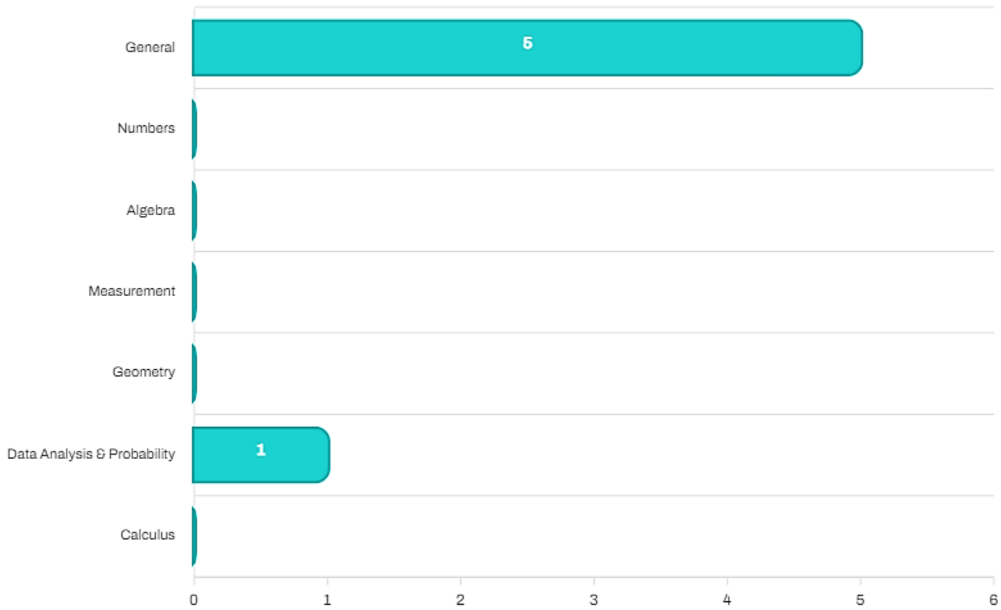

Figure 6. MOOC in mathematics by content elements

This suggests that statistics and probability are still rarely the focus of MOOC research on mathematics, while most studies tend to examine mathematics more broadly. This could be an indication that there is still room for further exploration into how MOOCs can be used to teach specific topics in mathematics, such as statistics and probability, more effectively.

Based on the research results, it is found that MOOC practices have reached 33 countries. In fact, if we look back at Figure 2, we see that research related to MOOCs has reached almost half of the world. This is because MOOCs are flexible in terms of space and time (Hsiao et al., 2019). In addition, the existence of MOOCs is also flexible, so they tend to be implemented in various learning conditions. MOOCs can be an alternative complement to conventional learning and can also substitute for conventional learning itself (Hsiao et al., 2019).

Look again at Figure 2. If we look closely, we find that countries spread across the African continent do not seem to have used MOOCs much. This means that if we compare the distribution of countries that use MOOC in mathematics based on continent, there are quite a few countries spread across the African continent that have implemented MOOC in mathematics. It is noted that from the 6 articles analyzed, Gonda et al. (2020) inform that there are only 2 countries, namely South Africa and Namibia, that have implemented MOOCs in mathematics. The results of this study align with Liyanagunawardena et al., (2013), who states that MOOCs can reach many students from various parts of the world as long as the students have access to courses via the Internet and adequate distance learning facilities and infrastructure. Therefore, MOOCs may not be a complete solution to learning but may face obstacles in implementation, especially in countries with less advanced access to technology. It is also stated that developing countries may not be able to implement MOOCs optimally, thus requiring more in-depth study.

The results of this study also align with Cagiltay et al., (2023), who states that around 93,58% of countries in the world have used MOOCs in learning. In addition, it is also noted that the use of MOOCs is directly proportional to the income level of a country. Evidently, around 38,73% of countries with high-income levels have implemented MOOCs; 25,98% of countries with upper-middle income levels; 23,04% of lower-middle income countries; and 12,25% of countries with low-income levels have also implemented MOOCs. The United States has the highest percentage of students accessing MOOCs for learning. It is recorded that around 51.03% of students in the United States have accessed MOOCs.

Laurillard and Kennedy (2017) also reinforce the results of this study. Laurillard and Kennedy (2017) state that MOOCs can reach students from more than 200 countries. Rulinawaty et al., (2024) also states that the existence of MOOCs represents a revolution in the world of education because it offers courses that are flexible, easy to reach, and accessible to students from all over the world. Based on the previous description, it can be concluded that the implementation of MOOCs in mathematics is able to reach almost all countries in the world. However, countries with low-income levels tend not to be optimal in utilizing MOOCs, such as countries across the African continent. Therefore, research related to MOOCs in mathematics is recommended to be carried out in these countries to promote equality or improvement in the quality of education, especially for countries on the African continent.

The results of the study reveal that there has been a decline in the number of publications discussing MOOCs in mathematics over the past five years. Figure 3 shows that there are no published articles discussing MOOCs in mathematics from 2023 to 2024. There is no further explanation for this. However, are the characteristics of mathematical material may be one of the causes of the lack of research using MOOCs in teaching mathematics. This is in line with Isnawan et al., (2022, 2023), who states that one of the obstacles students face during distance learning of mathematics is the lack of understanding. This is because the characteristics of mathematics tend to be difficult to explain without the presence of a teacher directly.

Additionally, some people believe that face-to-face learning alone does not provide optimal understanding to students, especially if mathematics learning is conducted online, such as using MOOCs. This belief aligns with research conducted by Juliyanti et al., (2023), which reveals that the task completion factor is one of the obstacles to learning mathematics online. This is because students' understanding of mathematical material tends to be low. This low understanding is caused by the lack of teacher explanation regarding the material or mathematical problems during online learning. Moreover, the greater workload compared to direct face-to-face learning is also one of the reasons students experience difficulties in learning mathematics online. This belief is supported by Supariani et al., (2021), who states that students tend to be confused, and have difficulty understanding teacher explanations, solving problems, and concluding well regarding mathematical concepts or formulas learned during online learning. Research also supports these previous beliefs. The study reveals that around 31,11% of students consider distance learning of mathematics online to be very challenging, and 29,63% state that the learning is challenging. In other words, more than 60% of students find that learning mathematics online tends to be more difficult to understand.

Based on the previous description, it can be concluded that there is a decrease in the number of published articles using MOOCs in mathematics learning. The exact causal factors are not found. However, the belief that mathematics is difficult to learn online is a rational factor to consider. However, this belief could also be incorrect. Therefore, research related to the factors causing a decrease in the number of MOOC publications in mathematics is a key recommendation for the results of this study. A more in-depth study of how to implement MOOCs in mathematics learning is also an interesting recommendation for subsequent researchers.

Look again at Figure 4. Based on the figure, it is observed that the quantitative approach is the most dominant approach used by researchers. In other words, there are not many studies related to MOOCs in mathematics that use a qualitative or mixed-method approach. The results of this study align with the research of Hussein et al., (2022) , which indirectly describes that the quantitative approach tends to be the choice of researchers when studying website-based mathematics learning media. The study reveals that website-based mathematics learning is quite recommended for use in mathematics learning. In contrast, Putra and Sustipa (2021) reveals that mixed-approach research is quite dominant when studying mathematics modules used for online learning. Although the results of this study differ from previous studies, a deeper analysis shows that the choice of research approach is closely related to the research objectives.

Gonda et al., (2020b) uses a quantitative approach because it aims to analyze the factors that influence students in gaining access to MOOCs in mathematics education. Vagaeva et al., (2021) chooses a quantitative approach because the research objective is to determine the role of MOOCs in mathematics lectures in higher education. Meanwhile, Yuniwati et al., (2021) aims to develop an attitude assessment instrument in mathematics lectures using MOOCs, hence the use of a quantitative approach. This result aligns with several theories that state that research objectives are the main factor for researchers in determining the type of approach or research used (Ossiannilsson et al., 2016; Creswell & Creswell, 2018). Based on the previous description, it can be concluded that the quantitative approach dominates research related to MOOCs in mathematics. Therefore, it is recommended that subsequent researchers choose a mixed-method approach for research related to MOOCs in mathematics. This is intended to obtain research results that are more relevant to the needs of students in learning mathematics.

If we look at Figure 5, we get information that all articles use adults as research participants. Three articles (Gonda et al., 2020; Vagaeva et al., 2021; Yuniwati et al., 2021) use engineering students as participants, and three others (Hollebrands & Lee, 2020; Taranto et al., 2021b; Yıldırım, 2022) use teachers. There are many factors behind this distribution, one of which is the characteristics of MOOCs. MOOC as a learning system has several requirements that must be met for learning to run well. Some of these requirements include the good ICT skills of students, the presence of a computer, laptop, or smartphone that supports it, and a stable and sufficient internet connection. Considering these requirements, it is very natural that MOOC practices focus more on adults. This is because students and teachers tend to have better ICT skills compared to school students, and adults have easier access to MOOC learning support devices. Based on the previous description, it can be concluded that adults dominate the use of MOOCs in mathematics. Therefore, this study recommends that the use of MOOCs in mathematics not be limited to the context of adults but also extend to students in schools. This is because, in several developing countries, the availability of supporting devices for MOOCs in mathematics has become adequate, and students' ICT skills also appear to be quite good, as students have been familiar with smartphones from an early age.

In general, the results of the study indicate that most of the mathematics materials studied in the previous six articles are not specifically tied to content elements. Only one article (Gonda et al., 2020) is related to data analysis and probability. This result shows that the dominant mathematics material discussed in the articles is mathematics in general. This seems to be related to the participants used in the studies themselves. The mathematics material discussed in higher education, especially for engineering students, is mathematics in general (Supriyadi & Taban, 2024). In other words, all content elements in mathematics are covered in the mathematics lecture. Similarly, in the context of teachers, teacher training activities usually do not focus on one content element but rather on all content elements. This is because all content elements will be studied by students at the school level, from elementary school to high school. Based on the previous description, it can be concluded that the content elements discussed in the six articles do not specifically refer to all content elements in mathematics learning. Therefore, this study recommends that future researchers examine the implementation of MOOCs in the context of school learning. This is intended so that all content elements in mathematics have the opportunity to be studied using MOOCs, thereby optimizing student competency for all content elements (Isnawan, 2023).

This study has several limitations. First, this study did not interact directly with teachers or students at school, so the research findings are highly dependent on the articles analyzed. Second, the articles analyzed are research articles that meet the criteria so that it is still possible that there is some important information that is not analyzed but is contained in articles that do not meet the criteria. Based on these limitations, the researcher recommends that subsequent researchers develop MOOCs that are tailored to the problems faced by students in learning mathematics. The use of design-based research (DBR) is quite recommended for use because the design is pragmatic or benefit-oriented and uses a combination of quantitative and qualitative data analysis in obtaining research results (Scott et al., 2020; Hoadley & Campos, 2022; Bedewy & Lavicza, 2023).

CONCLUSION

Based on the results of the study and discussion, several conclusions can be drawn regarding MOOCs in mathematics. First, quite a number of countries in the world have implemented MOOCs in mathematics, except for countries on the African continent. Second, there has been a decline in the number of publications related to MOOCs in mathematics. Third, qualitative approaches dominate. Fourth, all articles use adults as participants. Fifth, research related to MOOCs in mathematics does not examine all elements of mathematical content in detail. This conclusion then leads researchers to a hypothesis that mathematics learning with MOOCs tends to have a greater impact on students in college because the ICT skills of students in college tend to be better than those of students at the school level. In addition, mathematics learning with MOOCs tends to be more suitable for implementation in countries with good ICT support and infrastructure. This is what then causes the low number of MOOC implementations in mathematics learning in African countries.

This study then has implications for the discovery of a research trend on MOOCs in mathematics learning. The trend is that research on MOOCs in mathematics learning tends to be dominated by quantitative research at the tertiary level in countries with adequate ICT facilities. This implication leads researchers to recommend several research focuses on MOOCs in mathematics learning in the future. First, conducting research on MOOCs in mathematics on the African continent. Second, investigating the factors that cause the decline in MOOC implementation in mathematics. Third, using a mixed-method approach, especially DBR, as an alternative to studying MOOCs in mathematics. Fourth, ensuring that the use of MOOCs in mathematics covers all elements of mathematics subject content in schools.

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AUTHOR CONTRIBUTIONS

The first author was responsible for conceptualization, methodology, formal analysis, and writing (original draft preparation). The second author conducted a formal analysis, prepared resources, and handled visualization. The third author was responsible for validation, writing (review and editing), and supervision. The fourth and fifth authors were involved in validation and formal analysis.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

REFERENCES

Albadarin, Y., Saqr, M., Pope, N., & Tukiainen, M. (2024). A systematic literature review of empirical research on ChatGPT in education. *Discover Education*, *3*(1), 60. https://doi.org/10.1007/s44217-024-00138-2

Ardwiyanti, D., Prasetyo, Z. K., & Wilujeng, I. (2021). STEM research trends in Indonesia: A systematic literature review. *Journal of Science Education Research*, *5*(1), 38–45. https://doi.org/10.21831/jser.v5i1.41752

Bedewy, S. El, & Lavicza, Z. (2023). STEAM + X - Extending the transdisciplinary of STEAM-based educational approaches: A theoretical contribution. *Thinking Skills and Creativity*, *48*, 1–23. https://doi.org/10.1016/j.tsc.2023.101299

Binti M, M., & Adeshina, A. N. G. (2024). Exploring the Effectiveness of the Learning Cycle Model in Enhancing Mathematics Learning for Students. *Interval: Indonesian Journal of Mathematical Education*, *2*(2), 99-105. https://doi.org/10.37251/ijome.v2i2.1144.

Boaler, J., Dieckmann, J. A., Pérez-Núñez, G., Sun, K. L., & Williams, C. (2018). Changing students minds and achievement in mathematics: The impact of a free online student course. *Frontiers in Education*, *3*(Article 26), 1–7. https://doi.org/10.3389/feduc.2018.00026

Cagiltay, N. E., Toker, S., & Cagiltay, K. (2023). Exploring the influence of countries' economic conditions on massive open online course (MOOC) participation: A study of 3.5 million MITx learners. *International Review of Research in Open and Distributed Learning*, *24*(2), 1–17. https://doi.org/10.19173/irrodl.v24i2.7123

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (H. Salmon, Ed.; 5th ed.). Sage Publication, Inc. https://id1lib.org/book/3700358/d95149

Fitriani, F., Triandafillidis, T., & Thao, L. P. (2023). Exploring the Integration of Computational Thinking and Mathematical Modelling in STEM Education. *Interval: Indonesian Journal of Mathematical Education*, *1*(2), 73-82. https://doi.org/10.37251/ijome.v1i2.1341.

Gonda, D., Ďuriš, V., Pavlovičová, G., & Tirpáková, A. (2020). Analysis of factors influencing students' access to mathematics education in the form of MOOC. *Mathematics*, *8*(8). https://doi.org/10.3390/MATH8081229

Gulatee, Y., & Nilsook, P. (2016). MOOC's barriers and enables. *International Journal of Information and Education Technology*, *6*(10), 826–830. https://doi.org/10.7763/IJIET.2016.V6.800

Herliana, Maison, & Syaiful. (2024). Development and implementation of a five-tier diagnostic test to identify student misconceptions on fractions: A significant step towards improving mathematics education. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(2), 563–576. https://doi.org/10.22437/jiituj.v8i2.34159

Hew, K. F., & Cheung, W. S. (2014). Students' and instructors' use of massive open online courses (MOOCs): Motivations and challenges. *Educational Research Review*, *12*, 45–58. https://doi.org/10.1016/j.edurev.2014.05.001

Hidayat, R., Imami, M. K. W., Liu, S., Qudratuddarsi, H., & Saad, M. R. M. (2024). Validity of engagement instrument during online learning in mathematics education. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(2), 398–414. https://doi.org/10.22437/jiituj.v8i2.34453

Hizon, J. O., Cruz, N. Y., Collantes, L. M., Torres, J. M., & Mukminin, A. (2024). The impact of concept cartoons as an instructional material and formative assessment tool in teaching evolution on the achievement of grade 11 STEM students enrolled in synchronous modality. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(1), 170–179. https://doi.org/10.22437/jiituj.v8i1.32609

Hoadley, C., & Campos, F. C. (2022). Design-based research: What it is and why it matters to studying online learning. *Educational Psychologist*, *57*(3), 207–220. https://doi.org/10.1080/00461520.2022.2079128

Hollebrands, K. F., & Lee, H. S. (2020). Effective design of massive open online courses for mathematics teachers to support their professional learning. *ZDM - Mathematics Education*, *52*(5), 859–875. https://doi.org/10.1007/s11858-020-01142-0

Hsiao, C. C., Huang, J. C., Huang, A. Y., Lu, O. H., Yin, C. J., & Yang, S. J. (2019). Exploring the effects of online learning behaviors on short-term and long-term learning outcomes in flipped classrooms. *Interactive Learning Environments*, *27*(8), 1160-1177. https://doi.org/10.1080/10494820.2018.1522651

Hussein, M. H., Ow, S. H., Elaish, M. M., & Jensen, E. O. (2022). Digital game-based learning in K-12 mathematics education: a systematic literature review. *Education and Information Technologies*, *27*(2), 2859-2891. https://doi.org/10.1007/s10639-021-10721-x

Hyskaj, A., Ramadhanti, A., Farhan , H., Allaham, A., & Ismail, M. A. (2024). Analysis of the Role of the Flo Application as a Digital Educational Media for Adolescent Reproductive Health in the Technology Era. *Journal of Educational Technology and Learning Creativity*, *2*(1), 71-82. https://doi.org/10.37251/jetlc.v2i1.1414.

Isnawan, M. G. (2023). *Pengembangan program pembelajaran matematika*. Nashir Al-Kutub Indonesia.

Isnawan, M. G., Azis, A., & Almazroei, E. E. (2023). Parents' perspectives on distance learning mathematics during the Covid-19 pandemic: A phenomenological study in Indonesia. *European Journal of Educational Research*, *12*(1), 567–581. https://doi.org/10.12973/eu-jer.12.1.567

Isnawan, M. G., Suryadi, D., Turmudi, T., & Marfuah, M. (2022). Parental obstacles during distance learning mathematics in Indonesia: A phenomenology study. *European Journal of Educational Research*, *11*(2), 873–883. https://doi.org/10.12973/eu-jer.11.2.873

Juliyanti, A., Ihsanudin, & Rafianti, I. (2023). Students' difficulties in learning mathematics in online learning. *Jurnal Pendidikan Matematika*, *14*(1), 36–45. https://doi.org/10.36709/jpm.v14i1.37

Laurillard, D., & Kennedy, E. (2017). *The potential of MOOCs for learning at scale in the Global South* (31). https://www.researchcghe.org/wp-content/uploads/migrate/publications/wp31.pdf

Liyanagunawardena, T., Williams, S., & Adams, A. (2013). The impact and reach of MOOCs: A developing countries' perspective. *E-Learning Papers*, 1–8. www.reading.ac.uk/centaur

Ma, L., & Lee, C. S. (2018). Understanding the barriers to the use of MOOCs in a developing country: An innovation resistance perspective. *Journal of Educational Computing Research*, *57*(3), 571–590. https://doi.org/10.1177/0735633118757

Magro, E. D., Gebing, S., Heinzmann, L., Romagna, M. E., Studer, J., Goulart, T. M., Ayub, D. M., Rosito, M. C., Silva, J. M. C., Imran, H., & Kinshuk. (2017). MOOC as supplementary tutoring to public school students learning. *IEEE 17th International Conference on Advanced Learning Technologies (ICALT)*, 220–223. https://ieeexplore.ieee.org/document/8001766/authors#authors

Mawardani, A., Mirunalini, M., Meechi, C., & Shah, S. (2023). Development of Interactive Multimedia Based on Adobe Flash as a Learning Media Steps of Geographical Research. *Journal of Educational Technology and Learning Creativity*, *1*(1), 16-24. https://doi.org/10.37251/jetlc.v1i1.620.

Mohamed, R., Ghazali, M., & Samsudin, M. A. (2021). A systematic review on teaching fraction for understanding through representation on Web of Science database using PRISMA. *LUMAT*, *9*(1), 100–125. https://doi.org/10.31129/LUMAT.9.1.1449

Nugroho, N. E., Irianto, J., & Suryanto, S. (2024). A systematic review of Indonesian higher education students' and graduates' work readiness. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(1), 350–363. https://doi.org/10.22437/jiituj.v8i1.33073

Ossiannilsson, E., Altinay, F., & Altinay, Z. (2016). MOOCs as change agents to boost innovation in higher education learning arenas. *Education Sciences*, *6*(3), 1–13. https://doi.org/10.11647/OBP.0103.08

Pahmi, S., Juandi, D., & Sugiarni, R. (2022). The effect of STEAM in mathematics learning on 21st century skills: A systematic literature reviews. *PRISMA*, *11*(1), 93. https://doi.org/10.35194/jp.v11i1.2039

Putra, A., & Sustipa, W. (2021). Systematic literatur review modul matematika untuk pembelajaran secara daring. *Lentera: Jurnal Ilmiah Kependidikan*, *14*(1), 101–104. https://jurnal.stkippgribl.ac.id/index.php/lentera/article/download/295/254/326

Riazy, S., Simbeck, K., Traeger, M., & Woestenfeld, R. (2020). The effect of prior knowledge on persistence, participation and success in a mathematical MOOC. In H. C. Lane, S. Zvacek, & J. Uhomoibhi (Eds.), *Communications in Computer and Information Science* (Vol. 1473). Springer, Cham. https://doi.org/10.1007/978-3-030-86439-2_21

Rulinawaty, Purwanto, A. J., Samboteng, L., Kasmad, M. R., & Basit, M. (2024). Global trends and policy strategies and their implications for the sustainable development of MOOCs in Indonesia. In *ICAS: Vol. ASSEHR 776* (pp. 491–508). https://doi.org/10.2991/978-2-38476-104-3_47

Salsabila, U. H., Habiba, S., Amanah, I. L., Istiqomah, N. A., & Difany, S. (2020). Pemanfaatan aplikasi Quizizz sebagai media pembelajaran ditengah pandemi pada siswa SMA. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *4*(2), 163–172. https://doi.org/10.22437/jiituj.v4i2.11605

Sanchez-Gordon, S., & Luján-Mora, S. (2021). Technological innovations in large-scale teaching: Five roots of massive open online courses. *Journal of Educational Computing Research*, *56*(5), 623-644. https://doi.org/10.1177/073563311772759

Scott, E. E., Wenderoth, M. P., & Doherty, J. H. (2020). Design-based research: A methodology to extend and enrich biology education research. *CBE Life Sciences Education*, *19*(3), 1–12. https://doi.org/10.1187/cbe.19-11-0245

Sudirman, Yaniawati, P., Mellawaty, & Indrawan, R. (2021). Augmented reality application: What are the constraints and perceptions of the students during the covid 19 pendemic's 3D geometry learning process? *Journal of Physics: Conference Series*, *1783*(1), 012007. https://doi.org/10.1088/1742-6596/1783/1/012007

Supariani, N. K. D., Herlianti, R., & Djidu, H. (2021). Kendala dalam pembelajaran matematika secara daring. *EDUMATIC: Jurnal Pendidikan Matematika*, *2*(1), 17–23. https://doi.org/http://dx.doi.org/10.21137/edumatic.v2i01.466

Supriyadi, E., & Taban, J. G. (2024). Knowledge mapping of Computational Thinking and Science, Technology, Engineering, and Mathematics (CT+ STEM). *International Journal of Didactic Mathematics in Distance Education*, *1*(1), 24-36. https://doi.org/10.33830/ijdmde.v1i1.7599

Syutaridho, Ramury, F., & Nurhijah. (2023). The influence of Indonesia's realistic mathematics education approach on students' creative thinking ability. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *7*(2), 99–111. https://doi.org/10.22437/jiituj.v7i2.28700

Taranto, E., Jablonski, S., Recio, T., Mercat, C., Cunha, E., Lázaro, C., Ludwig, M., & Mammana, M. F. (2021a). Professional development in mathematics education—Evaluation of a MOOC on outdoor mathematics. *Mathematics*, *9*(22), 1–30. https://doi.org/10.3390/math9222975

Taranto, E., Jablonski, S., Recio, T., Mercat, C., Cunha, E., Lázaro, C., Ludwig, M., & Mammana, M. F. (2021b). Professional development in mathematics education—evaluation of a MOOC on outdoor mathematics. *Mathematics*, *9*(22). https://doi.org/10.3390/math9222975

Tømte, C. E. (2019). MOOCs in teacher education: institutional and pedagogical change? *European Journal of Teacher Education*, *42*(1), 65–81. https://doi.org/10.1080/02619768.2018.1529752

Vagaeva, O. A., Galimullina, N. M., Liksina, E. V., Efremkina, I. N., & Lomakin, D. E. (2021). Role of MOOCs in teaching mathematics to students majoring in engineering. *Journal of Physics: Conference Series*, *1889*(2), 1–6. https://doi.org/10.1088/1742-6596/1889/2/022043

Yaniawati, P., Sudirman, S., Mellawaty, M., Indrawan, R., & Mubarika, M. P. (2023). The potential of mobile augmented reality as a didactic and pedagogical source in learning geometry 3D. *Journal of Technology and Science Education*, *13*(1), 4. https://doi.org/10.3926/jotse.1661

Yıldırım, B. (2022). MOOCs in STEM education: Teacher preparation and views. *Technology, Knowledge and Learning*, *27*(3), 663–688. https://doi.org/10.1007/s10758-020-09481-3

Yuniwati, I., Yustita, A. D., Hardiyanti, S. A., & Suardinata, I. W. (2021). Development of attitude assessment instrument in engineering mathematics 1 course to assess discussion on MOOC platform. *Journal of Physics: Conference Series*, *1918*(4), 1–7. https://doi.org/10.1088/1742-6596/1918/4/042079

Zuhri, R. S., Wilujeng, I., & Haryanto. (2023). Multiple representation approach in elementary school science learning: A systematic literature review. *International Journal of Learning, Teaching and Educational Research*, *22*(3), 51–73. https://doi.org/10.26803/ijlter.22.3.4