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ONLINE MATHEMATICS LEARNING STRATEGY APPROACH: TEACHING METHODS AND LEARNING ASSESSMENT

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Abstract

The primary focus of this research is to develop strategies aimed at identifying effective methods applicable to online mathematics instruction and assessment. Teaching through distance education has many challenges, requiring educators' adeptness in utilizing e-learning platforms for both instructional delivery and assessment purposes. This study adopts a literature review methodology, drawing upon various previous studies relevant to this subject matter. The research findings reveal several online mathematical strategies and assessment techniques envisioned to adequately measures students' capacity to discern complex issues and employ critical thinking to resolve mathematical problems. The important role of the educator as a facilitator is underscored in crafting learning materials synchronized to the needs of students navigating the online platform. In this context, online mathematics instructional strategies are intricately intertwined with pedagogical dimensions and the appropriateness of utilized media and assessment modalities. Emphasizing interactive, creative, and innovative learning emerges as a critically important characteristic, particularly within the realm of online mathematics instruction.

Keywords: mathematics, learning, teaching, assessment, online

1. Introduction

As "Homo sapiens," humans are delineated as beings endowed with cognitive faculties and possessing a thirst for knowledge acquisition. Furthermore, humans inherently exhibit an innate curiosity toward the pursuit of novel information. This phenomenon is particularly intriguing, as it underscores the inherent educational proclivities of humans, thereby catalyzing a continuous learning journey aimed at harnessing their latent potential through diverse educational endeavors.

Learning, construed as a natural phenomenon, is characterized by a dynamic process entailing the transformation of behavior or potential behavior resultant from experiential encounters. The significance of education is a crucial aspect that supports every individual's life. Education entails a conscious and planned effort to establish an environment conducive to learning and the learning process. Through education, students actively develop their potential, acquiring religious-spiritual strength, self-control, personality, intelligence, noble morals, and the skills required by themselves, their communities, nations, and states (Yunita et al., 2022).

Naturally, every human being has experienced an educational process, both formally and informally, which can occur anytime and anywhere. Education is not only limited to gaining knowledge but is also useful for improving the quality and welfare of a person. Hopefully, with a good education, individuals will be able to develop their abilities and skills for a better future.

Formal basic education in Indonesia lasts 12 years through a structured educational path consisting of elementary school, junior high school, and senior high school. Generally, most students aspire to continue their education at the university level. In this aspect, universities are responsible for preparing professional graduates who can compete in the rapid global changes. This necessitates students to adapt and thrive in an ever-changing environment.

Based on the number of Indonesian students under the Ministry of Research, Technology, and Higher Education (*Kementerian Riset, Teknologi, dan Pendidikan Tinggi* - Kemenristekdikti) in 2018, which was the highest since 1997, the Central Bureau of Statistics (*Badan Pusat Statistik* - BPS) recorded in 2019 that the number of Indonesian students registered in 2018 was 7 million. Figure 1 comprises 4.5 million private university students (*Perguruan Tinggi Swasta* - PTS) and 2.5 million state university students (*Perguruan Tinggi Negeri* - PTN). The number of students in 2018 grew by 1.4% from the previous year's total of 6.9 million. The increasing number of students in tertiary institutions is influenced by the awareness of the importance of continuing their education to a higher level, which not only aims to improve skills and knowledge but also provides wider career opportunities.

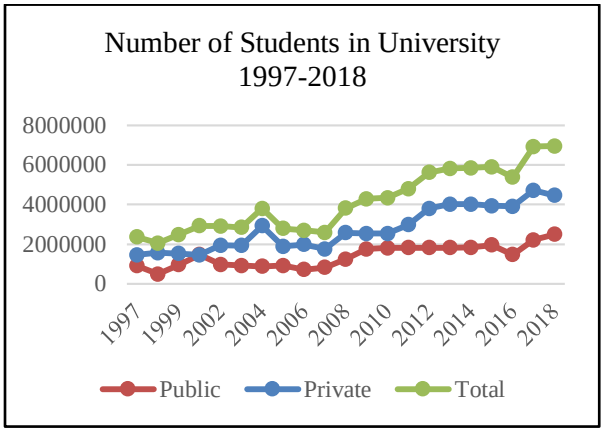

Figure 1. Number of Students in University 1997-2018 (BPS, 2018)

Currently, education based on Science, Technology, Engineering, and Mathematics (STEM) is an attractive choice for students in Indonesia because it equips them to prepare themselves to face increasing global competitiveness in scientific and technological innovation (Borowczak & Slater, 2015). STEM education is related to problem-solving, critical thinking, persistence, and collaboration to address the challenges of the 21st century (Estapa & Tank, 2017). Several interesting aspects encourage students to engage with STEM, such as learning methods that focus on real problems (Estapa & Tank, 2014), inquiry, hands-on, and open-ended activities developed through the engineering design process. Therefore, STEM encourages students to be creative by fostering various innovations (Cooper & Heaverlo, 2013) and breakthroughs (Bybee, 2013).

The mathematical approach in the STEM learning process is one of the tools (Doğan et al., 2018) for solving computational problems with a scientific approach. Based on its function as a language for science, engineering, and technology, mathematics is often referred to as the cornerstone of the STEM discipline (Maass et al., 2019). Problems involving mathematical models in STEM learning are used to apply mathematical theories in relevant applications in the STEM field. Ideally, mathematics should be more prominent and considered as a foundation for understanding concepts in other disciplines (Fitzallen, 2015). Mathematical representations are crucial for understanding real-life situations because they

enable the formulation and solution of real-world problems through mathematical modeling (Fried, 2022). Additionally, mathematical models require students to be able to represent, analyze, predict, or understand real-world situations (Bliss & Libertini, 2016) using estimates, assumptions, and strategies for solutions.

In mathematics, the average PISA test scores of Indonesian students fluctuate. The lowest average score was obtained in PISA 2003, which was 360. The highest average score was achieved in PISA 2006, with 391 points. In PISA 2018, Indonesian students scored an average of 379, (OECD, 2019). The low value of the PISA test in mathematics is caused by a lack of ability in mathematical literacy.

Mathematical literacy is defined as an individual's capacity to formulate, use, and interpret mathematical knowledge in a variety of contexts. This literacy includes mathematical logic and the use of mathematical concepts, procedures, facts, and tools to describe and predict phenomena. There are three basic elements that must be included in the mathematical modeling cycle (Dede, 2019), which students typically use in developing mathematical and logical frameworks (Anhalt et al., 2018) with ideas involving mathematical assumptions and approaches (Tezer, 2020). Based on the composition of the content and learning objectives of mathematics, it is expected to develop abilities such as mathematical communication, mathematical reasoning, mathematical problem-solving, mathematical connections, and mathematical representation (NCTM, 2000).

The important role of technology in supporting students' skills and abilities in mathematics is utilized to help students build models and solve problems with a mathematical approach using qualified mathematics software. Additionally, information and communication technology serve as important tools for learning and teaching mathematics. Traditional methods of learning mathematics have been replaced by methods that incorporate modern technology media. This shift is influenced by the changing paradigm of society in seeking and obtaining information, which demands very high speed. Students and lecturers can easily access technology via the internet to obtain references for mathematics learning materials from various sources.

Technology that supports learning mathematics with interactive methods will motivate students to learn more independently and help them explore various information related to mathematical models and methods applied in the real world. Utilizing technology-based learning modules that align with teaching practices has proven to be an effective approach for enhancing students' learning processes (Muhtadi et al., 2017). Additionally, technology also has the potential to increase mathematical understanding and can be used to facilitate learning discussions between students and lecturers. Today, telecommunications and internet technology are basic needs in the online learning process that help students adapt to mobile learning (m-learning) systems. It is easier for students and lecturers to conduct lecture activities remotely.

On the other hand, online learning methods are not easy and pose a challenge for students and lecturers who must quickly adapt to new learning patterns and methods. The challenges of online learning for mathematics are influenced by several factors. For example, there is limited space for interaction with lecturers and classmates, mathematical explanations may not be sufficiently understood, and there may be a lack of technological facilities and infrastructure at home.

Moreover, online learning also challenges lecturers to provide effective and efficient learning experiences. This method requires lecturers to adapt and develop teaching strategies to be more innovative, creative, and interactive through various media and platforms. This situation leads to a shift from traditional face-to-face learning in the classroom to home-based learning. During online learning, many students encounter difficulties with mathematics, which is considered a challenging subject due to its abstract, logical, systematic nature, and abundance of confusing symbols and formulas. Based on the previous background description, researchers want to know how to face challenges in teaching methods and the online mathematics learning assessment process.

This research addresses the specific challenges of online mathematics instruction and assessment, an area that has become increasingly relevant due to the rapid shift to online learning environments. Unlike previous studies that may focus broadly on e-learning, this research uniquely integrates pedagogical strategies with assessment techniques tailored specifically for mathematics, highlighting innovative and interactive methods that leverage technology effectively.

The findings from this study are critical for educators, policymakers, and curriculum developers. By identifying effective online teaching methods and assessment strategies, this

research aims to enhance mathematical literacy and problem-solving skills among students. This is particularly important in Indonesia, where improving PISA scores and overall mathematical competencies is a national priority. Additionally, the insights gained can help educators better support students in navigating the complexities of online learning, ensuring that they remain competitive in a global landscape increasingly driven by STEM fields.

Theoretical Framework

Learning

Learning is an activity that seeks to acquire knowledge and insight through interactions among students, educators, and learning resources in an educational setting. This process can be viewed as the evolution of students' ideas or as a conceptual shift over several hours (Niedderer et al., 2007). Another perspective suggests that learning is a multifaceted activity that defies complete explanation. Essentially, learning can be seen as a result of ongoing interactions between developmental aspects and life experiences. In a broader sense, teaching involves a deliberate effort by educators to guide students in their interactions with various learning materials, aiming for successful outcomes (Aprida & Dasopang, 2017). Beyond just gaining knowledge and skills, the goal of learning is also to shape students' character positively.

The learning journey should inspire students to pursue knowledge through diverse sources and educational media. It involves the interaction of students' cognitive systems (Psillos, 1999) (their ideas and conceptions (Petri & Niedderer, 2003) with the learning environment, as outlined in the "expressed idea" model. This process, known as the "evolution of students' ideas," (Givry, 2003) encompasses three types of evolution: the introduction of new ideas, expanding the scope of idea validity, and establishing connections between ideas to form a network.

In the learning theory framework, there are three main aspects: learning conditions, learning methods, and learning outcomes (Figure 2). Learning conditions consist of four components: student characteristics, which encompass behavior, interests, and talents; social and economic adjustment; and others. Additionally, within this aspect, there are characteristics of lessons that define the goals to be achieved and the obstacles present in the process of achieving these goals. Furthermore, the second aspect is learning methods, which comprise three components: organizing lesson materials, which involves the design of teaching materials integrated with delivery strategies to be utilized in the learning process.

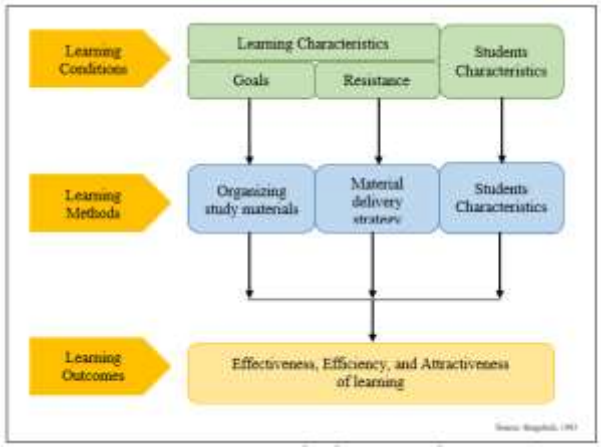

Figure 2. Learning Theory Framework (Reigeluth, 1983)

Online Learning

The transition from conventional learning methods to online learning represents an educational solution. Online learning (Rahmatia et al., 2020) utilizes internet networks, offering accessibility, connectivity, flexibility, and the ability to facilitate various types of learning interactions (Sadikin & Hamidah, 2020). Based on information and communication technology, online learning simplifies the learning process for students and lecturers, allowing them to engage anytime and anywhere. Several online-based teaching methods can streamline the process for lecturers to input lecture materials for an entire semester.

Generally, some of the media used to support the online learning process help students learn at their own pace, according to their convenience (Dhull & Arora, 2017). The selection of the types of online learning courses is also important in developing teaching strategies that will have an impact on the assessment process. Success in the learning and teaching process in online classes is a shared responsibility between lecturers and students. Several plans for mathematics online classes can be adapted from the basic steps, starting from determining aims and objectives that define the media technology that will be used (Mason, 2000).

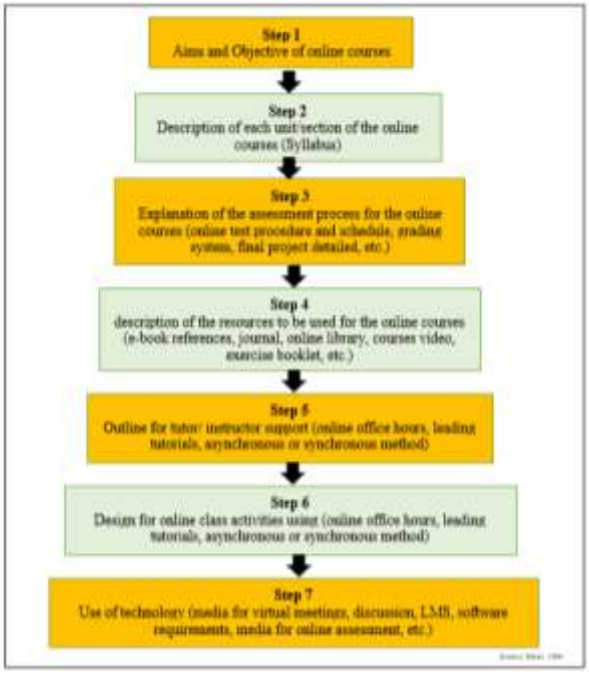

Figure 3. Plan for Online Mathematics Learning (Blum, 1996)

Online Course

The online course is a website-based learning process that is easily accessible via hardware using the internet network, where students can find class objectives, access lecture notes, and instructional materials, and take online exams (EC, 2014). Five components can support online courses (Tan, 2017), including content, hardware (devices used when conducting online learning such as computers, laptops, tablets, notebooks, cellphones, etc.), communication or interaction strategies, infrastructure in the form of internet networks, and supporting software used in learning. There are two types of online courses, as shown in table 1 (Nipper, 1989).In online learning, six golden rules (Huhtanen, 2019) can be used in creating online courses, including:

a. Make concise learning materials so that students can focus more on the provided information. Media in the form of online videos with a duration of 5-6 minutes is more effective for viewing (Hattie & Yates, 2013)
b. Organize content into modules by grouping various media thematically according to the course's timeline.
c. Enable interaction between lecturers and students through short quizzes, writing exercises, or discussions (Salmon, 2013).
d. Provide a channel for social interaction to facilitate communication between lecturers and students. This communication medium is used for discussion forums related to lecture material. Some of the media that can be used are Telegram, WhatsApp, or Facebook.
e. Conduct a pretest (Hattie & Yates, 2013) to help lecturers classify students based on their abilities and knowledge. Additionally, the pretest can help students understand the extent of their abilities regarding the topic to be studied.
f. Use continuous feedback and assessment. This formative feedback allows students to express their opinions regarding the course material. This constructive feedback is expected to increase effectiveness in the learning process. Additionally, feedback can serve as an assessment tool to measure students' abilities through weekly assignments. Other feedback can also be obtained from assessments in the form of peer assessments and repetitive essays.

Tabel 1. Types of Online Course (Kurt, 2018; Naidu & Oliver, 1999)

Partially Online Course	Fully Online Course
a. Integrate existing resource materials, both in print and non-print formats. b. Utilize a simple mailing list for several asynchronous discussions, where all lecture materials (lectures, reading references, discussion forums, assessments, etc.) are available on the Learning Management System (LMS) and can be accessed according to the lecture schedule. c. Offer more flexibility than the synchronous type, which has a fixed meeting schedule. Some commonly used partial online learning methods include blended learning, small private online courses (SPOC), flipped learning, and hybrid learning. d. Employ traditional classroom pedagogy and approaches, supported by online learning to deliver lecture material virtually. Class activities such as discussions, group work, and practicum	a. Most of its learning and teaching activities are carried out online. This course can be applied with both asynchronous and synchronous methods. b. Fully online courses can be conducted through synchronous discussions, where the lecturers and all students are online simultaneously. c. The lecturer will deliver course materials in real time using virtual meetings. This condition encourages students to be more active in online classes, facilitating their ability to ask questions, participate in online discussions, and take tests given by lecturers. d. Lecturers and students engage in virtual distance learning, eliminating direct interaction and physical meetings, allowing learning to take place from home. e. Utilizing the Learning Management System (LMS) application by transforming the

Partially Online Course	Fully Online Course
will adhere to a traditional classroom approach. In this scenario, online classes complement or replace lectures with virtual explanations of the material, enhancing the efficiency, effectiveness, activity, and productivity of learning activities during class.	traditional classroom learning process into a digital platform.

Online Teaching

Online teaching entails educating students via digital platforms utilizing the internet, which encompasses individual and group virtual meetings, video conferencing, and webinars. Effective online teaching is heavily influenced by various factors, including the provision of quality content, utilization of suitable learning resources, incorporation of interactive learning activities, and adoption of valid assessment techniques tailored to online learning environments. There are several teaching principles for online learning (Stephenson, 2018).

a. Foster student engagement.
b. Promote student collaboration.
c. Facilitate active participation in learning.
d. Provide timely feedback.
e. Stress the importance of allocating sufficient time to tasks.
f. Articulate high academic standards.
g. Acknowledge and value diverse talents and learning modalities.
h. Attend to individual variances.
i. Cultivate student motivation.
j. Mitigate the risk of overwhelming students with excessive information.
k. Establish a tangible real-world context.
l. Facilitate social interactions among students.
m. Offer experiential learning opportunities.
n. Encourage student introspection and contemplation.

The pivotal role of the Learning Management System (LMS) or Course Management System (CMS) in online instruction (Stephenson, 2018) empowers educators to disseminate lecture materials seamlessly across various locations and time zones. Leveraging the appropriate LMS can significantly enhance the efficacy of remote learning. Students can access lecture materials, engage in mathematical problem-solving exercises, and participate in discussions via chat forums within the LMS. The guiding principles (Stern, 2020; Zsohar & Smith, 2008) applicable to online instruction serve as essential drivers for the triumph of online mathematics education.

Online Assessment

Online assessment constitutes a fundamental component of online pedagogy. Its purpose is to gather data and ascertain students' comprehension of the instructional material. The insights gleaned from assessments serve as feedback loops, fostering enhancements not only in students' learning outcomes but also in pedagogical strategies for educators.

Figure 4. Key Ingredients for Online Teaching

The essence of assessment initiatives in online education is to abstract the learning journey, discerning elemental constituents such as:

a. The instructional content delivered by educators.
b. The pedagogical dynamics inherent in classroom interactions.
c. The evaluative mechanisms employed to gauge student comprehension.
d. The dissemination of performance feedback from teachers to students. This framework harmonizes seamlessly with conventional educational modalities.

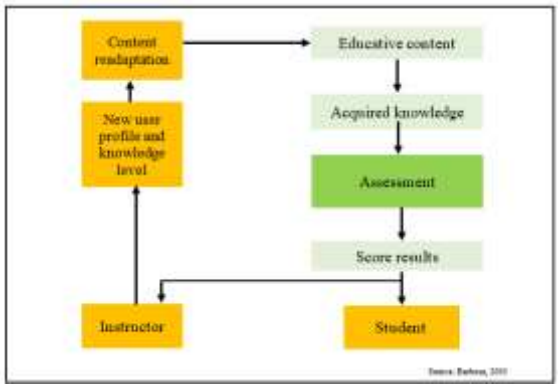

Figure 5. Assessment in E-Learning Process (Barbosa & Garcia, 2005)

Figure 5 demonstrates the significance of the assessment process within the online learning flow. Evaluations and tests serve as assessments not only for students but also for lecturers. While students receive scores for their learning, the assessment for lecturers aims to offer support and feedback during the teaching process. The presence of a circular

conceptualization of the assessment process aids system adaptation by establishing new user knowledge levels, evaluating, and profiling new learning, assigning user values accordingly, and facilitating user content re-adaptation.

2. Method

This research employs a library research methodology, involving the review of scientific references and the collection of data from literature using secondary data types. The necessary data for the research were obtained from library sources or documents, which were then compiled, analyzed, and synthesized to conclude the study of literature. This method examines and establishes links between the effectiveness of teaching and assessment in online mathematics learning at universities.

Scientific References and Criteria

The scientific references used in this research span publications from the last two decades, ensuring that the analysis includes contemporary insights and developments in the field of online mathematics education. These references include peer-reviewed research journals, articles, books, and reports from reputable sources such as Kemenristekdikti, BPS, and the PISA.

The criteria for selecting these references include their indexing in recognized databases such as Scopus, Sinta, and other reputable academic databases. This ensures that the data and findings referenced are credible, reliable, and relevant to the current educational landscape.

Analysis Method

The analysis method employed in this research involves a systematic review of the literature, as illustrated in Figure 6.

Figure 6. Analysis Method

The process begins with the identification phase, which involves gathering a comprehensive list of publications related to online mathematics education, teaching strategies, and assessment methods. Following this, the screening phase filters the gathered literature based on relevance, recency (publications from the last 20 years), and credibility (indexed in Scopus, Sinta, etc.). The extraction phase compiles key information from the selected publications, focusing on findings related to effective teaching and assessment strategies in online mathematics learning. Finally, the synthesis phase involves analyzing and synthesizing the extracted data to identify common themes, trends, and gaps in the existing research. This synthesis helps in forming a comprehensive understanding of effective practices in online mathematics education. The systematic review process ensures a thorough examination of the available literature, providing a robust foundation for the study's conclusions.

Data Sources

The data supporting this analysis comprise a literature review derived from secondary data sources such as research journals, government reports, and international assessments. Research journals include articles indexed in databases like Scopus and Sinta, which provide peer-reviewed and high-quality research findings. Government reports, particularly from Kemenristekdikti and BPS, offer official statistics and insights into national educational policies and demographics. Additionally, international assessments, such as reports from PISA, provide benchmarking data on students' mathematical literacy and performance internationally. Supplementary data were also sourced from other research journals and books available on the internet. This comprehensive approach to data collection ensures a diverse and well-rounded perspective on the challenges and opportunities in online mathematics education.

3. Results and Discussion

3.1. Strategies for Online Teaching in Mathematics

Dimensions of Online Mathematics Teaching

In this research, researchers identified the principal components of online mathematics learning strategies, assessed through the lenses of attitudes and mathematical advancement (Belmonte et al., 2019; Moreno-Guerrero et al., 2020), which can serve as benchmarks for various online learning methodologies, presented in table 2.

Media for Online Mathematics Learning

The media employed in online mathematics instruction is anticipated to afford lecturers and students easy accessibility, flexibility, robust functionalities, and clear intelligibility. Moreover, the frequency of media utilization constitutes a pivotal factor in determining the selection of media, encompassing:

a. Does the media facilitate enhanced interaction between lecturers and students and among peers within the framework of online mathematics courses?
b. Is the media capable of fostering productive collaboration?
c. Does the media facilitate seamless collaboration?
d. Can the media aid in efficiently disseminating course materials to students?
e. Can the media enhance students' proficiency in mastering course content?
f. Does the media offer comprehensive features catering to students (learning, exercises, and assessments) and lecturers (teaching and assessments)?

The proper selection of online learning media is anticipated to proficiently and engagingly present educational material. These media platforms are utilized to incentivize active engagement between students and lecturers during lectures, fostering discourse and interactive question-and-answer sessions.

a. References for online mathematics lecture
   1) YouTube (Various channels offer free online math lectures)
   2) Brilliant *(https://brilliant.org/)*
   3) Khan Academy *(https://www.khanacademy.org/)*
   4) Coursera *(https://www.coursera.org/)*
   5) edX *(https://www.edx.org/)*
   6) MIT OpenCourseWare *(https://ocw.mit.edu/)*
   7) Udemy *(https://www.udemy.com/)*
   8) OpenStax *(https://openstax.org/)*
   9) Saylor Academy *(https://learn.saylor.org/)*
   10) Harvard Online Learning *(https://online-learning.harvard.edu/)*
b. Discussion forum (online chat groups, social media, and texting/instant messages for mathematics)
   1) Mathematics Discord Server
   2) WhatsApp Group for Math Learning
   3) Telegram Math Study Group
   4) Facebook Math Discussion Group
   5) Reddit Math Community Chat
   6) Slack Channel for Mathematics
   7) WeChat Math Learning Group
   8) Line Math Study Chat
   9) Viber Math Discussion Group
   10) Instagram DM Math Study Circle
c. Online collaboration tools for mathematics
   1) *Desmos* (graphing calculator tool for real-time collaboration)
   2) GeoGebra (graphing tools for geometry, algebra, and calculus)
   3) *Mathigon* (interactive textbooks, puzzles, and simulations for mathematics)
   4) *Mathspace* (online platform with interactive math problems and solutions)
   5) *Scratch* (math simulations and games collaboratively)
   6) *Zoom, Google meet, Microsoft Teams* (video conferencing)
   7) *Google Docs/Google Sheets* (real-time collaboration on documents and spreadsheets)
   8) *Padlet, Jam board* (digital canvas for collaborate notes and images)
d. Online platform for mathematics' assessment
   1) *Quizizz* (customizable math quizzes and real-time feedback)
   2) *Kahoot!* (interactive math quizzes)
   3) *Formative* (create math quizzes with various question types and instant feedback)
   4) *Edulastic* (platform for creating math assessments)
   5) *Socrative* (create math quizzes and assessments)
   6) *Quizlet* (creating flashcards, quizzes, and study games for math topics)
   7) *GoFormative* (create math quizzes with drawing and graphing tools)
   8) *Wizer.me (*platform for creating digital worksheets and quizzes)
   9) *Google Forms* (create math quizzes and assessments)
   10) *ClassMarker* (platform for creating online math quizzes)

Tabel 2. Dimensions of Online Mathematics Teaching

No.	Dimension	Goals	Strategy
1.	Motivation	Assess the degree of motivation attained by students throughout the progression of the online mathematics learning paradigm.	Offer prompt feedback on digital math assignments, fostering an avenue for robust discourse on course material between lecturers and students. Effective communication serves as a catalyst for inspiring and emboldening students to engage actively in autonomous online mathematical learning endeavors.

No.	Dimension	Goals	Strategy
		Foster students' dedication and concentration towards learning, imbuing them with a sense of assurance that their lecturers empathize with the challenges posed by topics covered in online classes.	Address inquiries from students grappling with the subject matter, whether during scheduled online sessions or outside designated class hours, as per the instructor's timetable. Lecturers can establish platforms for Q&A sessions, utilizing either media group chats or the Learning Management System (LMS).
		Demonstrates lecturer engagement in online courses transcends live class sessions to encompass non-live periods.	Create weekly course materials in the form of presentations, documents, or videos to send to the LMS.
		Stimulate students' enthusiasm for learning and incentivize academic excellence.	Incentivize high academic performance by rewarding students who excel in exams. For instance, consider awarding additional points towards the final course grade as a form of recognition.
2.	Collaboration	Assessing students' collaborative capabilities in completing assignments and projects.	Formulating collaborative student projects for online courses, fostering group work during virtual classes. These projects may take the form of papers to be presented and deliberated upon during online sessions.
		Facilitating effective communication among students to facilitate collaboration on joint projects.	Assigning students the responsibility of selecting a team leader accountable for the project at hand. Moreover, ensuring that each student actively contributes to the collaborative endeavor.
3.	Participation	Assess the degree of engagement and rapport among students and between students and lecturers.	During online lectures, instructors employ random selection of students to respond to questions and encourage peer-to-peer interaction by prompting other students to comment on their classmates' responses.
		Monitor students' attendance and participation in online lecture sessions. Evaluation of student engagement will be conducted regularly, enabling continual improvement.	Utilize random student name-calling during online lectures to ensure attendance. Additionally, students can complete an online attendance sheet, which may not be mandatory at the outset but can be completed as per the instructor's discretion, possibly midway or toward the end of the session. Lecturers can designate a brief window for attendance completion, such as 5-10 minutes.
4.	Resolution	Assessing students' capacity to deliver responses based on questions posed by the lecturer. Here, students are expected to engage in critical thinking to address mathematical problems rooted in theories covered in class.	Incorporating case studies relevant to the practical application of mathematics in addressing real-world challenges. For instance, instructors may task students with a final project centered on analyzing stock trend developments in Indonesia using official data and mathematical software.
		Refining students' ability to think innovatively by fostering interdisciplinary collaboration. Students from diverse academic backgrounds can collaborate on projects, with those versed in mathematics contributing insights to draw conclusions and make decisions based on mathematical analyses.	Presenting a culminating project exploring the application of mathematics in various scientific domains. For instance, conducting predictive analysis on bacterial growth in food items. This endeavor serves to facilitate collaborative discussions among students, including those enrolled in programs like Food Business Technology.
5.	Class time	Assessing the time allocation dedicated by students to online mathematics learning. Additionally, a well-defined learning plan aids both students and lecturers in time management, particularly in readiness for the online learning process.	Monitoring student engagement with the Learning Management System (LMS), including tracking hours spent accessing course materials, assessing the last time of access, and identifying students who have yet to engage with the course material.

No.	Dimension	Goals	Strategy
		Students are afforded dedicated time for online mathematics learning over the course of a semester, as delineated in the initial lesson plan. This structured approach enables students to delve into specific topics outlined in the syllabus, fostering focused and targeted learning. Moreover, it empowers students to devise individualized study plans based on their priority scale.	At the outset of the online class, instructors furnish comprehensive explanations of the semester-long lesson plans. To enhance accessibility, instructors can upload the syllabus onto the LMS, categorizing each course according to difficulty level. Providing detailed insights into examination procedures, project requirements, and assessment criteria at the onset of the course is pivotal in equipping students with a robust study framework.
6.	Content	Assisting students in comprehending the content and objectives of their mathematics courses for the duration of one semester. At the outset of the class, instructors provide a succinct overview of the course, outlining the requisite preparations, students' responsibilities, and rights while participating in online mathematics classes.	Lecturers furnish comprehensive information about the course, encompassing: • Course description • Course objectives • Detailed session-by-session topics • Reference materials (including textbooks, e-textbooks, articles, journals, etc.) • Online learning modalities (both synchronous and asynchronous) • Assessment criteria (grading criteria for exams, homework, projects, quizzes, etc.) • Discussion platforms (whether live or non-live sessions, students are encouraged to establish class communication groups using chat features to facilitate discourse, in addition to utilizing discussion forums within the Learning Management System) • Technical prerequisites (mathematical software tools to be utilized during the learning process, such as Mathlab, Python, R, SPSS, etc.) • Scientific datasets earmarked for mathematical analysis (e.g., weather data, stock market data, sales figures, economic indicators, etc., which may be shared at the commencement of the lecture).
7.	Concept	Ensuring students attain a robust grasp of mathematical concepts entails the ability to comprehend and master subject matter by assimilating knowledge and articulating it in accessible formats. Mathematics embodies interconnected and mutually reinforcing concepts, necessitating a foundational understanding of prerequisite concepts before delving into advanced material.	Lecturers meticulously outline the theories slated for study and delineate strategies for their real-world application, including: • Theoretical exposition: Lecturers elucidate the theoretical underpinnings of the subject matter. Formats for theoretical presentation may encompass documents (PDFs, PowerPoint presentations) and video lectures (recorded lectures offering concise theoretical explanations, instructional videos sourced from YouTube or e-textbooks, etc.). • Practical application: Practicing theory involves activities that showcase its real-world applicability. These activities may include data analysis using mathematical software, data visualization techniques, mathematical modeling for predictive purposes, and the like.
8.	Ratings	Assessing the teaching and learning process involving lecturers and students is paramount for enhancing mathematics instruction, particularly in the online domain with its inherent constraints. Such evaluations serve as invaluable tools for gauging lecturer qualifications and instructional	Several methodologies through which lecturers and students can evaluate the teaching and learning process in online classes include: • Lecturer self-assessment: Lecturers can evaluate their teaching effectiveness by reviewing video recordings of their lectures to gauge the appropriateness, accuracy, and alignment with learning objectives. Seeking input from

No.	Dimension	Goals	Strategy
		efficacy while also measuring students' comprehension of course material over the duration of one semester.	colleagues can also provide valuable insights into teaching methodologies. • Student feedback: Students are invited to provide teaching evaluations both midway through the semester and at its conclusion. These evaluations aim to enable lecturers to enhance the learning experience by refining the quality of instruction. Typically, this feedback is solicited via anonymous survey forms, mandatory for all students enrolled in the course.

3.2. Strategies for Online Assessment in Mathematics

Assessment Methods in Online Mathematics Learning

Online discussion

Assessment activities are conducted through asynchronous discussions employing discussion boards, as well as synchronous discussions held during live classes, and may utilize discussion forums presented as chat rooms, fostering interaction between students and lecturers. The media employed for such purposes include discussion forums, video conferencing platforms, and chat rooms integrated within a learning management system (LMS).

Assignment for mathematics

Students are tasked with composing papers and generating research reports, case study responses, online assignments, mathematical proofs, problem sets, and concise essays. The format for report assessment can be introduced during the initial session of the online class, aiding students in initiating the development of topics for their research or projects to be undertaken throughout the course. This format serves to evaluate students' problem-solving abilities and their comprehension of mathematical concepts and principles. To assess students, instructors may consider employing formative assessments such as Wolfram Alpha, GeoGebra, and Desmos, alongside self-assessment practices. These methods foster metacognitive awareness and encourage students to take ownership of their mathematical learning journey. Additionally, instructors can utilize online proctored exams facilitated by remote monitoring software, integrating various question types to simulate a traditional exam environment.

Pretest, quizzes, and final exam

The assessment comprises multiple-choice questions, short responses, essays, true or false queries, drag-and-drop exercises, and other question formats. Before students embark on assignments or examinations, the lecturer will elucidate the assessment particulars, including the weight of each question, by elucidating the assessment rubric. This practice aims to mitigate the potential for subjective and biased assessments by lecturers. At the commencement of the course, the lecturer may administer a "Welcome Quiz" to gauge students' foundational knowledge. Additionally, various online platforms are available for testing and evaluating students' comprehension of mathematical concepts. Lecturers can construct questions encompassing multiple-choice, fill-in-the-blank, true or false, short-answer, and essay formats. After class sessions, lecturers may administer mini quizzes to gauge students' comprehension levels.

Online interactive activities

To enhance classroom engagement, instructors can incorporate interactive activities for students. For instance, they may select a math topic and prompt students to provide insights on its real-life applications. Additionally, to infuse a competitive atmosphere into the class, instructors can introduce educational games. These strategies not only facilitate comprehension of materials but also encourage exploration of mathematical concepts.

Fieldwork

Assessment may be conducted via a written assignment methodology, necessitating students to gather field data and compose an analytical report. For instance, a practicum conducted in a computer laboratory entails students undertaking programming-related coursework employing specific software applications.

Report and project presentation

Through the delivery of meticulously researched projects, students can be adeptly guided in cultivating and refining an array of essential skills, encompassing communication, collaboration, team leadership, problem-solving,

and discipline. Instructors may conduct evaluations utilizing a comprehensive rubric, comprising assessments pertinent to the substance of presentations, reports, as well as the soft skill components intertwined with the project. Areas ripe for enhancement among students entail crafting visually captivating presentations, fostering effective audience engagement, articulating a coherent and methodical delivery, incorporating pertinent content, and vigilantly managing time allocation throughout the presentation.

Journal paper

Preparing a journal paper serves as a method for both training and showcasing the author's theoretical comprehension of the subject matter. This is evidenced by students' adept analysis of a given problem and their subsequent proposal of viable solutions. Moreover, scholarly papers allow lecturers to discern the writer's capacity to apply procedural, principled, or theoretical frameworks to specific issues. In this context, students are cultivated to adeptly craft scientifically rigorous works, ensuring readability and engagement for their audience. Through the meticulous process of paper preparation, students not only accrue invaluable experience but also broaden their intellectual horizons, enriching their grasp of both theoretical constructs and practical applications. This, undoubtedly, contributes significantly to the cultivation of holistic and nuanced thinking.

3.3. Discussion

The results presented above highlight a wide array of strategies and tools available for online teaching in mathematics. However, it's essential to interpret these findings in association with previous relevant research to understand their implications fully.

Previous studies (Belmonte et al., 2019; Moreno-Guerrero et al., 2020) have emphasized the significance of attitudes and mathematical advancement in shaping effective online mathematics teaching strategies. These studies provide a theoretical framework for understanding the components identified in this research and their potential impact on student learning outcomes.

The diverse selection of media and tools outlined in this study reflects the evolving landscape of online mathematics education. By drawing on platforms such as YouTube, Coursera, and Zoom, educators can leverage multimedia resources and interactive technologies to create engaging learning experiences. Moreover, the inclusion of collaborative tools like Desmos and discussion forums underscores the importance of fostering student collaboration and interaction in online mathematics courses.

Overall, the results suggest that a multifaceted approach to online mathematics teaching, integrating a variety of media and interactive tools, can enhance student engagement, facilitate collaborative learning, and improve learning outcomes. However, further research is needed to explore the effectiveness of specific strategies and tools in different educational contexts and student populations.

4. Conclusion

In conclusion, this study has explored various strategies and tools for online teaching in mathematics, aiming to address the challenges posed by the transition to online education. Through an analysis of the dimensions of online mathematics teaching and the media and tools available for online learning, we have identified key components essential for successful online mathematics education.

The cornerstone of successful online mathematics education lies in the lecturer's adeptness at crafting learning materials aligned with educational objectives and ensuring their comprehensibility in the online milieu. The development of updated, pertinent, and contextually applicable materials is paramount for fostering students' knowledge acquisition and insights. Moreover, providing precise pedagogical instructions facilitates students' grasp of mathematical concepts, particularly in navigating problems rooted in mathematical theory.

Integral to seamless integration is the lecturer's duty to oversee the learning platform's management, ensuring its perpetual relevance through the dissemination of materials, assignments, exams, and the facilitation of online discussion forums. These virtual dialogues, fostering student-lecturer interaction, aim to stimulate collaborative learning endeavors and cultivate a conducive atmosphere for project-based collaboration.

Furthermore, lecturers are tasked with providing constructive feedback on both assignments and exams, fostering an open communication conduit via email, chat platforms, or other online mediums.

The aspiration is that online mathematics education will facilitate students' comprehension

of the learning material, courtesy of lucid instructions imparted by instructors, which can be disseminated through diverse platforms and methodologies. The envisaged outcome is that through this mode of education, students can conveniently avail themselves of educational resources and enjoy greater autonomy throughout the learning journey.

In conclusion, this study underscores the importance of effective online teaching strategies and tools in facilitating student learning in mathematics. It confirms the problem addressed in the results and discussion section regarding the need for adeptness in online teaching methods and the utilization of appropriate media and tools to enhance student engagement and comprehension. Further research and implementation of these strategies are crucial for the continual improvement of online mathematics education.

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