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The Relevance of Digital Practice in Indonesian Mathematics Teaching and Learning to Improve Learning Outcomes: Review of Empirical Evidence

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Abstract---This paper discusses literature for mathematics innovation in improving mathematics achievement outcomes in the era of digital. Efforts to improve student learning outcomes are closely related to teaching systems and management, including best practices of technological innovation in teaching, such as Mathematics at both the school and college level. We have compiled the relevant literature and reviewed it in search of evidence published in international scientific journals passionate about improving the quality of teaching through curriculum development with the integrity of digital innovation. This research is based on secondary data, and we process it with a phenomenological critical analysis approach, which begins with data preparation and then data organization. Scan transcripts, collect notes, and conclude. Next, explore data, create scratch code, review and revise all related themes. Finally, they presented these themes in cohesive passion writing. Considering the available data, it can be concluded that our findings from most of the studies we reviewed revealed that digital or multimedia-based teaching in the teaching of Mathematics programs was able to improve student learning outcomes. Therefore, this research will add to the treasures of teaching Mathematics in Indonesia towards the success of the millennial education, which is still suffering from a pandemic.

Keywords---digital innovation, digital practice, learning outcomes, mathematics, teaching mathematics, technological innovation

Introduction

It is indisputable when the planet earth enters an era of progress, as evidenced by technology in digital-based communication and information devices, also called the digital era (Choi et al., 2020; Taylor, 2016). The digital era can be interpreted as a situation in which digital-based communication and information devices increasingly dominate various human life activities in all sectors, including the education sector. This occurs as DaCosta et al. (2013); Hershatter & Epstein (2010); Henstra & McGowan (2016); Phillips & Trainor (2014), said that millennials are human digital propensity and age because of the inevitable human tendency towards information and communication technology in this information age, which directly connects with the increase in the stages of computer literacy, information literacy, and the level of progress, especially literacy in the world of education. In principle, integrating digital technology in mathematics learning is relevant to education demands in the modern era.

Because the advice that digital technology innovation is not proven in teaching and learning does not reduce the conceptual understanding and application of Mathematics itself, in other words, innovating technology in education does not replace the role of teachers and students' intuition in mathematics (Albeshree et al., 2020).

On the other hand, as Pettersson (2021), noted digitalization and education must be understood as a change in school to improve learning theory and the practice for learning concepts supported by technology. Therefore, digitalization can improve students' understanding of mathematical theory and practice, thereby facilitating students' understanding of mathematics. In contrast, the technology aims to enhance conceptual understanding and develop mathematical application abilities (Akca et al., 2007; Vanbecelaere et al., 2020).

Because technological advancement is a process of progress in communication contexts, technology in the field of information in education is also very helpful for us in many ways. For example, in terms of accelerating education, using technology also does not require expensive educational needs. Technology offers many advantages at relatively affordable costs for society's middle class to get added value from a product to be useful in both work and education matters. Putrawangsa & Hasanah (2018), as teaching experts in Mathematics, technology is useful for business activities, but technology can also improve student learning outcomes in mathematics studies (Putra et al., 2020; Sang et al., 2020; Maryanti et al., 2020). Likewise, technology can add to learning mathematics in an unlimited number of age groups from elementary to university. They also added that technology in digital form could also affect learning outcomes, so that how to teach mathematics should be introduced as little as possible at the primary school level in Indonesia. However, when reading Assaf (2018), mind that learning mathematics does not only have to be with technology, but mathematics is closely related to the process of teacher dedication to students and non-technological learning resources, let alone digital.

Various studies published along with the emergence of digital technology, around the 2000s, a growing number of studies with the theme of meta-analyzes are interested in examining how the adoption of digital-based technology can accelerate mathematics and other science education programs in both secondary and undergraduate schools, for example, by comparing student learning outcomes with the old method with methods using digital technology. Hillmayr et al. (2020), note that the ease of digital technology tools in accelerating learning in mathematics at the school level should be of concern to parties for digital effectiveness, which is proven to improve learning outcomes (Becker et al., 2020; Sudarmaji & Mulyana, 2020; Sandoval, 2020). Overall, it can be said that the use of digital technology has a clear impact on student learning outcomes. Therefore, attention to various kinds of studies and educators' preparation on properly targeting digital applications and tools can be pursued by modernizing overall mathematics learning through intelligent machine teaching and digital tools in practical mathematics teaching. Every existing digital tool will be more useful than the traditional system in schools in Indonesia today.

The views of Healy (2015); Kynigos (2015), challenging the role of mathematics teachers in the millennial era, which is full of digital tools, should be new hope for the world of mathematics teaching. Because every new study result from professionals will certainly bring enlightenment on how teaching mathematics is viewed from a technological perspective. The study shows that many hopes from technology can be taken to succeed in learning mathematics in this digital era. This is necessary for someone to directly lead to face the work of merging in order to update the content of teaching and daily tasks for the development of interest and motivation of teachers and students towards these resources, to improve the teaching and learning process, especially mathematics (Mahmud, 2019; Mahmud et al., 2020). For this reason, policymakers in the world of mathematics teaching can apply by finding learning resources very quickly through digital online-based technology so that they can realize various digital technology-based teaching models so that in the end, this good goal can bring change. For example, the study of Sulistyarningsih et al. (2019), states that teachers can take teaching material uploaded on the internet will provide a new model of teaching materials for school program development so that students can take advantage of the facilities available while they get sound character reinforcement directly from the student's classroom teachers are impossible to find through digital technology (Holmström, 2018; Chiu & Churchill, 2015).

Challenges of teaching mathematics in the digital age

In the digital revolution era, mathematics learning demands are getting heavier if teachers are still teaching the old way, namely the teacher learning center system. However, if the teachers have prepared themselves with a student-centered teaching system's skills, they will find it even more convenient to support various free technological applications available on online match learning resources. According to Hoyles (2016), engaging educators in mathematics in the digital age supports them from a typical problem in their work. This era provides opportunities for both parties, students, and teachers to learn cooperatively together as it has been applied in many school places that have already implemented it. In order to do so, so that teachers do not feel very heavy with typical teaching in

the digital era, teachers must be able to carry out learning by developing students' abilities by exploring their teaching skills from information sources such as websites as a vehicle for teachers to learn throughout their lives learning.

Likewise, as [Drijvers \(2015\)](#), researched, the way for mathematics teachers is that digital technology is so useful in mathematics class, and he keeps asking why it works. The answer is teachers can improve their skills by using digital technology infrastructure and virtual learning tools to provide flexibility for students to find unlimited quality learning resources, record data, analyze data, and compile reports and make presentations. Another way can also emphasize hands-on learning by distributing learning materials in the form of copies of necessary materials; with this method, students learn the theoretical aspects of knowledge at home and practice in a class by the teacher. Other methods include developing habits and independent learning abilities while providing more free learning time for learning in schools for competency development. They can develop soft-skills, critical thinking, creativity, and problem-solving for active teachers, especially authentic and non-routine problem-solving. There are also collaborative learning methods and social interaction as the primary approach used in competency development to introduce a culture of teamwork ([Van den Boom et al., 2007](#); [Aziz et al., 2012](#)).

So that mathematics teacher can carry out their duties properly so that students can achieve their learning success, they must have the ability and competence in mathematics content, the latest teaching methods, full of initiative, creative, dynamic. Moreover, innovative and, most importantly, currently mastering sufficient technological digital literacy skills. In order for teachers to be more effective, they must know what students need. So, mathematics must have sufficient understanding, starting from mastering the concept and applying various methods and approaches of transferring teaching materials. Teachers must also be good at the procedural skills and learning practices that students most need to face each exam with satisfactory learning outcomes. According to [Albeshree et al., \(2020\)](#) the methods commonly used by mathematics teachers are hands-on distribution, picture guides, methods of giving students opportunities to get different content, asking students to want to explain ideas, storytelling methods. There is a relationship with the outside world, demo methods, and telling concepts and new formulas and methods allow students to continue practicing even on their own while playing ([Tambychik & Meerah, 2010](#); [Rousselle & Noël, 2007](#)).

Mathematical teachers are not only challenged by teaching methods; they are also challenged by teaching strategies so that their students can effectively master learning outcomes. So, talking about teaching strategies, many strategies have been proven effective in an educational climate characterized by technological applications. According to [Walshaw \(2012\)](#), the teacher's understanding of mathematics teaching strategies is an important matter so that effective teaching can be achieved ([Ramnarain & Hlatswayo, 2018](#); [Hanson-Smith, 2016](#); [Assunção Flores & Gago, 2020](#)). Walshaw gives examples, for example, strategies to activate the potential for visualization to help students understand how their school is seen in the real world. Other lessons include cooperative learning strategies based on question and answer, strategy differentiation, and strategies to rely on digital technology in teaching; another community learning management strategy is useful. Moreover, strategies to improve the professionalism of mathematics teachers.

Improving learning outcomes

The most difficult challenge for every teacher, including mathematics teachers, is when faced with the teacher's efforts to achieve learning goals following the curriculum's demands. When asked how students' mathematics learning outcomes can be achieved, there are some simple strategies and tips, although sometimes they are difficult to apply. According to [Lin & Chen \(2017\)](#), a useful study through digital applications can make students more motivated, for example, teachers' ability to rearrange their teaching strategies. The two teaching and learning strategies and methods must be reorganized frequently so that teachers and students can improve their learning outcomes and continue to feel academically smooth. Other strategies include assessing student learning processes and regular class study studies and actively studying teaching actions with an inverted process model. Actively integrating technology in the classroom into one practical best, and there are advantages that the class is not monotonous but dynamic. That, among other things, can be applied if the teachers understand that their students want to get better mathematics learning outcomes ([Barana & Marchisio, 2016](#); [Kilicman et al., 2010](#)).

There is an understanding of what the results of learning in mathematics are. In general, as [Nasution & Surya \(2017\)](#), said learning mathematics results are the same as other subjects ([Hashim, 2018](#); [Sudarmaji & Mulyana, 2020](#); [Parpala & Iacob, 2017](#)). This is the acquisition of knowledge, skills, experience, and generally referred to as student learning outcomes competencies in mathematics programs and collections in final grades after the learning program is complete. Values are often described in terms of numbers or qualities. Writing learning outcomes in the certificate report will help students how the knowledge and skills of all the materials taught will be used as evaluation material

for students before entering the next level. Teachers and schools can rearrange the right programs and strategies to prepare teaching in the next term. The choice of teaching methods for mathematics materials must be managed again to achieve different results and grades quickly. The most important thing is that students have the enthusiasm to continue with a more progressive academic career. Of course, learning outcomes are beneficial for evaluating past learning, determining learning strategies right for students' real conditions. Because now students are in the digital learning era, digital tools will be the right choice. Finally, through the evaluation of learning outcomes, students will feel confident for those with good results, and vice versa, students will be able to improve learning methods if the learning outcomes are not yet high. Through information on learning outcomes, students will see future traces of learning in their world. Likewise, students are confident and involved in the world of Bella more productively in mathematics.

Concerning preparing mathematics with technology guidance [Jupri \(2018\)](#), study indicates that the role of technology in Mathematics education with digital technology Mathematics strategies will be more realistic. Efforts to improve learning outcomes in mathematics programs through digitalization cannot be separated from curriculum guidelines, which are official government documents. The curriculum clearly states that Information and Communication Technology content must be integrated into every subject, including mathematics. So are teachers and students. It is hoped that they will have good skills to take advantage of existing digital technology both in learning and real life. We researchers need to learn innovative ways of learning to improve students' competence in mathematics that are integrated with digital devices. Mathematics learning is tied to numbers or numbers, so that digital technology is a unified whole, so it is impossible to succeed if it is separated in learning. This is useful for supporting mathematics learning that may not exist in other fields of the subject matter. One of them is GeoGebra and algorithms ([Mahayukti et al., 2017](#); [Suarsana et al., 2018](#)).

For this reason, the author will conduct innovative mathematical research digital technology-aided or best practical teaching mathematics using digital technology in the 21st century teaches the digital age. Based on the evaluation, mathematics learning using best practice models in many countries has been done. The average result turns out to be very interesting when presented with the help of technology. The author is interested in understanding the implementation of mathematics learning combined with best practice models. The review of mathematics learning can bring new ideas in the context of Indonesian schools so that later it will provide opportunities for students to improve their skills 21st-century skills.

Method

This study's main objective was to find a meeting point of relevance to the use of digital technology by teachers in teaching Mathematics in improving learning outcomes in the era of modern technology. To answer this question, we chose a descriptive qualitative research design by reviewing the many publications that examine the effectiveness and technological innovation to improve student learning outcomes in mathematics in Indonesian schools. The first step we take is to collect relevant data and information. Next, we prepare and arrange the data. Then we started reviewing notes related to the theme. Before the document is ready, attempt to gather notes and other material for review. Then the initial code activity and coding results, and finally, we revise if the data we review is not relevant to the theme study questions. We will state these data as findings until we find validity and reliability data as suggested by [Glesne \(2015\)](#); [Sgier \(2012\)](#), in their qualitative data analysis study. Because this review relies on data, we get all the data with online data from online searches and Google scholars and are assisted by the Grammarly Premium writing editing application to display data and write better.

Result

A study of teaching mathematics involving digital technology has been carried out by [Mailizar & Fan \(2020\)](#), to discuss mathematics curriculum at the secondary school level in Indonesia. They advocate applying technology to mathematics classroom teaching and learning that examines teacher teaching practices through digital technology integration. The findings were from 341 maths class teachers in 93 schools. They found that most of approximately 80% of mathematics teachers did not apply digital technology constructively, so that the learning outcomes in each school studied had not shown promising learning outcomes.

The same evidence is from [Abidin et al. \(2017\)](#), who said that experience does not support teaching because most schools have banned the use of cell phones and other digital devices by students in classrooms and schools. Likewise, their findings found that most teachers considered digital technology disruptive, so teachers were not impressed and were reluctant to use it to learn mathematics and other subjects. Moreover, because teachers are

excited to pursue maths, teaching using new technologies is essential to approach. However, since this is common school law, every teacher cannot claim to be different. However, this requires web-based software that can operate on a wide variety of digital devices, from personal computers, laptops, and tablets to cell phones. The authors suggest developing group exercises for maths teachers to share their teaching repertoire on incorporating new technologies so that the objectives of learning mathematics that are focused on digital literacy technology can be realized.

[Almanthari et al. \(2020\)](#); [Tamah et al. \(2020\)](#), examine school closures in Indonesia during the COVID-19 pandemic have left 45.5 million school students and 3.1 million teachers dependent on online teaching and learning. This study has understood how secondary school mathematics teachers view barriers to online learning implementation during the pandemic at several barriers. They conclude that the first obstacle lies with students with severe difficulties using digital technology, which is a best practice during school closures. This reveals that the experience of digital online literacy for both teachers and students is significant so that it will have a positive impact on the level of barriers to learning with digital technology tools.

[Ariani et al. \(2017\)](#), discuss multimedia, both printed media, visual media, and audio media, which can be developed as media that innovate mathematics learning. Through Edmodo's social network, educational media production will also take advantage of technological developments. This study was carried out to build a realistic, relevant, and efficient digital classroom learning paradigm to increase learning outcomes using Edmodo social learning networks for elementary school mathematics learning. The results show that the prototype of elementary student mathematics learning tools using Edmodo is in a suitable category. As a result of Edmodo learning, 72 percent of students passed the evaluation with very satisfying learning outcomes. Thus Edmodo can be a promising method to engage students in a collaborative and innovative learning process under teacher technology and pedagogy guidelines.

[Pardimin et al. \(2018\)](#), explained the paradigm of implementing simple mathematics learning by adopting multimedia. This immersive digital learning model can be useful for fostering student interest in learning and making it easier to understand simple mathematics. The research results reveal that developing an illustrative mathematical T&L model will provide a complete explanation of the entire method with full benefits in developing a pleasant atmosphere to encourage the level of understanding in the absorption of mathematics learning.

[Sridana & Sarjana \(2020\)](#), investigated how to combine mathematics teaching with multimedia technology for primary school children in 21st-century competencies. They refer to the 4C definitions for leadership skills, teamwork, critical thinking and problem solving, and imagination and discovery. This concept is expected to be applied in Indonesian schools. Indonesian students are also full of values, such as teamwork, cooperation, critical reasoning, problem-solving, imagination, and innovation. Mathematics learning programs in junior high schools in Indonesia are required to inspire all prospective students who can cultivate these talents and habits. By designing learning resources and multimedia, teachers have shown that student-centered creative learning can improve learning achievement.

[Nurhayati et al. \(2020\)](#), discussed the dilemma of how teachers and students can develop their abilities to learn 21st-century skills. In classrooms in Indonesia, STEM learning with mastery of multidisciplinary science and multimedia needs to be streamlined. Visual capacity is not an absolute determinant of a student's production of 21st-century skills, the study said. However, this study concludes that digital skills are a significant supporting factor for 21st-century skill mastery applied and taught in the classroom. This thesis uses literacy techniques from foreign and national journals, books, and other similar materials to ensure that the findings are accurate with evidence from studies in other countries.

[Saputra et al. \(2018\)](#), said the Trigonometry Software had made Android-based learning media an alternative mathematics lesson method. Six analysts validated the learning through the participation of 95 student respondents. The results show that with a kappa value of 0.562 - 0.8433, this digital learning media can be trusted and has valid criteria. , more analysis is needed, the study said. The relevance and practicality of instructional media, this study uses the ADDIE creation model. [Mailizar & Fan \(2020\)](#), examines the knowledge and use of digital technology median teachers in teaching Mathematics in Indonesian. Their study found a lack of knowledge of Indonesian middle mathematics teachers, so that they were unable to use these digital tools. Most high school mathematics teachers in Indonesia have insufficient knowledge of multimedia mastery, so they are reluctant to apply it in teaching even though their field demands require it. This KJain further recommends that more multimedia teaching training programs for all mathematics teachers make it easier for them to explore knowledge and skills about the digital aspects of classroom technology. Although this study was only conducted in one of the provinces, this data is close to valid and reliable on mathematics teachers' proficiency in the mastery of digital technology skills and literacy.

[Novitasari & Khotimah \(2016\)](#), succeeded in observing the effect of using interactive multimedia on students' ability to understand mathematical concepts. This research was conducted at SMP Negeri 4 Tangerang in the

2014/2015 academic year class VIII. The statistical calculations of students' ability to understand mathematical concepts using interactive multimedia with quasi research methods experimental class show that the experimental class's mean is higher than the control class. The results showed that interactive multimedia affected students' ability to understand mathematical concepts.

Discussion

The primary purpose of this paper review study is to find a new understanding of the relevance of digital technology-based teaching practices or multimedia in mathematics learning in Indonesia to improve student learning outcomes through the study review method on the evidence of study evidence or publications that raise technological issues in mathematics education.

Significance of technology in improving learning maths

With the consideration of data-related literature data and data on journal publication reviews both nationally and internationally, we can say that the ten findings of the publication paper suggest that there is evidence of conformity between the application of multimedia or digital technology into mathematics teaching so that student learning outcomes can be achieved. Our findings are valid, namely with much evidence from other studies such as the findings of [Lestari \(2018\)](#), which proves that any technology has a significant role in improving the quality of education in an era where everything is all technology as the world is increasingly global in the education sector and others.

The evidence of our findings confirms that effective mathematics teachers optimize the potential of digital technology in developing students' understanding of mathematical concepts and applications, stimulating learning interest, and enhancing their ability to acquire diverse knowledge and competencies in mathematics. Our findings are also supported by [Hwa \(2018\)](#), who acknowledges that teaching changes in mathematics skills are much helped by the strength of teaching digital-style game models. Our findings also explain that when teachers use any technology model strategically, they can provide greater access to maths problems for all students at both the primary and secondary school levels. The majority of our findings give a good reason that the best practical learning technologies can provide dynamic opportunities for teaching in mathematics and STEM classrooms. On the other hand, our data reveal that teachers who are not technologically literate fail to improve the learning process and make concepts come alive through engaging and interactive media. So we can offer the above findings additional support to meet the needs of all students and teachers to create a mathematics learning experience tailored to the conditions and context of education in each region in Indonesia.

Another benefit of digital technology is that teachers allow students to help each other and work together to better understand the material because they not only do it in schools with limited schedules and time, but they can also do it more personally wherever they are. Students can often function as teachers for other students because learning through digital technology learning is very flexible and practical for mastering topics and solving problems repeatedly without the limitations of time, space, and other elements different from the classroom context. This matter was also discussed by [Ribble \(2015\)](#), the young generation who live and grow up in the digital era is now in school. They enjoy learning with a guide to teaching together with technology-based media and digital innovation. So teachers and important components must support the idea of innovation with digital literacy in education. Another benefit of digital technology is that teachers allow students to help each other and work together to understand the material better because they not only do it in school with limited schedules and time, but they can also do it more personalize wherever they are. Students can often function as teachers for other students because learning through digital technology instruction is very flexible and practical for mastering topics and solving problems repeatedly without the limitations of time, space, and other elements different from the context of learning in the classroom.

Improving math learning outcomes

When asked how technology and literacy can provide additional opportunities for both teachers and students to see and interact with mathematical concepts, our study's findings have also enabled students to explore and make discoveries with games, simulations, and digital tools both in the classroom and outside. This could not have happened if students studied the old way because technology and digital applications are excellent for teachers and students in learning with a web-based graphing calculator application. Digital technology also can improve the relationship between teachers and students genuinely. As teachers effectively integrate technology into the subject

area of mathematics, teachers grow into the roles of advisors, content experts, and coaches while students are super agile and agile actors (De Witte et al., 2015; Aswad, 2017; Laksana, 2017; Nunaki et al., 2019). Digital technology also teaches and learning to be more meaningful and fun because they are already structured or ready products for learning.

When asked what is the importance of mathematics in technology? So our data has slightly answered that there is a fundamental significance to the literary digital collaboration mathematical way of thinking. The working group, mathematics provides a method for organizing and structuring knowledge. Students will continue to be trained when mathematics is applied to multimedia technology, thus enabling teachers and teaching experts to produce systematic, reproducible knowledge transmitted to students (Voogt et al., 2013; Rudnycky, 2004). Then how does digital literacy technology become best practice in teaching mathematics and other sciences?. So our findings also prove that science is the study of nature by following a systematic observation process, including experimentation. Typically, mathematics and technology are tools scientists use to study scientific phenomena and changes in the universe. Finally, technology in its various models refers to the tools and inventions created through scientific knowledge to facilitate use in other fields of study such as mathematics studies in educational settings.

Conclusion

In this final section, we will present a summary of the discussion of this study's results, which raises the topic of the relevance of digital practice in mathematics learning in Indonesia to improve learning outcomes in a review of studies of empirical evidence from publications. In the ten publications we reviewed, most papers discussed the relevance of digital technology applications' effectiveness and usefulness to be best practice in improving the teaching outcomes of Mathematics programs in Indonesia. According to these data findings, many factors hinder the success of teaching Mathematics at this time, including the unpreparedness of teachers and students in using digital technology. Besides, schools are not prepared to provide digital technology devices, thus hampering best practices with digital applications in mathematics classrooms.

For the best practical digital literacy technology in teaching to be successful, various factors must be evaluated so that the best practical mathematics learning using tools of technology can be realized to accelerate the acquisition of learning outcomes under the demands and expectations of the parties. Hopefully, this study's results become meaningful input in efforts to advance Mathematics teaching, especially the involvement of technological applications and digital innovation in schools in the country.

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