Digitizing Mathematics and Science Learning:
What Do We Need to Prepare?

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ABSTRACT

Massive disruption in a short time has occurred due to the Global Pandemic of Covid-19. Digitization of learning has been inevitable at all levels of education after the pandemic forced us to close all educational institutions. This qualitative study aimed to describe perception and experience of teachers in secondary schools related to the digitization of education in aspects of learning implementation. Data were collected using an open-ended questionnaire which was completed online by 61 teachers in the fields of science and mathematics at the secondary schools. The data were analysed by conducting data reduction, verification and drawing conclusion. The results show that the teachers share their positive perception of the digitization of learning. Availability of devices and support system to digitized learning, such as curriculum, learning management system, internet connection, and electricity sources was the main obstacle to digitize learning so that it must be prepared immediately. Furthermore, knowledge about digital learning and strengthening of character education also needs to be prepared for educators and students in order to digitize math and science learning.

Keywords: digitizing learning, global pandemic, mathematic learning, science learning

1. INTRODUCTION

Disruption, digitization, and transformation of learning have been a discourse among educators for two decades at the beginning of the 21st Century. Experts have predicted a massive disruption that has an impact on education in schools and universities caused by the Industrial Revolution (IR) 4.0. The government responded to this situation by enacting various new education policies to anticipate and adapt to the situation faced now and in the future. One form of response to disruption in the IR 4.0 era is the digitization of education.

Digitization of education is an effort to transform education by utilizing digital platforms (both online and offline) as a medium to provide services in the educational sector. Digitization is more than using digital technologies to transfer data and perform computations and tasks [1]. Digitalization involves two aspects, namely the connection between people and things and the fusion of real and virtual worlds. [2].

Technically digitalization is related to the technology used in a process that includes: cloud computing [3], big data [4], advanced analytic [5], social software [6], and IoT (Internet of Things) [7][8].

The types of services in the education sector that have utilized this digital platform cover various aspects, ranging from information and communication services, correspondence and administration, testing, and learning. The simplest form of digitization is the utilization of digital media to disseminate information and communication. This can be done separately, independently and not require too much cost. More complex than disseminating information, digitization of correspondence and administrative services (such as accreditation services, financial accountability reports, activity documentation, and student enrollment) requires an integrated system (at least regionally) and real-time for users to get fast, efficient service.

Meanwhile, more complex digitization is carried out in aspects of testing (such as Computer-Based National Examination (CBNE) at secondary education level,

Computer-Based College Entrance Selection (CBCES), and Computer-Based Teacher Competency Test (CBTCT) for educators at primary and secondary education level) that require a nationally integrated system, and a higher level of data security. Furthermore, digitization in learning is taken by developing a Learning Management System (LMS) that is integrated online to support the learning process. The complexity of the digitization of learning is almost the same as digitization in the testing process because it requires an integrated system and, of course, a large database because it involves all learners and is accessed simultaneously by many users.

In terms of information and communication, correspondence and administration, as well as testing, digitization has been carried out for the past few years. A number of studies such as Retnawati et al [9], Alifiani et al. [10], have reported how the constraints and efficacy of digitization of education on these aspects. However, digitization in the aspect of learning is still not popularly implemented both at the higher education level, especially in primary and secondary education. Many colleges already have their own LMS. A number of secondary schools have also had it to support the learning process, but have not been utilized optimally.

In early 2020, the world was shocked by the Global Covid-19 pandemic that caused massive disruption in all sectors of human life. UNESCO reports that more than 1.5 million schools in the world have been forced to close due to the global pandemic. As a result, learning cannot be done in school, and alternatively learning is carried out online with various digital platforms. Various studies have reported efforts to maintain the continuity of the learning process even remotely, such as the development of learning models, the application of online tests, and various other digital transformations. On the positive side of the pandemic is the acceleration of the process of digital transformation of education. However, a number of studies show that higher education is not ready. [11]–[15].

This study aimed to describe the perception and experience of teachers in secondary schools related to the digitization of education in aspects of learning implementation. This research will answer three main questions related to math and science learning, namely 1) has the teacher digitized learning? (2) What is teachers' perception related to the digitization of

learning? and (3) What needs to be prepared in the framework of digitalization of learning.

2. METHODS

2.1. Research Design

The study uses a phenomenological approach to obtain information related to the experiences of math and science teachers related to the digitization of math and science learning in secondary schools.

2.2. Respondent

Data were collected using an online open questionnaire which 61 educators filled out in the fields of science and mathematics at the secondary schools who were selected based on their educational level and teaching experience (see Table 1). Because the purpose of the study was to define teachers' perceptions of digitalization of learning, researchers selected respondents from those who were relatively young, and the teaching experience was no more than ten years. Participants were selected from secondary schools in Java (n=23), Kalimantan (n=22), and Sulawesi (n=16). The researchers did not display the identities of all respondents (anonymously) and were replaced with codes T1, T2, T3, and soon. Researchers and respondents had no relationship to avoid bias in data collection or interpretation.

2.3. Data Collection

Respondents were asked to fill out a questionnaire containing open-ended questions online. The question asked in the questionnaire aims to get information about three things, namely (1) has the teacher digitized learning? (2) how is the teacher's perception regarding the digitization of learning? and (3) What needs to be prepared in the framework of digitization of learning.

The responses of 61 teachers to these questions were analysed qualitatively by reducing and verifying and making conclusions from qualitative data obtained. [16]. From these three questions, researchers are conducting in-depth interviews to get more in-depth information related to the digitization of mathematics and science learning.

Table 1. Participants' Characteristics

Subj.	Gender		Educ. Level		Teaching Experience (years)			
	M	F	S1	S2	<5	5-10	10-20	>20
Math.	21	24	40	5	24	16	4	1
Science	5	11	12	4	2	8	3	3
Total	26	35	52	9	26	24	7	4

S1 = Bachelor; S2= Master

In-depth interviews are conducted by selecting respondents using *snowball* techniques. The question asked is the deepening of the three above, which relates to (1) digital tools that have been used; (2) how the use of digital tools; (3) reasons for the use of digital tools; (4) the usefulness of digital tools; (5) the obstacles faced; and (6) anything that needs to be prepared to face the digitization of mathematics and science learning in secondary schools.

After interviews with ten math teachers and ten science teachers, the information obtained was saturated so that the selection of respondents for interviews was stopped. The data analysis is then forwarded to the final conclusion to answer the research question. Conclusions obtained from the results of the analysis are confirmed back to the respondents before publication.

2.4. Data Analysis

As outlined above that data analysis in this study is done during and after the data collection process. The data is analyzed using the stages presented by Miles, Huberman, and Saldana [16]: (1) data collection, (2) data display, and (3) verification/conclusions. The stages of analysis can be seen in Figure 1.
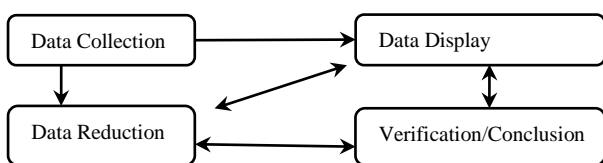

Figure 1 Data Analysis Procedure [16]

3. RESULT AND DISCUSSION

Data analysis produces information about the perception and experience of mathematics and science teachers in secondary schools related to the digitization of learning. The following will outline the data analysis results to answer this research question.

3.1. Have teachers digitized learning?

The results of the data analysis showed that all respondents had used digital media in learning, although it was still quite varied, with an average of 41% of the total learning time in one semester (teacher response was obtained before the pandemic). From these results, researchers conducted in-depth interviews with 20 teachers.

The results of the deepening obtained information about two things. First, information related to digital media is often utilized by teachers in learning mathematics and science. Second, the form of utilization of digital media in the learning of mathematics and science. The data analysis obtained information that digital media laptops and projectors are the most used. 16 out of 20 teachers have used it frequently in learning. Meanwhile, only 3 out of 20 people use smartphones as a digital medium.

The utilization of digital media that teachers have done includes preparing, processing, and sharing information/materials/learning resources, both offline and online (see Table 2). Preparing activities are carried out offline and online, including finding materials/learning resources (online/offline), preparing a learning plan, and storing data. Processing activities use digital media to process information, both in the form of mathematical data and science processes through digital media. Here is an example of the response of mathematics and science teachers related to the use of digital media in learning.

Sometimes I use software like GeoGebra on a laptop and it is displayed through a projector to help with the mathematical process [T4 – math teacher]

For example, in the material, unit conversion can use android applications. [T15 - science teacher]

I sometimes use virtual laboratory software to display science processes in front of the class through projector [T13 – science teacher]

Table 2. Forms of Utilization of Digital Media by Teachers

Responses	Reduction Results	Verification/Conclusion
• Prepare and store teaching materials and lesson plans • View learning materials/videos in the classroom through a projector	Digital media are used to prepare, store, and display learning resources/materials in the classroom	Forms of digital media utilization in learning include preparing, processing, and sharing information / materials / learning resources online and offline but still partially.
• Using math/science software • Using educational games in class • Visualize mathematical/science objects	Digital media are used in the processing of mathematical data as well as science processes.	
• Share videos via smartphone • Download learning resources from internet • Finding the meaning of difficult terms through the internet • Delivering tasks and learning materials	Digital media are used to find and share learning resources through online media.	

The utilization of digital media is no less important than the media sharing of materials and learning resources. Unfortunately, most take partial use of digital media. Only 3 out of 20 respondents have used digital media ranging from preparing, processing, and sharing. The time use of digital media at the processing stage is also very short compared to the utilization of conventional media (e.g., props, marker-whiteboard, and worksheet).

3.2. What is the teacher's perception of digitalization of learning?

The reduction and verification of teacher perception data related to the digitization of learning concluded that all respondents agreed that digitization of mathematics and science learning could be done. The utilization of devices such as laptops and smartphones need to be improved the learning quality. Here are some examples of teacher responses to the second question in the study.

On smartphones, many mathematical applications can be used to facilitate the understanding of mathematics, for example, the GeoGebra application. But unfortunately, at school, we are not allowed to bring a smartphone [T7 – math teacher]

It could be that they (students) use smartphones as long as the smartphone only contains learning materials - children in secondary school are very prone to become perpetrators /victims of technology abuse. [T11 - science teacher]

The digitization of learning by utilizing smartphones still depends on school rules, and security guarantees its use to students. According to the teacher, these two things are important issues to consider in the future.

Data reduction concluded that math and science teachers have four reasons for using digital media in math and science learning. First, the practicality of the practicalities offered by digital media. Second, the reason for efficiency can be obtained by using digital media. Third, the reason for the ministry or efforts to increase students' interest in learning. Fourth, alignment with the demands of the times (see Table 3).

Digital media offers a variety of tools that can help teachers and students perform various tasks. With digital media, it is easy for a teacher to present concrete objects/objects that are difficult to carry directly in the classroom or visually display mathematical / science objects that are difficult to describe through traditional marker-whiteboard media.

The results of the analysis of teacher perceptions about the usefulness of digital media provided that more than 60 percent of teachers agreed that digital media is very useful and helps facilitate the learning process. However, the teacher also noted that digital media would be more useful if it is in accordance with the material. That is, teachers are carried out intensive preparation or assessment related to the suitability of digital media selection and how the media is used.

Digital media accelerates in the delivery of materials while helping visualization for certain materials, although in addition conventional media (whiteboards) for mathematical learning still go hand in hand with their use. [T7 - math teacher

Digital media is very helpful in the learning process to be more effective with a note of need for clear direction [T9 – science teacher]

The teacher's response shows that the teacher's central role in learning is very important, however sophisticated the technology used. Conformity with the material that students will learn should be the teacher's main concern. In this second section, we also get the idea that from the point of view of teachers, the digitization of learning should not negate the role of teachers or the role of other conventional media.

Table 3. The Reason Teachers Utilize Digital Media in Math and Science Learning

Response	Reduction Results	Verification/Conclusion
● Help me in delivering learning materials ● Many tasks become easy to do. ● Easily visualize abstract objects	Reasons for practicality	The use of digital media in learning mathematics and science is for reasons of practicality, efficiency, attractiveness, and awareness of the demands of the times.
● Saves time, effort, and cost ● Speed up the calculation/verification process ● No need to waste time drawing abstract objects	Reasons for efficiency	
● Attracting the attention of students ● Motivate students especially those audio-visual learning styles ● Students don't get bored easily. ● Learning becomes fun ● Students are more focused on learning.	Reason for attractiveness	
● In accordance with the demands of the times ● Train students using digital media ● Introducing students to technology ● Aligned with 21st Century competence ● Support the development of students' digital literacy ● Students are used to using digital media in everyday life.	Reason for alignment with technological development	

Table 4. Perception of Mathematics and Science Teacher Related to The Use of Digital Media in Learning

Response	Reduction Results	Verification/Conclusion
● Digital media works well when adapted to the material. ● Digital media is very useful to get information on the development of science such as diseases, the environment. ● Not all materials can use digital media.	It needs to be aligned with the learning material	Utilization of digital media must go through careful planning related to the preparation, implementation, and monitoring of the student learning process.
● Digital media is good as long as there are guidelines on how to use it. ● Digital media still needs an explanation from the teacher. ● Digital media reduce the use of paper, but teachers still need to direct students ● Learning steps should be well planned.	The role of teachers is still needed in the utilization of digital media	

3.3. What needs to be prepared in order to digitize learning?

In this subsection, the results of data analysis from teacher responses to research questions related to matters that need to be prepared to face the digitization of mathematics and science learning. The results show four main things that need to be prepared to deal with the digitization of learning. Firstly, students and teachers need the availability of digital devices to carry out the learning process and complete tasks. These support devices include laptops/tablets/smartphones.

"*Parents of students who complain because it is difficult to buy mobile phones to take online classes*" [T7- Math Teacher]

Secondly, availability of support system such as curriculum, learning management system, internet connection, electricity. This support system is a need for schools to organize learning digitally. The absence of support system according to teachers inhibits the implementation of digitalization of learning.

"*We (teachers) want to innovate with digital media, but it is impossible for us (teachers) to provide the support system*" [T11 - science teacher]

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"*There are still students and even teachers who are unable to use digital media. This should be a concern before digitizing learning.*" [T13 – science teacher]

Fourthly, the character education is especially related to ethics in using digital media. This is particularly emphasized on digital media that is based online to prevent negative things that may occur due to media abuse. Some teachers mentioned their concerns if the use of online-based digital media was released without strict supervision.

"*Digital learning media is good, but it needs the cooperation of teachers, and parents in supervising children in using it.*" [T7- Math Teacher]

"*Digitization of learning mathematics, science, and other fields of study must be in line with strengthening character education. Character education, in my opinion, is a fortress for our children, because we (teachers and parents) cannot supervise them 24 hours a week.*" [T11 – Science teacher]

Information obtained from this subsection can be used as one of the references to carry out research that focuses on factors that affect the digitalization of learning.

In line with the results of this research, Piskurich [17] outlines some of the things teachers must do to digitize learning. First, prepare students to become independent learners who can direct themselves to study [18]. Second, identify and support students ready to follow the digitated learning [19]. Third, provide *the guideline* for the implementation of learning [20]. Fourth, prepare a learning model in learning [21]. In addition, there also needs to be readiness from the education unit (institution).

4. CONCLUSION

Math and science teachers have a positive perception of the digitization of learning, although they have not been able to apply it to the fullest. The necessary preparation for the digitization of learning is (1) preparing supporting facilities (digital tools, (2) support system to organize digital learning (curriculum, internet connections, and electricity), (3) preparation of knowledge on how to use digital media for teachers and students; and (4) strengthening of character education to avoid misuse of digital media.

This research provides recommendations for the digitization of mathematics and science learning in the future. First, it needs policy and program support to ensure the readiness of support systems for the digitization of learning. Second, training programs, mentoring, and tutorials related to digital media utilization need to be prepared by the government and researchers. In addition, there also needs to be a program to strengthen knowledge and character for students related to ethics using digital media.

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