

# Have the Teachers Integrated Technology in Mathematics Learning?

<sup>1</sup>Jailani, <sup>2</sup>Heri Retnawati, <sup>3</sup>Sugiman, <sup>4</sup>Elly Arliani, <sup>5</sup>Kana Hidayati, <sup>6</sup>Atmini Dhoruri, <sup>7</sup>Ezi Apino

<sup>1, 2, 3, 4, 5, 6, 7</sup> Department of Mathematics Education

Universitas Negeri Yogyakarta, Yogyakarta, Indonesia

Email- <sup>1</sup>jailani@uny.ac.id, <sup>2</sup>retnawati.heriny1@gmail.com, <sup>3</sup>sugiman@uny.ac.id, <sup>4</sup>arliani\_elly@yahoo.com, <sup>5</sup>kana@uny.ac.id, <sup>6</sup>atmini\_uny@yahoo.co.id, <sup>7</sup>apinoezi@gmail.com

Hasan Djidu

Department of Mathematics Education

Universitas Sembilanbelas November Kolaka, Southeast Sulawesi, Indonesia

Email- hasandjidu@gmail.com

**Abstract-** Technological literacy is one of the competencies that need to be mastered by the students in the 21st century. This competency can be trained by integrating the use of technology in mathematics learning. In fact, not all teachers can integrate technology in education properly, including in mathematics education. This study aimed to describe the use of technology in mathematics learning by teachers. This study was phenomenology qualitative research. The data were collected using an open-ended questionnaire, to gather opinions about the teachers' knowledge of technology and its integration in mathematics learning. The participants of this study were 61 high school mathematics teachers from Special Region of Yogyakarta, Indonesia. The data were analyzed using the Bogdan and Biklen method, with the stages of reducing data, finding relationships between themes, and conclusions. The results show that teachers have realized the importance of technology integration in learning, has known the kinds of technologies that can be integrated into mathematics learning, but in the implementation of learning, not all teachers have integrated the use of technology, including the use of calculators. The causes and solutions are discussed.

**Keywords –** The Use of Technology, Mathematics Learning, Phenomenology Study, Teacher's Competencies, Technological Literacy

## I. INTRODUCTION

In this decade, the information and communication technology rapidly develop. The development of information and communication technology has spread to various sectors, which are currently popularly called the Industrial Revolution 4.0. This development has a major impact on human life. On the one hand, various easiness is felt by all members of the community, but on the other hand, the emergence of various uncertainties including the loss of various jobs has become a troubling issue [1]. This becomes a clue to the urgency of the use of information technology (IT) that should be accompanied by an improvement in the quality of human resources.

In line with the efforts to develop IT in the current industrial era, improving the quality of human resources related to the competencies needed to cope with it. These competencies are the ability of communication, collaboration, critical thinking skills and problem-solving, and creativity [2], [3]. Those competencies are not suddenly directly mastered by everyone, but they can be mastered by the educational process. One of the institutions responsible for training this competency is school, including mathematics education which makes a major contribution to the development of IT.

Considering that the development of Industrial Revolution 4.0 cannot be separated from the development of IT. Thus, the integration of IT in learning, especially mathematics, is the chosen strategy to facilitate students and teachers to be IT literacy. Reynolds, Treharne, and Tripp [4] state that at least there are four roles of IT in mathematics learning. First, IT is a device for faster confirmation (checking answer). With IT, the students or mathematics teachers do not need to spend much time to check the answer. Second, TI is a visual device of an abstract mathematics' object. The current digital technology makes the teachers give an example or visualization of difficult mathematics figures manually drawn one by one, such as graphics, polynomials, trigonometric graphics, or three-dimensional shapes. Third, IT is a manipulative device to facilitate the students to manipulate mathematics'

objects. The students are possibly able to see the effect that occurred after they do certain changes toward a mathematics object. Fourth, IT assists to calculate a learning material that is not focusing on calculation. With IT the students can be more focused on observing an object behavior or product and are not disturbed by the difficult calculation process.

In this modern era, technology integration is not only used for the learning process but also used in the assessment process. Some experts (e.g. [5]–[7]) have reported that the use of technology in learning assessment provides many advantages. The use of technology for assessment allows measurement of performance using visualization, simulation, data analysis tools, and graphical representations [8]. The technology allows improving the quality of test administration, test scoring, test reporting, and interpretation [9]. By using technology, it is possible for a broader scale of assessment [10]. The use of technology in the assessment can also reduce the potential for fraud during the test administration so that the test results become more fair and accountable [11], as well as more accurate test results [7].

Unfortunately, research results in the last two decades show that IT has not been used well in learning because of several reasons. Some barriers are caused by the changes of various IT products that have not been realized yet by the teachers [12], the teachers' low-knowledge of the IT integration in learning [13]–[15], limited IT access and facilities' availability [16]–[18], even a negative attitude toward ICT in mathematics' learning [14], [16] causing unwillingness to use IT in mathematics' learning.

Having analyzed from the types, there are some IT facilities used in mathematics learning. A common technology device is a computer. Various of software in the computer can be used to facilitate mathematics learning [19]–[22], as an example to design mathematics games [23] that enable to train the students in implementing mathematical knowledge. Even, internet support can help the students to search for any information and get new knowledge that cannot be obtained by learning in the classroom or textbooks [24]. In a meta-analysis conducted by Li and Ma [25], they find out that computer technology had a positive impact on the students' mathematics learning achievement.

Although computer technology is quite powerful for learning mathematics, it has weaknesses in terms of economic aspects. Computer technology for learning requires expensive costs, so it becomes a problem especially for developing countries [26], [27]. The high cost of providing computer technology is one reason for educational institutions to not use technology in learning. Thus, alternative technology with low cost is needed to help facilitate the availability of technology for education. Handheld technology such as a scientific calculator is considered cheaper than computer technology, so it can be used as a solution to overcome the cost limitations in education.

Handled technology such as a calculator is one of the important IT hardware in mathematics learning [28], [29]. The calculator was first introduced and appeared on the market in the early 1970s. At that time, the calculator was introduced with only four main functions, namely addition, subtraction, multiplication, and division [28]. The calculator presence only as a calculation tool caused pros and cons at the time. Therefore, in the mid-1980s Casio introduced a graphing calculator (fx-7000G) eventually changing the paradigm of calculator uses [28]. It means that the calculator function is increasingly expanded, not only used as a calculation tool. Reynolds et al. [4] argue that the calculator function is not only as a calculation tool but also as an answer checker, as well as a tool for developing the students' thinking abilities.

The emergence of various types of technology for learning provides many choices for educational institutions. The choice of learning technology can be adjusted to the conditions and capacities of each educational institution. Besides financial strength, the success of technology integration in learning also depends on the readiness of the teachers [30]. Teachers' readiness can be portrayed by their competencies, such as professional, pedagogical, social, and personal competencies [31]. Teachers as the spearhead of education who are directly responsible for the learning process in the classroom, have an important role in the successful integration of technology in their classrooms. Besides, the government as a policymaker also needs to make a regulation that specifically regulates the use of technology in learning [32]. The regulation is needed to be a guide that serves as a guide for teachers.

In the Indonesian education system, the use of IT in a learning process has been regulated through several government policies starting from "the National Education System Law" or "SISDIKNAS (*Indonesian abbreviation*) law" [33], then reemphasized in the implementation of the Curriculum 2013 (K13) through Minister of Education and Culture Regulations concerning the standard of Indonesian educational process [34], [35]. In the policy, it is stated that the use of IT needs to be implemented to improve learning efficiency and effectiveness [34], [35].

After more than 15 years since the enactment of the SISDIKNAS Law and six years since the implementation of K13 in Indonesia, there is no complete information about the success or the barriers of IT implementation in learning at schools. Regarding this, a study to find out the extent of IT implementation in learning at schools is needed. In this study, we want to find out the information about IT integration in mathematical learning and describe teachers' barriers when applying technology in mathematics learning.

## II. RESEARCH METHODOLOGY

### 2.1 Research Design

This study was phenomenology qualitative re-search. The phenomenon observed in this study was regarding the trend in the use of various educational technologies in mathematics learning in Indonesia, especially in the Special Region of Yogyakarta. This phenomenon was interesting to study because there were still many obstacles faced by teachers, especially mathematics teachers, to integrate technology in their classrooms. This information, specifically, is needed to improve the process of learning mathematics in the future, as well as improving education policies in general.

### 2.2 Research Participants

The participants were 61 mathematics teachers of Senior High School in the Special Region of Yogyakarta, Indonesia. The teachers were from one city and four districts in the Special Region of Yogyakarta, consisting of 12 males and 49 females. All participants were asked to fill the questionnaire. During this process, the researcher explained that the collected data was used only for a research purpose, and all the participants' identities would remain confidential and anonymous. The questionnaire procedures neither affected the teachers' career nor anything else, only used as a research purpose.

### 2.3 Data Collection

The collected data by using an open-ended questionnaire was used to obtain the teachers' perspectives towards the technology and its integration in mathematical learning. The open-ended questionnaire revealed the teachers' understanding of the IT, the teachers' understanding of technology integration in mathematics learning, the technology implemented by the teachers in learning, and the use of calculators, the teachers' barriers of the technology integration, and the need or the implementation of the teachers' training to develop their profession.

To maintain the validity and consistency of the data, the method triangulation was carried out. After the participants filled out the questionnaire, the responses of several teachers were confirmed through interviews. Besides confirming some unique responses from the teachers, interviews were also conducted to obtain in-depth information related to the phenomena under study.

### 2.4 Data Analysis

All teachers' responses obtained through questionnaires were reduced. The reduction results are verified and compared with the results of the interview. Furthermore, the thematic analysis by Bog-dan and Biklen [36] was conducted to know the interrelations among themes. The purpose of determining the interrelations between these themes was to obtain an in-depth understanding of the observed phenomena [37]. By using the theme interrelations, the summary of the technology integration in mathematics learning was done.

### 2.5 Ethical Considerations

In this study, the only relationship between re-searchers and participants is to obtain data related to IT integration in mathematics learning. All data collected in this study only sourced from the responses of 61 mathematics teachers who participated in this study. Furthermore, the identities of all participants were anonymized and written with code: T1, T2, T3, ..., T61 to distinguish teachers 1 to teacher 61. Each teacher's response was recorded and inputted in a table to be analyzed and described. Some of the teachers' responses that can provide a general description of a phenomenon are selected and presented as examples in this article so T1 – T61 is not mentioned entirely in this article.

## III. RESULTS

### 3.1 Teachers' Knowledge of IT

The Information regarding the teachers' knowledge of IT was obtained by asking "what do you know about the information technology?". There were various teachers' responses to answer the question. Among those responses, the analysis results obtained three themes of the teachers' IT understanding (See Table 1). The analysis results showed that IT was not a new thing for all the teachers. Even though they defined in different ways, all of them agreed that IT was a device or media for various purposes.

Table 1. Teachers' Knowledge of IT

Teachers' Response	Theme	Conclusion
The technology was able to solve problems. Technology to support learning. Media to ease the learning process. Media to find out the learning information.	Media to ease the learning	Information Technology (IT) was not strange anymore for the teachers. The teachers had known if IT was a facility that could make, such as learning process or daily life problems
Computer development technology to ease human being jobs. Media to faster problem-solving. Assistance tools in completing daily activities.	Technology to help various human being needs	
Media to help to create, change, store, communicate/transmit the information. Concerning digital technology to transmit information. Media to process and transmit information using electronic tools. Technology to support and improve information quality Concerning the used computer to retrieve faster and high-quality information.	Technology device to ease searching, processing, and transmitting accurate information	

The teachers explained that IT was so useful for human beings to solve various daily-life problems. Also, most teachers stated that IT greatly facilitated humans to search, store, process, and transmit various information. With facilitates offered by IT, various important information could be obtained directly and quickly and through the incredible sources.

*"IT does not only help to retrieve the information but also keep the information credibility"* (T5)

*"I can retrieve a lot of information quickly by using IT"* (T11)

Many teachers also mentioned that IT was a very useful device to support the learning process. Based on their opinion, IT was useful very much in the learning implementation since it could be a medium for updating educational information and other things needed in learning.

*"The support of IT helps me to find the latest useful-learning information"* (T1)

*"There are many assessable references with the current development of IT"* (T2)

### 3.2 Teachers' Knowledge of the Use of IT in Mathematics Learning

Concerning the use of IT in mathematics learning, the teachers had already experienced enough on the use of ICT in learning. When they were asked about what kind of IT could be used for mathematics learning, they mentioned some online and offline based technology. The teachers mentioned some software. One of the most popular among the teachers was GeoGebra in geometry learning.

*"The students can use the GeoGebra application for the transformation geometry learning"* (T2)

*"Technology information can be online or offline. There is an online learning facility in Ruang Guru"* (T25)

*"Make use an online test, a virtual class, or a WhatsApp group"* (T30)

*"Internet is one of IT used to study, download teaching aids or math exercises"* (T17)

Instead of the previously-mentioned software, the teachers also stated some useful technological hardware in mathematics learning. The most mentioned among the teachers was a computer, and then a calculator, and a handphone. However, the teacher had not explained yet specifically how to use those technologies. It meant that IT known by the teachers had not been fully used in mathematics learning.

### 3.3 IT Used by the Teachers in Mathematics Learning

When asked about the used IT in learning, most responded that they had used a computer or laptop in mathematics learning. Meanwhile, only a few teachers mentioned that they had used a calculator, or cellphone to support mathematics learning.

*"Usually I search for additional information using the internet. In the classroom, I sometimes use a calculator to do calculations or use GeoGebra to make graphs"* (T23)

*"The common and often used technology are projectors to display images or display online learning videos"* (T12)

Some teachers had also used IT facilities to provide communication services with students outside class hours. This was done to help students who had difficulty when learning mathematics outside class hours.

“For example, children have difficulty in working on exercises, we as a teacher are ready to help them via WhatsApp” (T1)

“My children are invited to join the WhatsApp group to share worksheets or information” (T10)

The interview results also showed that there were still many teachers only using conventional media (blackboards, papers) in mathematics learning implementation. Only a few of them had used IT in mathematics learning. Many teachers had used IT, as mentioned above, it was only the students who need assistance. In other words, various current available IT products had not become the teachers' main media in mathematics learning.

### 3.4 Teachers' Knowledge of the Use of a Calculator in Mathematics Learning

The calculator is one of the most common and relevant media for mathematics learning. Even the calculator is one of the first-known media used by mathematics teachers in Indonesia before the expansion of various computer devices. Unfortunately, after adjusting various functions, or adding various features to the calculator, the mathematics teachers still have not known about it. The results of this study also provided an overview of this case. There are two things we asked regarding the use of calculators in mathematics learning. The first was the teacher's knowledge about the calculator functions in mathematics learning. The second was the use of calculators currently done by the teachers in mathematics learning. The analysis results of the teachers' responses are as follows.

#### 3.4.1 The knowledge of the functions of calculators in mathematics learning

Regarding the use of calculators in learning, the teachers answered some subject matters with the use of a calculator. The gathered analysis results revealed three ways how to use a calculator based on the teachers' perspectives. Those three ways were as a calculation tool, a counting result checker tool, and a mathematical concept explorer tool. The analysis results can be seen in Table 2.

Table 2. The Teachers' Knowledge of the Use of a Calculator

Teachers' Response	Theme	Conclusion
Improve the calculation speed Perform calculations involving decimals or large numbers Integral, metrics, volume, exponents Learning of statistics, logarithms, sequences & series, interest, trigonometry, factorial notation Determine trigonometric values for non-special angles Calculators could be used in trigonometric learning, statistics with manually-difficult-calculated numbers.	A calculation assistance tool	Almost all teachers argued that a calculator was only a calculation tool and a calculation aid tool. Only a few teachers used a calculator to construct a concept.
Fast the calculation of numbers/match with the results of manual calculations Match with the results of a manual count	Check calculation results	
The calculator helped in series and statistics learning.	Study patterns	

The analysis results of the teachers' responses showed similar points of view. Almost all respondents argued that a calculator in mathematics learning was as a calculation aid tool. Those teachers stated several mathematics subject matters with the use of a calculator (for example integrals, matrices, volumes, exponentials, sequences and series, and trigonometry). A calculator was seen as a speeding tool of a calculation process, especially the decimal or trigonometry calculation process with no special angels' involvement. However, some teachers viewed that a calculator could not always speed the calculation process. For a special case, a calculator was only used to clarify or match the manual calculation result.

“A calculator is only used when the numbers are difficult to calculate manually. But sometimes if manual calculation is easier, then the calculator is used only for matching” (T22)

One of the teachers suggested that a calculator could be used to explore mathematical concepts. The teacher mentioned the use of a calculator to ease studying the concepts of series or statistics. Nevertheless, the teacher had not provided a deeper explanation regarding the application of the calculator.

#### 3.4.2 Barriers to the Use of Calculators in Learning Mathematics

Although the teachers had mentioned various uses of calculators in various mathematics subject matter, many teachers had not or did not even want to use calculators in mathematics learning. Seventeen respondents said that they did not use a calculator in learning mathematics. Many reasons were said by the teachers so that they had not or did not use a calculator in mathematics learning. The analysis results of the teacher responses can be seen in Table 3.

Table 3. The Barrier Factors Using a Calculator

Teachers' Response	Theme	Conclusion
Students needed to be familiarized with manual counting so they were not addicted to a calculator. We trained students not to use a calculator. Because students become addicted to such tools. The exact count could be quickly solved manually, then calculated with a calculator. The learning material was less explored with a calculator.	The calculator made the students addicted.	The main barrier factors of the use of calculators in mathematics learning were caused by the teachers, students, subject matter, and the availability of calculators
The teachers only taught grade-X and the material did not require a calculator. The material of grade-XI such as limits, derivatives, and integrals did not require a calculator.	Not all materials required a calculator.	
The limited tool and abilities, skills using a calculator.	The teacher and student mastery of the use of calculators were still limited.	
The students could not use a calculator as a learning facility/tool		
Inadequate skills in using the Science calculator.		
Children were less able to understand the use of a calculator.	Not all students owned a calculator.	
Not all students had a calculator. Students had no scientific calculator.		

The analysis showed that four factors become calculator-use barriers, especially in mathematics learning. These factors were related to the readiness of the facilities, the mastery of the calculator, the subject matter, and the teacher's attitude towards the use of a calculator. Among these four factors, two factors become the most dominant; the readiness of the facility (calculator availability) and the teachers' factors. The teachers stated that the calculator (especially the scientific calculator) had not owned by the students yet. This, of course, would be difficult if the teachers had to use the calculator when learning. Furthermore, many teachers showed the negative attitudes towards the use of a calculator in the classroom. According to them, the calculator had a potential negative impact on children's motivation and learning.

*"Indeed, the calculator speeds up the counting process. But the calculator will make my students lazy to work manually"* (T24)

*"We want to get children accustomed to counting without tools such as a calculator when learning mathematics so they are not spoiled"* (T9)

When related to the previous response, it seemed to be a relationship between the teachers' views of the use of a calculator with a negative perception of the calculator impact. Since a calculator was only seen as a calculation tool, many of them refused the use of a calculator in learning. Meanwhile, only a few teachers stated that the calculator could be used for other purposes instead of used for a calculation. This was confirmed by some teachers' responses stating that they still had not mastered the use of a calculator so it was difficult to use it in class. Besides, some teachers also stated that some mathematics materials did not need a calculator. For this reason, they had never used a calculator in mathematics learning.

*"Not all material can be calculated with a mathematical calculator"* (T19)

On the other hand, some teachers stated that they had used a calculator in mathematics learning because it was considered to be easy. However, from the given responses, it seemed that the use of calculators had not been done maximally. It seemed from the mathematics teachers' response stating that the used calculator was only to assist in the counting process.

*"We use a calculator to help calculate real numbers with large exponents"* (T41)

*"Trigonometric values from angles without special angles are calculated with the help of a calculator"* (T32)

*"The calculator speeds up calculations on roots, exponents and logarithms"* (T27)

### 3.5 Training and socialization of the use of IT in learning

Following the teachers' responses to the use of a calculator, it was obtained that one of the main problems was the teachers' knowledge regarding the use of a calculator in mathematics learning. This lack of understanding could be caused by several things. One of them was the absence of comprehensive training or socialization related to the use of a calculator or IT in mathematics learning. This was proved by the response of 29 people from 33 teachers who become our respondents who claimed never participated in training or socialization related to the use of a calculator. Only four teachers had ever joined but still did not get enough knowledge among them.

*“Sometimes I forget how to use a scientific calculator because I haven't used it for a long time” (T30)*

*“I once used a scientific calculator, but now it has never been used ... so I need to study again” (T26)*

The use of scientific calculators seemed to have not yet been mastered by almost all the teachers. The only requirement to use a calculator was the knowledge they got by studying on their own. Unfortunately, knowledge was easily forgotten because it was rarely used.

The same thing found when the teachers were asked about the training of the use of IT in learning. As many as sixteen teachers claimed that they had never received training on the use of IT in learning. Meanwhile, eighteen teachers claimed that they had already participated in the training. The training material received by most teachers was the use of the basics of GeoGebra. The training materials related to the use of a calculator, or online learning were still rarely obtained. Therefore, more than 80% of respondents (teachers) suggested the need for comprehensive training related to the use of various media, especially calculators and GeoGebra in learning. Besides, several teachers also revealed the need for training to develop interactive learning tools and media or online media.

#### IV. DISCUSSION

The current development of IT cannot be stopped. IT seems to have spread almost all dimensions of human life, including an education. The use of IT in education provides opportunities for students to learn or to use various IT facilities [16]. The results of this study indicate that the teachers are already aware of the role of IT as a medium or device facilitating various human needs. The teacher responses also show that mathematics teachers also know the role of IT in supporting the process of mathematics learning. This awareness provides evidence that the use of IT in learning is not something new for the teachers.

However, knowledge about the importance of IT in mathematics learning is not in line with its implementation. This can also be seen from the teachers' responses when explaining the barriers of calculator implementation in learning. The occurred barriers are caused by external factors (availability of facilities, characteristics of subject matter), and internal factors (teacher's attitude towards the use of a calculator, and competence of the use of a calculator). The limited-time issue is also often used as an excuse not to implement calculators since it is considered that using a calculator is no more effective than using conventional methods. These results are in line with what has been reported in some research results in various countries (e.g. [12]–[14], [16]–[18]).

The results of this study indicate that the teacher factors are the most dominant. Based on the results of the analysis of the mathematics teacher's response, we conclude that the teachers' knowledge of the calculator function is still limited. Almost all respondents stated that the calculator was only as a calculation tool. Also, many teachers stated that the subject matter in grade-X or XI did not require a calculator. This emphasizes that the knowledge of the function or usefulness of the calculator was still very minimal. Some teachers also stated the issues of the availability of calculators in learning. The problem with the availability of this calculator is the same as the findings of McCulloch et al. [38] when researching the use of IT to 21 secondary teachers in the United States. However, the availability of facilities in this study does not seem to significantly influence the use of calculators in learning. This is in line with the opinion of Drijvers and Weigand [28], and Retnawati et al. [39] which also states that the availability of a device or technology does not guarantee the quality of learning. Learning with quality IT also requires the competence of teachers in using IT.

The misconceptions of calculator functions have implications for the emergence of various other problems. First, the low level of knowledge also shows the low competency in using a calculator. Second, the lack of knowledge and competence results in calculators is not used in learning mathematics. This is because the function of a calculator is solely seen as a calculation tool so that teachers feel it is impossible to use a calculator for other purposes than that. Third, there is a negative perception of the calculator. The assumption that the calculator will be the barriers to the students' willingness to calculate manually and is even considered to be the development barriers of students' thinking abilities. Whereas the current development of calculator technology allows an educator to make it as a concept exploration tool, a representation tool, and a calculation result checker tool.

The facts revealed from the results of this study indicate that increasing the competence and knowledge of teachers in using IT is an urgent thing to do. As recommended by Jones [12], mathematics teachers need to prepare time to identify and analyze how the use of IT in mathematics learning. One of the teachers' preparations supports is qualified knowledge related to the use of IT (especially calculators). The national curriculum has an important role in this case to support the integration of various information technologies in mathematics learning [24]. At a narrower level, training and socialization of the use of IT were one way out that can be done to help improve the teachers' knowledge. The goal of the training implementation is to provide knowledge and training to teachers in preparing and compiling mathematics learning teaching materials with the use of IT. Besides, the use of IT in

mathematics learning assessment also needs to be introduced. The hope, with sufficient knowledge, the teachers no longer has difficulty in integrating IT (especially calculators) in mathematics learning.

#### V. CONCLUSIONS AND IMPLICATIONS

Based on the results and discussion above, several conclusions can be drawn. First, teachers' knowledge about the use of educational technologies (especially calculators) in mathematics learning still needs to be improved. This is necessary to avoid various misunderstandings related to the use of these technologies, especially related to the use of calculators. Second, many teachers still have a negative perspective on the use of calculators in mathematics learning. Third, a calculator in learning is still used as a calculation tool only and has not been used as an exploration, representation, or affirmation tool. Fourth, IT training in mathematics learning still needs to be done to improve teachers' competencies in using various forms of IT in mathematics learning.

Although the findings of this study have provided quite in-depth information regarding the capabilities of mathematics teachers in integrating technology in their classrooms, the study participants who came from only one province became a limitation of this study. The findings of this study can be used as a framework for other researchers to uncover more comprehensively related to the phenomenon of the use of technology in education, both through survey and other relevant approaches. Through surveys, it is possible to obtain more extensive information for the development of the education system in the future.

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