Using technology in young children mathematical learning: a didactic perspective

R Novita¹ and T Herman²

¹ School of Postgraduate Studies, Department of Mathematics Education, Universitas Pendidikan Indonesia, Jl.Dr.Setiabudhi No.229, Bandung 40154, Indonesia, & Department of Mathematics Education, STKIP Bina Bangsa Getsempena, Indonesia.
² Department of Mathematics Education, Universitas Pendidikan Indonesia, Jl.Dr.Setiabudhi No.229, Bandung 40154, Indonesia.

E-mail: ritanovita@upi.edu

Abstract. Technology has penetrated every aspect of modern life, not least in young children's education. So that the involvement of technology in learning is something we absolutely must do. For more than two decades, many stakeholders have indicated the potential use of technology in mathematics education. Nevertheless, various obstacles and concerns are still felt in this integration effort, especially in learning mathematics at young children's ages. This article uses the literature review method to discuss the extent of the role of technology in learning mathematics for children in terms of didactic perspective. Some documents, such as journals and books related to using technology in young children's mathematical learning, were analyzed to gather related information. The literature review stages that have been carried out are planning, organizing, drafting, editing, and redrafting. Therefore, the discussion can provide new knowledge for educators in their efforts to determine the best way to integrate technology into young children's classroom settings.

1. Introduction
The use of technology in education is not unique or uncommon in this 21st century. Technology has penetrated all facets of community life and different levels of education [1-2]. Because of the Covid-19 pandemic, technology has become an increasingly important part of interacting and carrying out operations. To endorse physical distancing, all educational institutions are now expected to perform online learning. Whether they like it or not, and whether they are ready or not, all educational institutions must use technology to ensure that the learning process can be carried out. In primary education or early mathematics programs, technology has launched a new method to help children develop their skills in all fields of study and across all age groups [2-4]. Using technology wisely has many benefits in supporting learning and relationship and optimizing opportunities for young children’s cognitive, social, emotional, physical, and linguistic development [3]. Likewise, when technology tool (encompasses a broad range of digital devices such as computers, tablets, multitouch screens, interactive whiteboards, mobile devices, DVD and music players, audio recorders, etc.) is used in learning, it can increase children motivation and attention [5-6].
For more than two decades, many stakeholders have indicated the potential use of technology in mathematics education [7–11]. According to the National Council of Teachers of Mathematics (NCTM) [1], technology is an essential tool for learning mathematics in the twenty-first century, and all schools must ensure that all students have access to it [12]. Hoyles & Lagrange [13] revealed that digital technology development is very rapid and used globally, influencing almost all aspects of the education system. Regarding mathematics itself, Olive and Makar [14] argue that mathematical knowledge and mathematical practice are interrelated and that the use of technology can strengthen this relationship. Therefore, technology plays a vital role in linking mathematical knowledge and mathematical practice, enabling students to learn more effectively [7-8, 15-16]. In addition, visual representations are critical for explaining ideas and concepts in mathematics, and new technologies provide new affordances for representation [4].

Nevertheless, many teachers, educators, and researchers discuss the integration of digital technology or digital tools in mathematics learning [4, 9]. The possible questions raised related to the actual role and potential of technology in mathematics learning are how technology can be utilized in mathematics education? How to ensure the use of technology works or vice versa? What factors can support the use of technology can work well or on the contrary? As well as many other questions. In fact, some people worry that using technology, particularly hand-held calculators, will negatively impact children's math proficiency. However, meta-analyses of published research papers have repeatedly demonstrated that using a calculator positively impacts students' proficiency [9]. In response to this, Goodwin [4] stated that teachers must consider students' prior knowledge when using any technology to align the pedagogical approach with the needs of students. The teachers must ensure in their didactic design that a plenary session should take place after the use of technology (instructive and constructive multimedia) to focus students' attention on aspects of mathematics

In addition, related to using technology in early mathematics classes is also still being disputed. Despite concerns about whether young children should have access to technology and screen media in their learning programs, the concern in early mathematics classes is whether technology can help children understand mathematics well. This apprehension arises because there is an assumption that the representations produced by technology encourage children in superficial processing [4], and at this age, children still need a smidgeon of real-world experience while studying mathematics [17, 18]. However, many studies conducted have shown that the use of technology in mathematics in early childhood has a positive impact [7, 9-10, 19-21]. Some of the positive impacts obtained by the use of technology are the increase in children's cognitive (cognitive flexibility) [8, 19] on understanding mathematics, increase children's motivation and efficiency [11], and can increase children's awareness and achievement [7, 22].

Therefore, this article tries to discuss how the role should be played by technology in learning mathematics for children. This part will relate to didactical aspects of learning so that it is expected to enlighten teachers in designing technology-based mathematics learning for young children.

2. Method
The data in this article was gathered through a literature review. The literature review is performed by combining the literature, arranging it into a set of relevant subjects, and summarizing it by highlighting the key points to be explored [23]. The Literature review approach is used in this article to obtain all relevant information from written sources such as journals and books that have been published about using technology in young children's mathematical learning. The phases of the literature review that were completed are as follows: [24]: (a) planning, (b) organizing, (c) draft-ing, (d) editing, and (e) redrafting.

To identify the topic and select the literature for review (planning), we analyze, synthesize, and evaluate articles that become a reference (organizing). This study tries to review the articles and books with the keyword ‘technology in young children, young children learn mathematics using technology, and technology in a didactical perspective’. The documents used as sources in this study are limited to documents published in the last ten years. However, some documents are inevitably published in fewer than ten years,
which is used to show technology development. These documents are tracked through websites such as google scholar, SpringerLink, ScienceDirect, and ResearchGate.

In addition, the search for topics or themes to be explained is based on the deductive approach we took, where work procedures move from top to bottom or general to specific [25] related to the process of learning mathematics in young children, teachers, students and artifacts or technology used [26, 27].

3. Results and Discussion

3.1. Technology in mathematics learning in terms of didactic aspects
The vital relationship between humans and different technological devices in this life is one example of how technology has become a significant feature of education. Of course, in this global information society, the ability to use several technological resources is a prerequisite for success [9, 28-29]. Digital technology is one tool that can play an essential role in the creation of mathematical knowledge and skills since it is a potent and expressive tool for learning [30]. The use of ICT-based digital technology in teaching has been used for a long time; for example, in math classes, technology in the form of a basic calculator has been used since 1970 [9]. Then the development of technology becomes more rapid with the discovery of computers and various sophisticated software from time to time. Even a simple calculator develops into a multi-functional tool, which can integrate graphics, produce symbolic, statistical, and dynamic geometry manipulation, and provide website-based applications.

At first, the general philosophy in learning mathematics was based on the idea of a "didactic triangle" between students, teachers, and mathematics material, as shown in figure 1. According to Tall [27], the didactic triangle depicts mathematics as part of a system of knowledge shared by those who have first understood it, in this case, the teacher. Mathematics is in the mind of the teacher. Physical representations are usually only contained in textbooks. In this case, mathematics is static in the form of fixed words or images. Dynamic representations can only arise through the verbal explanation of the teacher and can also through diagrams illustrated by the teacher.

![Figure 1. Didactic triangle [27]](image)

As technology develops rapidly, of course, this also impacts the world of education, especially the idea of a didactic situation. The era of globalization requires the world of knowledge to continually adjust technological developments to improve the quality of education, especially in the learning process.

Within the scope of mathematics education, the potential use of digital technology in improving the quality of mathematics learning is now widely recognized. Technology offers students new opportunities to
communicate and analyze their mathematical thinking quickly and accurately; collect and analyze data, and explore relationships between numerical, symbolic, and graphical representations [9]. The National Council of Teachers of Mathematics (NCTM), the largest association of mathematics teachers globally, even states technology as one of the six principles in school mathematics. Technology is considered very important in teaching and learning mathematics [31].

Recognition of the importance of technology in mathematics learning also impacts the current shift in mathematics education philosophy. Technological advancements bring a new dimension to the learning situation. Previously, only students, teachers, and mathematics were the essential components of the didactic triangle. Then, today's technology (also known as computers [27, 32]; or ICT devices [33] which is the fourth component that forms didactic tetrahedrons in the appropriate educational context.

Integrating technology brings a new component into the learning system and creates new relationships between the didactic triangle elements. There are four interrelated triangles and are seen as a unit to form a tetrahedron. The four triangles are the teacher-student-mathematics triangle, the teacher-student-technology triangle, the teacher-math-technology triangle, and the student-math-technology triangle. Each triangular surface of the tetrahedron model consists of a specific perspective on the role of technology in mathematics education. The didactic triangle (student-teacher-mathematics) is the basis of the tetrahedron model. This relationship represents the learning process as an interaction between the teacher, students, and mathematics material. There is a planning/teacher preparation process in preparing devices and learning paths based on the subject matter that must be delivered, the teaching process by the teacher to students, and the learning process experienced by students when dealing with mathematical material.

Figure 2. Tetrahedron models of didactic situations [20-21, 26-27]

The teacher-student-technology triangle describes the learning process as an interaction between teacher, student, and technology. The interaction between teachers and technology will positively impact the effective use of technology in learning. Teacher-student communication in the context of this triangle shows the teacher's role directly in mediating students' use of technology in learning mathematics. Student-technology interaction highlights the phenomenon of students' use of technology in the learning process. The use of technology by students enables students to explore mathematical work. So that student interaction with this technology can facilitate students in the process of building knowledge.
The teacher-technology-mathematics triangle depicts teacher activities mediated by the instrument (technology) in planning and implementing mathematics learning. Teacher-technology interaction shows the role of the teacher who is required to be able to analyze and decide what technology or learning media is appropriate for each material to be taught so that the learning process takes place effectively and supports the achievement of learning objectives. The teacher-mathematics interaction in this triangle can be represented by the verb "to transpose," where the main activity is the first part of the didactic transposition of mathematics as scientific knowledge to mathematics as the knowledge that must be taught. Therefore the mathematical-technological side illustrates that technology can be used to explain a mathematical material. Different mathematical materials might be sufficient if described with different technologies as well.

The technology-mathematics-student triangle illustrates the learning activities of mathematics mediated by technology. This triangle represents phenomena related to learning mathematics with technology, where students' conceptualization of mathematical concepts is mediated by technology. Technology is seen as a new approach to presenting a mathematical theory (technology-mathematics). Technology also acts as a medium that helps students in learning mathematical material (student-mathematics). Then, the student-technology side highlights the phenomenon of the use of technology by students in the process of learning mathematical material. The role of the teacher concerning the student-technology-mathematics triangle is indirect.

Therefore, the teacher is tactically an essential component in any learning situation. In learning, the teacher's role cannot be eliminated, but rather the part of the teacher changes, and the teacher becomes a facilitator. Students then actively manage their steps of learning and develop valuable stimuli [17]. This is also supported by [34], where according to him, the design, the role of the teacher, and the educational context are essential factors that influence the success of technology in education, especially mathematics education. The role of the mathematics teacher is significant in learning with the use of technology. The teachers manage the mathematical teaching process that has technology-rich (substantially different from traditional teaching). Still, the teacher's central role is also to prepare technology, design appropriate assignments, arrange activities, and manage the course of learning, such as building student motivation and assessing student learning progress.

In the student-technology-mathematics triangle, for example, there are two teacher roles in his instrumental activities. First, the teacher should choose and decide what tools (technology) to use and use in learning. Second, the teacher can be an intermediary in using tools by students when learning takes place. Teachers must be able to identify and structure teaching and learning situations through specific models that present essential elements that influence learning in the classroom. These crucial elements are none other than mathematics, students, technology, and the teacher itself [32]. The whole tetrahedron is a comprehensive model of the didactic situation of mathematics learning. This means that the combination of the four components is interrelated to one another in learning mathematics with additional elements of artifacts, namely the use of technology.

To fulfill this central role, teachers must possess mathematical knowledge, artifacts (media), didactic knowledge of mathematics, and didactic knowledge of objects. Meanwhile, Drijvers [34] notes that designing and implementing mathematics learning with a technology need a professional development process that includes instrumental genesis or technological and pedagogical knowledge development. Previous research [35] has proven that teacher professional development improves student achievement and performance.

According to Goodwin and Highfield [4], digital technology is based on the constraints of the underlying pedagogical aspects, namely: instructive, manipulable, and constructive. Procedural learning is facilitated by instructive digital technology, which relies on evaluative feedback and repetitive encounters with forced representation. Meanwhile, manipulable digital technology enables students to engage in exploration and experimentation by manipulating forced images. Furthermore, in which students generate their representations, constructive digital technology is often the aim of the practice, enabling mathematical
modeling and what Noss and Hoyles [36] refer to as the expressive use of technology. Although instructive technology may be sufficient for procedural learning, manipulable and constructive technology, according to Goodwin and Highfield [4], better supports conceptual awareness. Therefore, related to pedagogic aspects, teachers must know about appropriate technology to teach specific concepts. This aligns with what was delivered by King [37] that technology can also be used to learn children with special needs with customized plans and features.

Regarding the use of technology in didactic design in early mathematics classes, teachers must ensure that the technology used is under the mathematical concepts being taught. Teachers must consider students' prior knowledge when using any technology to align the pedagogical approach with the needs of students. The teachers must ensure in their didactic design that a plenary session should take place after the use of technology (instructive and constructive multimedia) to focus students' attention on aspects of mathematics [4, 9].

3.2. Technology in early mathematics program

Technology has a significant role in today's world, and sometimes its presence takes over social work. Of course, technology has both positive and negative sides [3, 9]. Technology is an innovation that can be introduced in early mathematics programs, elementary school level [7, 17, 22, 38] or early childhood education program [4, 11, 39]. The implementation of technology in this level of education certainly raises many questions that need to be answered as to whether technology is good for early mathematics programs? When is the right time for teachers to use it? How important is the use of technology in early mathematics learning?

The same as students in general, children at the elementary school level and their teachers are also targets that are directly affected by technological progress because they are the ones who have to use it [11, 40-41]. Teachers must immediately leave the learning process traditionally and change it into adaptive and technology-based learning to help students in the learning process. It is essential to realize that learning with the help of technology at the elementary school level provides many benefits and advantages, including: (1) can develop motivation and interest in learning in students; (2) can help improve the cognitive aspects of students, and (3) can offer instant learning feedback [11, 38].

Many studies report that using well-designed technology in the mathematics learning process can maintain children's attention, motivation, and achievement [3, 5, 9, 22, 42]. Children in cognitive development need attention and motivation in learning. Because basically, cognitive development is related to intellectual abilities such as attention, memory, problem-solving, language, academics, and daily knowledge [43]. According to Berk [43], children in childhood up to secondary education are more selective in controlling their attention, so using a computer will trigger interest and increase their awareness of learning. Technology in the form of computer equipment can be used as a learning tool that helps improve these cognitive aspects.

Dunlosky [42], on the other hand, contends that teaching methods must ensure children's development, both cognitively and linguistically, in order to improve their development and create strength in front of each student. Mathematics must be combined with other activities and structured in such a way that students effectively explore their environment, work through and exploit real-world tasks, and participate in discovery activities in learning environments focused on games [44]. Indeed, coming up with unusual combinations and partnerships, having fun, and encouraging students to connect with another is difficult. However, it is thought to encourage learning progress.

Regarding the learning environment, Lee [45] reports his findings of the attitudes of children (elementary schools) in integrating technology in their learning environment. Interviews with students revealed that: (a) their interest in learning increased because they were attracted by animation, (b) students could easily access to other websites to explore and search for more information both themselves and with the guidance of the teacher so students felt they were always can use technology to access information to achieve better scores;
(c) many of them prefer to do exercises on the computer because they can get feedback immediately after completing the problem and the task (without any shame if the scores obtained are not on target); (d) students feel flexible because they can always continue to the next exercise when completed the assigned task; (e) students have more time to think for themselves; they get more satisfaction from their achievements. Overall, the results of research Huang, Liu, & Chang [35] revealed that an integrated online learning environment could attract young children interested in learning and allow students to explore on their own even with the minor help of the teacher. This study’s implication in learning mathematics is that technology designed with good planning and paying attention to didactic aspects and children's characteristics will have an excellent impact [3-4, 9, 11, 46], because basically, the technology that is used wisely and appropriately will contain the power to have a significant influence on student attitudes and behavior and can increase student engagement and motivation. The conclusion is that the teacher remains a vital element in the design of learning using technology.

3.3. Some Findings
The use of technology in classrooms was introduced more than five decades ago, since the use of calculators for the first time in 1970 [9, 46]. Of course, as its development, technology provides advantages and disadvantages [3, 9, 38]. Some of the concerns illustrated in some studies include the use of technology feared to have a negative effect on the achievement of understanding mathematical concepts, as well as the use of technology in early mathematics programs [4, 9, 17, 35]. However, these concerns seem to be refuted through the results of some studies conducted consistently (meta-analysis of research), which show that the use of technology in the classroom has a positive impact on student achievement and student attitudes towards mathematics [7–9, 19–21, 47].

Concerns about the use of technology in children are primarily due to children's psychology. Parents and educators doubt when the right time to give technology to children, while the relationship between technology and mathematics is more about how bad or good the influence of technology on understanding mathematical concepts. Therefore, the use of technology in children has become something important to discuss. Several studies mention that technology such as computers contributes to early childhood education, especially in core areas such as language, literacy, and mathematics [46]. This potential will be achieved depending on the technology used and how technology is used. This confirms that primarily technology in learning mathematics in children holds great potential in developing knowledge related to mathematics. However, this is inseparable from the teacher’s role in choosing, determining, and even designing what technology is appropriate for learning. The National Association for the Education of Young Children (NAEYC), in partnership with the Fred Rogers Center for Early Learning and Children's Media [3], released a position statement promoting the use of interactive technologies by young children:

"Technology and interactive media are tools that can promote effective learning and development when they are used intentionally by early childhood educators, within the framework of developmentally appropriate practice, to support learning goals established for children."

Therefore, teachers must utilize the enormous potential of these technologies by using strategies and approaches appropriate to the child's development and the mathematical concepts taught. Regarding mathematics, Goos [9] emphasizes that technology provides opportunities for students to learn mathematics more actively, such as experimenting, investigating, and solving problems, so students are encouraged to think creatively. The same thing was said by Olive and Makar [14] that mathematical knowledge and mathematical practice could not be separated even the relationship between the two can be more durable with the use of technology.

The strategies that teachers can use in applying technology in learning to children are suggested that the technology used is based on children's development. NAEYC emphasizes that Technology can enhance
cognitive and social learning when it supports "play, creativity, exploration, pretend and active play and outdoor activities." So the teacher's role in choosing and designing technology suitable for the learning of mathematics to be taught is enormous. To fulfill this central role, teachers must have sufficient mathematical knowledge, knowledge of the media, didactic knowledge of mathematics, and didactic knowledge related to technology (technology literacy).

4. Conclusion
The learning process using technology is increasingly believed to be helpful, especially in primary schools. Young children, which are the most crucial age in developing mathematical concepts, spearheaded mathematics education's success at the next level. The utilization and integration of technology in mathematics learning at this level is expected to facilitate and support effective mathematics learning. The use of technology from a didactic and pedagogic perspective plays a significant role in primary education. Didactically, the part of technology does not eliminate the teacher's role in the teaching process but rather makes the teacher as a facilitator in choosing the right technology in the learning design that is being designed. Likewise, in the broader realm of pedagogy compared to didactics, technology in mathematics learning in young children can stimulate thinking and skills and increase student motivation in knowledge. Therefore, attendance and implementation in primary schools is not something that needs to be avoided but must be utilized as well as possible by educators.

There are many ways that teachers can do in playing their roles as facilitators and promoters to integrate technology in learning mathematics for children. Among the things that the teacher can do are: (a) Using technology in learning in a purposeful way that is similar to other mathematical learning material such as blocks, art supplies, toys, books, and task instruments; (b) Teachers can make students aware that technology is one tool that they can use to record, store, revisit and share what they learn from their lessons every day; (c) Teachers must also be able to realize that technology can be a tool which makes it very useful for them to introduce mathematical concepts that have limitations to be presented directly for example in demonstrating 3-dimensional objects to children. Next, what needs to be stressed is the teacher's knowledge about technology literacy has the most crucial role in realizing the effectiveness of mathematics learning by utilizing technology.

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