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Epistemological Perspective of Mathematical Philosophy On Technology-Based Learning

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ABSTRACT

This research is a literature study (library research) that uses a qualitative approach. This research aims to examine the extent to which technology plays a role in mathematics learning from the perspective of the epistemology of mathematical philosophy. The study of the epistemology of the philosophy of mathematics that is being discussed is how the development of the philosophy of mathematics influences technology. What is the relationship between the philosophy of mathematics and technology-based learning? As well as examples of technology-based mathematics learning models. The results and discussion of this article can be concluded: Philosophy is a science that has a close relationship with human life. The philosophy of mathematics influences the development of technology in general. Technological developments influence the development of learning. From a learning perspective, technology is not only something related to machines, but also related to people, ideas, and activities in learning. The use of technology in the form of hardware and software can improve student learning outcomes. Currently, there are many software tools available for use in learning, such as GeoGebra. Choosing the right learning model and mathematics learning technology can make learning more effective.
Keywords: *philosophy of mathematics, technology, technology-based learning.*

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INTRODUCTION

The process of learning mathematics at school is a complex thing. Mathematics education experts continue to study and research models, methods and approaches that are most suitable for teaching mathematics (Arifin, 2018; Asriningtyas et al., n.d.). The model developed must not ignore the conditions and characteristics of students but also not reduce the meaning of mathematics (Fadhilah Zamzam, 2017). Basically, education does not only convey the teacher's ideas and thoughts, but also the teacher must be able to interact with students so that students can come up with brilliant ideas (Sullivan, 2011). Therefore, educators must know more about who their students are. If the teacher does not have this, interaction in learning will not be achieved optimally. Students are humans who have differences in terms of abilities, talents, interests, character and so on (Sumirattana, Makanong, & Thipkong, 2017). For this reason, as a teacher, you need to know the character of your students to find a more suitable learning method, so that students can develop optimally.

The development of mathematics lessons cannot be separated from the philosophy of mathematics (Ernest, 1991). Mathematics is considered the mother of all existing fields of science, in its development mathematics plays an important role in other fields. The results of mathematical studies are widely used in various fields, for example mathematical logic is used in computer programming languages, architecture uses mathematics to design houses, politics uses existing statistical systems in counting votes and population censuses (Erita, Desyandri, & Alfiyanti, 2022) Mathematics itself cannot be separated from the philosophy of mathematics which involves critical thinking, logic and strong reasoning Nurhayati, Syukri, & Badarussyamsi, 2021). Philosophy emerged because humans felt amazed and surprised. Initially, humans were amazed and surprised to see natural phenomena, because human nature is never satisfied, human problems are increasingly complex so that not all problems can be answered satisfactorily (Novita Sari & Armanto, 2022)

Philosophy is the mother of science, as time goes by the development of science becomes more specialized and independent. Philosophy provides radical and substantive answers and explanations to problems. Philosophy of mathematics explains the nature of mathematical science and examines the assumptions and foundations of mathematics (Suyitno & Rochmad, 2015). Epistemologically, the philosophy of mathematics tells the origins of mathematics and how a system of mathematical sciences was formed. Apart from that, the development of science is increasingly advancing day by day, marked by the emergence of various new sciences. One of the impacts of the development of science is that technological development is increasingly rapid. Technology is used in various sectors of activity. The role of technology in human activities is very large. Technological developments have an influence on the world of education, especially in the teaching and learning process. In order for learning activities to be more effective, media is needed that can support the absorption of as much information as possible. Currently technology can be a learning resource, learning media and even a classroom for learning.

Technology that is understood by ordinary people is something related to machines, but learning technology has a

broader meaning, namely a combination of human elements, machines, ideas, procedures and management. Learning technology can be seen as a product and process (Oktaviyanthi, n.d.; Sulistyorini, 2021). As a learning technology product, it is a concrete object, namely radio, television, projector and so on. In terms of the technological education process it is abstract. Technology can improve quality and reach if used wisely. Technological developments lead to the birth of new ways of life, currently various activities starting with the letter e are booming, for example e-books, e-libraries, e-lanoratory and others based on (Erita et al., 2022; Utama & Wibawa, 2021). Effective learning activities require media that supports the absorption of as much information as possible. Technology plays an important role as a source of information related to the material to be taught.

One of the goals of the philosophy of science is to emphasize that science and technology are instruments, not goals. The aim of this research is to clarify the role of mathematical philosophy in technology-based learning. Philosophy of mathematics and promotes independent thinking and critical thinking towards technological developments. This shows the importance of academic philosophical mathematics critical analysis and contributions to science and technological development

METHOD

This research is qualitative research using literature study techniques. A literature study is a summary of the essence of previously existing research related to a specific problem to provide readers with more detailed information regarding the issues raised in the article (Denney & Tewksbury, 2013). Literature study is a research activity that collects data from the library, reads and notes and then manages it. This is done to show the foundation of thinking to build a theoretical framework, a basis for thinking and a basis for preparing research hypotheses.

In this research, data collection was carried out by collecting articles from various journals. Meta data search using the Google Scholar database via the Publish or Perish program. The database search was limited to the last 5 years, namely from 2019 to 2023. Articles were obtained from various journals indexed Sinta 6 to Sinta 1. Key words for the journals collected were Philosophy, philosophy of mathematics, Technology-based learning. Identify articles through screening (n = 200) from Google Scholar (2019 – 2023) using Publish or Perish, then carry out the article screening process (n = 167). To see eligible articles, read the titles and abstracts to conclude that there are only 26 articles. Next, the entire contents of the article were read so that 12 articles were studied in this research. There are 3 articles for Philosophy, articles taken from 2020 to 2022. For philosophy of mathematics, 5 articles were selected from 2021 to 2023. Meanwhile there are 7 articles for technology-based learning taken from 2019 to 2023.

RESULTS AND DISCUSSION

According to Aristotle, philosophy is a science (knowledge) which includes truth which contains the sciences of metaphysics, logic, rhetoric, ethics, economics, politics and aesthetics (philosophy of beauty) (Nurhayati et al., 2021). Meanwhile, according to (Putawa, 2022) philosophy is a field of knowledge that discusses

everything, including the God of the universe and humans. Al Farabi said that philosophy is the science of natural forms and the true nature of truth (Mariyah et al., 2021). Philosophy is the study of science that involves critical thinking, philosophical reflection and involves fundamental questions about life and the world (Kivunja & Kuyini, 2017) . The philosophy of mathematics fundamentally reviews the existence and nature of mathematics. Concepts such as whether mathematics is only a human construct or exists independently have an impact on how technology is used and developed (Ratnaya, 2011). The growth of the philosophy of mathematics and technology is increasingly rapid day by day and has a huge impact on everyone's life. It can be said that every inch of human life has been touched by technological progress. The philosophy of mathematics and technology are not simple entities because they are interrelated and have intrinsic drives and creative instincts in humans (Ernest, 1991; Nurhayati et al., 2021). There is a relationship between the philosophy of mathematics and technology. Mathematical philosophy provides important supporting materials for technological progress, namely in the form of theories. Meanwhile technology really helps expand scientific research which is the study of philosophy

The philosophy of mathematics helps in the development of mathematical tools used in technology. Epistemologically, the philosophy of mathematics considers how technology develops, whether it is subjective or objective, can mathematics be used as an effective tool to understand the universe? This is because the mathematical language is universal so that it can be used in the development of modern technology. Research in mathematical epistemology helps understand the foundations of mathematics. Increasingly advanced and developing mathematical theories allow us to develop more sophisticated tools and technology (Erita et al., 2022) Mathematics can also influence the development of artificial intelligence (AI). Knowledge of the mathematical nature and limits of knowledge in AI can help us understand the possibilities and limitations of this technology. Understanding the nature of mathematical knowledge helps improve algorithms and develop more efficient technology. The following are 2 examples of developments in mathematical philosophy that influence technology

1. Development of programming languages and special mathematical tools for computing and modeling purposes in technology. For example, integer theory is very important in the development of cryptography for data security ((Ruslan, 2019)).
2. Algorithm Development: Mathematics is the basis of many algorithms used in technology. The development of AI algorithms, such as artificial neural networks, relies heavily on mathematics such as artificial intelligence. Technologies such as virtual reality (VR) and augmented reality (AR) can change the way students interact with mathematical material and research results.

The rapid development of technology greatly influences various sectors of human life. The effects resulting from technology can be positive and negative. According to Jacob (1988) there are seven negative impacts produced by technology, two of

which are:

1. Human functions and roles at work have been replaced by technology. Starting from the industrial revolution, human power working in factories was replaced by steam engines that developed at that time. Many jobs done by humans are being replaced by robots. For example, using automatic machines to pay toll road tickets, there are many other examples.
2. Dependence on technology. People feel they cannot live without technology, their self-confidence decreases if they don't use technology at work. Feel that technology is a measuring tool that allows someone to do work

DEVELOPMENT OF MATHEMATICAL PHILOSOPHY TOWARDS LEARNING MODELS

The use of philosophy as the mother of science is important for exploring various problems in education, which is part of a critical process to improve and increase the quality of education. Learning models are used to make it easier to achieve learning goals. The use of learning models must be adapted to the material because not all material is suitable for the learning model used. One learning model that is appropriate to mathematics is Problem Based Learning (PBL)(Sadijah, Murtafiah, Anwar, Nurhakiki, & Cahyowati, 2021). The PBL model was developed based on constructivist learning theory so that students are conditioned to construct their own knowledge to develop their thinking abilities. Students are given real problems related to everyday life, it is hoped that they can solve these problems with various solutions. The PBL model stimulates students to think creatively. Epistemologically, the PBL concept is in accordance with the concept of mathematical philosophy. According to mathematical realism, mathematical knowledge is an entity that exists independently within the student. In PBL students are introduced to problems as an effort to get students to explore mathematical concepts themselves (Hadi, Retnawati, Munadi, Apino, & Wulandari, 2018; Kurniati, Harimukti, & Jamil, 2016). In PBL, the concept of constructivism in philosophy is very embedded. It can be seen that mathematical knowledge is built by individuals through experience and personal construction. Students are asked to develop solutions to mathematical problems they face with personal understanding. The following is the PBL syntax.

1. Orientation: Students are faced with a problem, the problem given must be a problem that provides many hypotheses, so that students are used to thinking creatively to solve the problem.
2. Organizing students. Through group learning, social interaction occurs, so students are able to communicate and work as a team to solve problems.
3. Conduct an investigation. Students work together in groups to solve problems. During this activity, students can carry out research or experiments to prove the assumptions they have made.
4. Present the results of the work. Students are trained to elaborate on the results they have obtained and then explain what they have found when carrying out investigations.

Mathematical knowledge can be built by interacting with other friends.

The social constructivism system is one of the systems built in PBL and is part of the philosophy of mathematics (Kusaeri, Hamdani, & Suprananto, 2019). PBL learning activities encourage students to act in making decisions based on the experiences they have experienced

Besides PBL, the learning model that is often used for mathematics learning is Project Based Learning. Epistemologically, PjBL shows how students gain knowledge through constructing activities with project-based learning. Philosophical studies with the PjBL epistemological approach are as follows:

1. Constructivism: So that students can build their knowledge, teachers prepare lessons using projects. The hope is that through this project activity students can build understanding and knowledge by interacting.
2. Contextualism: Projects prepared by teachers should be connected to real problems that reflect the real situation in society. As a result, classroom learning is more meaningful and effective.
3. Collaboration: The learning system in PjBl is carried out in groups, so that students will get used to interacting with friends to solve problems or work on projects given by the teacher.
4. Problem Solving: Through projects given by teachers to students, students will get used to facing problems and try to solve them.
5. Reflection: this reflection activity is very useful for students to understand the knowledge they have gained through projects created

MATHEMATICAL PHILOSOPHY OF TECHNOLOGY-BASED LEARNING

The development of mathematical philosophy greatly influences the development of learning, one of which is technology-based learning. One approach to the philosophy of mathematics is the constructivist approach. This approach assumes that students' mathematical knowledge must be built through interaction activities with the material. Technology can be used as a bridge to build students' understanding of mathematical material (Azmi & Salam, 2023). Mathematics software such as Geogebra, Autograp, mathlingo can make students active in discovering mathematical concepts. Students can explore various mathematical theories that they get from books by using mathematical software. The following is an example of painting a height line using geogebra

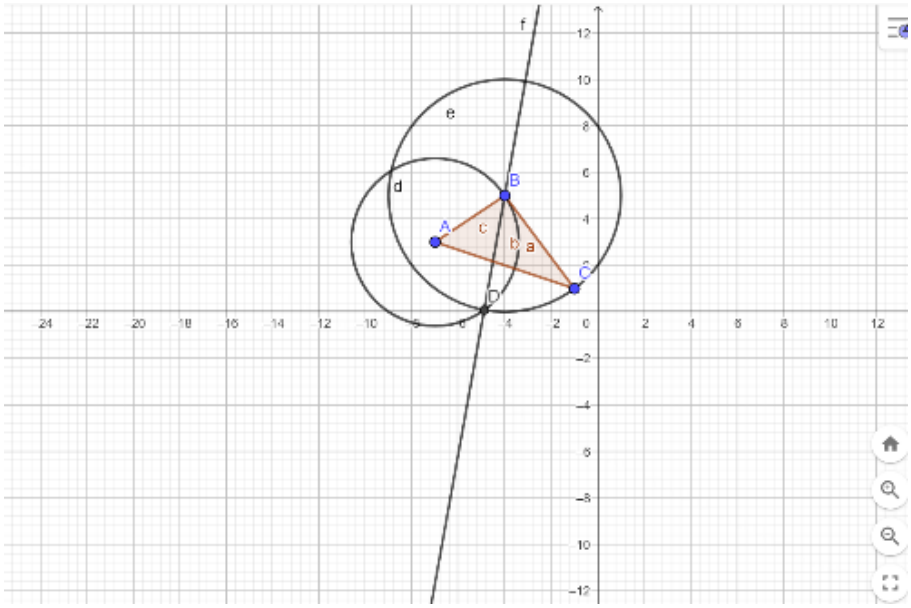

Figure 1. Drawing a height line using Geogebra

Epistemologically, to build mathematical knowledge, it is very important that learning is carried out collaboratively and interactively. Students can experience mathematical concepts directly through visual and interactive experiences (Ernest, 1991). Currently, learning using technology is able to facilitate students' learning in a collaborative way so that it is more efficient (Hasratuddin, 2010)). Learning is no longer constrained by distance and time. Students can have discussions anytime and anywhere. For example, by using WhatsApp, students can do video conferences to discuss mathematics assignments, without having to come to other students' homes. Technology enables mathematics learning outside the traditional classroom and certain lesson times (Nurhayati et al., 2021). Students can access math resources anytime and anywhere, which changes the dynamics of learning.

Technology also promotes the idea of lifelong learning. Students, both children and adults, can continue learning mathematics by accessing various online resources and courses (Erita et al., 2022)). In addition to collaborative principles, mathematics learning needs to connect real world concepts with practical applications. In this case, the use of technology can help students see how mathematics is used in real situations through simulation activities using applications.

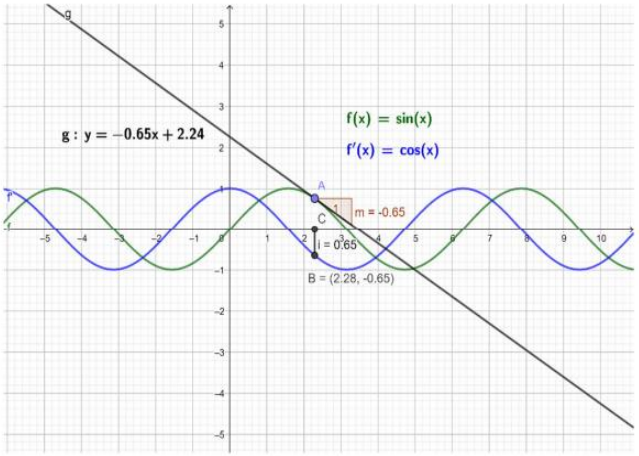

Figure 2. The use of geogebra for algebraic and graphical representation

Epistemologically, in the assessment and feedback process, mathematics learning is a continuous process (Suryadi, 2015). The use of technology in learning to carry out various assessments such as formative assessments, direct feedback, and more precise measurements of students' understanding, which allows them to continuously improve their understanding (Ratnaya, 2011). Technology that can be used such as the Geogebra class room where teachers can give assignments and provide assessments, live worksheets are websites that provide space for teachers to prepare test instruments online then after students take the test students will get the results. Another example is the use of technology for the State Civil Service (ASN) entrance exam, where the test results are immediately visible. Technology-based learning recognizes that mathematical knowledge can come from various sources. In addition to teachers, texts, and books, digital resources such as instructional videos, simulations, software, and online resources can be important sources of mathematical knowledge. Technology applies the concept of lifelong learning. Both children and adults can continue to learn mathematics by accessing various online resources and courses

CONCLUSION

Philosophy studies the origins of the development of a science. Mathematics is a branch of philosophy. The development of mathematics and mathematical philosophy has encouraged the development of various sectors, one of which is technology. Currently, not one inch of our lives can be separated from technology. Technology in learning is not just electronic items, humans, learning tools and ideas are part of learning technology. Learning has also experienced rapid progress as a result of technology. The existence of learning software and other technological tools makes the learning process easier. One of the software that can be used in learning is Autograp. With Autograph, drawing function graphs becomes easier. One learning model that can be used in mathematics learning is the problem based learning model. The PBL model was developed with the principles of constructivist learning theory. The principle of constructivism is closely related to the philosophy of mathematics. This research provides

information on how philosophy and philosophy of mathematics influence the development of technology-based learning. For future researchers who are interested in studying similar topics, it is recommended that they conduct a study regarding the vision of mathematical philosophy towards technology-based mathematics learning. Meanwhile, teachers can apply the use of technology in learning to increase students' interest in learning, while students can develop technology that can be used in positive ways, especially learning.

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