The Role of Technological Pedagogical Content Knowledge in Analyzing the Adoption of Constructivist Thinking in Primary-Level Mathematics Education

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Abstract: This study aims to describe the utilization of Technological Pedagogical Content Knowledge (TPACK) as an appropriate strategy for examining the implementation of constructivist pedagogy in the context of mathematics education at the primary school level. The present study employs a qualitative research design, specifically a phenomenological approach. The study was carried out at SD Negeri 25 Lubuh Lintah. The data collection techniques employed in this study include observation, interviews, and documentation. The teacher must facilitate a pedagogical approach allowing students to discover and understand basic concepts independently. Learning is still dominated by the teacher, who primarily provides notes. Students only copy notes written on the whiteboard by the teacher. It affects the stimulation of their minds, which is less productive. The findings of the analysis on applying constructivist ideas in mathematics in primary education indicate that the learning activities being implemented do not follow the basic principles of constructivist pedagogy. Implementing technology pedagogical and content knowledge (TPACK) models for teachers or educators is the best way to overcome the learning challenges teachers and students confront.

1 INTRODUCTION

Education plays a crucial part in every aspect of human existence and directly affects how a person develops in every aspect of his personality. According to PAI Admin (2019), philosophy offers guidance and a systematic approach to educational practice, whereas educational practice offers subject matter for philosophical contemplation. One perspective that has influenced the field of education is the concept of constructivism. The philosophical school of constructivism significantly influences various concepts within science, learning theory, and the learning process. Constructivism, as the fundamental concept of the learning paradigm, points out the imperative of active engagement for students in learning, in which they construct their knowledge through real-life situations (Umbara, 2017).

The philosophy of Constructivism emphasizes the capacity for adaptation, as highlighted by Yusdita et al. (2022) in their research. They argue that constructivism requires individuals, including students, to utilize their abilities to effectively adjust to the evolving demands of educational progress following current circumstances. In this scenario, students must show a higher engagement than the teacher. Students ought to be able to acquire knowledge independently rather than relying solely on transmitting information from the teacher. The author's research (Waston, 2014) highlights the significance of creativity and activeness as the primary mechanisms employed in the search for a fulfilling life. The constructivist educational approach places a significant emphasis on the active involvement of students in initiating their own learning experiences. The philosophy of constructivism is a scholarly discipline that explores the concept of knowledge as a process of self-construction. According to this perspective, individuals develop their understanding through active engagement with various entities such as objects, phenomena, experiences, and their surrounding environment. According to Nurhidayati (2017a), constructivism is a theoretical framework that involves the assimilation of knowledge derived from concrete experiences, facilitated by collaborative activities, and improved through processes of reflection and interpretation. Hence, it

can be observed that students have varying conceptions of knowledge, which are dependent on their individual experiences and the particular interpretive frameworks they employ.

The basic principle of constructivism is that all knowledge is constructed not for direct perception by the five senses but rather for interpretation by the human brain. Knowledge itself is nothing more than an accumulation of prior experience. This claim was confirmed by the author's research (Nurhidayati, 2017a), from which it can be inferred that the basic principle of the constructivist education of thought is that all knowledge is created rather than directly perceived by the senses (smell, touch, hearing, touch, and so on), contrary to what realists generally believe. (Haryanto, 2012) claims that thought is subjective in his work. As a result, according to the constructivist school of thought, knowledge is created via understanding and experience. The constructivism philosophy is influenced and more readily identified by the name "The Paradigm of Clutter" since the nature and outcomes of subjective thinking are unknown and depend on each individual.

The constructivism theory must collaborate with other concepts, such as the relationship between social interaction and biologically active learning, to be effective in practice. This statement is supported by research (Nurhidayati, 2017b), from which the author can draw the following conclusion: "There is no single theory of constructivism, but there are at least two main ideas that are the same; first, active learners are, biologically speaking, engaged in creating their knowledge; and second, social interaction is a crucial component in the creation of knowledge. Consequently, these two components lead to a person's behavior.

It is consistent with mathematics, which studies many abstract structures and their connections. For students to fully understand the abstract structure of mathematics, practical principles must be used during the learning process. The idea that arithmetic instruction should be relevant may be applied to learning, particularly in primary schools. It aligns with the constructivism education theory, which holds that there are two learning processes: teaching and learning.

According to constructivism, learning primarily focuses on helping students give meaning to what they are taught using their prior knowledge and understanding. By supporting the teacher's creativity as a learning mediator, more focus is placed on creating meaningful connections between prior knowledge and new knowledge in this process. According to the constructivist model of learning,

students prior information and ideas are modified to create new knowledge (Sani, 2013).

According to a constructivist perspective on learning, numerous key factors affect a learning activity's success, including (von Glaserfeld in Pannen et al., 2001: 3): a) The teacher's function as a mediator and facilitator in a variety of tasks: (1) offering educational opportunities that allow students to take charge of their designs, research, and procedures; (2) offering resources that encourage students to think critically; (3) inspiring students and exposing them to conflict; (1) Students are accountable for their learning results. The teacher assists students in evaluating their hypotheses and conclusions. They incorporate ancient knowledge into new learning contexts. (2) Students must have experience formulating and testing hypotheses, manipulating objects, finding solutions to problems, describing, researching, dialogue, holding reflections, expressing questions, and expressing ideas to form new constructions. (3) They must be able to judge what they learn by looking for meaning and comparing it to what they already know (Umbara, 2017).

Constructivism defines teaching as assisting a student in creating his knowledge. Teaching is not about passing knowledge from those who already know it (teachers) to those who do not (students), but rather about assisting someone in building their knowledge through activities related to the phenomena and objects they are interested in learning about. According to the constructivist viewpoint, several tasks need to be completed, and some ideas that the teacher has to be conscious of when instructing, such as: a) the instructor needs to engage with students frequently to understand what they already know and believe more fully. b) To involve students, goals and what will be made in class should be discussed. c) Teachers must comprehend which learning opportunities best meet the demands of their students. Participating as a student among other students is one way to accomplish this. d) Assistance with kids who are having difficulty learning is necessary. e) Teachers must be flexible in their thinking to comprehend and value students' ideas since sometimes students form opinions based on premises that the teacher does not share. According to constructivism, there are three main components of teaching: a) adaptation, which is accomplished through assimilation and accommodation; b) concepts in the environment; and c) the creation of meaning.

According to Piaget's theory of intellectual development, children in elementary school (6 - 12

years old) are in the concrete operational phase, characterized by high curiosities and special sensitivity in developing knowledge, skills, awareness, and attitudes (Marina, 2020). This line of constructivism is consistent with this theory. It is believed that integrating constructivism's principles with the characteristics of primary students can boost students' engagement and innovative thinking during the learning process. However, during its implementation at SD Negeri 25 Lubuk Lintah in grades 4, 5, and 6, the teacher's position was not yet recognized as a mediator and facilitator in the learning process.

The teacher has not provided the students with a learning opportunity that allows them to be in charge of studying the topics on their own. By merely providing notes, the teacher still controls the learning process. Only notes written by the teacher on the board are copied by the students. It undoubtedly affects how productively their brains are stimulated. According to constructivism, learning activities must allow students to gain experience by creating, testing, and manipulating hypotheses, solving problems, seeking solutions, describing, researching, holding dialogue, asking questions, and expressing ideas to create new constructions. By developing their pedagogical skills, teachers should be able to overcome the obstacles to applying this learning. Teachers can create learning activities customized to their students' needs or skills by mastering pedagogical competencies, and they can assess how well they are implemented (Nurhamida, 2018).

Learning demands in society 5.0 cannot be separated from the role of technology, communication, and information to confront the times, in addition to the need for teacher abilities in teaching or high pedagogical competency. The TPACK (Technological, Pedagogical, and Content Knowledge) paradigm may combine pedagogical and technological competencies to satisfy the expectations of 5.0. Due to its overview of integrating learning material, knowledge, pedagogy, and technology in learning, TPACK as a learning model can help educators become more professional in their teaching (Susilawati & Khaira, 2021). The researcher proposes TPACK as a solution for examining the application of constructivist thinking in primary school mathematics instruction because of the benefits of the model and its consistency with the learning that takes place. This study aims to describe TPACK as a response to the analysis of constructivism thinking's application to learning mathematics in primary schools.

2 METHOD

This study is qualitative and employs a phenomenological methodology. This strategy was adopted because the researcher wished to assess the phenomena that significant informants experienced. The research analyzes phenomena, social behavior, and individual or group thought. The study was conducted in grades 4, 5, and 6 at SD Negeri 25 Lubuk Lintah.

Purposive sampling is the sampling method used. For the findings of this study to apply to math instruction in lower grades later on, considerations for grades 4, 5, and 6 were sampled. It was done to see the phenomena that lead to concept failure encountered by high-grade students. The measures taken to gather data are (a) extending the data collecting time; (b) making regular, serious observations; (c) utilizing triangulation; and (d) involving colleagues in the discussion.

The following are the procedures and methods for analyzing research data: a). researcher completely recounts all phenomena and experiences of research participants; b). researcher identifies the statements (interview findings), describes them, and elaborates on them without repeating them; and c). The researcher identifies the statements (interview findings). The researcher uses all of his creative possibilities to reflect on his ideas, d) the statement is concluded in key sections, and a thorough account of the experience is written; e) the researcher develops all justifications for the significance and the core of the explanation, and f) the researcher summarizes his findings in a written report based on the experiences of all informants.

This study examines the learning and teaching processes in grades 4, 5, and 6 of SD Negeri 25 Lubuk Lintah's use of constructivist thinking in learning primary school mathematics. Interviews and observation sheets were the tools utilized to collect research data.

3 RESULTS AND DISCUSSION

SD Negeri 25 Lubuk Lintah locates at Jalan Masjid Baiturrahman, in the village of Lubuk Lintah, within the Kuranji District of Padang City, located in the province of West Sumatra. The school is situated in the central area of Padang City. The school presents three distinct challenges concerning nature, animals, and humans. The school's location, situated beneath a hill without any surrounding fences, allows

unrestricted access to numerous animal species, contributing to its natural environment. SD Negeri 25 Lubuk Lintah is under the leadership of a single school principal, Etifirza, S.Pd. The school is staffed by eight teachers, three education staff members, and one school operator. SD Negeri 25 Lubuk Lintah has obtained accreditation level C.

Constructivism is a general theoretical framework employed in educational and learning methodologies during its evolution. Constructivism is an epistemological perspective that centers on the active engagement of students in the processes of knowledge creation, interpretation, and reorganization, thereby emphasizing the individualized nature of these cognitive activities.

The constructivist approach is the foundation for numerous educational principles and movements, including emphasizing active student engagement in the learning process and cultivating independent learning skills among students. There is a growing recognition of the importance for students to possess the capacity to cultivate their knowledge independently. Additionally, there is a corresponding recognition of the role that teachers should play as facilitators, mediators, and managers of the learning process. Constructivism is a philosophical framework within the knowledge field that posits that knowledge is a product of individuals engaged in learning. According to Umbara (2017), knowledge is not simply a compilation of factual information but a cognitive construction that individuals develop based on their interactions with objects, experiences, and their surrounding environment.

Knowledge is not "something already there" that we can absorb but rather a dynamic construction of individuals who rearrange themselves to learn new things each time. According to constructivism, people create knowledge due to their interactions with events, objects, and surroundings. Constructivism begins with knowledge creation, and the reconstruction of knowledge refers to the alteration of information held by someone who has already been created or built. This alteration results from interaction with their environment (Nurhidayati, 2017b).

According to research done at SD Negeri 25 Lubuk Lintah, the teacher's position in the learning process has not yet been recognized as a mediator and facilitator. The teacher has not created a learning environment where students are free to explore the concepts they learn independently. By merely providing notes, the teacher still controls the learning process. Only notes written by the teacher on the board are copied by the students. It appears from teaching activities that the teacher has not interacted with students very much, and the learning environment offered does not meet the needs of the students. It is shown by the activities of students who engage in learning; nonetheless, student engagement or activity in learning is still relatively low. Activities that have not been included in activities that make reasoning based on students' roles. It undoubtedly affects how productively their brains are stimulated. According to constructivism, learning activities must allow students to gain experience by formulating, testing, and manipulating hypotheses, solving problems, seeking solutions, describing, researching, holding dialogue, asking questions, and expressing ideas to create new constructions. It allows them to create their own experiences, which helps the concepts become deeply embedded (Jabir et al., 2016).

The learning environment that the teacher has created for the students might be characterized as substandard in terms of constructivism and failing to prepare them for the integration of technical requirements required in 5.0. To achieve the required learning competencies and follow the times' demands, the teacher must maximize learning with the TPACK model (Fitria, 2021). From a constructivist point of view, this integration requires teacher competency to balance each element of technology expertise, pedagogy, and content to achieve balanced, successful learning.

Three categories of activities—adaptation of technical help, instructional design, and administrative aid—are used by TPACK to address these restrictions. The program's description, outcomes, and thorough documentation are provided below.

3.1 Technology Adaptation Assistance

3.1.1 Create Interactive Lessons

A teaching strategy that actively incorporates students in the learning process is known as interactive learning. Interactive learning utilizing technology is one of many interactive learning activities. Positive responses to the development of this technology are possible, one of which is for teaching strategies. Suggestions for educational films, motivational e-books, and other resources, for instance. Here, we offer educational opportunities like using anappropriate laptopto take ANBK tests at school and learn while playing the web. The scores were as high as 85%, and we observed significant student growth in using computers to complete

ANBK exams, as well as their active and passionate participation in learning while playing the web. Some of the children's achievements in this program included the following:

a. Students in grade 5 at SDN 25 Lubuk Lintah took the ANBK test.
b. The utilization of a Web link to implement playing while learning.
c. The students are more enthusiastic about learning.

Figure 1: Interactive Learning with Students.

3.2 Create Interactive Lessons

3.2.1 Introducing the AKM Kelas Application and Practicing the Use of the AKM Kelas Application to Students

The Ministry of Education and Culture (Kemendikbud) created the AKM class (Minimum Competency Assessment) as an educational program. The AKM activities in this lesson aim to assess how well the students have understood their subject matter. The literacy and numeracy categories emphasize this class's AKM exercises, which measure students' progress in these areas. The results were as high as 90%, and we observed significant student growth in using laptops to complete the AKM class tests. Additionally, they demonstrated activity and enthusiasm when completing the pretest and posttest for the AKM class, as seen in the following examples:

a. The class AKM pretest and posttest were successfully implemented
b. Students can already utilize laptops and computers during exams
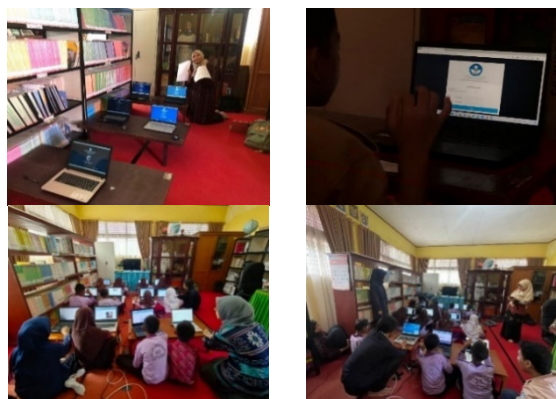c. Students who are enthusiastic when taking tests on laptops

Figure 2: Introducing the AKM Kelas application and practicing the use of the AKM Kelas application to students

3.3 Teach

3.3.1 Teaching Literacy and Numeracy to Students

Through mathematics and non-mathematics learning activities, numeracy literacy development strategies can be used at the classroom level. Then, at the school level, literacy activities can also be established through the infrastructure with numeracy nuances, providing interventions for high-risk students, and holding parent-involved numeracy activities. The development of numeracy and literacy must occur at the classroom, school, and regional levels by providing training for teachers, administrators, and supervisors.

The results we got from adopting this program, as evidenced by children who could not read before or could only spell, can now read and be as high as 80%. Compared to the prior Numeration exercises, when only a small number of students memorized multiplication from 1 to 10, the changes are much better now, with 8 out of 10 students memorizing it smoothly.

Figure 3: Teaching Literacy and Numeracy Activities to Students.

3.3.2 Provide Additional Lessons to Students that Still Lacking in Literacy and Numeracy

This program is available during school hours. This exercise wants to teach students who struggle with literacy and numeracy. The ability to think critically and absorb information is related to literacy. So, it goes beyond only spelling and reading comprehension. The supplementary learning offered at this school helps students' numeracy as well. The outcome of success rate used in this program is 70%. The introduction of this program is crucial because it addresses the literacy and numeracy gaps among students at SD Negeri 25 Lubuk Lintah. Students' accomplishments include:

a. Increasing literacy levels through additional learning activities
b. Students have started fluently in reading and arithmetic.

Figure 4: Provide additional lessons to students that still lack literacy and numeracy.

3.4 Administration

3.4.1 Creating a Literacy Corner

Schools use the literacy Corner program to stimulate students' interest in reading. It is not easy to grow a literacy movement. Building a literacy culture requires time, energy, and resources. It is believed that the literacy corner used in every area of the classroom is sufficient to encourage students to read frequently during breaks or while they wait for the change in class hours. Also, each class has text-rich environmental assistance, such as the displayed student work, picket schedules, and lesson plans. This literacy corner takes the shape of a reading corner in the back of the classroom. Ithas bookshelves, mats for the children to sit on, reading materials, and educational resources. The teacher gives lesson assignments by using sources from the available reading material in the classroom literacy corner, writing motivational words and poetry, affixing it to the class wall magazines, and participating in the school literacy corner program. 95% of this program's implementation attempts were successful. The following outcomes were attained as a result of the reading corner's implementation:

a. Increasing students' interest in reading at SDN 25 Lubuk Lintah
b. Making the classroom cozy and lovely when the teaching and learning process is taking place
c. Inviting children to read more and think critically
d. Bringing books closer to the students can increase their enthusiasm for reading

Figure 5: Create a literacy corner in each class.

3.4.2 6th Grade Entrepreneurship Activities

The entrepreneurship program aims to provide students with the resources they need to understand entrepreneurship, have entrepreneurial character, seize chances, and obtain practical experience in the field. Students are asked to prepare various inexpensive snacks that can be sold for affordable prices for schoolchildren, starting at Rp. 1,000. Examples of these snacks include corn dogs, balls of noodles, crispy mushrooms, and various drinks. 95% of the program has been successfully implemented. The outcomes attained by students are:

a. Students can comprehend how to practice entrepreneurship correctly.
b. Exercise risk-taking, inventiveness, and originality.
c. Encourage students to feel confident.

Figure 6: Entrepreneurial Activities in Grade 6.

Activities created after analyzing the educational environment and actual student learning can go smoothly and get a decent grade. Implementing TPACK in classrooms as teachers and students in the campus program work together effectively instruct. Students share their technological expertise, and teachers share their views on the subject matter and their pedagogical skills with the class. Good cooperation will help to determine whether the planned actions are successful.

4 CONCLUSIONS

According to an analysis of the use of constructivist thinking in primary school mathematics learning, the learning activities are inconsistent with constructivist understanding. The best way to get around teachers' and students' learning challenges is to use the technology pedagogical and content knowledge (TPACK) model for educators.

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