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THEORY AND PRACTICE OF CONSTRUCTIVE APPROACHES IN MATHEMATICS LEARNING

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ABSTRACT

The purpose of this study is to examine the theory and practice of constructivism in learning mathematics. This research is qualitative research using library research methods. Data was obtained by collecting various literature sources such as books, journals, and online research articles that are appropriate to the research problem. Data analysis in this study was carried out by content analysis. The research results show that teachers need to give students the freedom to experiment and provide relevant contexts for their theory development. In practice, teachers must consider that each student is unique and different in the way they understand and construct their knowledge. Therefore, teachers need to facilitate the learning process by considering the individual differences of students, ensuring that they have useful experiences and gain a deep understanding of the topics being taught.

Keywords: constructivism, mathematics learning theory and practice

ABSTRAK

Tujuan dari penelitian ini adalah untuk mengkaji teori dan praktik pembelajaran konstruktivisme dalam pembelajaran matematika. Penelitian ini merupakan penelitian kualitatif dengan menggunakan metode penelitian kepustakaan. Data diperoleh dengan mengumpulkan berbagai sumber literatur seperti buku, jurnal, dan artikel hasil penelitian secara online yang sesuai dengan masalah penelitian. Analisis data dalam penelitian ini dilakukan dengan content analysis. Hasil penelitian menunjukkan bahwa guru perlu memberikan siswa kebebasan untuk bereksperimen dan menyediakan konteks yang relevan untuk pengembangan teori mereka. Dalam prakteknya, guru harus mempertimbangkan bahwa setiap siswa memiliki keunikan dan perbedaan dalam cara mereka memahami dan membangun pengetahuan mereka. Oleh karena itu, guru perlu memfasilitasi proses pembelajaran dengan mempertimbangkan perbedaan-perbedaan individual siswa, memastikan bahwa mereka memiliki pengalaman yang bermanfaat dan memperoleh pemahaman yang mendalam tentang topik yang diajarkan.

***Kata kunci**: konstruktivisme, pembelajaran matematika, teori dan praktik*

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INTRODUCTION

Mathematics education is one of the crucial aspects of education for students worldwide. However, many students still face difficulties in comprehending complex and abstract mathematical concepts, which subsequently affect their low achievement in mathematics (Soviawati, 2011; Huda & Kencana, 2013; Ali & Jameel, 2016; Akkarya, 2017; Langoban, 2020; Yeni et al., 2020, Agustyaningrum et al., 2022). According to Sa'ad et al. (2014), students' low achievement in mathematics can be attributed to various factors, both internal and external. External factors, for instance, can originate from teachers, concerning their competence and teaching methods. Therefore, teachers need to understand appropriate learning theories that align with students' characteristics to design effective mathematics instruction. In this regard, learning theories can serve as a guide for teachers to address issues in mathematics education and enhance students' achievement. One of the learning theories that can be applied in mathematics education is constructivism.

Constructivism, within the context of mathematics education, is based on the belief that students construct their own understanding of mathematics through the experiences they encounter (Istiadah, 2020; Rahim et al., 2021). Students are not merely passive recipients of information from teachers but actively engage in the learning process and construct their own knowledge through their experiences. In the constructivist approach, the teacher acts as a facilitator who assists students in constructing their understanding of mathematics through various activities and discussions. Thus, students are given the freedom to explore and develop their own ideas about mathematics, which can help them comprehend more complex mathematical concepts.

The constructivist approach to mathematics education also emphasizes the importance of active student involvement in learning. In this regard, students are regarded as active knowledge builders, who actively participate in mathematics education and construct their understanding of mathematical concepts through their experiences (Sugrah, 2019; Wibowo, 2020). Constructivism also underscores the significance of understanding students' contexts and backgrounds in mathematics education (Umbara, 2017). In this context, students are considered to possess diverse knowledge related to mathematics, and thus, different strategies and approaches to learning should be employed to assist them in understanding mathematical concepts.

However, there are several challenges that arise in implementing constructivism in mathematics education. One primary challenge is that this approach requires more time to achieve learning goals compared to conventional instructional approaches (Hashim & Noh, 2017). Sufficient time needs to be allocated for students to experience and comprehend mathematical concepts before they can develop a deeper understanding. Although constructivism has proven to be effective in helping students construct their own understanding of mathematics, this approach also encounters certain challenges in its implementation. Therefore, it is important for us to understand the theory and practice of the constructivist approach in mathematics education.

MATERIAL AND METHODS

This study is qualitative research using the literature review method. Library research, also known as literature review, is a research activity conducted by gathering information and data from various written sources such as previous studies, notes, articles, and magazines related to the research problem (Sari & Asmendri, 2020). Data for this study were collected through internet searches with the keyword’s constructivism and constructivism approaches in learning mathematics. In this research, the data and information examined are the theory and practice of the constructivist approach in mathematics education. The researcher utilized various database sources, including Google Scholar, ResearchGate, ScienceDirect, Semantic Scholar, and the Education Resources Information Center (ERIC). Based on a literature search, 32 articles were obtained that were relevant to the research objectives. Subsequently, the researcher analyzed the collected references and relevant articles using content analysis method.

RESULT AND DISCUSSION

Constructivism

Constructivism is a belief system that metaphorically compares the construction of knowledge, or the process of knowing, to the construction of buildings and furniture (Ernest, 2010). The process of construction depends on the tools one already has, the ideas about the world one already has through experience. A person can build knowledge about something based on what they already know about it and how they conceptualize new experiences based on previous experiences. The knowing process is related to an individual's cognitive, emotional, psychomotor, mental, and metacognitive responses to changes in these beliefs (von Glasersfeld, 1995). Thus, a person's knowledge construction depends on what he or she already has in the form of prior knowledge and beliefs, and how new experiences fit into existing beliefs, schemes, or behaviors (Steffe & Kieren, 1994).

In the context of learning mathematics, individuals can construct knowledge about mathematical concepts based on prior knowledge and conceptions, as well as how they conceptualize new experiences based on previous experiences. The process of knowing in constructivism involves cognitive, affective, psychomotor, mental, and metacognitive responses to changes in these conceptions. Thus, a person's knowledge construction depends on what they have previously possessed in terms of knowledge and conceptions, as well as how new experiences can be aligned with existing conceptions, schemes, or new actions.

The teacher's role in teaching constructivist knowledge is to support or guide students through authentic situations, situations, challenges, and assessments (Christie, 2005). Teachers design classrooms as learning communities (Bielaczyc & Collins, 1999). The student's role is to be a learner by participating actively and constructively in tasks, situations, interactions, and problems. Students become active and creative members of learning communities and contribute to each other's learning (Cooperstein & Kocevar-Weidinger, 2004).

In general, we are familiar with two prominent perspectives of constructivism: radical constructivism and social constructivism. These two perspectives of constructivism are most used in research and mathematics education.

1. Radical Constructivism

Radical constructivism is a form of constructivism that has long been applied in research and mathematics education. The most famous philosopher associated with radical constructivism is Von Glasersfeld. The philosophical views related to radical constructivism consist of two basic principles:

1) Knowledge is not acquired passively through the senses or through communication, but actively constructed by the knowing subject.
2) The cognitive function is adaptive and serves the organization of the subject's experience of the world, rather than the discovery of an objective ontological reality (von Glasersfeld, 1995).

These two principles form the basis of radical constructivism as an epistemology in mathematics teaching and learning research and pedagogy. The Radical Constructivist paradigm sees the mind as an organism undergoing an evolutionary process (Wuketits, 1984). The evolution referred to is the cognitive restructuring of the world of experience that continues to adapt to perceptual or conceptual or mental schemes that become better articulated through the reorganization of that world (Ernest, 1995; von Glasersfeld, 1995).

Radical constructivist teachers may adapt different teachings based on a student's cognitive, emotional, and developmental stages. Teachers use creative and constructive situations to present, discuss, test, decide and apply problem-solving models to draw students' attention to the topic and its context (von Glasersfeld, 2001). Students develop ideas about what they learn through active and adaptive cognitive processes. These include reflective and reflexive thinking and reasoning about content, processes, and products (Leo, 1990).

Radical constructivist teachers do not play a leading role in the classroom. Instead, it brings democratic ideals into the classroom and enriches learning opportunities for students through participation in a variety of activities. These activities aim to create new experiences or apply previous ones while building knowledge through the student. Teachers see their role in the classroom as

facilitators or guides for students (Belbase, 2011). Teachers must consider the active role of students in learning and create an environment in which students feel comfortable learning at their own pace, abilities, and interests. Learning is not just about absorbing new information, but about building meaning and understanding what, how and why we do it. The focus then shifts to thoughts and meanings related to the learner's experience (Hein, 1991). Learning is an active process involving meaning construction, a mental process at the level of abstraction and a brain process at the physical level. Another characteristic of constructivist learning is that "Learning involves language. Learning includes language." Learning is a social activity. Learning is situational and learning takes time" (Hein, 1991). The concept of social activity and learning situations is consistent with Ernest (1995). He states that "all knowledge is constructed by the individual (the learner), based on cognitive processes in interaction with the experiential world" (Ernest, 1995). This understanding clearly suggests that learning is about self-awareness, the reorganization of one's experience while adapting to social, cultural, and natural environments. Radical constructivism considers the roles of teacher and student as collaborators, with the social, cultural, and natural environment as the backdrop for their (students') knowledge construction.

Radical constructivism does not mean without weaknesses and limitations. These limitations are related to social and cultural adaptations of knowledge. In this paradigm, the role of language and interactions among peers and communities of practice are poorly conceptualized. An overly focused focus on the individual processes of perceiving and constructing knowledge creates a dilemma. It is this dilemma that leads radical constructivism to social construction.

2. Social Constructivism

As Ernest (2010) states: ``Social constructivism sees the individual learner and social reality as inseparable relationships.'' and other connected individual networks (Vygotsky, 1978). Communication and interpersonal interactions play an important cognitive role. Rather than being considered only in the context of the individual, the mind is extended to broader social and cultural contexts, and meaning making is considered as a social phenomenon. Humans' role in constructing meaning is assessed in the broader context of their relationships with others (individuals and environments). The mind is a social entity that forms meaning through communication, interaction, and exchange of social and cultural ideas (Ernest, 1995). Socially constructed worlds are associated with world metaphors. The personal world is part of the collective social world. It assumes that there is no isolated personal reality far removed from the socially and culturally constructed world. A metaphor for the world is a world of socially and culturally connected experiences. It does not deny the existence of an absolute reality in the common world. But social constructionism is not concerned with the nature of reality in the social and cultural world. An individual's personal experience becomes a social and collective experience when it is shared, interacted with, transmitted, reconstructed, and maintained as knowledge. Knowledge of the world is constructed from shared experiences of the social, cultural, and/or physical world. Even the physical world is interpreted in social and cultural contexts. And mathematics teaching and learning is tied to social responsibility and values (Ernest, 1991 & 1998; Wilding, 2011).

Social constructionism has its own peculiarities. His three foundations of social constructionism in mathematics are:

"(1) The basis of mathematical knowledge is linguistic knowledge, conventions and rules, and language is a social construct. (2) Mathematical knowledge that can be objectively accepted after publication with subjective individual mathematical knowledge. (3) Objectivity (objective knowledge) itself is socially understood and accepted" (Ernest, 1999).

In the view of social constructivism, the role of the teacher is to create an interactive and constructive environment for students to learn through discussions and group work or peer collaboration. Students construct knowledge through interaction within and outside the classroom. They play an active role in learning and construct knowledge through participation, negotiation, and shared values.

3. Constructivism in Mathematics Learning

In the process of learning, including mathematics learning, the goal is to acquire knowledge. A teacher is expected to design learning in the best possible way to facilitate students in acquiring knowledge. A constructivist teacher is required to be a facilitator for their students. The teacher should not only directly provide knowledge to the students but also facilitate them in constructing their own knowledge. In the constructivist view, students are seen as active agents who create their cognitive structures and interact with their environment.

Constructivism assumes that people construct or can construct knowledge through their interaction with their environment (Amineh & Asl, 2015; Ginting, 2018). Constructivism emphasizes how individuals learn rather than how teachers teach (Suparlan, 2019). Knowledge is subjective and relative. Subjective experience forms understanding. Knowledge is therefore forever dynamic according to the subject's experience in interacting with the social and cultural environment (Rusman, 2017). The constructivist learning paradigm is an alternative paradigm resulting from changes in the education system in the industry 4.0 era (Miranda et al., 2021).

Teaching is not the transfer of knowledge from the teacher to the students but rather an activity that allows students to construct their own knowledge. Teaching means involving students in constructing knowledge, creating meaning, seeking clarity, being critical, and justifying. Teaching itself is a form of learning (Bettencourt, 1989). According to constructivists, teachers play the role of facilitators and mediators to help students succeed in their learning process. The emphasis is on student learning rather than teacher guidance.

The principles of constructivism in learning are: (1) Knowledge is constructed by the students themselves, both personally and socially. (2) Knowledge is the result of students' logical thinking, not the transmission of knowledge from teachers to students. (3) Students continuously construct actively, resulting in more complex, complete, and scientifically informed concepts. (4) Teachers act as facilitators and provide facilities and conditions to facilitate students' development (H. Huang, 2002; Murphy et al., 2005; Gordon, 2009; Nursikin, 2016; Masgumelar & Mustafa, 2021).

Constructivism has several implications for learning, including (Hoover, 1996):

1) Learning cannot be seen as the transfer of known or unknown knowledge. A constructivist teacher is not someone who only teaches completely new material. Instead, a constructivist teacher acts as a guide for students and provides them with opportunities to test their current understanding.
2) Teachers need to consider students' prior knowledge and provide the necessary learning environment for students to construct new knowledge. Teachers also need to pay attention to individual differences in the implementation of learning.
3) Student participation is the most crucial aspect of constructivism. Teachers should engage students in the learning process and use their understanding as a basis for acquiring new knowledge. Additionally, teachers should ensure that learning experiences encompass issues that are important to students and are not solely relevant to the teacher's needs and the education system.
4) It requires sufficient time to actively gather new knowledge. Students need enough time to reflect on new experiences, consider the relationship between new and previous experiences, and see the world more clearly.

When applying constructivist theory, teachers should demonstrate the following qualities:(1) apreciating student initiative and independence, (2) prioritizes primary data and manipulative material with an emphasis on reasoning skills, and (3) emphasizes student performance in evaluation, analysis, prediction, and production. (4) modify learning patterns and strategies based on subject characteristics and student responses; (5) Develop students' understanding of concepts before they share their own understanding of concepts. (6) Provide opportunities for discussion among peers. (7) motivate students to investigate with open-ended questions that encourage critical thinking and solicit peer opinions; - Discussion among peers, (8) preparing students for initial response, (9) engaging students in experiences that may contradict their original hypotheses to stimulate student discussion, (10) students (11) Foster curiosity in students using different learning models (Kaufman, 1996; Koohang et al., 2009; Beerenwinkel & von Arx, 2017).

In the constructivist approach, teachers play the role of facilitators who assist students in constructing their own knowledge. Teachers not only provide knowledge directly to students but also facilitate them in constructing knowledge through interaction with the environment. In constructivism, students are viewed as active participants who create their cognitive structures and interact with their social and cultural environment. This view acknowledges that knowledge is subjective and relative, formed through individuals' experiences and interactions with the environment. The constructivist learning paradigm is a relevant alternative in the era of Industry 4.0 as it prioritizes how individuals learn and construct knowledge rather than solely focusing on how teachers teach.

In the implementation of constructivism, there are several important implications. First, learning is not only about the transfer of new knowledge but also considers students' prior knowledge. Teachers need to create a suitable learning environment for students to construct new knowledge. Second, student participation is a crucial aspect of constructivism. Teachers should be involved in students' learning process, using their understanding as a basis for acquiring new knowledge. Additionally, learning experiences should encompass issues that are important to students and relevant to their needs and interests. Furthermore, constructivism requires sufficient time for students to reflect on new experiences, consider their relationship with previous experiences, and develop a deeper understanding. By effectively applying the principles of constructivism, teachers can become effective facilitators, helping students construct their own knowledge and acquire more complex and scientifically informed understanding.

CONCLUSION

Learning is the process of constructing knowledge from the abstraction of human experiences. The construction process occurs both personally and socially, and it is an active process. Several factors influence learning outcomes, including experiences, prior knowledge, cognitive abilities, and the socio-cultural environment. Teaching, on the other hand, is the process of assisting individuals in forming their knowledge. Teaching is not about transmitting knowledge from a teacher to a student, but rather about helping individuals construct their own knowledge through activities related to phenomena or objects they want to understand. This means that in this context, we need to develop infrastructure and provide contextual settings that enable meaningful interactions to occur. The teacher's role in this process is to actively ask questions, stimulate thinking, raise issues, allow students to express their thoughts and concepts, and become partners in critically examining students' concepts. Most importantly, it involves taking students' ideas as they are and showing them if they work. Teachers need to have a comprehensive and deep understanding of the subject matter so that they can be more flexible in accepting different ideas from students. In practice, teachers should consider that each student has uniqueness and differences in how they understand and construct knowledge. Therefore, teachers need to facilitate the learning process by considering individual differences among students, ensuring that they have meaningful experiences and acquire a deep understanding of the topics being taught.

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