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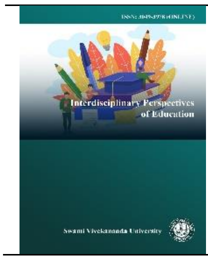

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EMPLOYING CONSTRUCTIVISM IN MATHEMATICS TEACHING: A REVIEW OF DEVELOPING PROBLEM-SOLVING ABILITY THROUGH CONSTRUCTIVIST APPROACH

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Abstract

This study aims to review the development of problem-solving ability through the constructivist approach. Furthermore, it examines the integration of constructivism in mathematics learning, particularly the development of problem-solving skills through inquiry-based learning, collaborative discourse, and the use of open-ended tasks that create cognitive conflict and provide scaffolding for students to develop robust strategies. The study also highlights major gaps in the literature on integrating constructivism in mathematics learning. Findings reveal that evidence regarding the use of constructivism in mathematics is mixed, inconsistent, and varied. In addition, only a few studies focus on the constructivist strategies that can enhance individuals' comprehension of mathematical concepts. The study emphasizes that the teaching philosophy of constructivism holds immense potential in mathematics education if implemented appropriately. It further suggests that future scholars should investigate the implementation of constructivism across multiple domains and identify strategies to enhance the effectiveness of this pedagogical approach.

Keywords: *Constructivism, Mathematics Learning, Problem-Solving, Inquiry-Based Learning, Collaborative Learning.*

1. Introduction

Mathematics education in the last decades has been characterized by the instructive paradigm where the teacher takes the role of the transmitter of the knowledge and the students are the recipients. Such practice typically leads to students who know how to perform algorithms but are not able to apply their learning to new and complex situations- something which is highly demanded in the 21st century. Perceived inefficiency of these classic approaches to build authentic mathematical literacy has fomented a paradigm shift to student-off centered approaches that have most eminently been constructivism. Mathematics is essential for the evolution of human cognition, reasoning, and thinking. It permits solid and exact analysis of a variety of circumstances, resulting in accurate forecasts, suitable management, efficient problem-solving, and judgment invocations in everyday life (Pengmanee, 2016). However, numerous studies (Rodgers et al., 2011; Banerjee, 2016) have revealed that the standards of mathematics education are diminishing and the understanding of the young learners, their preparedness and knowledge is growing poorer. The organisation of study programmes, the educational experience, and pedagogical methods to teaching mathematics are the crucial elements that impact the growth of mathematical education. Moreover, in the present scenario, mathematics instruction consists mostly of conveying key concepts to learners while emphasising problem-solving strategies. Also, conventional instructions include the passive transfer of theoretical, representational, and existent mathematical frameworks to individuals, compelling them to acquire thinking patterns established by others, which do not drive students to improve their performance (Vintere, 2018). This has led to the employment of new pedagogical techniques like constructivism in order to enhance the self-administration of concepts and practical applications of mathematics among the learners. Constructivism can be described as a theory of learning that determines how people build their knowledge. Moreover, as per the concepts of constructivism, rather than being a passive activity, knowledge production is an active one. Constructivists assume that knowledge must be created by learners via active participation in the learning procedure, rather than being simply placed into their minds (Major, & Mangope, 2012). Over the past few years, there has been a significant focus on active learning. It was considered a noteworthy transition from conventional education. Educators who are looking for new ways to improve their education have embraced the active learning technique (Narli, 2011). This study, therefore, aims to review the development of problem-solving ability by using the constructivism approach by compiling the views of different researchers and scholars.

The search of constructivism in mathematics education shows gaps in the past studies. First there is the implementation gap because constructivist approach effective in small classrooms or in high resourced contexts, has been challenging in terms of standardising them in large and resource-short context (Vaishali & Misra, 2019; Rao & Reddy, 2017). Second, teacher preparedness, as there is abundant research pointing towards the necessity of systematic professional development that would prepare teachers to support constructivist problem-solving tasks through design, scaffolding and assessment (Olivares, 2024). Third, it is a technology and culture disconnect, in which not many studies find it out how digital technologies, the socio-cultural setting, and local education norms can mediate the performance of constructivist pedagogies (Lee et al., 2021; Chaiarwut et al., 2024). Lastly, there are still unresolved theoretical concerns, those of the polarisation between radical/social constructivism, and the absence of new assessment strategies to measure mathematical thinking and problem solving in constructivist settings (Noorloos et al., 2017).

2. Statement of the Problem

The shift in mathematics instruction stresses studying mathematics in practical and situational settings, the ability to create solutions, and student-to-student engagements as well as student-to-educator interaction (Yusmarni et al., 2019). There exist five major aspects pertaining to the application of constructivism in mathematical learning which includes the language of communication, knowledge development, accepted perspectives, existing knowledge, and active engagement. In recent research on mathematical learning, the constructivist theory has been influential and provides the basis of contemporary initiatives for reforming mathematics education. However, it has been affirmed applying constructivist teaching techniques is challenging due to the lack of a standardized approach (Mumu, Prahmana, & Tanujaya, 2017). The current study, therefore, aims to review the development of problem-solving ability by using the constructivism approach. The manuscript predominantly focuses on comprehending the status of research studies on constructivism and problem solving in the past years and identifies the significant gaps pertaining to integrating constructivism in mathematics teaching learning. Further, the study highlights the areas that need to be revisited in order to improve the problem-solving abilities of the students by employing the constructivist approach.

3. Objectives of the Study

This study aims to review the development of problem-solving ability by using the constructivism approach.

- To review the aspects of integrating constructivism and mathematics learning.
- To assess the development of problem-solving ability by using the constructivism approach.
- To study the status of studies on constructivism and problem solving over the past years.
- To highlight the major gaps in the literature on integrating practical application of constructivism in mathematics teaching-learning.

4. Research Methodology

In order to achieve the intended aims of the current study, a systematic review of the literature was used. A systematic literature review (SLR), according to Dewey and Drahota (2016), is “reveals, organizes, and thoroughly inspects material in an attempt to solve a clearly defined topic.” The parameters should be expressly specified in a well-defined method or plan before the systematic review begins. It's a transparency study or thorough search strategy that covers several databases and academic publications and may be replicated by other researchers. The current study involved the survey of various abstracted journals, review papers, and other literary sources gathered through various databases like Google, ERIC, Scopus, and Springer Link**,** keywords like Constructivism, Mathematics, Constructivism approach, and problem solving were used to obtain empirical pieces of evidence. Furthermore, the systematic literature review is carried out in the current study in many steps: first, the research topic is defined; second, the review methodology is validated and evaluated; third, the literature is identified; and last, the identified literature is screened for inclusion. Furthermore, these procedures were followed by a quality assessment, the extraction of relevant data, the collection and analysis of the critical data, and finally the conclusions. Rounds of reviews on relevant articles are undertaken to integrate the most relevant content. Additionally, databases such as Google Scholar, **ERIC, Scopus, and Springer Link** as well as numerous articles and reports, have been rigorously reviewed to provide an unbiased assessment of the effectiveness of incorporating constructivism in mathematics education.

5. Analysis and Interpretation

The analysis and interpretation of the study has been presented below:

- **Historical background of Constructivism**

In order to improve the educational system requirements, several reforms in instructions pertaining to the qualification of teachers, curriculum, teaching and learning, finance, and textbooks were conducted in Taiwan in the 1990s. Moreover, the constructivism approach was first introduced in the elementary schools' mathematics curriculum in Taiwan in 1993. Although, this practice of constructivism was dismissed in 2003 since the students who were taught the concepts of mathematics using constructivism in the first year failed to accomplish results in high school as compared to those who were taught using conventional techniques previously (Chiu & Whitebread, 2011). Although the constructivist theory could not accomplish its goals and be successful in Taiwan, several teachers, instructors, and scholars have made efforts to integrate the aspects of constructivism in contemporary classroom settings (Liu & Chen, 2010). Several concepts and ideologies have been identified in the implementation of constructivism in mathematics learning. The two ideologies and concepts that have been extensively contested and documented in recent years of mathematics teaching are social and radical constructivism (Belbase, 2014). In the context of radical constructivism, learners' mathematical conceptions of what they comprehend are built through an adaptive procedure or through active cognition. Students must participate in self-examination on mathematics achievement, as per the radical approach. Integration, adjustment, adaptability, and restoration are all stages of training in the radical constructivism process. Students learn mathematics by actively constructing the meaning of notions they acquire through self-organization, rebuilding and representation, as well as social interaction with colleagues, seniors, and educators (Belbase, 2016). On the other hand, according to the theory of social constructivism, mathematical knowledge is built through social connections. Moreover, the theory suggests that when it comes to studying mathematics, mediation is quite important. It emphasizes that children learn from one another and from society via active exchanges and involvement in communal or peer interactions. Moreover, the theory reveals that for students, mentoring and assistance are required for the proper understanding of mathematical concepts (Panthi & Belbase, 2017).

- **Constructivist Assumptions for Learning**

Constructivism has philosophical, psychological, sociological, and educational foundations. While it is critical for instructors to grasp constructivism, it is also critical to comprehend the consequences of this learning philosophy for the training and professional development of teachers. The basic premise of constructivism is that human cognition is built and that learners build new information on top of existing knowledge. This viewpoint contrasts starkly with one where learning is defined as the passive dissemination of knowledge from one person to another, a viewpoint in which receipt, rather than creation, is paramount (Bada & Olusegun, 2015). The concept of created knowledge is surrounded by two essential ideas. One is that learners use what they currently know to build new interpretations. There is no blank space on which fresh information may be inscribed. Instead, learners bring existing experience-based information to new learning circumstances, which impacts what new or altered knowledge they will create from new educational experiences (Adom et al., 2016). The second idea is that instead of being passive, learning is an active process. In the context of what they discover in the new teaching process, learners question their expertise. When learners are confronted with situations that contradict their present knowledge, their comprehension might shift to incorporate new information. During this whole process, learners stay active: they apply present understanding, take note of important aspects in new learning situations, assess the coherence of past and developing information, and alter practice pertinent to that judgment (Adom et al., 2016).However, constructivism has been criticized by a number of academics, including education professionals and instructors. Many referred to it as misinformation, a catastrophic trend, poor teaching tactics, and flamboyant and flashy drill and practice methods of education (Mayer, 2004; Hayes, 2012; Clements & Batista, 2009, Kirschner et al., 2006). Furthermore, some proponents ascertained inadequacies not as a result of the techniques, but rather as a result of the fact that these teaching approaches require a significant amount of knowledge and experience which are not always well-established in actual classrooms; this does not disprove the statement of the concept, but only the integration (Marzano, 2011; Clements & Batista, 2009; Tobias & Duffy, 2009).

- **Constructivism in Problem Solving**

The capacity to evaluate mathematical problems and develop logical explanations is referred to as problem solving. It is the foundational ability that allows a learner to apply many other mathematical abilities. Students understand that mathematics makes perfect sense and can be comprehended as their mathematical thinking develops. Students discover how to assess circumstances, choose problem-solving techniques, draw inferences, create and explain findings, and identify how to apply those methods. Problem solving is capable of reflecting on potential solutions and determining whether or not they are reasonable. Learners recognize the importance and pervasiveness of reasoning in the domain of mathematics (Pengmanee, 2016).

In the context of problem solving, a constructivist lesson does not educate children on how to obtain the outcome; rather, it identifies the issue and allows learners to analyze it on their own. When a student offers a response, teachers strive not to declare whether the answer is accurate or incorrect but instead encourage pupils to agree or disagree with a person's viewpoint. Ideas are exchanged in such a classroom setting until a consensus is formed on what constitutes a reasonable learner. Students are motivated by their own understanding as well as their surroundings In such classroom settings, the instructional materials are created utilizing a constructivist method, in which students develop and discover how to apply mathematical ideas on their own and also answer certain questions that need learners to explore and acquire the information on their own. Finally, the learners comprehend the supplied learning materials and gain new information (Dewi & Harahap, 2016).

The goal of the study conducted by Noorloos et al. (2017) is to grab interest in a comparatively recent semantic theory termed inferentialism, which was created by scholar Robert Brandom. Inferentialism is a semantic theory that explains conceptual creation in light of inferences people make while recognizing, crediting, and questioning each other's convictions. The study claims that inferentialism can aid in the resolution of some issues that are affecting constructivism in general. The issues include that constructivists, firstly have not resolved the social-individual dichotomy satisfactorily, secondly, are indeed challenged by relativism, and thirdly have been ambiguous in their definition of construction. The study contemplates that inferentialism (a) encompasses a potent conception of standards that can achieve the social-individual divide, (b) emphasizes the actuality that restricts the inferences, and (c) evolves a clearer understanding of learning in aspects of perfecting webs of causes. As a result, inferentialism is a strong alternative to constructivism as a conceptual framework.

Within the educational framework, learning and improvement of mathematics reasoning are imperative. PEIM is a program for constructivist intervention that assists in enhancing mathematical performance, impacts the distinct stakeholders responsible for learning maths, and ensures proactive enhancement in the performance of the students. The program is developed on four aspects (i) learners become independent and are responsible for their learning by the construction of their knowledge. (ii) educators must act as a guide to ensure the construction of knowledge in order to enhance the learner's problem solving skills. (iii) concepts of mathematics must be ordered on the basis of importance and complexity for the learners and finally, the educational institutes must display a constructivist environment highlighting teamwork among the learners (Bermejo et al., 2021).

The 4IR has led to the transformation and alterations in different job profiles due to enhanced digitisation and automation. In order to ensure that future generations are able to cope with the transformations as a result of 4^{th} IR, the schools are expected to formulate such curriculums that improve the transferable skills (like interpersonal, intrapersonal, and cognitive) and learning experiences of the students. In this context, Lee, Lee, and Wong (2021) proposed a constructivism learning design that assisted the students in involving in deep learning procedures in the domain of mathematics. Learners in the suggested CLD first collaborate to address a difficult issue involving mathematical concepts they have yet to master, after which they are involved in the instruction that draws on their answers in the teaching of the subject, as well as practices that consolidate these concepts (Lee et al., 2021).

Inquiry-based learning and problem-solving in collaboration have proven to enhance meaningful knowledge and critical thinking in students who take advantage of constructivist approaches. Saban and Kocak (2020), and Liu et al. (2019), established that these two methods encourage students to engage actively and understand the mathematics problems better. Specifically, inquiry-based approaches foster learning as the students are asked to investigate mathematical concepts and develop more robust problem-solving strategies and mathematical reasoning in general. These strategies are consistent with the approach in Piaget and Vygotsky that focuses on the realization of active learning, social learning and holistic reasoning in creation of knowledge.

In India, other authors, such as Rao and Reddy (2017) and Joshi (2020), also find restrictions in the application of constructivism, pointing out that the method improves the problem-solving skills of the students. It has been found that the Indian students who are exposed to constructivist oriented pedagogical techniques, which include collaborative learning and open-ended tasks, achieve most dramatic changes in their problem-solving and mathematical understanding. Nevertheless, there are still problems, such as the necessity of training the teachers and the size of the classes, and the conventional examination system does not allow the full implementation of these practices in some cases. Vaisali and Misra (2019) pointed out that even though the advantages are undeniable, constructivist strategies have a lot of resistance related to the insufficient number of resources and proper training of teachers. These obstacles indicate that despite its potential, constructivism cannot be successfully applied unless there are some changes in the educational system. In a quasi-experimental design with students in their third-grade, Çibukçiu (2025) recruited the students who were taught through constructivist methods and compared them with the students who were taught using teacher-centered methods, finding out that the results of using constructivist approaches to teaching were significantly better, the mean generally improved in problem solving with the corresponding scores being $M = 39.77$ in the first group and $M = 59.46$ in the teacher-centered one ($p < .001$), suggesting a significant gain in performance. In Nigeria, another study by Avwiri and Obioma (2025) documented that substantially higher mean problem-solving scores were recorded in a group of secondary school students taught using a constructivist approach and there were no gender differences in the study. Besides, digital innovations based on the principles of constructivism promise to improve--a constructivist learning innovation on a digital platform has been developed and piloted in mixed-methods research, where an improvement in executing mathematical problem-solving skills, including the planning, monitoring, and strategic control in learners, were observed (Chaiarwut et al., 2024). In the meantime, a socio-constructivist perspective on the subject of teacher training appeared to suggest that pre-service primary education teachers saw problem-solving strategies based on the model of Building Thinking Classrooms as promoting critical thinking and engagement (Olivares, 2024). All these studies support this idea- that constructivist pedagogy in thoughtfully scaffolded, collaborative, and technologically enabled environments efficiently develops problem-solving competence, meta-cognitive growth, and inclusionary classroom cultures. However, at the same time, they are also indicators that in order to overcome the difficulties associated with autonomy, and social dynamics, implementation has to be complemented by teacher readiness and the careful design and development of specially designed instruction.

- **Strategies for Effective Constructivism**

Instructors that employ constructivist teaching techniques enable students to obtain their own opinion and views, which change their past knowledge in the context of the applied class material (Gunduz and Hursen, 2015). Learner traits are addressed in constructivist learning techniques, as well as the student's active engagement and relationship to his or her experience and knowledge in the process of learning. The usage of a learning module aids in the learning process. As proclaimed by Rufii (2015) the most common strategy to implement effective constructivism is to employ an appropriate learning module that may include worksheets for student assessment, learning materials, and guidance for lecturers.

Additionally, learners participate largely in teams in the constructivist classroom context, and education and training are collaborative and adaptive. Strong verbal communication skills, as well as cooperation and idea-sharing, are all heavily emphasized. This is in contrast to the conventional classroom, wherein learners learn via imitation and concepts are rigidly followed and led by a guidebook. Several interactive activities are held in constructivist classroom settings, like experimentation, field trips, discussions within the classrooms, and incorporating visual content (Lessani et al., 2017).

Moreover, Hus and Jancic Hegedis (2019) also mentioned several strategies pertaining to constructivist teaching tactics in their research study, which included experiential learning (Matriano, 2020), research-based learning, problem-based learning (Watts, 2013), project-based learning, and practical learning. Firstly, experiential learning involves integrating the sensory and emotional experiences of the learners and motivating them to think as a whole (Wurdinger & Carlson, 2010). Secondly, research-based learning involves employing aspects of scientific knowledge that assist the learners in processing and learning content simultaneously (Hus & Jancic Hegedis, 2019). Next, problem-based learning includes the facilitation of learning through complex problem-solving tactics. The learners develop collaborative clusters in order to identify the elements of the complex problem and comprehend the effectiveness of the adopted strategies (Roopashree, 2014). In project-based learning, the learners generally use multidisciplinary concepts in order to understand the strategies of project management and incorporate them to consequently develop a complete product (Hus & Jancic Hegedis, 2019). The practical learning of students is achieved through studying library activities, learning computer skills and functioning, and preparing a variety of materials to be exhibited. Corcoran (2020) highlighted how constructivist learning environments can help learners discover their mathematical abilities and develop positive attitude in mathematics. The most essential consequence of this teaching method is practical information that can be applied throughout one’s life. Moreover, as mentioned previously, teamwork, involves two or more teachers working together to create a stronger link between relevant topics, allowing students to gain a broader understanding (Rufii, 2015).

- **Major gaps in the literature on integrating practical application of constructivism in Mathematics teaching learning**

When these gaps are considered together it can be seen that the evidence concerning constructivism in mathematics education is disparate and even lacking. Despite the demonstrated positive effect of constructivist pedagogy on problem solving, little is known about its durability, whether it can transfer to different contexts, and what kinds of strategies are most likely to result in success when implemented across a whole system (Çibukçiu, 2025; Avwiri & Obioma, 2025). Thus, additional empirical study is required to apply constructivist approaches in other cultures, large- and small-size class settings, and various technological contexts and to create assessment frameworks that reflect the complexity of the ways students think mathematically. This research paper has pointed out this gap by bringing the available evidence together along with providing guidelines to further reliable, sustainable integration of constructivism in teaching-learning mathematics.

6. Findings and Discussion

Constructivism has been famous as a learning philosophy that advocates active involvement in knowledge absorption. Major and Mangope (2012) explain that knowledge is not an issue but it is created as one engages them intellectually and makes reflections about them. As noted in the current review the issue of falling performance and loss of student motivation in mathematics has rejuvenated the discussion of teacher pedagogical alternatives like constructivism. However, the results have been mixed, especially in the case of applying constructivism in the mathematics curriculum in Taiwan, hence eliciting doubts concerning its general applicability (Rao & Reddy, 2017). Critics cite that constructivism is inconsistent, resource-demanding and very difficult to administer in large classrooms and may end up compromising procedural fluency (Kirschner et al., 2006). Nevertheless, the adherents stress its ability to augment conceptual grasp and problem solving in case of reasonable scaffolds and support (Schoenfeld, 1985; Çibukçiu, 2025). In mathematics education two strands of constructivist thought are apparent. Radical constructivism refers to the fact that the development of mathematical concepts goes through adaptive individual cognitive processes, whereas social constructivism emphasizes that mathematical knowledge is created in dialogue and through collaboration and through a common process of meaning-building (Noorloos et al., 2017). Both views are reflected in the teaching strategies that were identified in the reviewed literature, such as experiential learning, inquiry-based education, project- and problem-based tasks. Taken together, these strategies serve to point out the importance of involving students in realistic tasks that motivate them to reason, work together and reflect. In sum constructivist approaches, although controversial, have a strong potential in nurturing mathematical problem-solving when supported by well-prepared teachers and adapted to local contexts.

7. Conclusion

The literature review shows that evidence regarding the use of constructivist methods in teaching mathematics is contradictory and dependent on a situation. Although there is evidence to support the considerable benefits of constructivism to problem solving, critical thinking and student involvement, some of the studies also raise concern that the process of implementing constructivism may be inconsistent, time intensive and not easy to standardize across education systems. These differences are consistent with existing theoretical disagreements in the literature-between radical and social constructivism-and practical issues in the training of teachers, the provision of resources, and through assessment practices. Although limited, this review highlights that constructivist processes are most successful when accompanied by instruction, scaffolding and mentoring of teachers. Furthermore, there is growing evidence that technology-enhanced constructivist conditions are able to further enhance problem-solving skills as well, but these factors still need to be further nailed down in regards to long-term and cross-cultural implications.

Future research needs to explore the validity of constructivism in mathematics learning by looking at longitudinal research, cross-national comparative research studies, and evaluations of the digital learning innovations as well as designing assessment methods that would be able to measure higher-order thinking. This review then presents distilled contributions of the various scholars in casting light to the potential and the limitations of constructivist pedagogy. It offers a platform for further research to resolve theoretical tensions and to promote the lasting, global use of constructivist approaches in mathematics classrooms.

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