

EXPLORING DESIGN THINKING IN EDUCATION: A COMPREHENSIVE REVIEW OF LITERATURE IN MATHEMATICS TEACHING CONTEXTS IN INDIA

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Abstract

With an emphasis on its applications in the field of teaching mathematics in India, this review paper explores the underexplored area of design thinking in education. The importance of a well-written literature review as a crucial element of educational research. The review offers a structured and ordered assessment of the body of research in the areas of teaching thinking, design thinking in education, and the integration of design thinking in mathematics education. It does this by drawing on the systematic study technique described by Machi and McEvoy (2012).

To guarantee a thorough coverage of scholarly articles, the literature review method comprises a detailed inspection of research papers acquired from several databases, such as WorldCat, ERIC, and Google Scholar. Shodhganga is a well-known collection of Indian research theses. The researcher looks through empirical papers available there to incorporate insights from the Indian context. The investigation is guided by the methodical creation of search questions that are suited to particular sections of the literature review, such as the integration of design thinking in mathematics education and the teaching of thinking skills.

The selected research papers are carefully annotated and summarized in order to provide a coherent presentation in the literature review. The significance of this evaluation in identifying current knowledge gaps and laying the groundwork for upcoming research projects is highlighted in the paper's conclusion. This thorough investigation seeks to direct scholars towards expanding on the body of current knowledge and providing significant contributions to the incorporation of design thinking into mathematics teaching within the context of Indian education.

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Objective of Review:

This thorough literature review has several goals, one of which is to provide light on the field of design thinking in education, which is still mostly untapped when it comes to teaching mathematics in India. The major objective is to conduct a comprehensive review and assessment of the literature in the areas where teaching thinking, design thinking in education, and design thinking integration in mathematics education converge.

By meticulously annotating and summarizing a chosen number of research papers, the review seeks to provide a cogent synthesis of current knowledge, with a focus on identifying knowledge gaps. The paper also seeks to highlight the role that this evaluation has played in laying the groundwork for future research projects, with an emphasis on pointing scholars in the direction of advancing our understanding of the subject and contributing significantly to the field of design thinking in mathematics education within the particular context of Indian education.

Introduction: While design thinking has become a popular paradigm for creativity and problem-solving across a range of fields, its application to education—especially in the context of teaching mathematics in India—is still largely unexplored. This review study aims to close this gap by carefully analyzing the state of educational research as it stands today. Our main objective is to conduct a thorough literature evaluation in the complex fields of teaching thinking, design thinking in education, and incorporating design thinking into mathematics education.

We use research submissions for PhDs from universities and studies on environmental and sustainability education from non-governmental organizations in the framework of this literature review. The review includes research articles and literature reviews from worldwide journals that undergo peer review. Although the main focus is on design thinking among secondary school in-service mathematics teachers, studies involving school students, pre-service teachers, university students, and other subjects like science and management are included to broaden the scope whenever relevant research is found.

The geographical diversity of the studies enriches the context, with approximately 20% of the research originating from India and the remainder from countries such as the United States, Australia, New Zealand, The Netherlands, Spain, Turkey, South Africa, Indonesia, Singapore, Hong Kong, Korea, Japan, and Taiwan. Despite the review's temporal span from 2000 to 2020, a noteworthy 80% of the studies examined are concentrated in the period from 2013 to 2020.

The reviews are divided into three categories to provide a methodical presentation: studies related to teaching thinking through mathematics education among students, studies related to teaching thinking through mathematics education among teachers, and the

implications of the aforementioned studies. While the main focus of the research is on student teachers and in-service teachers, studies that also incorporate businesses, innovations, and community participation are included where appropriate. But occasionally, the complexity of design thinking causes distinctions between creative and inventive thinking to become hazy, resulting in classification overlaps.

As we navigate through the subsequent sections, the review aims to identify key insights, knowledge gaps, and avenues for future research, ultimately contributing to the advancement of both educational and design thinking domains.

Review of various studies:

Studies related to Teaching Thinking through Mathematics Education among Students:

Study by Kwon (2002)

Kwon (2002)^[1] explores applying Realistic Mathematics Education (RME) to college differential equation education. The study proposes a novel approach based on RME's instructional design theory and technology, incorporating qualitative and numerical methods for differential equation learning and teaching.

Kim et al.'s Classroom Architect Project (2013)

Kim, Kwek, Meltzer, and Wong (2013)^[2] introduce the Classroom Architect project-based curriculum, utilizing design thinking to assess mathematical concepts. The curriculum involves students constructing a 3-D virtual model of an ideal classroom, emphasizing problem-solving, flexible thinking, and collaboration for lasting comprehension of design thinking and mathematics.

Penuel, Roschelle & Shechtman's Co-design Study (2007)

Penuel, Roschelle & Shechtman (2007)^[3] define co-design as a team-based process involving teachers, researchers, and developers. The study identifies key process components, explores tensions, and suggests

that co-design contributes to building community, common language, and teacher professional development.

Mehalik, Doppelt, & Schuun's Comparative Study (2008)

Mehalik, Doppelt, & Schuun (2008)^[4] compare middle school students' performance in science through traditional scripted inquiry versus a design-based, systems approach. The study involves 10 teachers and 587 students in the design group, showing higher gains and no gender-related performance gaps, recommending the adoption of a systems design approach for enhanced science education outcomes.

Studies related to Teaching Thinking through Mathematics Education among Teachers:

İncikabi et al.'s Study (2013)

İncikabi et al. (2013)^[5] examined the relationship between critical thinking skills and logical thinking dispositions among 99 Turkish university primary mathematics education teacher candidates. Findings revealed low levels of logical and critical thinking dispositions. While logical thinking skills improved from second to third grade, critical thinking skills showed no significant change by grade level or high school type. The study suggests a need for enhancing critical and logical thinking skills in teacher education programs.

Ansori et al.'s Research (2020)

Ansori et al. (2020)^[6] investigated the critical thinking process of prospective mathematics educators engaging with a two-dimensional geometry problem. The study, focusing on stages like problem analysis and conclusion derivation, utilized a descriptive qualitative research methodology. Thirty-five students from the Mathematics Education Study Programme participated, revealing inadequate critical thinking abilities among aspiring mathematics educators. The research emphasizes the importance of addressing and improving critical thinking skills in mathematics

education programs.

Celik and Ozdemir's Study (2020)

Celik and Ozdemir (2020)^[7] investigated the correlation between mathematical thinking sub-dimensions and critical thinking disposition among 181 pre-service mathematics teachers. The study, utilizing a correlation-type relational survey model, found a significant relationship between critical thinking and higher-order thinking, reasoning, mathematical thinking skills, and problem-solving. Reasoning, mathematical thinking skills, and problem-solving emerged as significant predictors of critical thinking disposition, emphasizing their predictive value in shaping critical thinking among pre-service mathematics teachers.

As'ari, Mahmudi & Nuerlaelah's Research (2017)

As'ari, Mahmudi & Nuerlaelah (2017)^[8] explored the critical thinking dispositions of prospective mathematics teachers in Indonesia, identifying three levels: non-critical thinkers, emergent critical thinkers, and developing critical thinkers. The majority fell into the non-critical thinker level, highlighting the need for reforms in teacher education institutions to enhance critical thinking skills and dispositions among prospective mathematics teachers.

Özgün-Koca et al.'s Study (2010)

Özgün-Koca, Meagher, & Edwards (2010)^[9] investigated the development of Technological Pedagogical and Content Knowledge (TPACK) in preservice secondary mathematics teachers during a technology-rich methods class. The study utilized participant surveys and assignments analyzed through the TPACK framework to trace the evolution of preservice teachers' beliefs about technology in teaching. Positive shifts were observed, transitioning from viewing technology as a reinforcement tool to seeing it as a tool for developing mathematical concepts. The study emphasized the pivotal role of the

methods course in shaping preservice teachers' views on using technology for teaching mathematics.

Sonawat & Kothari's Study (2013)

Sonawat and Kothari (2013)^[10] explored primary school teachers' perspectives on rote and meaningful learning in mathematics and its relation to the learning experiences of 145 children. The study considered variables such as school type and teachers' experience. Questionnaires for teachers and activities for children were used for data collection, revealing significant differences in meaningful learning perspectives between aided and unaided primary school teachers. The research highlighted a shift in children's learning patterns from rote to meaningful learning in primary schools and emphasized the influence of teachers' perspectives on children's learning approaches in mathematics.

Joakim Samuelsson's Study (2007)

Joakim Samuelsson's (2007)^[11] study delved into the experiences of student teachers preparing to teach math in early elementary school in Sweden. The research, involving 197 education students, revealed weaknesses among those with less math background in secondary school. Almost 80% expressed negative emotions toward math, emphasizing the potential impact of these beliefs on their future teaching approaches. The study identified limitations in students' experiences, suggesting targeted improvements in teacher training programs to enhance their experiences and approaches to teaching math.

Kala S. Retna's Study (2015)

In a 2015 study by Kala S. Retna^[12], teachers' perceptions and challenges in adopting design thinking to enhance student learning were explored, addressing a gap in empirical research. Conducted in Singapore schools, the qualitative case study utilized in-depth interviews and participant observation. Findings indicated teachers believed design thinking could enhance creativity, problem-solving, communication,

and teamwork skills, fostering empathy. However, challenges included resource limitations, time constraints, fear of poor grades, and the difficulty of transitioning from traditional methods. The study highlighted the complexities involved in integrating design thinking into the educational context.

Implications of various studies:

In a thorough examination of multiple studies, common findings and some conflicting observations emerge, offering insights into various facets of education. Studies by Karwande (2010), Paul (2013), and Singh (2018) collectively stress the significance of pedagogical innovation, effective instructional strategies, and integrating novel approaches in mathematics and physics education.

Kwon's (2002)^[1] research on Realistic Mathematics Education (RME) shows that innovative teaching methods, like reinventing traditional math ideas, enhance students' understanding of slope fields and solution function graphs. Similarly, Kim et al.'s (2013)^[2] project-based curriculum, incorporating design thinking, results in long-term retention of design thinking and mathematical concepts, enhancing problem-solving skills. Penuel, Roschelle & Shechtman's (2007)^[3] study on co-design underscores collaborative efforts improving teaching practices, curriculum, and technology.

In contrast, İncikabi et al.'s (2013)^[5] study on math teacher candidates reveals that while logical thinking improves over grades, critical thinking skills remain relatively unchanged. Ansori et al.'s (2020)^[6] research emphasizes addressing cognitive difficulties to enhance critical thinking among future math teachers. Celik and Ozdemir's (2020)^[7] findings stress the significance of reasoning, mathematical thinking, and problem-solving in predicting critical thinking disposition among pre-service math teachers. As'ari, Mahmudi & Nuerlaelah's (2017)^[8] study highlights the prevalence of non-critical thinking among prospective

math teachers, indicating a need for reforms in teacher education.

Özgün-Koca, Meagher, & Edwards (2010)^[9] demonstrate that training future math teachers in technology positively impacts their ability to teach mathematics. Sonawat and Kothari's (2013)^[10] research on primary school teachers shows a shift from rote to meaningful learning in mathematics.

Joakim Samuelsson's (2007)^[11] study underscores challenges faced by student teachers in Sweden with limited math backgrounds, emphasizing the need for improved training programs. Innabi and Sheikh's (2007)^[13] research in Jordan contradicts the broader theme, revealing a lack of improvement in math teachers' understanding of critical thinking despite educational reform. Malele and Ramaboka's (2020)^[14] study on design thinking suggests that it enhances students' thinking and learning, while Kala S. Retna's (2015)^[12] research indicates challenges such as resource constraints and time hindering its effective use.

Regarding design thinking in India, limited research suggests a potential gap in understanding how design thinking is specifically applied to teaching secondary school mathematics. Targeted studies exploring the impact, challenges, and best practices of incorporating design thinking into the pedagogy of secondary school mathematics in the Indian educational landscape are needed.

Conclusions: As a conclusion, this paper has conducted an extensive and methodical analysis of many aspects related to the field of education, with an emphasis on the integration of design thinking into mathematics education, teaching thinking skills, and design thinking in education. The literature review has been carefully constructed to cover a broad range of research, including the viewpoints of both teachers and students on teaching thinking skills, as well as the

various uses of design thinking in management, teacher preparation, and schools.

The inclusion of research conducted both in India and abroad has enriched the exploration, The investigation has been enhanced by the addition of studies carried out both domestically and internationally, offering a worldwide viewpoint on the topic. A variety of annotated summaries, bibliographies, and implications have been provided in order to provide a thorough grasp of the corpus of current knowledge. This adds to the body of knowledge already in existence while also highlighting the gaps in the literature and pointing future scholars in the direction of topics that demand more inquiry.

The gaps in the current research landscape that have been found highlight the need for more investigation and research projects in the areas of teaching thinking and design thinking in various educational settings. This paper emphasizes the need to address these areas and make a significant contribution to the changing environment of education by identifying these gaps and providing a solid foundation for the subsequent research.

The conclusions drawn from this thorough analysis support the importance of the current study in filling in these gaps and making significant contributions to the field of education. We hope to build on the insights from this review to inform a more nuanced understanding of teaching thinking and design thinking in education as we move ahead and explore the study's theoretical and conceptual framework. This will advance the scholarly discourse in this dynamic and ever-evolving field.

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