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Enhancing Problem-Solving Skills of Middle Stage Students through Design Thinking Interventions: Evidence from an Empirical Study

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Abstract

The present study examines the effectiveness of Design Thinking interventions in enhancing the Problem-Solving ability of middle-stage students in science. In the context of contemporary educational reforms emphasizing competency-based learning and 21st-century skills, the study explores the impact of an innovative, learner-centred teaching approach on students' cognitive development. It further investigates the influence of gender and type of school, along with their interaction effects, on problem-solving ability. An experimental research design with a pre-test–post-test control group was employed. The sample consisted of 200 eighth-grade students selected randomly from government and private schools of Amritsar. The experimental group was taught using the Design Thinking framework, incorporating stages such as empathizing, defining, ideating, prototyping, and testing, while the control group received conventional instruction. Data were collected through a self-constructed Problem-Solving Ability Test and analysed using mean, standard deviation, t-test, and two-way ANOVA. The findings revealed that students exposed to Design Thinking demonstrated significantly higher problem-solving ability compared to those taught through traditional methods. Significant differences were also found with respect to gender and type of school. Additionally, the interaction effects between treatment and gender, and treatment and type of school, were statistically significant, indicating that the effectiveness of the intervention varies across different learner groups and educational contexts. The study concludes that Design Thinking is an effective pedagogical approach for developing problem-solving skills among middle-stage learners. It highlights the need for integrating innovative, activity-based teaching strategies into school education to foster critical thinking, creativity, and meaningful learning experiences.

Keywords

Design Thinking, Problem-Solving Ability, Middle-stage Students, National Education Policy (2020).

Introduction

The National Education Policy (NEP) 2020 envisions a transformative restructuring of India's education system by emphasizing holistic, multidisciplinary, and competency-based learning, moving away from rote memorization toward critical thinking, creativity, and experiential pedagogy; it introduces the 5+3+3+4 curricular structure aligned with learners' cognitive development and highlights the integration of 21st-century skills such as problem-solving, design thinking, and digital literacy (Government of India, 2020). Building upon this vision, the National Curriculum Framework for School Education (NCFSE) 2023 operationalizes NEP 2020 by providing detailed curricular and pedagogical guidelines that focus on reducing content overload, promoting conceptual understanding, and adopting competency-based assessments; it strongly advocates experiential learning, interdisciplinary approaches, and the development of critical and analytical abilities among learners (NCERT, 2023). Design thinking, as an innovative and learner-centred pedagogical approach, plays a crucial role in enhancing problem-solving abilities, particularly at the middle stage of schooling (Grades 6 to 8), which marks a significant transition in learners' cognitive development. This stage is characterized by the gradual shift from concrete operational thinking to more abstract, analytical, and reflective modes of reasoning, making it an appropriate phase to introduce structured approaches like design thinking that emphasize inquiry, creativity, and real-world application (NCERT, 2023). *Design thinking* is fundamentally a human-centred, iterative process that involves stages such as empathizing with users, defining problems, ideating solutions, prototyping, and testing, thereby enabling learners to engage deeply with complex issues and develop innovative solutions (Razzouk & Shute, 2012). By integrating these stages into classroom practices, educators can create meaningful learning experiences that go beyond textbook knowledge and encourage students to actively construct their understanding through exploration and reflection. The incorporation of design thinking in the middle stage aligns closely with constructivist learning theories, which posit that learners build knowledge through active engagement with their environment rather than passive reception of information (Piaget, 1970; Vygotsky, 1978). In this context, design thinking provides a structured yet flexible framework that allows students to investigate problems, collaborate with peers, and experiment with multiple solutions. This process not only enhances their cognitive abilities but also fosters metacognitive skills, enabling them to reflect on their thinking and learning processes. Moreover, design thinking encourages students to approach problems from multiple perspectives, thereby promoting divergent thinking and creativity, which are essential components of effective problem-solving (Dorst, 2011). Another significant advantage of design thinking in the middle stage is its emphasis on iterative learning and resilience. Unlike traditional problem-solving approaches that often focus on arriving at a single correct answer, design thinking encourages learners to explore various possibilities, test their ideas, and refine their solutions based on feedback and evaluation. This iterative cycle helps students develop perseverance, adaptability, and a growth mindset, which are critical for success in an increasingly complex and dynamic world (Carroll et al., 2010). Furthermore, engaging in design thinking activities enables students to connect theoretical knowledge with practical applications, thereby enhancing the relevance and authenticity of their learning experiences. For instance, students may work on projects related to environmental sustainability, community development, or technological innovation, which require them to apply concepts from multiple disciplines such as science, mathematics, and social studies. Collaboration is another key dimension of design thinking that significantly contributes to the development of problem-solving abilities at the middle stage. Students often work in teams to identify problems, generate ideas, and develop solutions, which fosters communication, teamwork, and interpersonal skills. Collaborative learning environments provide opportunities for students to share diverse perspectives, challenge assumptions, and co-construct knowledge, leading to more comprehensive and innovative outcomes (Johnson & Johnson, 2009). This aligns with the objectives of NEP 2020 and NCFSE 2023, which emphasize the importance of social and emotional learning alongside academic achievement (Government of India, 2020; NCERT, 2023). Additionally, design thinking promotes empathy by encouraging students to understand the needs and experiences of others before proposing solutions. This user-centred approach not only enhances the effectiveness of problem-solving but also cultivates values such as compassion, inclusivity, and ethical responsibility. The role of teachers in facilitating design thinking at the middle stage is pivotal. Educators must adopt the role of facilitators and guides who support students in their inquiry and exploration rather than merely delivering content. This requires a shift in pedagogical practices, as well as continuous professional development to equip teachers with the necessary skills and knowledge to implement design thinking effectively (NCERT, 2023). Teachers need to create a classroom environment that encourages curiosity, experimentation, and risk-taking, where students feel safe to express their ideas and learn from failures. Furthermore, assessment practices must also evolve to align with design thinking methodologies. Traditional assessments that focus solely on content recall are inadequate for evaluating the complex skills developed through design thinking. Instead, formative and competency-based assessments that consider the learning process, creativity, collaboration, and problem-solving strategies should be adopted (Black & Wiliam, 2009).

In the Indian educational context, the National Education Policy (NEP) 2020 and National Curriculum Framework for School Education (NCFSE) 2023 provide strong policy support for the integration of design thinking in the middle stage. Initiatives such as experiential learning, project-based activities, coding, vocational exposure, and "bagless days" create opportunities for students to engage in hands-on learning and apply design thinking principles in real-world contexts (Government of India, 2020). The use of digital technologies further enhances the implementation of design thinking by providing tools for research, collaboration, prototyping, and presentation. Digital platforms, simulations, and interactive applications enable students to visualize concepts, test ideas, and communicate their solutions effectively, thereby enriching the learning experience. Despite its numerous benefits, the implementation of design thinking in schools also presents certain challenges. These include limited teacher preparedness, lack of adequate resources and infrastructure, rigid curricular structures, and resistance to change among stakeholders. Addressing these challenges requires a systemic and collaborative approach involving policymakers, educators, institutions, and communities. Continuous professional development programs, investment in educational infrastructure, and the development of flexible curricula are essential for creating an enabling environment for design thinking (NCERT, 2023). Additionally, there is a need to build awareness about the importance of 21st-century skills and to foster a culture of innovation and creativity within educational institutions. So, design thinking serves as a transformative approach to enhancing problem-solving abilities at the middle stage of education, aligning closely with the objectives of NEP 2020 and NCFSE 2023. By fostering creativity, critical thinking, collaboration, and empathy, it equips learners with the competencies required to address complex real-world challenges and become active contributors to society. Its integration into the curriculum not only enriches the learning process but also prepares students for the demands of the future, making it an essential component of contemporary education.

Theoretical Framework of Design Thinking

Design Thinking has emerged as a transformative educational approach that promotes creativity, innovation, collaboration, and problem-solving among learners. Originally developed in the fields of engineering, architecture, and product design, Design Thinking has gradually been adopted in education due to its potential to create learner-centred environments that encourage active engagement and meaningful learning experiences (Baricevic & Luic, 2023; Patel et al., 2024). The theoretical foundations of Design Thinking in education are deeply rooted in several educational and psychological theories that emphasize experiential learning, knowledge construction, social interaction, reflection, and human-centred problem-solving. These theoretical perspectives provide a strong framework for understanding how Design Thinking supports learning and development in contemporary educational settings (Yu et al., 2024).

One of the most significant theoretical foundations of Design Thinking is *Constructivist Learning Theory*, proposed by Jean Piaget. Constructivism posits that learners actively construct knowledge through their interactions with the environment rather than passively receiving information from teachers. According to Piaget, learning occurs when individuals engage in experiences that challenge their existing understanding, leading to the processes of assimilation and accommodation. Design Thinking aligns closely with this perspective because it encourages learners to investigate real-world problems, explore multiple possibilities, and develop their own understanding through inquiry and experimentation (Yu et al., 2024). During the stages of empathizing, defining, ideating, prototyping, and testing, students actively engage with problems and construct knowledge through hands-on experiences. Rather than focusing solely on memorization, Design Thinking promotes deeper understanding through exploration, reflection, and application of concepts in authentic contexts (Baricevic & Luic, 2023). Another important theoretical foundation is *Social Constructivism,* developed by Lev Vygotsky. Vygotsky emphasized that learning is fundamentally a social process and that knowledge is co-constructed through interaction with others. His concept of the Zone of Proximal Development (ZPD) suggests that learners can achieve higher levels of understanding when supported by teachers, peers, or mentors. Design Thinking strongly reflects social constructivist principles because it is inherently collaborative (McLaughlin et al., 2023). Learners work together to identify problems, share perspectives, brainstorm ideas, develop prototypes, and evaluate solutions. These collaborative activities encourage communication, teamwork, and collective problem-solving. Through discussion and feedback, learners gain new insights and refine their understanding, which enhances both cognitive development and social skills (McLaughlin et al., 2023). Teachers in Design Thinking environments act as facilitators who guide learners and provide scaffolding rather than serving as the sole source of knowledge.

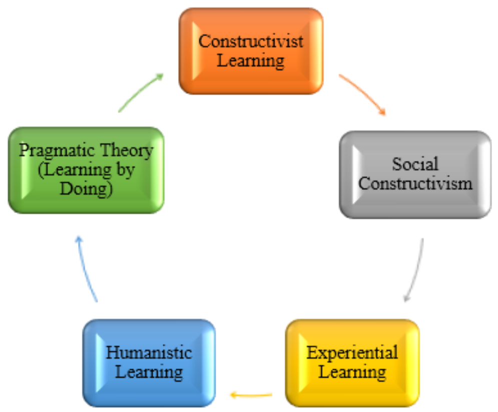

Figure 1: *Theoretical Framework of Design Thinking* (Dewey, 1938; Kolb, 1984; Piaget, 1972; Rogers, 1969; Vygotsky, 1978).

Experiential Learning Theory, proposed by David Kolb, also serves as a critical foundation for Design Thinking in education. Kolb argued that learning is a continuous process in which knowledge is created through the transformation of experience. His experiential learning cycle consists of four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Design Thinking embodies these principles by engaging learners in authentic experiences that require them to address real-world challenges (Barana & AlZoubi, 2024). Students observe situations, gather information, reflect on their findings, generate ideas, create prototypes, and test their solutions. This iterative process allows learners to learn through action and reflection, thereby deepening their understanding of concepts and enhancing their ability to apply knowledge in different contexts. Experiential learning encourages learners to take ownership of their learning and develop practical skills that are essential for success in the modern world (Guaman-Quintanilla et al., 2023). Then *Humanistic Learning Theory***,** advanced by Abraham Maslow and Carl Rogers, provides another important theoretical basis for Design Thinking. Humanistic theorists emphasize the importance of personal growth, self-actualization, learner autonomy, and emotional well-being. They argue that education should focus on the whole person rather than merely transmitting academic knowledge. Design Thinking incorporates these principles by placing human needs and experiences at the centre of the learning process. The empathy stage, which requires learners to understand the perspectives, emotions, and needs of others, reflects the humanistic emphasis on compassion and interpersonal understanding (Liu et al., 2024). Furthermore, Design Thinking empowers students to make decisions, express creativity, and pursue meaningful solutions, thereby fostering intrinsic motivation and self-directed learning. By valuing learners' ideas and experiences, Design Thinking creates supportive learning environments that encourage confidence, curiosity, and personal development (Liu et al., 2024). The philosophical ideas of John Dewey also play a significant role in shaping the theoretical foundation of Design Thinking, which shows the importance of the *Learning by Doing* method in *Pragmatic theory*. Dewey believed that education should be connected to real-life experiences and that learning occurs most effectively through active participation and reflective inquiry. He argued that students should engage in meaningful activities that help them solve practical problems and contribute to society. Design Thinking closely aligns with Dewey's philosophy because it encourages learners to address authentic challenges that are relevant to their lives and communities (Barana & AlZoubi, 2024). Students investigate issues, explore solutions, test their ideas, and reflect on outcomes, thereby engaging in a cycle of action and reflection that Dewey considered essential for meaningful learning.

Problem-Based Learning (PBL) also contributes significantly to the theoretical framework of Design Thinking. Problem-Based Learning is a learner-centred approach in which students acquire knowledge and skills by working to solve complex, real-world problems. Both PBL and Design Thinking emphasize inquiry, collaboration, critical thinking, and learner autonomy. However, Design Thinking extends beyond traditional problem-solving by incorporating empathy, creativity, and iterative prototyping (Patel et al., 2024). Learners are encouraged not only to identify solutions but also to understand the human dimensions of problems and continuously refine their ideas based on feedback. This focus on innovation and user-centred solutions enhances students' ability to think critically and creatively while developing practical problem-solving competencies. Additionally, Design Thinking is influenced by theories of creativity and innovation, which emphasize the generation of novel and useful ideas. Creativity theorists argue that learning environments should provide opportunities for imagination, experimentation, and risk-taking. Design Thinking fosters these conditions by encouraging learners to generate multiple ideas, explore alternative perspectives, and view failure as an opportunity for learning and improvement (Guaman-Quintanilla et al., 2023). The iterative nature of prototyping and testing helps students develop resilience, adaptability, and a growth mindset, which are essential attributes in rapidly changing social and professional environments. In contemporary education, Design Thinking is also supported by twenty-first-century learning theories that emphasize the development of skills such as creativity, critical thinking, communication, collaboration, and digital literacy. These competencies are increasingly recognized as essential for success in a knowledge-based and technology-driven society. Design Thinking provides a structured framework through which learners can develop these skills while engaging in meaningful and authentic learning experiences (Patel et al., 2024). Furthermore, research indicates that psychologically safe learning environments strengthen the effectiveness of Design Thinking by encouraging students to share ideas, experiment freely, and learn from failure (Moffett et al., 2024).

1. *Model of Design Thinking*

Design thinking models provide structured frameworks that guide learners through a systematic yet flexible process of solving complex, real-world problems using creativity, empathy, and iterative learning. One of the most widely recognized and contemporary models is the five-stage model proposed by the Hasso Plattner Institute of Design, commonly known as the Stanford D. School model, which includes the stages of Empathize, Define, Ideate, Prototype, and Test, and is particularly effective for developing problem-solving abilities among Middle-stage students (Grades 6–8). At this stage, learners are transitioning toward abstract thinking and are capable of engaging in inquiry-based, collaborative, and experiential learning; thus, the structured yet flexible nature of this model makes it highly suitable for classroom application (Razzouk & Shute, 2012; Yu et al., 2024).

- In the Empathize stage, students are encouraged to understand the needs, feelings, and experiences of others through observation, interviews, or discussions. For middle-stage students, teachers can design simple, relatable activities such as asking students to interview peers or community members about everyday problems. For example, students may explore the issue of heavy school bags by talking to classmates and identifying how it affects their daily lives. This stage helps develop empathy, communication skills, and social awareness, which are essential components of holistic education (Patel et al., 2024).

- The next stage, Define, involves clearly articulating the problem based on the insights gathered. Teachers can guide students to frame problem statements in a structured way, such as "*Students need a way to carry school materials comfortably because heavy bags cause physical strain.*" At the middle stage, scaffolding is important; educators can provide templates or prompts to help students organize their thoughts. This stage enhances analytical thinking and helps students focus on the root cause of problems rather than surface-level symptoms (Guaman-Quintanilla et al., 2023).

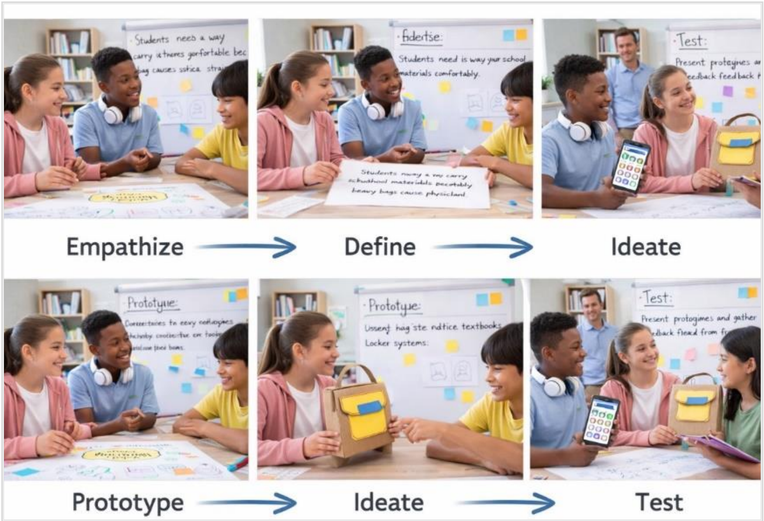

Figure 2: *Five Stages of Design Thinking with Examples*
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- During the *Ideate* stage, students brainstorm multiple solutions to the defined problem. At this level, activities such as mind mapping, group discussions, and creative sketching can be used to encourage divergent thinking. For instance, students may suggest ideas like digital textbooks, locker systems, ergonomic bags, or timetable restructuring to reduce load. Teachers should create a non-judgmental environment where all ideas are welcomed, fostering creativity and innovation. Research indicates that this stage significantly enhances students' creative confidence and ability to think beyond conventional solutions (Berglund, 2024).

- In the *Prototype* stage, students convert their ideas into tangible forms such as models, drawings, charts, or simple digital designs. For middle-stage learners, low-cost materials like cardboard, paper, or digital tools can be used to create prototypes. For example, students might design a model of a lightweight school bag or a digital timetable app. This hands-on process bridges the gap between abstract ideas and real-world applications, reinforcing experiential learning and conceptual understanding (Yu et al., 2024).

- Finally, the *Test* stage involves presenting the prototype to peers, teachers, or users and gathering feedback for improvement. Students can demonstrate their models in class, conduct peer reviews, or even test their solutions in real-life scenarios. For example, they may ask classmates to evaluate the practicality of their bag design or timetable plan. This stage emphasizes reflection, iterative improvement, and resilience, as students learn to refine their ideas based on constructive feedback rather than viewing failure negatively (Razzouk & Shute, 2012).

Applying the Hasso Plattner model in middle-stage classrooms promotes interdisciplinary learning and aligns with competency-based education. For instance, a project on "reducing plastic waste in school" can integrate science (understanding environmental impact), mathematics (data collection and analysis), social science (community awareness), and art (designing eco-friendly alternatives). Through such projects, students not only develop problem-solving skills but also build collaboration, communication, and critical thinking abilities. Moreover, the iterative nature of the model encourages continuous learning and adaptability, which are essential competencies in the 21st century. So, the Hasso Plattner design thinking model provides a practical and engaging framework for enhancing problem-solving abilities among middle-stage students. By guiding learners through empathy, problem definition, idea generation, prototyping, and testing, it transforms classrooms into dynamic spaces of innovation and inquiry. When implemented effectively with age-appropriate strategies and real-life examples, this model fosters creativity, critical thinking, and holistic development, preparing students to address complex challenges in their academic and everyday lives.

2. *Problem-Solving Ability*

Problem-solving ability in design thinking refers to the capacity of learners to identify, analyse, and address complex, real-world problems through a structured yet flexible, human-centred approach. Design thinking enhances problem-solving by integrating empathy, creativity, critical thinking, and iterative experimentation, enabling learners to move beyond conventional linear methods toward innovative and context-sensitive solutions. Recent research strongly supports the role of design thinking in improving students' problem-solving abilities. A comprehensive meta-analysis by Yu et al. (2024) found that design thinking significantly enhances students' problem-solving skills, creativity, and innovation by engaging them in active, experiential learning processes where they iteratively refine solutions based on feedback. This iterative cycle, comprising empathizing, defining, ideating, prototyping, and testing, helps learners develop deeper cognitive engagement and the ability to approach problems from multiple perspectives. Furthermore, design thinking strengthens problem-solving ability by promoting "Problem Framing" and "Need Finding," which are critical in addressing complex or "wicked problems." Unlike traditional approaches that focus on solving predefined problems, design thinking encourages learners to explore and redefine the problem itself, leading to more meaningful and sustainable solutions (Bender-Salazar, 2023). This ability to frame problems effectively is essential in developing higher-order thinking skills, as it requires learners to analyse contexts, identify underlying causes, and consider user needs before proposing solutions. Empirical studies in educational settings also demonstrate that integrating design thinking into classroom practices significantly improves students' creative problem-solving abilities.

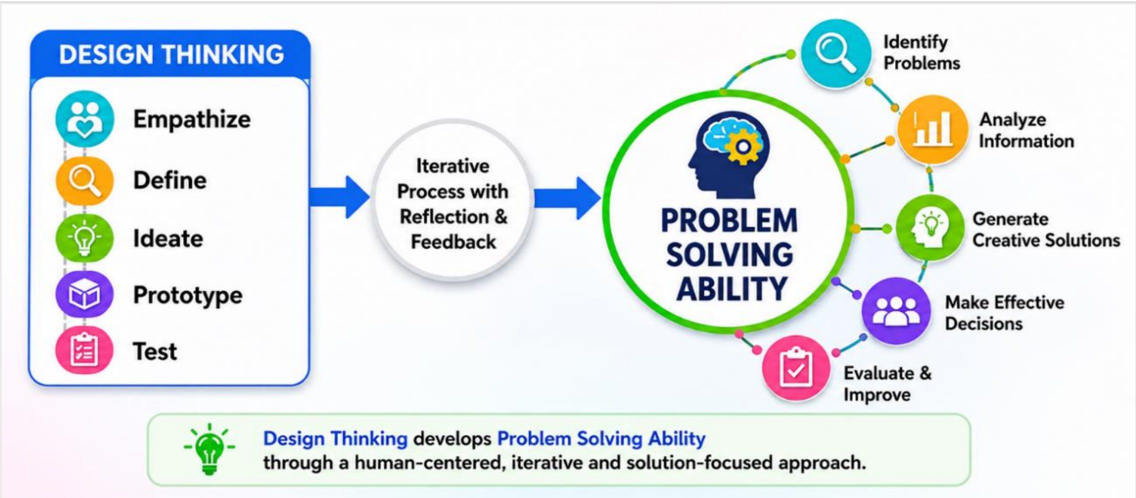

Figure 3: *Relationship between Design Thinking and Problem-Solving Ability* (Yu et al., 2024).

For instance, a recent study (Appakarat & Chumsukon, 2025) showed that students who engaged in design thinking-based learning activities exhibited notable improvements in their ability to generate innovative solutions and apply knowledge in real-life situations. Similarly, research on design thinking combined with gamification revealed that students' problem-solving ability increased substantially after participating in structured design thinking activities, highlighting its effectiveness as a pedagogical strategy (Kongnisai et al., 2024). Design thinking also enhances problem-solving through its collaborative and interdisciplinary nature. Learners work in teams to brainstorm ideas, evaluate alternatives, and co-create solutions, which fosters communication, teamwork, and collective intelligence. This collaborative process enables students to integrate knowledge from multiple disciplines, thereby developing holistic and flexible problem-solving skills. Additionally, recent studies indicate that design-based learning approaches significantly improve students' critical thinking, computational thinking, and problem-solving abilities by engaging them in authentic, real-world tasks (Efeoglu & Moller, 2025). Another important dimension is the development of a growth mindset and resilience. Design thinking encourages learners to view failure as an integral part of the learning process, as prototypes are tested and refined multiple times. This iterative approach helps students become more adaptable and persistent when facing challenges, which is a key aspect of effective problem-solving. Moreover, the emphasis on empathy ensures that solutions are user-centred and socially relevant, thereby enhancing the quality and impact of problem-solving outcomes.

So, design thinking serves as a powerful framework for developing problem-solving skills by integrating the analytical, creative, and social dimensions of learning. It enables learners to identify problems effectively, generate innovative solutions, and refine their ideas through iterative processes. With strong empirical evidence supporting its effectiveness, design thinking is increasingly recognized as a critical pedagogical approach for fostering problem-solving skills in contemporary education.

Review of Related Literature

The integration of design thinking into education has evolved significantly over the past decade, with increasing emphasis on its role in enhancing students' problem-solving abilities. Early empirical work by Carroll et al. (2010) demonstrated that engaging middle school students in design thinking activities led to improved creativity, collaboration, and active engagement in learning tasks. These findings were further supported by Razzouk and Shute (2012), who conceptualized design thinking as a structured yet flexible process involving problem identification, ideation, and iterative refinement, thereby fostering higher-order cognitive skills essential for effective problem-solving. Subsequent research highlighted the alignment between design thinking and constructivist learning theories, in which learners actively construct knowledge through experience, reflection, and social interaction. Henriksen et al. (2017) emphasized that design thinking encourages exploration of multiple perspectives and experimentation, which enhances creative problem-solving capacities. Similarly, McLaughlin et al. (2019) noted that design thinking promotes interdisciplinary collaboration and reflective practices, enabling learners to apply theoretical knowledge to real-world contexts. Further empirical and systematic investigations have reinforced the effectiveness of design thinking in educational settings. Li and Zhan (2022), through a systematic review, found that design thinking significantly improves students' problem-solving skills, creativity, and collaboration by engaging them in iterative learning processes. However, challenges such as a lack of teacher preparedness and assessment tools were identified by Razali et al. (2022), indicating the need for institutional support. More recent studies have focused on specific dimensions of design thinking and their impact on learning outcomes. Bender-Salazar (2023) highlighted the importance of problem-setting and need identification, arguing that students develop a deeper understanding when they engage in defining problems before solving them. Guaman-Quintanilla et al. (2023) further reported that design thinking enhances teamwork, creativity, and problem-solving through collaborative and interdisciplinary approaches. In addition, Yu et al. (2024), through a meta-analysis, confirmed that design thinking has a statistically significant positive effect on student learning outcomes, particularly in problem-solving and innovation. Kongnisai et al. (2024) also demonstrated that integrating design thinking with gamification increases student engagement and improves problem-solving performance. Recent empirical studies continue to highlight the effectiveness of design thinking-based interventions in improving students' cognitive and creative abilities. Appakarat and Chumsukon (2025) reported significant improvements in students' creative problem-solving skills and academic achievement when design thinking strategies were applied in classroom settings. Similarly, Cavus et al. (2026) found that iterative design-based learning processes enable students to refine their solutions and enhance analytical thinking over time. Zhang and Zhang (2026) further indicated that design thinking significantly predicts creativity and innovation, with self-efficacy acting as a mediating factor. Collectively, these studies provide strong evidence that design thinking fosters not only cognitive development but also social and emotional competencies, making it a comprehensive approach for enhancing problem-solving abilities among middle-stage students. Despite the growing body of literature supporting design thinking as an effective pedagogical approach, several critical Research Gaps remain, particularly in the context of middle-stage education.

Firstly, although numerous studies have established the positive impact of design thinking on problem-solving skills, most of the existing research has been conducted in higher education or professional learning environments, with comparatively limited empirical studies focusing specifically on middle-stage students (Guaman-Quintanilla et al., 2023; Yu et al., 2024). This creates a gap in understanding how design thinking interventions can be effectively adapted to the developmental needs and cognitive levels of learners in the middle stage.

Secondly, many studies rely on short-term interventions and cross-sectional designs, which do not adequately capture the long-term impact of design thinking on students' problem-solving abilities. There is a lack of longitudinal research examining how sustained exposure to design thinking influences the development of critical thinking, creativity, and problem-solving skills over time (Li & Zhan, 2022). This limits the ability to generalize findings and understand the durability of learning outcomes.

Thirdly, there is insufficient focus on standardized assessment tools for measuring problem-solving skills within design thinking frameworks. Most studies use qualitative observations, self-reports, or context-specific rubrics, which may lack reliability and validity across different educational settings (Razali et al., 2022). This indicates a need for the development of robust, validated instruments to assess the effectiveness of design thinking interventions consistently and measurably.

Additionally, a significant gap lies in the limited integration of design thinking within formal school curricula, particularly in developing countries. While policy frameworks increasingly emphasize 21st-century skills, there is a disconnect between theoretical recommendations and classroom practices due to inadequate teacher training, lack of resources, and rigid curricular structures (Bender-Salazar, 2023). Research exploring scalable and context-specific implementation strategies is still scarce.

Furthermore, although recent studies have explored innovative approaches such as gamification and design-based research, there is a need for more empirical evidence on how these integrations influence problem-solving abilities in diverse classroom settings (Kongnisai et al., 2024; Cavus et al., 2026). Additionally, limited attention has been given to the role of socio-emotional factors such as motivation, self-efficacy, and collaboration in mediating the relationship between design thinking and problem-solving outcomes (Zhang & Zhang, 2026). Lastly, there is a lack of comparative studies examining the effectiveness of design thinking against traditional teaching methods in enhancing problem-solving skills. Such comparative analyses are essential to establish the relative advantages of design thinking and justify its inclusion in mainstream education systems. To conclude, while existing literature provides substantial evidence on the benefits of design thinking, gaps remain in terms of target population (middle-stage students), longitudinal evidence, standardized assessment, contextual implementation, and integration with emerging pedagogical approaches. Addressing these gaps will contribute to a more comprehensive understanding of how design thinking can be effectively utilized to enhance problem-solving skills in school education.

Statement of the Problem

In context with the above justification, the problem at hand can be stated as Enhancing Problem-Solving Skills of Middle-stage Students through Design Thinking Interventions: Evidence from an Empirical Study.

Delimitations of the Study

- The study included only eighth-grade Middle-stage students from Amritsar city.
- This study focused on both Government and Private Schools.
- The study included only Eighth-grade boys and girls.
- The study focused on science topics only.

Objectives of the Study

- To study the effect of the Design thinking method on the problem-solving ability of 8th-grade students.
- To study the Problem-Solving ability of 8th-grade students with respect to gender.
- To study the interaction between treatment and gender on the gain scores of Problem-Solving abilities among 8th-grade students.
- To study the Problem-Solving ability of 8th-grade students with respect to the type of School.
- To study the interaction between treatment and type of school on the gain scores of Problem-Solving ability among 8th-grade students.

Hypotheses of the Study

- There was no significant difference in the mean gain scores of Problem-solving abilities among 8th-grade students taught through the design thinking teaching method and the conventional teaching method.
- There was no significant difference in the mean gain scores of Problem-solving abilities among 8th-grade students with respect to gender.
- There was no interaction between treatment and gender on the mean gain scores of Problem-Solving abilities among 8th-grade students.
- There was no significant difference in the mean gain scores of Problem-solving abilities among 8th-grade students with respect to the type of school.
- There was no interaction between treatment and type of school on the mean gain scores of Problem-solving abilities among 8th-grade students.

Sample

The study's sample size consisted of 200 Eighth-Grade students from Amritsar. For this purpose, the investigator used the random sampling technique.

Study Design

There were two groups: Experimental and Control. Two hundred students were divided into two groups: experimental and control. The researcher administered the Problem-Solving Ability Test (Pretest) to Grade 8 students (both experimental and control groups). The control group received traditional teaching, but the experimental group studied the steps of Hasso Plattner's Design Thinking paradigm. The students were taught hybrid learning strategies such as empathy, definition, ideation, prototyping, and testing. In the first three steps (Empathy, Define, Ideate), students brainstormed with community members (environmental activities) with the assistance of a teacher to solve the problem, and in the final two steps (Prototype and Test), students created a digital prototype or model by providing a solution, to which the teacher provided feedback. Students used Miro boards to create a prototype product, and the teacher gave them feedback. The investigator then administered a post-test to assess the students' problem-solving abilities in both groups.

Tools to be used in the Study

- **Design Thinking Modules in Science**: The investigator created the learning modules based on the Design Thinking Method in Science using Florida State University's ADDIE (Analysis, Design, Development, Implementation, and Evaluation) instructional design methodology from 1975. During the analysis phase, learners' profiles, curricular needs, learning objectives, and available resources were all reviewed. The design step required using the Hasso Plattner Design Thinking Model, which includes the stages of Empathize, Define, Ideate, Prototype, and Test, as well as the Miro Board application for prototype development. Five science concepts from the Grade VIII NCERT curriculum, including Irrigation System, Food Poisoning, Inexhaustible and Exhaustible Resources, Deforestation, and Noise Pollution, were chosen for their relevance to societal challenges and scientific concepts. All these modules were validated by four specialists in science education, and changes were made based on their feedback. During the implementation phase, a pilot study was conducted to test the modules' practicality and usefulness in improving students' problem-solving abilities. Finally, both offline workbooks and online project development with the Miro Board were used to measure students' comprehension, inventiveness, and application of scientific topics.

- **Problem-Solving Ability Test:** The investigator designed the Problem-Solving Ability Test in Science for Students, which is based on the George Polya Model of Problem-Solving Ability (1988) and addresses four dimensions: Understand the problem, create a plan, carry it out, and reflect. There are several tools for assessing problem-solving ability (Sushma and Irfan: Problem Solving Ability Test; Roma Ralhan; Dubey & Mathur: Problem Solving Ability Test; Passi test of Creative Problem Solving). But all of these examinations are for the secondary stage, not the middle. The dimensions of all of these tools did not meet the standards established by the research work. However, the Polya model offers a clear, step-by-step procedure that is simple to teach, apply, and evaluate across disciplines. The investigator conducted a pilot study to test the reliability of the test effectively. The scoring key was used to analyse the students' responses, and the exam was reviewed in light of their performance as well as feedback from teachers and other students. Item analysis was then used to determine each item's difficulty level and discriminatory power. The students' results were organized in descending order, and the top 27% and lower 27% groups were constructed using the approach proposed by Kelley (1939). The test items' quality was evaluated by calculating their Difficulty Value (DV) and Discriminatory Power (DP). Based on the item analysis, three items were discarded, while twenty-five items with acceptable difficulty levels and discriminating power, as advised by Hopkins and Antes (1990), were included in the final draft of the exam. The Problem-Solving Ability Test's dependability was confirmed using the Test-Retest method on the same sample of 50 Grade VIII students, with a one-week delay between administrations. The Pearson Product-Moment Correlation Coefficient was calculated, resulting in a reliability coefficient of 0.83, suggesting that the test is highly consistent and reliable. To determine validity, both face validity and content validity were assessed. The researcher, educational professionals, and scientific teachers evaluated the test to check its face validity and appropriateness. Seven education and science teaching specialists provided expert comments to determine content validity. Their ideas for adding, deleting, modifying, and clarifying items were incorporated, and the language of the items was modified accordingly. After rigorous evaluation and revision in cooperation with the research supervisor, the final form of the Problem-Solving Ability Test was created, demonstrating its content validity and suitability for measuring problem-solving ability among Grade VIII students.

Statistical Techniques

The data were analysed using statistical methods such as mean, standard deviation, t-test, and Analysis of Variance (ANOVA).

Results & Conclusions

Hypothesis – 1

“There was no significant difference in the mean gain scores of Problem-solving abilities among 8th-grade students taught through the design thinking teaching method and the conventional teaching method”.

Table 1: *Showing Mean Gain Score, SD, and t-Value of Experimental and Control Group in Relation to Problem Solving Ability in Science.*

Group/Method	N	Mean Gain Score	S. D	df	t- Value	Remarks
Experimental Group	100	13.16	8.80	198	16.78	Significant at the 0.05 level
Control Group	100	6.79	2.30			

Table 1 reveals that the mean gain score of the Experimental Group (13.16) is considerably higher than that of the Control Group (6.79). The standard deviation for the Experimental Group (8.80) indicates moderate variability, whereas the Control Group (2.30) shows relatively less dispersion in scores. The calculated *t-value* (16.78) is significantly higher than the critical table value (1.97) at the 0.05 level of significance with 198 degrees of freedom. This clearly indicates a statistically significant difference between the two groups. Therefore, the null hypothesis stating that *“There was no significant difference in the mean gain scores of problem-solving abilities among 8th-grade students taught through the design thinking teaching method and the conventional teaching method”* was rejected. It can be concluded that the Design Thinking teaching method was significantly more effective than the Conventional teaching method in enhancing students’ problem-solving ability in science.

A graph has been drawn to depict the mean gain scores of the experimental and control groups on the basis of Problem-Solving ability in science and has been represented in Figure 4.

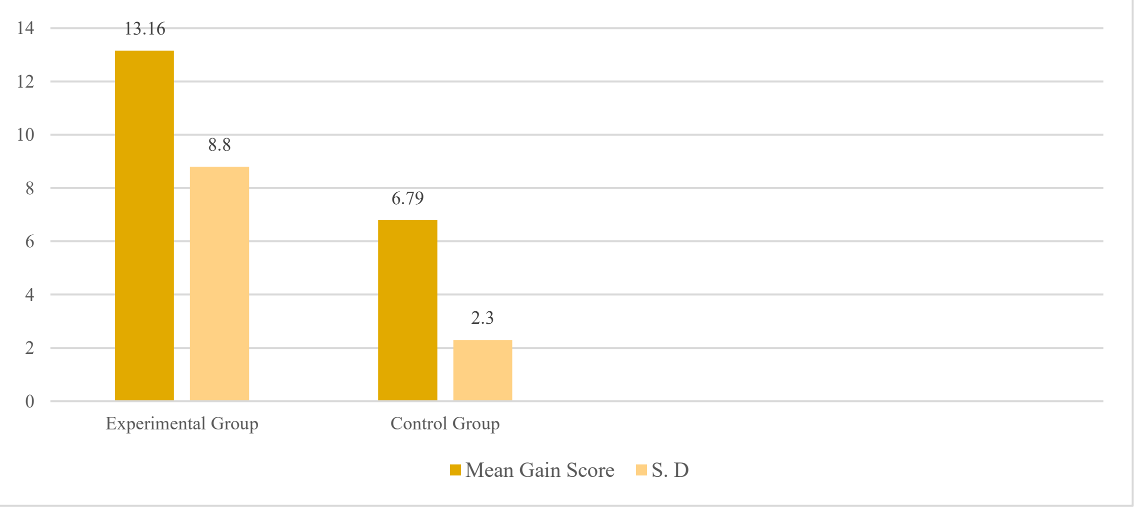

Figure 4: *Showing Graphical Representation of Mean Gain Scores & SD of the Experimental and Control Groups on Problem-Solving Ability Science*

These findings are supported by recent studies. Zhang and Zhang (2026) found that the integration of Design Thinking significantly improves students’ creativity and problem-solving skills in science learning. Similarly, Luka (2023) reported that students taught through Design Thinking pedagogy performed significantly better in problem-solving tasks compared to those taught using traditional teaching methods. Thus, the present findings are in alignment with recent research, confirming that Design Thinking is an effective pedagogical approach for enhancing problem-solving ability among students.

Hypothesis – 2

"There was no significant difference in the mean gain scores of Problem-solving abilities among 8th-grade students with respect to gender"

Table 2: *Showing Mean Gain Score, SD, and t-Value of Problem-Solving Ability with Respect to Gender.*

Variable	Gender	N	Mean Gain Score	SD	t-value	Remarks
Problem-Solving Ability	Boys	100	16.20	21.16	22.78	Significant at the 0.05 level
	Girls	100	14.10	18.10		

Table 2 shows the comparison of mean gain scores of problem-solving abilities among 8th-grade students with respect to gender. It is observed that the mean gain score of boys (16.20) is slightly higher than that of girls (14.10). The standard deviation of boys (21.16) and girls (18.10) indicates variability in both groups, with boys showing comparatively higher dispersion. The calculated t-value (22.78) is much greater than the critical value at the 0.05 level of significance, indicating that the difference between boys and girls was statistically significant. Therefore, the null hypothesis stating that "*There was no significant difference in the mean gain scores of problem-solving abilities among 8th-grade students with respect to gender*" was rejected. It can be concluded that gender significantly influences problem-solving ability, with boys performing better than girls in the present study.

A graph has been drawn to depict the Mean gain scores of boys and girls on the basis of Problem-Solving ability and has been represented in Figure 5.

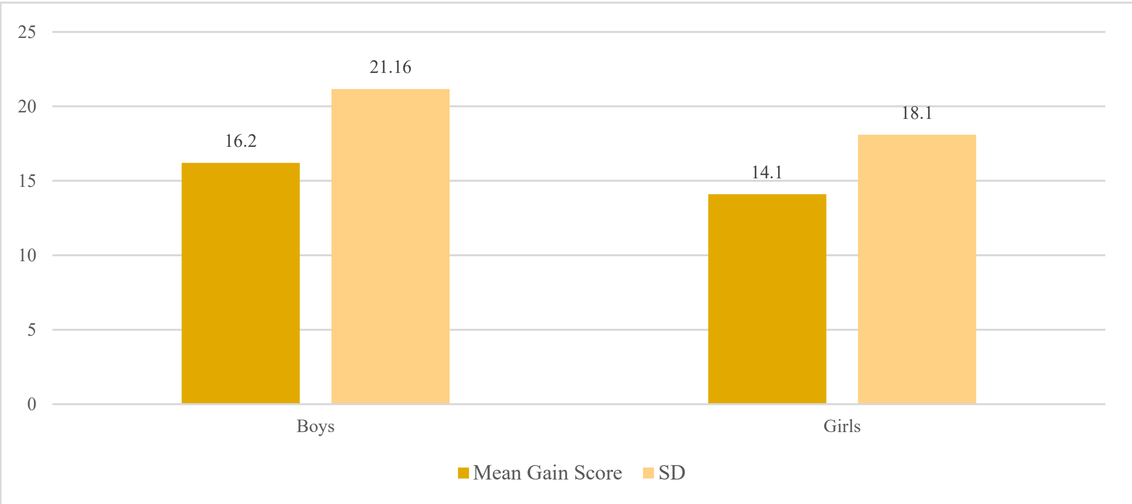

Figure 5: *Showing Graphical Representation of Mean Gain Scores of Boys and Girls on Problem-Solving Ability*

These findings are supported by recent research. A meta-analysis by Hu (2024) reported statistically significant gender differences in computational thinking and problem-solving related skills, with boys showing slightly higher performance, although the effect size was small. Similarly, a study by Phothong et al. (2023) found that design-based learning outcomes vary across gender, indicating that instructional approaches like Design Thinking may influence boys and girls differently in developing problem-solving abilities. Thus, the present findings are consistent with recent research, suggesting that gender plays a significant role in shaping students' problem-solving abilities, even within innovative pedagogical approaches like Design Thinking.

Hypothesis – 3

"There was no interaction between treatment and gender on the mean scores of Problem-Solving abilities among 8th-grade students."

Table 3: *Showing Summary Table of Two-Way ANOVA of Treatment, Gender on Problem-Solving Ability.*

Sources of Variance	Sum of Squares	df	Mean Sun of Squares	F	Significance
Gender (A)	509.30	1	504.20	6.802	.000
Treatment (B)	223.116	1	225.250	768.180	.005
Gender * Treatment (AxB)	40.180	1	35.140	5.180	.008
Error	2878.209	197	25.209		
Total	3989.401	200			

Table 3 presents the results of the two-way ANOVA conducted to examine the main and interaction effects of treatment (Design Thinking vs. Conventional Method) and gender on students' problem-solving ability in science. The analysis reveals that the main effect of gender (A) is significant, as the obtained F-value (6.802) is significant at the 0.05 level. This indicates that there exists a significant difference between boys and girls in their problem-solving ability. The main effect of treatment (B) is also found to be highly significant ($F = 768.180$, $p < 0.05$), which clearly shows that the teaching method has a strong influence on students' problem-solving ability. Students taught through the Design Thinking method performed significantly better than those taught through the Conventional method. Further, the interaction effect between gender and treatment (A×B) was significant ($F = 5.180$, $p < 0.05$). This indicates that the effectiveness of the teaching method differs with respect to gender. In other words, the impact of Design Thinking on problem-solving ability is not uniform for boys and girls. Thus, the null hypothesis stating that *"There was no interaction between treatment and gender on the mean gain score of problem-solving ability among 8th-grade students"* was rejected. It can be concluded that both gender and teaching method have significant independent as well as interactive effects on problem-solving ability in science.

These findings are supported by recent studies. Henriksen et al. (2017) emphasized that Design Thinking enhances higher-order thinking and problem-solving skills, but learner characteristics such as gender can influence learning outcomes. Similarly, Koh et al. (2024) found that innovative pedagogies like Design Thinking significantly improve 21st - century skills; however, variations exist across student groups, suggesting interaction effects between instructional strategies and learner variables. Therefore, the present findings align with contemporary research, highlighting that Design Thinking is an effective instructional approach, and its impact varies depending on gender differences among learners.

Hypothesis – 4

"There was no significant difference in the mean gain scores of Problem-solving abilities among 8th-grade students with respect to the type of school."

Table 4: *Showing Mean Gain Score, SD, and t-Value of Experimental and Control Group with Respect to the Type of Schools*

Variable	Type of School	N	Mean Gain Score	SD	t-value	Remarks
Problem-Solving ability	Government	100	17.80	21.18	27.04	Significant at the 0.05 level
	Private	100	22.25	32.30		

Table 4 presents the comparison of mean gain scores of problem-solving abilities among 8th-grade students with respect to the type of school. It is observed that the mean gain score of students from private schools (22.25) is higher than that of students from government schools (17.80). The standard deviation for government schools (21.18) and private schools (32.30) indicates variability in both groups, with private school students showing greater dispersion in scores. The calculated *t-value* (27.04) is much higher than the critical table value at the 0.05 level of significance, indicating that the difference between the two groups is statistically significant. Therefore, the null hypothesis stating that *"There was no significant difference in the mean gain scores of problem-solving abilities among 8th-grade students with respect to the type of school"* was rejected. It can be concluded that the type of school significantly influences students' problem-solving ability, with private school students outperforming government school students in the present study.

A graph has been drawn to depict the Mean gain scores of Governments and Private Schools on the basis of Problem-Solving and has been represented in Figure 6.

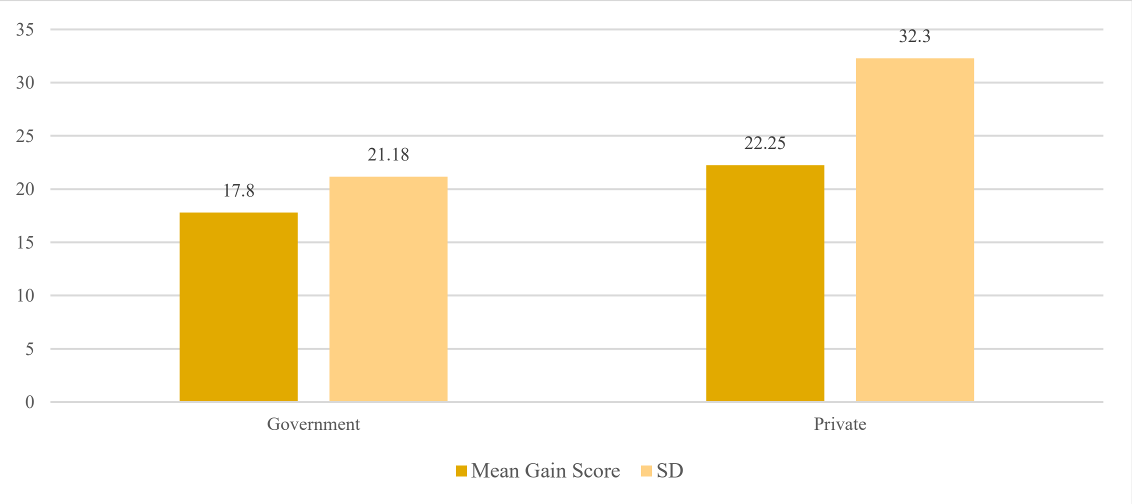

Figure 6: *Showing Graphical Representation of Mean Gain Scores of Governments and Private School Students on Problem-Solving Ability*

These findings are supported by recent studies. A meta-analysis by Yu et al. (2024) reported that innovative pedagogical approaches like Design Thinking significantly enhance students' problem-solving and learning outcomes by promoting active engagement and idea generation. Similarly, a systematic review by Alvarado (2025) highlighted that Design Thinking fosters critical thinking, collaboration, and effective problem-solving skills through active and student-centred learning environments, which are often more effectively implemented in resource-rich educational settings. Thus, the present findings are in line with contemporary research, suggesting that learning environments and institutional context (such as the type of school) play a crucial role in the development of students' problem-solving abilities, especially when innovative teaching methods like Design Thinking are used.

Hypothesis – 5

"There was no interaction between treatment and type of school on the mean scores of Problem-solving abilities among 8th-grade students"

Table 5: *Showing Summary Table of Two-Way ANOVA of Treatment, Type of Schools, on Problem-Solving Ability*

Sources of Variance	Sum of Squares	df	Mean Sun of Squares	F	Significance
Type of Schools (A)	606.12	1	345.90	7.988	.000
Treatment (B)	222.170	1	222.166	899.299	.000
Type of Schools * Treatment (AxB)	37.888	1	37.150	5.678	.000

Error	2789.707	197	27.155		
Total	3890.245	200			

Table 5 presents the results of the two-way ANOVA conducted to examine the main and interaction effects of treatment (Design Thinking vs. Conventional Method) and type of school (Government vs. Private) on students' problem-solving ability in science. The analysis shows that the main effect of type of school (A) is significant ($F = 7.988$, $p < 0.05$), indicating that students from different types of schools differ significantly in their problem-solving ability. The main effect of treatment (B) is also found to be highly significant ($F = 899.299$, $p < 0.05$), which clearly demonstrates that the teaching method has a strong influence on students' problem-solving ability. Students taught through the Design Thinking method performed significantly better than those taught through the Conventional method. Further, the interaction effect between type of school and treatment (A×B) was also significant ($F = 5.678$, $p < 0.05$). This indicates that the effectiveness of the teaching method varies according to the type of school. In other words, the impact of Design Thinking is not uniform across different school environments. Thus, the null hypothesis stating that *"there was no interaction between treatment and type of school on the mean gain scores of problem-solving abilities among 8th-grade students"* was rejected. It can be concluded that both treatment and type of school have significant independent as well as interaction effects on problem-solving ability.

These findings are supported by recent research. A meta-analysis by Yu et al. (2024) found that Design Thinking significantly enhances students' problem-solving, creativity, and innovation by promoting active engagement and learner-centred approaches. Similarly, a recent study by Cavus et al. (2026) reported that design-based learning approaches significantly improve students' problem-solving and critical thinking skills; however, the effectiveness varies across educational contexts, indicating the influence of environmental factors such as the type of school. Additionally, a systematic review by Alvarado (2025) highlighted that Design Thinking fosters critical thinking, collaboration, and effective problem-solving, but its success depends on institutional conditions such as resources, teaching practices, and learning environment. Therefore, the present findings are consistent with contemporary research, emphasizing that Design Thinking is an effective instructional approach, and its impact is moderated by contextual factors like the type of school.

Discussion of Findings

The present study was conducted to examine the effect of the Design Thinking teaching method on the problem-solving ability of 8th-grade students in science. The findings of the study are discussed in relation to the stated hypotheses and supported by recent research evidence.

1. The results related to Hypothesis 1 revealed a significant difference between the Experimental and Control groups in terms of problem-solving ability. Students taught through the Design Thinking method showed higher mean gain scores compared to those taught through the Conventional method. This clearly indicates that Design Thinking is more effective in enhancing problem-solving ability. These findings are in agreement with recent studies such as Zhang and Zhang (2026) and Luka (2023), which reported that Design Thinking significantly improves students' creativity, engagement, and problem-solving skills through active and learner-centred approaches.

Figure 8: *///*

2. With respect to gender (Hypothesis 2), a significant difference was found between boys and girls in their problem-solving ability. The findings indicated that gender plays an important role in influencing learning outcomes. This may be due to differences in learning styles, participation levels, or socio-cultural factors affecting engagement in classroom activities. Similar findings have been reported in recent studies (Hu, 2024; Phothong et al., 2023), which highlight that gender differences exist in problem-solving and cognitive performance, although these differences may vary across contexts.

3. The findings related to Hypothesis 3 showed that both treatment and gender have significant main effects, and their interaction effect is also significant. This indicates that the effectiveness of the Design Thinking method varies with gender. In other words, boys and girls respond differently to innovative teaching methods. This finding is supported by studies such as Henriksen et al. (2022) and Koh et al. (2024), which emphasize that learner characteristics influence the outcomes of Design Thinking-based instruction.

4. In relation to the type of school (Hypothesis 4), the results indicated a significant difference between students from government and private schools. Private school students showed higher problem-solving ability compared to government school students. This may be attributed to better resources, learning environments, and exposure to innovative teaching strategies in private schools. These findings are consistent with recent studies (Yu et al., 2024; Alvarado, 2025), which highlight that institutional context and learning environment significantly affect students' learning outcomes and problem-solving skills.

5. Finally, the findings of Hypothesis 5 revealed a significant interaction effect between treatment and type of school. This suggests that the effectiveness of the Design Thinking method is influenced by the type of school. The method may yield better results in environments where adequate resources, teacher training, and supportive infrastructure are available. Similar conclusions have been drawn in recent research, indicating that the success of innovative pedagogies like Design Thinking depends on contextual and institutional factors (Çavuş et al., 2025; Alvarado, 2025).

Overall, the findings of the study clearly demonstrate that the Design Thinking teaching method is highly effective in enhancing problem-solving ability among students, but its effectiveness is influenced by variables such as gender and type of school. The study highlights the importance of adopting innovative, student-centred teaching approaches while also considering learner characteristics and institutional context to maximize educational outcomes.

Discussion of Findings

1. The study was limited to Grade VIII students only. Future studies may include students from elementary, secondary, and higher education levels.

2. The study was confined to the Government and Private schools of Amritsar city. Similar studies may be conducted in different districts, states, and educational boards for wider generalization.

3. Only the Science subject was included in the intervention. Future research may examine Design Thinking in Mathematics, Social Science, Languages, and other subjects.

4. The intervention was conducted for a short duration. Longitudinal studies may be conducted to examine the long-term effects of Design Thinking.

5. The study focused only on Problem-Solving Ability. Future studies may investigate creativity, critical thinking, collaboration, communication, digital literacy, and academic achievement.

6. Only gender and type of school were considered as variables. Additional variables such as socio-economic status, motivation, self-efficacy, learning styles, and parental support may be explored.

7. The findings were based on a self-constructed Problem-Solving Ability Test. Future researchers may develop and standardize more comprehensive assessment tools.

Educational Implications of the Study

1. The findings of the present study have important implications for improving the teaching-learning process at the school level. The study clearly shows that the Design Thinking teaching method is more effective than the conventional method in enhancing students' problem-solving ability. This suggests

that teachers should move beyond traditional lecture-based methods and adopt innovative, student-centred approaches. By engaging students in activities such as identifying problems, generating ideas, and testing solutions, teachers can help develop deeper understanding and critical thinking skills.

2. The study also highlights the role of gender in influencing problem-solving ability. This implies that teachers need to adopt inclusive teaching strategies that address the diverse learning needs of both boys and girls. A supportive and participatory classroom environment should be created where all students feel encouraged to express their ideas and actively engage in learning activities.

3. Further, the significant difference based on the type of school indicates that the learning environment plays a crucial role in students' academic development. Students from private schools performed better, which may be due to better resources, infrastructure, and exposure to innovative teaching practices. Therefore, efforts should be made to improve the quality of education in government schools by providing adequate facilities, modern teaching aids, and opportunities for experiential learning.

4. The findings also emphasize the importance of teacher training. Teachers need to be equipped with the necessary skills and knowledge to effectively implement Design Thinking in the classroom. Regular workshops, seminars, and professional development programs should be organized to help teachers understand and apply innovative teaching strategies.

5. Moreover, the study suggests that the curriculum should be redesigned to include Design Thinking as an integral part of teaching, especially in science education. Incorporating real-life problems and project-based activities can make learning more meaningful and relevant for students, thereby improving their problem-solving ability.

6. The significant interaction effects found in the study indicate that the effectiveness of teaching methods is influenced by factors such as gender and type of school. This means that a uniform approach to teaching may not be effective for all learners. Teachers should adopt flexible and adaptive strategies to meet the varying needs of students and different educational settings. Finally, the study underscores the importance of developing 21st-century skills among students. By promoting creativity, collaboration, communication, and critical thinking, Design Thinking can prepare students to face real-world challenges effectively. Policymakers should support the implementation of such innovative approaches by providing necessary resources and ensuring equal educational opportunities for all students.

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