Impact of Design Thinking on Middle School Students in the Science Classroom

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Abstract: Design thinking is innovative pedagogy emerges to enhance creative problem solving skill. Design thinking pedagogy based on the user experience and cooperative learning. The objective of present research was to analyze a lesson plan rooted in the Design Thinking (DT) approach that fosters student comprehension, participation, and problem-solving in science education. The interpretative qualitative research methodology has been used to analyze the research questions. Data was collected from 40 middle school learners through observation and reflective journals of learners. Results show that participation of learners in the classroom enhances the science concepts. Moreover reflective journals reveal that design thinking pedagogy helps to develop the problem solving skill among students.

Keywords: *Design Thinking, Science Education, Problem Solving.*

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I. INTRODUCTION

Active learning strategies often encourage learners to link new information with their existing mental frameworks, thereby deepening their comprehension. Additionally, educators may create learning experiences that challenge misconceptions, enabling learners to update their mental models with a more precise understanding. Design Thinking (DT) serves as a prime example of an active learning approach. Essentially, DT is a cyclical design method that emphasizes innovative problem-solving and inspires people to think creatively, collaborate, and empathize with end-users. DT provides an effective method for fostering transversal skills within educational environments by nurturing creative thinking, leadership abilities, presentation skills, project management, ethical considerations, storytelling, negotiation, empathy, and a readiness to learn through a collaborative and iterative approach. Design Thinking also strengthens critical thinking abilities, boosts creativity, and encourages teamwork among students (Novo et al., 2023).

The methodology focuses on cultivating design thinking abilities in students through education. When integrated into various subjects, it can act as a stress reliever, offering a break from the pressures of exams and other academic challenges. Although design thinking is a wide-ranging concept that can be hard to articulate, it can be implemented practically and effectively. This method highlights learning through experiential activities, substituting memorization with active involvement. It provides children with early exposure to creative problem-solving by recognizing user needs and guiding product development. This strategy promotes exploration, analytical thinking, and problem-solving, assisting students in becoming more reflective and innovative learners. Our approach intends to improve students' cognitive skills by involving them in the process of creation and production rather than solely repeating what they have been taught. We aspire to nurture children's reasoning abilities by motivating them to ask questions, analyze issues, and formulate solutions. Design thinking is an approach which uses a human centric open-ended problem-based approach to modify the teaching & learning is directed in the practical application of technical and scientific knowledge education and to solve the various difficulties that teachers and students are facing in the context of digital learning. The technology is continuously changing due to being triggered by the design thinking approach.

A strategy for finding innovative solutions to issues is called design thinking. Instead of beginning with a problem statement, this type of solution-focused thinking begins with a goal. In the classroom process the problem's parameters and potential solutions are then investigated concurrently by concentrating on the present and the future (Cross, 1982b).

The DT has been linked to the growth of critical thinking, problem-solving, and the capacity to operate in complex and dynamic environments—all of which are essential components in preparing college students to meet the demands of the modern workplace. Meinel and Leifer (2011)Design Thinking is "This human-centered approach combines knowledge from design, social sciences, engineering, and business. It merges a focus on end users with cross-disciplinary teamwork and

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ongoing refinement to create innovative products, systems, and services".

Basically five primary stages of the DT's iterative process are empathy, definition, ideation, prototype, and testing. The DT's capacity to promote creativity and innovation is one of its core features. Students develop thoughtful and creative analytical abilities by investigating various concepts and solutions, which are essential in a setting that is becoming increasingly varied and dynamic. The DT encourages students to challenge the existing quo, put forth novel concepts, and come up with creative and practical solutions to difficult problems. The DT encourages group collaboration and cooperation. Design thinking also promotes experimentation and error-based learning(Alvarado, 2025). Filho (2016),The approach consists of three main stages: (i) the inspiration stage, which focuses on gaining a deep insight into the problem by examining user requirements and actions; (ii) the ideation stage, which includes producing relevant innovative concepts for the situation and rapidly crafting inexpensive prototypes of selected ideas; and (iii) the implementation stage, where key concepts and prototypes are refined to create a solution ready for use.

Design Thinking represents a creative approach that emphasizes idea generation without judgment, removing the fear of failure, and promoting the fullest engagement and participation of individuals in the problem-solving process. It employs the human experience as a catalyst for innovation and can be applied in any context or environment. This method leverages the insights, techniques, and design tools used by designers to address various issues, fostering empathy, creativity, critical thinking, reflection, transdisciplinarity, abstraction, and collaboration (Nunes et al., 2021).

The design thinking (DT) framework encompasses a variety of models. Below are the five stages of DT illustrated.

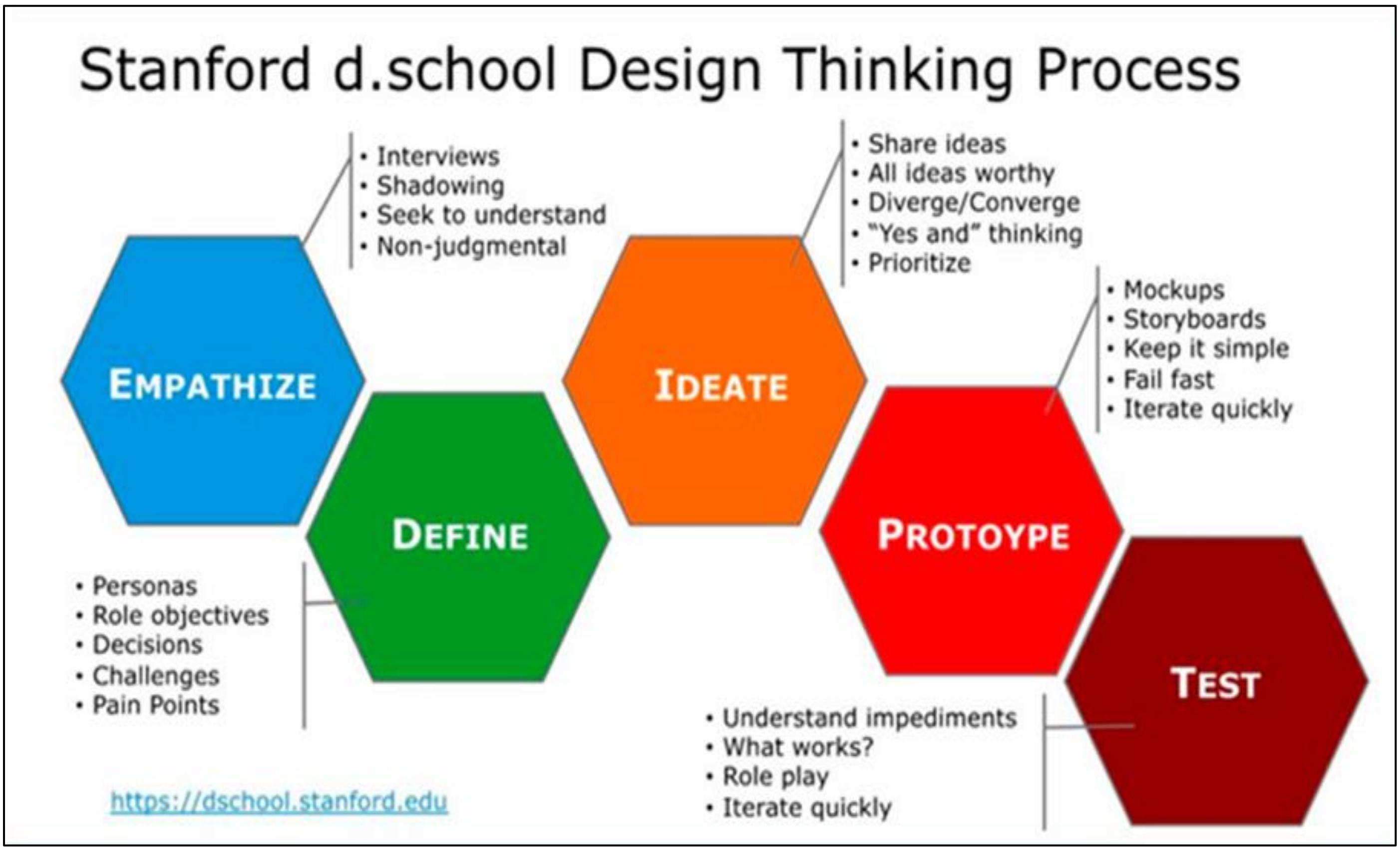

Fig 1 Design Thinking
(Source: https://www.researchgate.net/figure/DSchools-Design-Thinking-Process-https-dschoolstanfordedu_fig1_332285147)

- Empathize: In this phase,The learner attentively observes, participates actively, pays close attention, and listens thoughtfully to the situation at hand. The objective of this phase is to comprehend the individuals connected to the design challenge. This entails understanding the requirements of the target audience and the particular issue that must be resolved (Midler et al., 2016).
- Define: In this stage, The student effectively expresses the challenge based on their revised understanding and the issue at hand. The learner constructs clear problem statements to guide their work (Pandit et al., 2024).
- Ideate: During this phase, learners generate ideas, with all contributions valued. The suspension of judgment allows the team to explore unconventional solutions and foster unique concepts for consideration (Brenner et al., 2016).
- Prototype: In this stage, Students actively participate in the design thinking process to develop solutions for the target audience. This iterative phase promotes the opportunity to experience setbacks. Prototypes can be created without

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significant time commitments or extensive resources. It entails converting the selected solution concepts into affordable, smaller models or any outputs that users can engage with or assess (Albay & Eisma, 2024).

- Test: The last stage of the design-thinking process entailed assessing and evaluating the prototype. Students carried out tests to collect feedback and enhance the prototype for a better solution. Testing not only allows students to learn from their mistakes but also fosters critical thinking and efficient problem-solving (Nguyện et al., 2025).
- Iteration is crucial: The five stages outlined above do not necessarily follow a fixed order. These processes can happen at the same time and can be revisited repeatedly. Design Thinking (DT) practitioners engage in this process multiple times to find workable solutions. DT serves as a technique to tackle complex challenges in a human-centered manner, requiring collaborative and cross-disciplinary efforts within organizations. When teaching learners about DT, it is crucial to establish a strong foundation that includes their values, attitudes, skills, and potential, along with fostering creative habits and a supportive environment. Educators and innovators should consider these essential qualities of design and innovation when guiding individuals to create tangible solutions for complicated and open-ended problems (Aflatoony et al., 2018).

This approach is consistent with interpersonal, socio-cultural, and social constructivist educational theories, as well as experiential, authentic learning, and reflective methods. Design Thinking education focuses on instructional practices that involve students in active learning, including problem-based, inquiry-based, and project-based strategies. Furthermore, Design Thinking has been integrated into educational programs through the creation of "maker spaces" or genius hours, which provide students designated time to pursue their creative skills and passions (Juliani, 2014 ; Parker et al., 2021).

II. LITERATURE REVIEW

(Ericson et al., 2009) The application of design thinking techniques in the classroom, particularly in engineering and design courses, is examined in the research "Design Thinking Challenges in Education." (Pandit et al., 2024) The study "Design Thinking as a Pedagogical Approach in Educational Settings" explores the application of design thinking in school classrooms to cultivate essential 21st-century abilities such as creativity, empathy, and collaboration. Design thinking has the potential to enrich education, schools must provide teachers with adequate training and the flexibility needed for effective application. (Nunes et al., 2021) design thinking helps instructors and students become more creative, empathetic, and adept at solving problems. receive mentorship training to foster empathy, creativity, and teamwork in the classroom.

The integration of design thinking into teaching methods and curriculum development in both schools and universities promotes creativity, empathy, collaboration, and innovation, enabling students to tackle complex real-world issues more effectively (Lor, 2017). Design thinking gives solution based thinking (Pusca, 2018), traditional educational systems, which prioritize exams and predetermined outcomes, pose challenges for its adoption. Design thinking has the potential to be transformative, there is a pressing need for improved frameworks, more extensive longitudinal studies, and well-structured teacher training programs. (Wippermann & Schmidberger, 2023) innovative practices in higher education brings digitization, sustainability, and contemporary learning requirements. (Nguyện et al., 2025) The goal of the project "Integrating Design Thinking into STEM Education: Enhancing Problem-Solving Skills of High School Students" is to determine how design thinking can help students in STEM classes become more adept at solving problems. Challenges like time limits, teachers' lack of training, and students' struggles with open-ended tasks are also highlighted in the study. (Zhu et al., 2019) The study titled “Convergent Thinking Moderates the Relationship between Divergent Thinking and Scientific Creativity” aims to explore the impact of various thinking styles on students' scientific creativity. Merely having divergent thinking is not enough to achieve scientific creativity; convergent thinking significantly moderates this process by assisting students in assessing, refining, and logically applying their ideas. (Jones, 2008)The research "Why Do Students Take Part? "A Study of Classroom Participation" explores the variables that affect students' involvement in class instruction.The classroom setting, instructor conduct, students' self-esteem, and the perceived importance of the material all affect how involved the students are. Participation is decreased by a lack of support and a fear of making mistakes.

➢ *Research Objectives*

- To analyze a lesson plan rooted in the Design Thinking (DT) approach that fosters student comprehension, participation, and problem-solving in science education.
- To investigate how design thinking techniques can be applied in the teaching of science concepts within school classrooms.

III. METHODOLOGY

➢ *Research Design:*

The present study adopts interpretative qualitative research design (Elliott & Timulak, 2015). The aim of using qualitative methods is to achieve a comprehensive understanding of the implementation of design thinking in science education by collecting data in three stages. Intervention of design thinking in middle school.

➢ *Participants*

The study included prospective science education teachers chosen using purposive sampling. The middle school students, for class VII and IX especially from the science classroom.

- Data Collection tools and techniques: Data has been collected in three levels, first development of lesson plan based on the design thinking strategies. Second intervention with middle school learners in science classroom and third

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was impact of design thinking on students participation, comprehension and problem solving skills.

- Classroom Observation Sheet: The Classroom Observation Sheet serves as a structured instrument for systematically documenting student behaviour and engagement throughout the Design Thinking-based science lessons. It comprises indicators such as participation, collaboration, and problem-solving skills which the researcher assesses using Yes/No. Such sheets facilitate the objective and reliable capture of real-time classroom behaviours (Cohen et al., 2017). In this research, the sheet offers clear evidence of student interactions with DT activities and illuminates how their engagement evolves during the intervention, making it an essential source of observational data.

➢ *Intervention Process:*

First step of intervention program was development of Design thinking based lesson plan for chapter Changes around Us and Atom and Molecules from NCERT textbook. The second step was design thinking based classroom process (pedagogy) in class VII and IX grade. The third step was observation while intervention of design thinking pedagogy in both levels of class.

IV. RESULTS AND FINDINGS

The data collected from prior intervention during intervention and post intervention has gives following results.

➢ *Comprehension*

From the classroom observation, it was clear that while engaging in activities, students were developing their comprehension and understanding of the problem better. For example, in one class, students folded a rectangular paper sheet to make a triangular shape without tearing it. Through this activity, students observed that even without tearing, the shape and size of the paper changed. After this, many similar examples emerged from the whole class, where change was occurring, but the physical properties remained unchanged. This showed that students had started understanding the concept and were beginning the ideate process based on the definition.

Students cited more examples as ideate such as the melting of ice cream, vapour coming out while heating tea, the spring inside a pen or vehicle becoming smaller when pressed (change in size), and cutting an apple to eat it. These examples showed that students were able to ideate the concept in collaboration.

Moreover, a similar process was observed in follow up classes. Students performed activities to identify and understand the problem. For example, one group was asked to cut a paper sheet repeatedly until it could no longer be cut normally. Another group was asked to make a about invisible things that we believe exist. Through these activities, students not only understood the problem but also started generating ideas.

To define the concept of Atom, students tore the paper into smaller pieces, *"Sir, now the paper cannot be torn further."* At this point, both groups summarized the idea that matter is made of tiny particles called atoms, which are invisible. The whole class built different analogies about the atom. The student further explained that cells form tissues, tissues form organs, organs form organ systems, and organ systems form the body. Students cite more examples that letters form words, and words form sentences. In this way, students connected the concept of atoms to matter.

➢ *Participation*

From the classroom observation, it was seen that students' active participation was enhanced. During group activities, students were actively participating and discussing ideas with peers. As a result of active participation, students were able to identify and define problems clearly.

For example, in classroom activity, a group was given an elastic band. All students in the group took turns stretching the elastic band. One student said, *"Sir, the size is changing,"* and another student added, *"Sir, the shape is also changing."* This showed that students were carefully observing and identifying the problem through hands-on activity. Students were also helping and supportive towards others during the activity.

Active participation and teamwork, students were able to suggest tentative solutions for all the problems. In follow up class, one group was asked to write the name of an element 25 times in 10 seconds. During this activity, a student asked, *"Sir, can we use the symbol instead of writing the full name?"* This question showed that the student had identified a problem and step by step thinking of a solution process.

➢ *Problem-Solving Skills*

The group of VII grade students made a paper boat using a paper sheet and said, *"Sir, the size and shape of the paper have changed."* Further examples for physical change students gave daily life examples, the spring in a car seat gets compressed when someone sits on it. The student gave possible solutions for the reason behind only shape changes, and nothing new is formed. Moreover, students gave more examples for physical changes i.e.,The spring inside a pen also becomes smaller when pressed, but it does not form a new object. These examples showed that students were clearly identifying the nature of the change.

In collaboration students were not only identifying problems but were also suggesting possible solutions with the help of each other. For instance, in an activity where students had to write the name of an element 25 times in 10 seconds, a student said, *"Sir, we cannot write the full name so many times, but if we use the symbol instead of the name, we can write it easily."* This showed that the student had identified the problem and suggested an effective solution.

In follow up classes, all students shared the analogies they had created in their groups. These analogies showed their scientific understanding along with divergent thinking. The concept discussed was that matter is made up of atoms. One group explained that just like a car is made from many small spare parts, matter is made from atoms. Another group said that letters form words, and words form sentences. One more group

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explained that cells form tissues, tissues form organs, organs form organ systems, and organ systems together form the human body.

V. DISCUSSION

From the classroom observation, it was clear that while engaging in activities, students were developing better comprehension and understanding of the problem. Students had started to understand the concept and were transitioning from the define stage to the ideate stage. It was also observed that students explored the given example (reference point) and tried to understand it in different ways. They were giving different answers and solutions to the same problem or question. This process is known as divergent thinking (Van Uum & Van Der Zanden, 2025). At the same time, students were able to analyse the problem using core scientific principles along with their existing knowledge and shared solution based thinking. Through this process, they were able to arrive at the most appropriate answer. This type of thinking is known as convergent thinking (Zhu et al., 2019). Participation was found to be an effective way to identify or define a problem. Students were carefully observing and identifying problems through hands-on activities. They were also helping each other during the activities. Because participation was high, students were able to suggest tentative solutions. This type of classroom interaction can be described as open and unstructured participation (Jones, 2008).When participation increases, the number of identified problems (define) also increases. As more problems are identified, students generate more ideas and solutions (ideate). Previous research also supports this view, stating that increased classroom participation helps establish responsibility among students, increases the number of engaged participants, triggers memory retrieval, and promotes advanced cognitive processes (Frymier & Houser, 2017).

Problem-solving skills help students identify the beginning of a problem and find effective solutions in all the classes (Foster 2019). During activities, students were able to identify problems and link their solutions with scientific knowledge, which reflected their conceptual understanding. Students were also able to form analogies. Students using constructivism to define problem students are able to develop innovative solutions. It shows reflective and higher order thinking were used to define the prototypes (Guaman-Quintanilla 2023). This connection highlights that the define stage acts as a roadmap for generating concepts in the form of ideate (Nguyện et al., 2025).

VI. CONCLUSION

This research investigates how design thinking influences middle school students in the science classroom. The results of this research indicated that student engagement in the classroom improves their comprehension, involvement, and problem-solving abilities. This implies that the design thinking method is more effective and focused on the user. This research carries significant implications for practices in science classrooms. The goal of the study was to determine the reasons behind the challenges that educators and learners have when putting design thinking into practice. Research shows that student reflections, teamwork observations, and classroom experiences use DT effectively. Moreover, study emphasis on design thinking pedagogy fosters students' creativity, empathy, and active participation. The study concludes that design thinking is highly successful in encouraging creative learning, but educators should be more cautious in helping students deal with uncertainty, comprehend the viewpoints of others, and define issues precisely.

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