Effect of Design Thinking Method on Academic Achievement, Creativity and Digital Skills in Science among Middle Stage Students

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Abstract

The current study examines how middle-stage students' academic achievement, creativity and digital skills in science are affected by the design thinking method. A sample of 100 eighth-grade students from two separate schools were selected by the Simple Random Sampling method; fifty each in the experimental group and control group. The investigator followed the five-step design thinking model of Hasso Plattner–2005 to teach the students, which included Empathy, Define, Ideate, Prototype and Test. A hybrid mode of Learning was followed to conduct the study. In the first three steps (Empathy, Define, Ideate), students deal with the community members through environmental activities and find out the solution to the problem through brainstorming sessions in the last two steps (Prototype and Test), students create the prototype in a digital form based on the provided solution and then teacher provided feedback in an online mode. Miro boards were used by the students to design a project in the prototype stage and then the teacher provided feedback to the students. The pre- and post-tests were analysed statistically using Mean, SD, T-Test and ANOVA to assess students' academic achievement, creativity and digital skills in science. The results of this study demonstrated a positive and significant difference between students who were taught the Design Thinking technique and those who were taught the conventional way, which helped to develop the student's creativity, digital skills and learning of science.

Keywords: *Design Thinking Method, Creativity, Digital Skills and Academic Achievement*

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Introduction

There are a lot of complicated problems in our world today that are changing quickly and cannot be resolved by technology alone. To address issues and enhance our quality of life, society thus requires capable innovators and problem solvers. Due to the perception that schools are required to impart these abilities, students need to be given assignments and evaluations that prepare them to lead a classroom in the twenty-first century. The fundamental tenet of this approach is that people who leave science school to enter the profession need a specific set of abilities to prosper and advance society in a setting that is becoming more complex and competitive. For students to acquire the skills and competencies of the twenty-first century, they need to have access to a classroom that is both responsive and engaging. Education must redefine its goals, curriculum and creative pedagogical approaches to satisfy the expectations set by society to fulfil such a large obligation. However, the National Education Policy (NEP 2020) noted that it will become more and more crucial for kids to not only learn but also learn how to learn, given the rapidly evolving global environment and work landscape. Critical thinking, problem-solving, creativity, interdisciplinary learning, innovation, adaptation and assimilating new information in developing sectors must replace the material focus of education. The advancement of pedagogy is necessary to make education more immersive, comprehensive, integrated, inquiry-driven, discovery-oriented, learner-centred, discussion-based, flexible and of course, fun.

In the current scenario, educators emphasise practical methods of learning by changing theoretical ideas into practical forms through the use of various approaches and methodologies, allowing students to study practical information from a young age and gain more abilities. One of these approaches is known as Design Thinking (She, Farrell, Brunton and Costello, 2021). One such scientific approach that aids in the creation of prototypes while taking into account creativity, visualisation, design and redesign in response to feedback is Design Thinking (DT), which provides workable answers to any socio-economic or educational issues. The double helix relationship between design and thinking, which possesses both generative and creative qualities—is highlighted by the design thinking process. The cognitive process of design work or the methods and techniques designers employ to generate new ideas or objects or to address practical issues are referred to as “Design Thinking” (Cross, 2011;

Simon, 1969). Therefore, to negotiate workable solutions to global educational and political conflicts as well as environmental challenges that will surely persist into the next century, educators must create collaborative and authentic learning activities that help students develop their knowledge, abilities and values (UNESCO, 2015). To overcome these challenges, design thinking is a very innovative method, which is mostly used in the classroom by teachers for the enhancement of students' learning where they come up with creative solutions and effectively solve the problem.

Evolution of Design Thinking in Education

The evolution of Design Thinking in Education is schematically presented below:

Herbert A. Simon (1959)

Firstly Design Thinking term coined by Herbert A. Simon in 1959 in his book 'The Sciences of the Artificial'. This book talk about Design through Artificial Intelligence Tool in Mathematics, Science and Engineering field.

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Peter G. Rove (1987)

In his 1987 book, 'Design Thinking,' Peter G. Rove presented the design thinking methodology. Design thinking in architecture and urban planning is the main topic of the book.

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David Kelley (2005)

David Kelley founded Stanford's D. School, also referred to as the Hasso Plattner Institute of Design. Since 2005, the Stanford D.School has implemented a design thinking methodology for education that consists of five steps: Empathy, Define, Ideate, Prototype, and Test.

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Indian Institute of Technology (IIT), Bombay (2010)

In Indian Context, Design thinking approach first conceptualised in 2010 in Indian Institute of Technology, Bombay, in Architecture and Engineering fields.

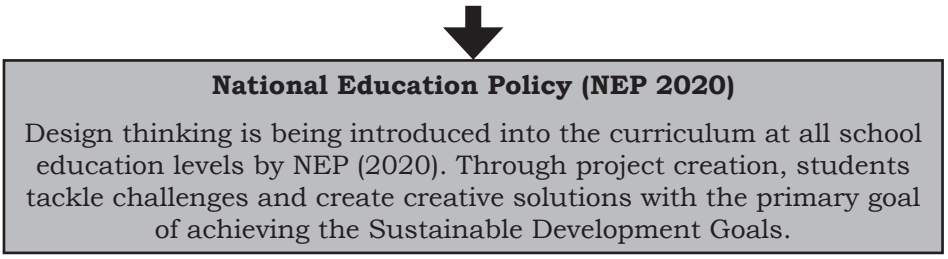

Figure: 1 Evolution of Design Thinking in Education

Hasso Plattner Model of Design Thinking

One well-known and important method for fostering creativity and solving problems is the Stanford D. School Model of Design Thinking. The Hasso Plattner Institute of Design at Stanford University created this paradigm, which is also known as the 'D. School,' which offers a methodical framework for addressing difficult problems and encouraging original solutions. The five steps of the model—Empathise, Define, Ideate, Prototype, and Test—help individuals or organisations manage the design process. The instructor supports the groups in each Design Thinking phase by observing them working autonomously, asking open-ended questions and providing clarification only when necessary. The Design Thinking model's steps are as follows:

Step 1 Empathise: The teacher introduces the problem to be solved in the first stage, inviting the pupils to comprehend it. Since the problem of the design is not his own, he must need to acquire some empathy to be able to design for them. Empathy can take the form of observing, engaging, watching and listening through interaction with teachers, parents and the community. In this stage, the teacher said to the students to look at an issue from multiple perspectives or come up with new ideas.

Step 2 Define: In the second step, 'define', all of the data that the students gathered during the 'empathise' stage is compiled, and they analyse and synthesise the problem to determine its central issue. They share with their fellow students and map them. Notably, the issue must be human-centred rather than personal. To solve an issue creatively, the define stage assists students in gathering ideas and determining the possible sources of the problem.

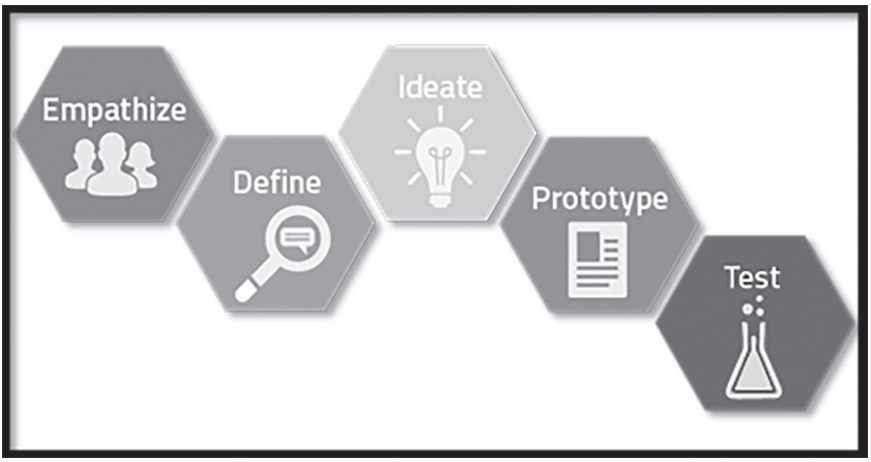

Figure: 2 Hasso Plattner Model of Design Thinking (Taimur and Onuki, 2022)

Step 3 Ideate: In this stage, there is more focus on idea generation. Brainstorming is the most used technique in the idea stage. With the teacher's assistance, students are challenged to come up with novel, 'out of the box' solutions to the difficulties faced by users. The teacher should offer the best solutions to the problem and students should gather different ideas or solutions and select a few of them. The third step of the design thinking process is where creativity happens, and it's crucial to remember that the ideation stage is a judgement-free setting.

Step 4 Prototype: According to the design thinking process paradigm, the prototype is the fourth step. Thus, to generate solutions, ideas are exchanged during brainstorming. The iterative creation of artefacts is the mode. A quick and crude stage of the design process is the prototype phase. It's a means of rapidly communicating a concept during the design process. The design thinking process's fourth step is all about trying new things and making concepts into real products. This phase is referred the experimental stage. The proposed solutions may be accepted, improved, changed or rejected at the prototype stage, depending on how effectively they function in that form. Prototype planning, digital design or physical design are more forms of this method (D. School, 2019).

Step 5 Test and Feedback: Testing and feedback are part of the fifth phase in the design thinking process paradigm. Prototyping is followed by user testing, but it's important to keep in mind that

the design thinking process rarely stops there. The results of the testing phase will often lead you back to a previous step, providing you with the information you need to reword the original problem statement or come up with new ideas you hadn't thought of before. The purpose of this step is to test the developed prototype and get user input. Testing could be useful to demonstrate whether or not the problem statement was successfully articulated. Students receive feedback through an iterative approach that includes testing. The goal of the testing phase is to determine what works and make the required adjustments in response to the teacher's feedback (Huyen, Lam and Tu, 2021).

Digital Tool (Miro Board) for Design Thinking

Design thinking offers an abundance of tools that facilitate the efficient creation of digital prototypes and models. However, according to the age level of the students, the investigator chose only one tool 'Miro Board' after the meeting with experts and the supervisor, which was important from the point of view of literature and experts' opinions on the design thinking method. Miro board is an online and free access designing app, where students create a prototype in an online mode after environmental and brainstorming activities, then the teacher provides feedback based on their work and students recreate a prototype or model according to the needs of the curriculum, which helps to improve the learning outcomes of the students. So, Miro boards help the learners to gain much experience, which helps in lifelong learning and developing the knowledge, skills and positive attitude towards learning effectively.

Academic Achievement

The word 'achievement' describes the results or degrees of success that a person or group achieves after finishing a task; when this happens after a class period, it is called academic achievement (Odom, McConnell and Brown, 2008). Based on the reasons provided above, it is possible to conclude that academic performance is concerned with the development of knowledge, facts, comprehension and skill acquisition. Teachers should receive sufficient training on how to use innovative teaching strategies, such as design thinking. Design thinking is an innovative strategy that helps students find creative solutions to problems, which increases students' curiosity and motivation. The facilitator

encourages students to draw inspiration from limitations during the design thinking process. They are, therefore, able to perform better and achieve greater academic levels.

Creativity

Creativity entails developing fresh and inventive ideas, thinking beyond the box and approaching challenges in novel ways. It frequently requires imagination, uniqueness and the capacity to see things from multiple angles. In other words, creativity is the ability to develop or invent new objects, concepts, ideas and solutions. It is a 21st-century ability that can transfer an imaginary environment into the real world. However, creativity is primarily concerned with creative thought. It provides a distinct approach to solving new difficulties. Visual arts, writing skills, problem-solving abilities and a sense of perspective are examples of creative thinking. It broadens our knowledge, allowing us to build something new or reimagine an old concept (UNESCO, 2015). Successful people will be those who are creative enough to come up with a plan for improving everyone's quality of life. In 1961, J.P. Guilford discussed creativity from a psychological standpoint. He presented the Structure of Intellect Model, which focuses on students' intelligence and creativity. So, educators today emphasise learning by doing or practical innovations, which are part of the design thinking method. To foster a healthy and fruitful educational environment, educators use design thinking to build new transdisciplinary methods and strategies. Creativity is centred on design thinking. The perspective on design thinking and the design process demonstrates that design thinking does not exist without creativity. This demonstrates that there is a clear link between design thinking and creativity since students develop prototypes or models of their creative thinking. Involving people at any step of design thinking will require individuals to be creative, which will be a factor that boosts their ability to be creative (Cengiz, Guler, Guler and Tuncel, 2023).

Digital Skills

Digital skills have implications for inclusivity, social cohesion, creativity and productivity. According to UNICEF (2018), digital skills are necessary for kids to have meaningful access to the internet, so they can fully exercise their rights to privacy, creativity, expression, information and education while also being safe and

successful online. It advocates for a comprehensive approach to digital literacy in terms of skills (emphasising that children should be equipped with the technical, cognitive and social skills required to be protected and productive in the digital age), stakeholders (claiming that parents and educators should play an active role in their children's digital skills) and integration with classroom instruction. The ability to locate, evaluate, use, exchange and produce content on digital devices, such as computers and smartphones, is known as digital skills. They boost students' confidence when they use technology for business, learning and everyday life activities. Conversely, design thinking is a new and unique approach to education. In the digital age, the Design Thinking (DT) methodology can only promote transformative learning in a hybrid manner. The five stages of the design thinking paradigm are— Empathise, Define, Ideate, Prototype and Test or Feedback. Typically, as students reach the fourth stage of design thinking, they create digital creative solutions in the form of models and posters utilising various online digital tools, such as Miro Boards, Mural, Canva, Mind Mapping and so on. Testing or feedback is the last step, which allows the instructor to assess the model and offer digital comments. Understanding what works and making the necessary adjustments based on feedback are the objectives of the testing phase. Students make appropriate revisions based on feedback and authentically carry out the digital design thinking process. So, the design thinking technique uses the hybrid mode of learning, where the first three steps deal with environmental exposure (outside activities) and the latter two steps deal with the online learning environment (indoor activities).

Review of Literature

Carroll, Goldman, Britos, Koh, Royalty and Hornstein (2010) found several practical implications that help strengthen the connections between design thinking and academic subject learning:

1. According to one study, design thinking pushes students to think creatively and take chances, which has an impact on how they participate in the learning process.
2. Design thinking fosters metacognitive awareness by helping students understand where they are in the process.

The summary and synthesis of the design thinking method is the subject of Razzouk and Shute's (2012) additional significant

study. It illustrates how having strong design thinking abilities may aid in both adapting to unforeseen changes and solving incredibly complex challenges. While the design process incorporates deep cognitive processes (such as reasoning and analysis) that could help our children develop critical thinking skills, it also calls for dispositional and personality traits like persistence and creativity. Requiring kids to memorise facts and repeat them whenever asked is not a good way to prepare them for success in the real world. To improve students' academic performance, we should instead provide them with opportunities to engage with the material, consider it critically and apply it to generate new knowledge.

The contributive works of Bower, Highfield, Furney and Mowbray (2013) describe a development and assessment project that aims to change Macquarie University's pre-service teacher education programmes to better foster students' design thinking for technology-enabled learning. The qualitative case methodology, which also looked at the change processes and assessed the effectiveness of integrating ICT, allowed pre-service teacher education programmes to successfully integrate and model technology uses while promoting the same model of training for students. The programme placed a strong emphasis on learning design and design thinking because these subjects offer special chances to integrate technology, enabling teachers to become successful and innovative designers rather than just technical consumers.

Another significant study on students' self-perceptions of design and creativity was carried out by Jackson, Mentzer, Laux, Sears and Asunda (2016). Investigating middle school students' design thinking and creative change engagement in an engineering design curriculum was the aim of this correlation study. The study findings suggest that design experiences can have a favourable impact on self-efficacy perceptions about design and creative thinking. Because these two categories overlap, strategies for boosting self-efficacy in design and creative thinking may be transferable. The concurrent increase in creative thinking confidence as a result of participation in a design curriculum enhances design's educational usefulness. Then, other contributive works of Noel and Liub (2017) assess and synthesise the body of current information to support the development of design thinking education at the primary school level and perhaps bring about a paradigm change in education at this level. Even though it is well known that design education

can effectively support traditional educational models in teaching subjects like mathematics and language arts, incorporating design thinking principles into children's education, such as empathy, collaboration and facilitation, human-centredness and creativity through iterations of prototyping and testing will give kids a solid foundation for whether they decide to pursue traditional educational requirements. Design thinking as a method and mindset for cooperatively resolving wicked problems in various educational contexts is the subject of another study by Panke (2019).

In education, Design thinking frequently takes many forms. Teachers seek out unexpected ideas, sophisticated solutions and original thoughts; they want to facilitate a learning or development activity in a novel and engaging way, and they want to help their students acquire transferable skills and competencies. Across a wide range of fields and topics, design thinking in formal educational contexts has been extensively documented. Design thinking is a common theme in both K12 and higher education, serving as an instructional design method in course material creation, a curricular development technique, a teaching strategy to achieve subject-specific learning goals, a learning goal in and of itself and a facilitation technique in student support. The impact of design thinking during instruction in terms of achieving curriculum goals is then examined by Lin, Shadieva, Hwangb and Shena (2020). The current design thinking framework has been altered and used in the information technology course. It examined how design thinking helped achieve the various curricular goals through the case study and experimental design. Two seventh-grade courses with distinct information technology curriculum designs were examined; one was taught using standard teaching techniques, while the other was taught using the design thinking approach. The findings revealed that design thinking can assist both low-level students (mastery of core information knowledge and abilities) and high-level students (creation of innovative, diverse and practical digital works). Classic disciplines are taught utilising the cutting-edge design thinking technique to help students build 21st-century abilities.

Rao, Puranam and Singh (2020) discovered that design thinking improves creativity. The experiment gave 255 middle school students a three-day training session called Design for Change, followed by divergent thinking activities and self-confidence exams before and after the programme. The final results show that design thinking

greatly improved the fluency and descriptiveness of creativity as well as students' self-confidence, although the flexibility and originality of creativity were, on average, higher than those of the control group. We recommend that to implement this new innovative technique in the classroom, teachers provide orientation to digital tools before experimenting, which helps to boost creativity from a lower to a higher level. The Stanford D School model of design thinking was used in a study by Pratomo, Siswandari and Wardani (2021) to examine the efficacy of entrepreneurial learning and to encourage students to participate more actively in class activities to develop their creative abilities and entrepreneurial awareness. The results of this study demonstrate that the experimental class's creativity skills and entrepreneurial alertness after receiving entrepreneurship education using the design thinking method differed significantly from those of the control group, and the experimental group's creativity skills and entrepreneurial alertness. Therefore, design thinking techniques can enhance academic accomplishment, digital skills, creativity and problem-solving ability in the classroom.

An additional research project by Simeon, Samsudin and Yakob (2022) investigated the impact of applying a design thinking teaching strategy on the performance of male and female students in a few selected secondary school physics concepts in STEM education. When STEM and design thinking modules were used to teach chosen physics subjects, both male and female students fared better, with male participants outperforming females. One of the consequences is that physics teachers must be creatively taught to establish and implement a gender-balanced STEM-design thinking methodology. Teachers should be trained on how to employ STEM-related design thinking modules to provide opportunities for students to use their physics knowledge in real-world scenarios. This is critical in a world where technology is evolving fast and 21st-century abilities are required to solve real-world problems. The impact of a design thinking teaching method on biology students' performance in Lagos State's Education District IV was then examined in a significant study conducted by Udeani and Okelwuo (2023). The findings demonstrated that students' academic performance improved when they were taught using the design thinking method.

Salazar (2023) reviewed the literature and concluded that design thinking is a useful strategy for problem-solving and identifying needs for entrepreneurial teams tackling wicked

challenges. Design thinking, a way of creative and collaborative issue-solving derived from designer strategies, is a product design and development methodology that is increasingly being utilised to advance innovation and structure creation processes across disciplines. The findings of this research demonstrate that the design thinking method has a positive influence in all contexts and at all levels. The findings also indicate that this would be a method of facilitating learners' active involvement between the inside (via digital technology) and outside environments (via social activities or exposures) using a design thinking approach. Active involvement of the full person's ideas, feelings and physical actions or digital exposure to design thinking would not only encourage better knowledge through direct experience but would also aid in equipping their interest in the subject.

Jackson and Jick's (2024) other significant study on the impact of the design thinking method on secondary school students' academic performance. The investigator applied the pre- and post-tests to students to check the academic achievement of students in mathematics. Findings show that students gained much more after treatment rather than the conventional treatment. Other findings show that girls gained better scores than boys, so it shows that girls have a stronger ability to design things than boys. Most studies strongly show that girls have emotional aspects and boys have a logical ability to tackle problems. So, the design thinking method helps to achieve better learning outcomes, which effectively helps in lifelong learning.

After reviewing the related literature, the researcher found that a few studies by Carroll, Goldman, Britos, Koh, Royalty and Hornstein, (2010), Razzouk and Shute (2012), Bower, Highfield, Furney and Mowbray (2013), Jackson, Mentzer, Laux, Sears and Asunda (2016), Noel and Liub (2017), Panke (2019), Lina, Shadieva, Hwangb and Shena (2020), Rao, Puranam, and Singh (2020), Huyen, Lam and Tu (2021), Pratomo, Siswandari and Wardani (2021), Quintanilla, Everaert, Chiluiza and Valcke (2022), Velu (2022), Simeon, Samsudin and Yakob (2022), Charles (2022), Taimur and Onuki (2022), Udeani and Okelwuo (2023), Behera (2009), Salazar (2023), and Jackson and Jick (2024) have been done on academic achievement, creativity, problem-solving ability and digital skills variables related to design thinking approach. Design thinking is a very innovative approach and has taken attention in education perspectives for the last few years. The findings of

this research demonstrate that the design thinking method has a positive influence in all contexts and at all levels. The findings also indicate that this would be a process of facilitating learners' active involvement between the inside (via digital technology) and outside environments (via social activities or exposures) using a design thinking approach. So, the researcher has decided to conduct the study on a design thinking approach related to specific variables like academic achievement, creativity, problem-solving ability and digital skills in science among middle school students.

Direction for the Present Study

Studies of the relevant literature summarised that very few researches are undertaken in foreign contexts on school students, teacher educators, entrepreneurial and problem-solving abilities, collaboration and teamwork. But design thinking-related variables like academic achievement, creativity and digital skills of students in Indian context scanty research studies are found. These studies were conducted on graduate and higher education levels but not on middle-stage learners.

According to NEP 2020, experiential learning establishes a link between theoretical knowledge and conceptual understanding among middle-stage learners. In this stage, students develop abstract thinking through practical knowledge. In the same way, design thinking is an innovative, constructivist and experiential learning strategy that provides practical knowledge of concepts through the interaction between the inner and the outside world and helps to develop creative thinking, digital skills and problem-solving ability effectively.

Very little research is undertaken on design thinking and school science. Science, which includes instilling in students an inquiry and research mindset, is critical in addressing today's challenges in India and around the world, such as climate change, healthcare improvement, technological advancement and application for sustainable development, just and equitable livelihoods, and living in harmony with nature. As a result, providing high-quality science education as well as its interrelationship with other courses, such as social science and vocational education, requires a multidisciplinary approach. This would help pupils understand how science and scientific research may solve our society's most serious problems. So, the researchers were prompted to study the design thinking method in an educational context to assess

academic achievement, creativity and digital skills in science among middle-stage learners.

Objectives of the Study

1. To study the effect of the design thinking method on the academic achievement of Grade 8 students.
2. To study the academic achievement of Grade 8 students concerning gender.
3. To study the interaction between treatment and gender on the gain scores of academic achievement among Grade 8 students.
4. To study the effect of the Design Thinking method on the creativity of Grade 8 students.
5. To study the creativity of Grade 8 students for gender.
6. To study the interaction between treatment and gender on the gain scores of creativity among Grade 8 students.
7. To study the effect of the Design Thinking method on the Digital skills of Grade 8 students.
8. To study the Digital skills of Grade 8 students concerning gender.
9. To study the interaction between treatment and gender on the gain scores of digital skills among Grade 8 students.

Hypotheses of the Study

1. There was no significant difference in the mean gain scores of academic achievement among Grade 8 students taught through the design thinking method and conventional teaching method.
2. There was no significant difference in the mean gain scores of academic achievement among Grade 8 students concerning gender.
3. There was no interaction between treatment and gender on the mean gain scores of academic achievement among Grade 8 students.
4. There was no significant difference in the mean gain scores of creativity among Grade 8 students taught through the design thinking teaching method and conventional teaching method.

5. There was no significant difference in mean gain scores of experimental and control groups with respect to different dimensions of creativity among Grade 8 students. (Flexibility, Fluency and Originality).
6. There was no significant difference in the gain scores of creativity among Grade 8 students with respect to gender.
7. There was no interaction between treatment and gender on the gain scores of creativity among Grade 8 students.
8. There was no significant difference in the mean gain scores of digital skills among Grade 8 students taught through the design thinking teaching method and conventional teaching method.
9. There was no significant difference in mean gain scores of experimental and control groups with respect to different dimensions of digital skills among Grade 8 students (Information skills, Communication skills and Content Creation Skills).
10. There was no significant difference in the mean gain scores of digital skills among Grade 8 students with respect to gender.
11. There was no interaction between treatment and gender on the mean gain scores of digital skills among Grade 8 students.

Tools to be used in the Study

- **Academic Achievement Test:** For measuring the achievement test in science of Grade 8 students, the researcher developed a pre-post achievement test based on Bloom's Taxonomy that was given by Benjamin Bloom in 1956 and was revised in 2001. The researcher developed 30 items based on multiple choice questions, which fulfils the aim of learning outcomes of students.
- **Lesson Plans:** Lesson plans for selected scientific concepts were developed by the researcher using the design thinking model, which was developed by the Hasso Plattner Institute of Design at Stanford University, also known as the D. School. This paradigm provides a methodical framework for addressing difficult problems and encouraging innovative solutions. The model's five phases—Empathise, Define, Ideate, Prototype and Test—guide people or groups through the design process. The

instructor supports the groups in each design thinking phase by observing them working autonomously, asking open-ended questions, and providing clarification only when necessary.

- **Creativity Test:** The Investigator developed a test on creativity according to the age level of students from an Indian Perspective. In this test, the researcher developed 15 items based on three dimensions of creativity. In the fluency part, the researcher provided incomplete scientific words, students provided multiple answers to complete this task. In the Flexibility part, the researcher provided names and statements of some things and then students were instructed to write the maximum possible and different uses of these things. In the originality part, the researcher provided some incomplete pictures, sentences and puzzle games and then students had to complete them and provide the answers according to the aspects of originality (Sisk, 2012).
- **Test on Digital Skills:** The researcher constructed a test on Digital skills for Grade 8 students, which helped to check the basic digital skills based on the Digital Competence Framework for Citizens (DCFC) (2016). The five dimensions of DCFC are Information Skills, Communication and Collaboration and Digital Content Creation, Safety and Problem Solving. In this study, the investigator adopted only three dimensions according to the needs and age level of students. These dimensions were: Information skills, Communication and Collaboration skills and Digital Content Creation skills.

1. Informational skills included skills relating to searching for information and the ability to manipulate or use information, some referred to the evaluation of information.
2. Communication and Collaboration skills include communication in digital environments, sharing resources through online tools, engaging with and taking part in communities and networks, connecting with people and working together using digital tools, and having cross-cultural understanding.
3. Content Creation skills included various activities on social media but also more general design and editing skills. So, the investigator developed 30 multiple-choice questions based on these three dimensions meant for middle-stage students.

Sample

This study's sample size included 100 eighth-grade students taken from Amritsar city. For this purpose, the investigator used the Random Sampling technique.

Study Design

There were two groups: the Experimental group and the Control group. Fifty students were assigned to the experimental group, while the remaining fifty were assigned to the control group. Investigator administrated the Pre-test of Academic Achievement test, Creativity test, Problem-Solving ability Scale and Digital skills scale on Grade 8 students (Both Groups: Experimental and Control). The experimental group was taught through the steps approach of Hasso Plattner's model of Design thinking and the Control group was taught through the conventional teaching method. Hybrid modes of Learning were followed to teach the students, which deals with Empathy, Define, Ideate, Prototype and Test. In the first three steps (Empathy, Define, Ideate), students dealt with the community members (environmental activities) with the help of a teacher and found out the solution to the problem through brainstorming sessions and in the last two steps (Prototype and Test), students created the prototype or model in a digital form by providing a solution and then teacher provided feedback in an online mode. Miro boards were used by the students to design a project in the prototype stage and then the teacher provided feedback to the students. The investigator administered the post-test to assess students' academic achievement, creativity, and digital skills in science in both groups.

Statistical Analysis

The data was evaluated using relevant statistical procedures, such as Mean, Standard Deviation, t-test, and ANOVA.

Results and Discussions

Hypothesis 1

There was no significant difference in the mean gain scores of Academic Achievement among Grade 8 students taught through the design thinking teaching method and conventional teaching method.

Table 1: t-value of Experimental and Control Group concerning Academic Achievement in Science

Group/Method	N	Mean Gain Score	SD	df	t-value	Remarks
Experimental Group	50	9.28	5.60	98	11.60	Significant at 0.05 level
Control Group	50	2.71	1.20			

It is evident from Table 1, which shows that the mean gain scores in Science of the Experimental and Control groups were 9.28 and 2.71, and the value of SD for the two groups was 5.60 and 1.20, respectively. It's further indicated that the t-value of the two groups was 11.60, which was higher than the table value (1.97) at a 0.05 level of confidence. Hence, there was a significant difference between the Experimental group (taught through the Design Thinking Method) and the Control Group (taught through the conventional teaching method) in their academic achievement in science. Thus, our Null Hypothesis that there was no significant difference in the mean gain scores of Academic achievement among Grade 8 students taught through the Design thinking teaching method and the Conventional teaching method was rejected.

Hypothesis 2

"There was no significant difference in the mean gain scores of academic achievement among Grade 8 students concerning gender."

Table 2: Showing Mean Gain, Score, SD and t-value of Experimental and Control Groups Concerning Gender

Variable	Gender	N	Mean Gain Score	SD	t-value	Remarks
Academic Achievement	Boys	50	13.18	19.15	22.76	Significant at 0.05 level
	Girls	50	16.28	26.10		

From Table 2, it is found that the mean gain score of boys was 13.18 and the girls was 16.28. To analyse the significant difference in academic achievement with respect to gender, the researcher has performed an 'Independent Sample test'. It was found that the t-value was 22.76, which was greater than the table value (1.97) at a 0.05 level of confidence. So, our Null Hypothesis, There was no significant difference in the mean gain scores of academic achievement among Grade 8 students with respect to gender,

was rejected. As a result, there was a considerable variation in the academic achievement of boys and girls. Because the mean gain scores of girls were higher than the boys, which was taught through the design thinking method. It can be concluded that girls performed better through the design thinking method.

Hypothesis 3

"There was no interaction between treatment and gender on the mean gain scores of academic achievement among Grade 8 students."

Table 3: Showing Summary Table of Two-way Anova of Treatment, Gender on Academic Achievement in Science of Students

Sources of Variance	Sum of Squares	df	Mean Sun of Squares	F	Significance
Gender (A)	503.28	1	503.28	4.611	0.000
Treatment (B)	118.206	1	120.565	592.660	0.011
Gender × Treatment (A×B)	30.129	1	30.129	3.280	0.002
Error	2346.844	97	20.231		
Total	3646.000	100			

Table 3 also reveals that the f-value for the interaction effect of gender and treatment on the academic achievement of students was 0.002, which was significant at a 0.05 level of confidence. The strong interaction effect suggests that gender and treatment (taught through the design thinking method) have a major impact on the academic achievement of students. Thus, our Null Hypothesis, There was no interaction between treatment and gender on the mean gain scores of academic achievement among Grade 8 students, was rejected.

Hypothesis 4

"There was no significant difference in the mean gain scores of Creativity among Grade 8 students taught through Design thinking teaching method and conventional teaching method."

Table 4: Showing Mean Gain Score, SD and t-value of Experimental and Control Groups Concerning Creativity

Group/Method	N	Mean Gain Score	SD	df	t-value	Remarks
Experimental Group	50	8.70	7.20	98	13.75	Significant at 0.05 level
Control Group	50	3.44	2.21			

It is evident from Table 4, which shows that the mean gain scores of creativity of the Experimental and Control Group were 8.70 and 3.44 and the value of SD for the two groups was 7.20 and 2.21, respectively. It's further indicated that the t-value of the two groups was 13.75, which was greater than the table value (1.97) at a 0.05 level of confidence. Hence, there was a significant difference between the Experimental group (taught through the Design Thinking Method) and the Control Group (taught through the conventional teaching method) in their creativity in science projects. Therefore, our Null Hypothesis, "There was no significant difference in the mean gain scores of Creativity among Grade 8 students taught through the Design thinking teaching method and the Conventional teaching method" was rejected. It can be concluded that the Design thinking method also helps to increase the creativity of students effectively.

Hypothesis 5

"There was no significant difference in mean gain scores of Experimental and Control groups with respect to different dimensions of Creativity among Grade 8 students (Flexibility, Fluency, and Originality)."

Table 5: Showing Mean Gain Score, SD and t-value of Experimental and Control Group with Respect to Dimensions of Creativity

Dimensions of Creativity	Groups	N	Mean Gain Score	SD	df	t-value	Remarks
Flexibility	Experimental	50	6.78	1.56	98	2.70	Significant
	Control	50	2.60	1.70	98		
Fluency	Experimental	50	5.90	2.09	98	3.90	Significant
	Control	50	2.00	1.99	98		
Originality	Experimental	50	4.26	2.99	98	1.99	Significant
	Control	50	1.98	2.10	98		

Table 5 shows that the obtained t-value 2.70 was greater than the table value (1.96) at a 0.05 level of significance. Hence, our null hypothesis is "There was no significant difference in mean gain scores of Experimental and Control groups with respect to different dimensions of Creativity among Grade 8 students. (Flexibility, Fluency, and Originality)" was rejected. The mean gain scores of the Experimental and Control Groups for dimensions of creativity (Flexibility) were 6.78 and 2.60 and the value of SD for the two groups was 1.56 and 1.70, respectively. It can be concluded that

the experimental group performed better through the design thinking method, which helps to increase the ability to generate a large number of ideas to solve the problem, rather than the control group taught through the conventional teaching method.

Table 5 shows that the obtained t-value 3.90 was greater than the table value (1.96) at 0.05 level of significance. Hence, our null hypothesis "There was no significant difference in mean gain scores of Experimental and Control groups with respect to different dimensions of Creativity among Grade 8 students. (Flexibility, Fluency and Originality)" was rejected. The mean gain scores of the Experimental and Control Group for dimensions of creativity (Fluency) were 5.90 and 2.00 and the value of SD for the two groups was 2.09 and 1.99, respectively. It can be concluded that the experimental group performed better through the design thinking method, which helps to increase the ability to generate a wide variety of ideas to solve the problem, rather than the control group taught through the conventional teaching method.

Table 5 shows that the obtained t-value of 1.99 was greater than the table value (1.96) at a 0.05 level of significance. Hence, our null hypothesis is "There was no significant difference in mean gain scores of Experimental and Control groups with respect to different dimensions of Creativity among Grade 8 students. (Flexibility, Fluency, and Originality)" was rejected. The mean gain scores of the Experimental and Control Groups for dimensions of creativity (Originality) were 4.26 and 1.98, and the value of SD for the two groups was 2.99 and 2.10, respectively. It can be concluded that the experimental group performed better through the design thinking method, which helps to increase the ability to generate innovative and unusual ideas in a fresh way to solve the problem, rather than the control group taught through the conventional teaching method.

Hypothesis 6

"There was no significant difference in the mean gain scores of Creativity among Grade 8 students with respect to gender."

Table 6: Showing Mean Gain Score, SD and t-value of Experimental and Control Group with Respect to Gender

Variable	Gender	N	Mean Gain Score	SD	t-value	Remarks
Creativity	Boys	50	14.23	21.10	24.11	Significant at 0.05 level
	Girls	50	19.20	25.30		

From Table 6, it is found that the mean gain score of boys was 14.23 and the girls was 19.20. To analyse the significant difference in creativity with respect to gender, the researcher has performed an 'Independent Sample test'. It was found that the t-value was 24.11, which was greater than the table value (1.97) at a 0.05 level of confidence. So, our Null Hypothesis, "There was no significant difference in the mean gain scores of creativity among Grade 8 students with respect to gender", was rejected. As a result, there was a considerable variation in the creativity of boys and girls. Because the mean gain scores of girls were higher than the boys, which was taught through the design thinking method. It can be concluded that girls performed better through the Design Thinking method because they have the creativity to design things and projects effectively.

Hypothesis 7

"There was no interaction between treatment and gender on the mean gain scores of creativity among Grade 8 students."

Table 7: Showing Summary Table of Two-way Anova of Treatment, Gender on Creativity of Students

Sources of Variance	Sum of Squares	df	Mean Sun of Squares	F	Significance
Gender (A)	604.28	1	604.50	5.611	0.000
Treatment (B)	120.206	1	120.206	591.670	0.005
Gender × Treatment (A × B)	30.150	1	30.230	2.180	0.001
Error	2244.844	97	22.244		
Total	3789.000	100			

Table 7 also reveals that the f-value for the interaction effect of gender and treatment on the creativity of students was 0.001, which was significant at a 0.05 level of confidence. The strong interaction effect suggests that gender and treatment (taught through the design thinking method) have a major impact on the creativity of students. Thus, our Null Hypothesis is "There was no interaction between treatment and gender on the mean gain scores of creativity among Grade 8 students." Was rejected. It can be concluded that the design thinking method helps to enhance the creativity of students (boys and girls) through inside and outside environmental activities.

Hypothesis 8

"There was no significant difference in the mean gain scores of Digital Skills among Grade 8 students taught through Design thinking teaching method and Conventional teaching method".

Table 8 Showing Mean Gain Score, SD and t-value of Experimental and Control Groups with Respect to Digital Skills

Group/Method	N	Mean Gain Score	SD	df	t-value	Remarks
Experimental Group	50	9.90	7.99	98	11.10	Significant at 0.05 level
Control Group	50	3.47	4.18			

It is evident from Table 8, which shows that the mean gain scores of digital skills of the Experimental and Control Group were 9.90 and 3.47 and the value of SD for the two groups was 7.99 and 4.18, respectively. It's further indicated that the t-value of the two groups was 11.10, which was greater than the table value (1.97) at a 0.05 level of confidence. Hence, there was a significant difference between the Experimental group (taught through the Design Thinking Method) and the Control Group (taught through the conventional teaching method) in the Digital skills of students. Therefore, our Null Hypothesis, "There was no significant difference in the mean gain scores of Digital Skills among Grade 8 students taught through the Design thinking teaching method and Conventional teaching method" was rejected. It can be concluded that the Design thinking method also helps to increase the digital skills of students effectively because, in the fourth stage of Design Thinking, students create prototypes/ models in digital form according to instructions from the teacher.

Hypothesis 9

"There was no significant difference in mean gain scores of Experimental and Control groups with respect to different dimensions of Digital skills among Grade 8 students (Information skills, Communication skills and Content Creation Skills)".

Table 9: Showing Mean Gain Score, SD and t-value of Experimental and Control Group with Respect to Dimensions of Digital Skills

Dimensions of Digital Skills	Groups	N	Mean Gain Score	SD	df	t-value	Remarks
Information Skills	Experimental	50	7.77	2.16	98	5.80	Significant
	Control	50	2.68	1.20	98		

Communication Skills	Experimental	50	8.90	2.19	98	4.99	Significant
	Control	50	3.01	2.00	98		
Content Creation Skills	Experimental	50	7.26	6.99	98	7.09	Significant
	Control	50	2.98	3.10	98		

Table 9 shows that the obtained t-value 5.80 was greater than the table value (1.96) at a 0.05 level of significance. Hence, our null hypothesis, "There was no significant difference in mean gain scores of Experimental and Control groups with respect to different dimensions of Digital skills among Grade 8 students (Information skills, Communication skills and Content Creation Skills)" was rejected. The mean gain scores of the Experimental and Control Groups for dimensions of Digital skills (Information Skills) were 7.77 and 2.68 and the value of SD for the two groups was 2.16 and 1.20, respectively. It can be concluded that the experimental group performed better through the design thinking method, which helps to increase the information skills of students related to searching and using the information to create or design the digital model rather than the control group.

Table 9 shows that the obtained t-value of 4.99 was greater than the table value (1.96) at a 0.05 level of significance. Hence, our null hypothesis, "There was no significant difference in mean gain scores of Experimental and Control groups with respect to different dimensions of Digital skills among Grade 8 students (Information skills, Communication skills and Content Creation Skills)" was rejected. The mean gain scores of the Experimental and Control Group for dimensions of digital skills (Information Skills) were 8.90 and 3.01 and the value of SD for the two groups was 2.19 and 2.00, respectively. It can be concluded that the experimental group performed better through the design thinking method, which helps to increase the ability to communicate in digital environments, share resources through online links, and interact with teachers and their peer groups to solve the problem, rather than the control group, which taught through the conventional teaching method.

Table 9 shows that the obtained t-value 7.09 was greater than the table value (1.96) at 0.05 level of significance. Hence, our null hypothesis, "There was no significant difference in mean gain scores of Experimental and Control groups with respect to different dimensions of Digital skills among Grade 8 students (Information skills, Communication skills and Content Creation

Skills)" was rejected. The mean gain scores of the Experimental and Control Groups for dimensions of Digital Skills (Content Creation Skills) were 7.26 and 2.98, and the value of SD for the two groups was 6.99 and 3.10, respectively. It can be concluded that the experimental group performed better through the design thinking method, which helps to increase the ability of students to create, edit or design prototypes/models in digital form, rather than the control group, which was taught through the conventional teaching method.

Hypothesis 10

"There was no significant difference in the mean gain scores of Digital Skills among Grade 8 students with respect to gender."

Table 10: Showing Mean Gain Score, SD and t-value of Experimental and Control Group with Respect to Gender

Variable	Gender	N	Mean Gain Score	SD	t-value	Remarks
Digital Skills	Boys	50	15.80	22.01	23.45	Significant at 0.05 level
	Girls	50	11.76	16.56		

From Table 10, it is found that the mean gain score of boys was 15.80 and the girls were 11.76. To analyse the significant difference in creativity with respect to gender, the researcher has performed an 'Independent Sample test'. It was found that the t-value was 23.45, which was greater than the table value (1.97) at a 0.05 level of confidence. So, our Null Hypothesis that there was no significant difference in the mean gain scores of Digital Skills among Grade 8 students with respect to gender was rejected. As a result, there was a considerable variation in the digital skills of boys and girls. Because the mean gain scores of boys were higher than the girls. We can conclude that a review of the literature favoured that boys performed better through the Design Thinking method in digital skills because they have the technological interest to design things and projects in digital mode in an effective way.

Hypothesis 11

"There was no interaction between treatment and gender on the mean gain scores of Digital Skills among Grade 8 students."

Table 11: Showing Summary Table of Two-way Anova of Treatment, Gender on Digital Skills of Students

Sources of Variance	Sum of Squares	df	Mean Sum of Squares	F	Significance
Gender (A)	555.28	1	308.58	6.512	0.005
Treatment (B)	118.206	1	121.45	523.65	0.000
Gender * Treatment	28.111	1	32.230	3.180	0.002
Error	2344.454	97	34.006		
Total	3970.088	100			

Table 11 also reveals that the f-value for the interaction effect of gender and treatment on the creativity of students was 0.002, which was significant at a 0.05 level of confidence. The strong interaction effect suggests that gender and treatment (taught through the design thinking method) have a major impact on the digital skills of students. Thus, our Null Hypothesis, There was no interaction between treatment and gender on the mean gain scores of Digital Skills among Grade 8 students, was rejected. It can be concluded that the design thinking method helps to enhance the digital skills of students (boys and girls) through digital activities.

Discussion of the Findings

The study's findings indicate a positive and significant difference between students exposed to the Design Thinking method and those exposed to the standard method of treatment. So, the outcomes of this study are congruent with Mary Cantwell's (2020) research, which found that design thinking is a human-centred approach to learning that greatly enhances student accomplishment. The results of the alternative hypothesis revealed significant disparities in academic achievement, creativity, and digital skills based on gender. Because girls performed better than boys in achievement tests and creativity skills. Most literature demonstrates that girls have higher IQ levels (academically) and creativity talents, such as designing projects or models and generating a huge number of ideas effectively. However, boys have technological talents that allow them to solve problems and design projects in digital form more effectively than girls. Overall, the design thinking method

improves students' learning outcomes, creativity and digital abilities more than traditional teaching methods. We strongly recommend that schools be given alternative power sources outside of the national grid to power ICT facilities, equipment and packages, particularly for female students. They will soon be able to support themselves. Implementing the design thinking method in the classroom can help teachers and students think and act creatively as well as solve problems in novel ways, allowing them to create successful and relevant teaching and learning experiences. Based on previous research, we can say that the design thinking method and effective instructional strategy should be conveyed to teachers and teacher educators in the present scenario, which helps students acquire these skills (like problem-solving ability, creativity and digital skills) throughout their formal education. To increase their students' learning capacity, teachers should improve their students' design thinking skills. Students are more likely to perform well in class if they are familiar with effective learning approaches. Teachers are in charge of creating an effective learning environment in their classrooms. The teacher should act as a facilitator, allowing students to come to their conclusions through independent discovery and investigation. Additionally, the experimental group was able to gather valuable insights from the experiences of both teachers and students and conduct numerous brainstorming sessions with professionals, teachers and students to generate ideas, and develop the skills necessary for effective learning thanks to the application of the design thinking method. As a result, the experimental group members were able to present a dynamic and captivating teaching style. Consequently, exceptional performance, and creative and inventive outputs are facilitated by the design thinking method.

Conclusion and Educational Implications of the Study

The study's educational implications include the following:

This study showed how Design Thinking enhances instruction and learning. Students can produce innovative outcomes in a variety of projects and performance problems when design thinking is applied in the classroom. Relationships between teachers and students can also be improved by using the design thinking approach. Design thinking may connect academic educational research with practical implementation in schools. It meets the critical criteria for effective 21st-century learning by facilitating

cross-disciplinary projects and investigating complex phenomena from a holistic constructivist standpoint.

According to our research, boys performed better than girls in school when it came to digital skills. Schools should have access to alternative power sources outside of the national grid to power ICT packages, equipment, and facilities, particularly for female students. They'll be able to sustain themselves soon.

Today, design thinking is a well-known and acknowledged problem-solving method that combines an end-user focus with multidisciplinary collaboration and iterative experimentation to develop desirable, user-friendly and economically viable solutions or improvements. Thus, adding Design Thinking into business school curricula, whether in a single course or across the curriculum, may assist students in developing the creative and critical thinking skills required to face complex situations.

Through both indoor and outdoor activities, the study discovered that design thinking may foster values, diversity and teamwork while also improving students' knowledge and abilities. The blended mode, which is the most important need of today's society, was used in this study. Therefore, using the design thinking process in the classroom will aid in effectively achieving 21st-century curricular goals. To conclude, we can say that the design thinking method improves students' learning outcomes, creativity and digital skills compared to traditional teaching methods. We demand that ICT packages, equipment and facilities in schools—particularly for girls—be powered by alternative power sources outside of the national grid. They will be able to stand independently shortly. Teachers and students can think and act more creatively and solve problems in novel ways when the design thinking method is used in the classroom. As a result, they can design effective and captivating teaching and learning activities that help accomplish Sustainable Development Goal 4 on Quality Education.

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