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The Effectiveness of a Teaching Strategy Based on Smart Learning in Developing Design Thinking Skills among Fifth scientific grade Female Students in Mathematics

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Abstract

The aim of this research was to determine the effectiveness of a teaching strategy based on smart learning on design thinking skills among fifth scientific grade students in mathematics. To achieve this goal, the experimental approach was adopted using a two-group design equivalent to several variables. The research sample consisted of (60) female students, who were divided into two groups (experimental and control), with (30) students in each group. The experimental group was taught using a proposed strategy based on smart learning, while the control group was taught using the traditional method. A design thinking test consisting of (10) essay-type items was prepared. SPSS was used to analyze the data, and the results showed the superiority of the experimental group compared to the control group.

Keywords: Effectiveness, A Proposed Strategy, Smart Learning, Achievement.

Introduction

Research Problem

In light of the rapid development in educational technology, there has been a need to review traditional teaching methods, especially in teaching mathematics, which requires a deep understanding of abstract concepts and relationships. Smart technologies have proven effective in simplifying concepts and enhancing classroom interaction, contributing to the development of design thinking skills among students by stimulating their creativity, analyzing problems, and seeking innovative solutions using unconventional methods. The International Conference on Emerging Trends in Mathematical Sciences and Computing (IEMSC-25) recommended the integration of these technologies into mathematics education.

Accordingly, the researchers distributed a questionnaire consisting of (20) items to a sample of (70) male and female teachers, with the aim of diagnosing the educational reality and identifying weaknesses. The results were as follows:

1. 73% indicated that they do not encourage students to use diverse methods in solving problems, which limits independent thinking.
2. 75% indicated that they do not encourage thinking outside the box when solving mathematical

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problems.

3. 90% reported that they do not use smart educational applications to explain mathematical concepts.
4. 90% reported that they do not use interactive assessment tools such as Kahoot.
5. 82% confirmed that students significantly lack thinking skills.

The survey findings reveal that the inadequate design thinking abilities of female mathematics students stem from their dependence on conventional teaching techniques and subpar evaluation systems, resulting in their progression to advanced levels of study without the requisite competency. The literature highlights that this weakness is not due to a lack of mental capacity, but rather to the absence of a stimulating educational environment that provides structured opportunities for training and practice. In response, the researchers seek to employ a strategy based on smart learning, as it provides an interactive and flexible environment that enhances design thinking by focusing on understanding, experimentation, and problem-solving in non-linear ways, in line with the nature of mathematics. Accordingly, the research problem is represented by the following question:

What is the effectiveness of a teaching strategy based on smart learning on design thinking skills among fifth scientific grade students in mathematics?

The Importance of the Research

1. The research presents a modern teaching strategy in mathematics based on smart learning, with the aim of addressing the difficulties students face in understanding mathematics and helping them solve mathematical problems (Jawad et. al., 2021, p. 173) (Hassan & Hammadi, 2023, p.4)
2. Providing a test of design thinking skills for fifth-grade science students, which contributes to providing a scientific tool that can be adopted to measure one of the most important skills of the twenty-first century and contributes to bridging the gap in assessment tools in this educational field.
3. Creating a flexible and interactive learning environment helps students connect new knowledge to their previous experiences, which enhances the development of higher-order thinking skills such as analysis and planning, which are among the fundamental pillars of design thinking (Ghali and Hassan, 2024, p. 492).
4. The research presents a vision for using smart learning strategies in teaching mathematics, contributing to the development of design thinking by enhancing mathematical expression, clarifying relationships, and generating innovative solutions (Al-Yasiri et al., 2013, p. 285).
5. The research reinforces the importance of linking mathematical content to real-life situations, which adds meaning to the knowledge students acquire, increases their motivation to learn, and contributes to strengthening the relationship between school and society. (Majeed et al., 2023, p. 44) (Jawad, 2022).

Research Objective: The current research aims to identify the effectiveness of a smart learning-based strategy on design thinking skills among fifth-grade science students in mathematics.

Research Hypothesis: There is no statistically significant difference at the significance level

(0.05) between the average scores of students in the experimental group who studied using a smart learning-based strategy and the scores of students in the control group who studied using the traditional method on the design thinking test.

Research Limits

a- Scientific Fifth-grade students in girls' daytime middle and secondary schools affiliated with the General Directorate of Education in Karkh I in Baghdad Governorate for the first semester of the 2024-2025 academic year.

b- The first four chapters of the mathematics textbook (Logarithms, Sequences, Conic Sections, Circular Functions) prescribed for the fifth-grade science class by the Ministry of Education, by Al-Taie et al., 12th edition, 2024.

c- Strategic steps based on smart learning, represented by (preparation and attracting attention, presentation and presentation of knowledge, self-direction, communication and sharing with others and expressing knowledge, feedback and evaluation).

d- Design thinking skills, represented by (empathy, specification, idea generation, modeling, testing).

Defining Terms

A. Effectiveness: It was defined as "the effect that an experimental treatment can have as an Independent variable in one of the dependent variables (Shahata et al., 2013, p. 231). It is defined procedurally as the effect of the experimental treatment, as an independent variable, on the dependent variable, represented by design thinking. It is measured by the differences between the mean scores of the two groups in the post-test.

B. Strategy: It is defined as: "A plan followed by the teacher and learner, aiming to achieve the desired learning outcomes. It is essentially based on learning theories and models, ensuring the learner's comprehensive growth and development according to their abilities and aptitudes" (Abu Sharekh, 2010, p. 8). The researchers define it procedurally as: a set of procedures, activities, and methods that the school chooses or plans to follow one after the other, in a sequential manner, using the available capabilities, to help female students master the objectives sought from teaching.

C. Smart learning: It was defined by (Zhu, ZT, Yu, MH & Riezebos, 2016: p.3) as creating learning environments that rely on modern technology to facilitate smart teaching methods and support individual learning for students, enabling them to develop higher thinking skills, by relying on assessment, incentives, motivations and individual services. The researchers define it procedurally as: a modern educational method that employs interactive tools and techniques to simplify mathematics concepts for fifth scientific grade students, through interactive activities that enhance understanding and problem-solving, while monitoring individual performance with the aim of improving thinking and achieving educational goals.

D. Design Thinking: It is a non-linear methodology (beginning with empathy and ending with testing) that comes together in an integrated and coordinated strategy and is applied to problems facing society in various fields (Brown, 2009, p. 70). The researchers define it procedurally: It is a group of mental processes, which include (empathy, definition, idea generation, modeling, testing) that are practiced by fifth scientific grade students in mathematics when solving mathematical problems, and is measured by the score they obtain in the design thinking skills

test prepared for this purpose.

Theoretical Background

First: The Concepts

Smart Learning

Learning is a continuous process through which individuals acquire skills and knowledge through experience or study. This process leads to a change in an individual's behavior as a result of their interaction with the environment and educational content. On the other hand, education is an organized process aimed at transferring knowledge from the teacher to the learner using a variety of methods and approaches. Education relies on guiding the learner toward understanding concepts and developing their intellectual skills. Within the framework of smart learning, technology is used to personalize education and stimulate interaction between the learner and the content, which contributes to enhancing deep understanding and innovation in the learning process (Alrikabi, 2022). Smart learning contributes to the development of critical thinking and problem-solving skills (Majeed et al, 2021) (Kwak, 2010, p. 5). Also smart education relies on technological tools that help provide a flexible learning environment that supports individual learning and student interaction with educational materials (Lim, 2011, p. 8).

Types of Smart Learning: Smart learning encompasses multiple models that vary depending on the tools used and educational objectives; the most prominent of these are:

- Smart application-based learning: This relies on the use of interactive applications such as PhotoMath, Desmos, and GeoGebra to simplify mathematical concepts and visually present solutions, enhancing analytical and deductive skills (Ibrahim, 2025).
- Learning via interactive digital platforms: This utilizes platforms such as Google Classroom and Edmodo to manage academic content, assignments, and direct communication (Maru, et. al. 2022).
- Adaptive learning: This uses intelligent algorithms to automatically adjust content based on the student's level to improve the individual learning experience (Demartini, et. al., 2024).
- Collaborative learning: Promotes collaboration and knowledge sharing through smart tools such as Padlet and Jamboard (Emmanuel, et. al., 2024).
- Game-based learning: Integrates content into stimulating educational games such as Kahoot and Quizizz, increasing student motivation and classroom interaction (Ismaizam, et.al., 2022)
- Mobile learning: Relies on smart devices to access content anytime, anywhere, supporting continuous and flexible learning (Abduljawad, and Ahmad, 2023).
- Distance learning: Education is delivered online using tools such as Zoom and Microsoft Teams, and is a flexible solution to ensure the continuity of learning despite the distance (Al-Faris, 2024, p. 29)

The researchers relied on the first type (smart application-based learning) to teach female students, due to its interactivity, ease of access, and effectiveness in simplifying mathematical concepts and enhancing understanding and achievement.

Steps of the proposed smart learning strategy:

- 1- Preparation and Attraction: The lesson begins with an introductory video that engages

2- Presentation and Knowledge Delivery: Concepts are presented using a data show and computer, utilizing smart applications such as Desmos, GeoGebra, or PhotoMath, depending on the lesson topic, through examples documented in students' notebooks.

3- Self-Directed Task: Students are assigned an exploratory activity in which they implement concepts independently using smart applications, which contributes to consolidating understanding through experimentation and observation.

4- Communication, Sharing, and Expressing Knowledge: The class is divided into groups to solve problems using smart applications. The solutions are then presented and shared among the groups.

5- Feedback and Evaluation: A digital quiz is conducted via the Kahoot application, providing immediate feedback and replaying incorrect questions to enhance understanding.

Both researchers believe that these steps represent an integrated framework that achieves the principles of smart learning by activating the role of the student, enhancing digital interaction, and developing independent learning and teamwork skills. They also contribute to raising the level of achievement and achieving educational goals using innovative methods that align with the requirements of the digital age.

Design Thinking:

The concept of design methods began in the 1950s and 1960s and developed significantly in the 1970s through the efforts of researchers interested in analyzing design as a mental process (Cross, 2011, p. 16). In 1991, IDEO (1) was founded under the leadership of Tim Brown, becoming a leading global authority in applying design thinking in fields such as education and healthcare (Connie, 2018, p. 65). At the beginning of the twenty-first century, the concept was strengthened by the contributions of Tom Kelly and Nigel Cross, and the establishment of the Stanford University School of Design (Hassi & Laakso, 2011, p. 40).

Design thinking is a modern concept that has proven effective in supporting creativity and solving complex problems. Tim Brown contributed to establishing this concept in his book, *Change by Design*, in which he described it as a non-linear, integrative approach that combines multiple skills working together in a dynamic, iterative process. Brown believes that design thinking consists of three interconnected spaces: inspiration to gather visions, ideation to generate solutions through brainstorming, and implementation to test these solutions and achieve them practically, noting that the movement between these stages is not linear but rather flexible according to need (Brown, 2009, p. 21– 38).

Shawahin (2021) agrees with this view, emphasizing that design thinking does not rely on isolated skills, but rather on their integration within a flexible thinking process that focuses on the ultimate goal from the outset. This type of thinking also combines an analytical approach based on logic and reasoning with an intuitive approach based on imagination and innovation, enabling the generation of practical and innovative solutions simultaneously. Being an iterative process, initial solutions may lead to a redefinition of the problem, opening up new avenues for dealing with it effectively (Shawahin, 2021, pp. 11– 13).

Design Thinking Skills:

1- Empathize skills: This skill involves deeply understanding the problem through analyzing

the challenges presented, using appropriate drawings, diagrams, and symbols. This helps clarify the relationships between the problem's components, transforming them from an abstract concept to a more meaningful and perceptible level.

2- Determination skills: This level focuses on analyzing the data extracted based on understanding the problem during the empathy stage, with the aim of accurately framing it, identifying motivations and needs, and formulating the essential questions that lead to a solution. This skill relies on clarity of what is required and identifying the basic elements of the problem.

3- Ideate skills: This skill builds on what was developed in the empathize and define stages. Brainstorming techniques are used to generate a wide range of potential solutions, whether innovative or traditional, with the aim of exploring as many alternatives as possible to address the problem flexibly and deeply.

4- Prototype skill: This skill involves creating a prototype based on previously generated ideas, focusing on initially testing the most appropriate solution without committing to absolute accuracy. The goal here is to test the model's effectiveness in addressing the problem and explore its scalability.

5- Test skill: In this stage, the developed prototype is tested to evaluate its effectiveness and gather the necessary feedback. These results are used to make the required improvements, leading to the formulation of the most efficient and appropriate final solution to the problem. (Brown, 2009, pp. 70-83)

The researchers believe that design thinking contributes to the development of leadership and strategic thinking skills, and helps approach ambiguous problems from multiple perspectives, creating innovative solutions that can be implemented quickly and effectively.

Second: Previous studies

Studies that dealt with the independent and dependent variables; as in table (1).

Table (1): Previous Studies That Addressed Smart Learning								
Researcher(s), Country, & Year	Educational	Methodology	Sample and Type	Variables		Statistical Tools	Results	
				Ind.	Dep.			

1	Hassan, 2023) – Iraq	Sixth Scientific Grade	Experimental	60 students	Mathematics	proposed strategy based on design thinking model (Independent)	Academic achievement and intrapersonal intelligence (Dependent)	Pearson correlation for validity Cronbach's Alpha for reliability and Difficulty and discrimination indices Effectiveness of alternatives	Indicated the superiority of the experimental group students who were taught using the proposed strategy over the control group students taught using the traditional method.
2	(Jasim & Ghanim, 2024) – Iraq	Intermediate School	Experimental	101 students	Mathematics	Two proposed strategies based on anchored instruction	Design thinking and mental rotation	Kuder-Richards on 20 Cronbach's Alpha t-test Effect size formula Scheffé's formula One-way ANOVA	Results revealed a statistically significant difference in favor of the experimental group in the design thinking and mental rotation tests.

Research Methodology and Procedures

The researchers adopted the experimental approach because it is appropriate for the study's objectives, as it allows for a precise study of the relationship between variables (Jassim, 2024). A true experimental design was used, based on two equivalent groups (experimental and control), with only a post-test, as shown in table (2).

Group	Equivalencies	Independent Variable	Measurement of Dependent Variable
Experimental	1. Prior achievement in mathematics 2. Design thinking test 3. Intelligence test	Teaching based on a smart learning-based instructional strategy	Design thinking test
Control		Teaching based on the traditional method	

Table (2). The Experimental Design Adopted in The Research

Research community, sample, and control procedures: The research community included all fifth-scientific grade students in government daytime secondary and preparatory schools affiliated with the Baghdad/Karkh First Education Directorate for the academic year (2024-2025), totaling (609) students. Al-Dawoodi Girls' Preparatory School was randomly selected to represent the research sample, and it consisted of two sections: an experimental group (33 students) who studied using the smart learning strategy, and a control group (31 students) who studied using the traditional method, with failures excluded from the analysis. The researchers sought to control the variables that might affect the validity of the results. They confirmed the equivalence of the two groups in some variables, as shown in Table (3), and controlled the external variables, such as random sample selection, standardization of the experimental procedures during the period (9/29/2024 - 1/5/2025), and maintaining the stability of classroom conditions, the confidentiality of the experiment, and the interaction of educational situations.

No.	Variable	Group	Number of Students	Mean	Standard Deviation	Degrees of Freedom	Levene's Test F	T-value	Significance Level (p)
1	Prior Achievement	Experimental	30	82.6333	12.27974	58	0.038	0.074	0.941 (Not Significant)
		Control	30	82.4000	12.10472				
2	Design Thinking	Experimental	30	32.9667	9.80669	58	0.271	0.025	0.959 (Not Significant)
		Control	30	32.8333	10.12025				

3	Intelligence	Experimental	30	30.3000	6.62363	58	1.108	1.389	0.170 (Not Significant)
		Control	30	26.7333	9.23984				

Table (3). Statistical Description of the Three Equivalence Variables

Research Requirements:

- Proposing Instructional Strategy Steps.
- Content Analysis: The educational material allocated for the experiment was identified for both groups.
- Formulating Behavioral Objectives: Bloom's Taxonomy of the Cognitive Domain was adopted, and (206) behavioral objectives were formulated covering all levels.
- Preparing Instructional Plans: Daily plans were prepared for both groups according to the behavioral objectives, bringing the total number of plans to (120), with (60) plans for each group.

Research Tool: A tool was developed to measure the dependent variable in this research, the Design Thinking Test, with the aim of verifying the study hypothesis and addressing the research problem. The test was designed for fifth-grade science students for the academic year (2024– 2025) and consisted of (10) essay paragraphs.

The construction steps included: defining objectives, formulating paragraphs, preparing answer instructions, and setting precise scoring criteria. The total score ranged from (0– 100), with (10) points for each paragraph.

- The paragraphs were presented to specialized referees, and those accepted at a score of 80% or higher were approved.
- The test was administered to two pilot samples: the first (30 students) to determine the appropriate time (90 minutes), and the second (100 students) to extract the psychometric properties.

Statistical analysis of the design thinking test:

- The difficulty coefficient ranged between 0.602 and 0.674, which is within the acceptable range.
- The discrimination coefficient ranged between 0.533 and 0.756, indicating the items' ability to differentiate between performance levels.

Validity:

- Face validity:** The initial version of the test was presented to a group of judges to ensure the validity of the wording and scientific accuracy.
- Construct validity:** Pearson's correlation coefficient was used to measure the relationship between each item and the total score. The values ranged between (0.686** - 0.880**), reflecting high internal consistency at a significance level of (0.01).

Reliability: The reliability coefficient using Cronbach's alpha was (0.93), indicating a high

degree of consistency. Temporal stability was verified by repeated correction by the two researchers, with agreement reaching (100%), while the agreement coefficient between the two researchers was (98%). Therefore, the tool is valid for formal application.

1. Presentation and Interpretation of Results:

To verify the validity of the null hypothesis, the researchers applied the test to the primary sample, then used SPSS to analyze the results. The results were shown in Table (4).

No.	Group	Number of Students	Mean	Standard Deviation	Standard Error of the Mean	95% Confidence Interval for the Mean	
						95% CI - Upper Limit	95% CI - Lower Limit
1	Experimental	30	30.8333	5.69382	1.03954	7.83304	1.36696
2	Control	30	26.2333	6.77054	1.23613	7.83507	1.36493

Table (4)

Arithmetic mean, standard deviation, standard error, and confidence interval for the scores of the female students in the research sample on the design thinking test.

Statistical Description of the Research Groups: Levene's Test was applied to two equal independent samples to verify the homogeneity of variance in the scores of students from both the experimental and control groups. After confirming the assumption of variance homogeneity, an independent samples **t-test** was conducted to examine the significance of the differences between the mean scores of the students in the **design thinking test**, at a significance level of **0.05** and **58 degrees of freedom**. As shown in table (5), the results were interpreted accordingly.

Levene's Test F	Levene's Sig. (p)	T-test T	T-test Sig. (p)	Degrees of Freedom (df)	Significance Level ($\alpha = 0.05$)	Interpretation
0.681	0.413	2.848	0.006	58	0.05	Statistically Significant

Table (5)

(F) and (t) values for the experimental and control groups in the design thinking variable

Thus, the null hypothesis is rejected and the alternative hypothesis is accepted in favor of the experimental group.

Statement of Effect Size of the Independent Variable on the Dependent Variable: The researchers used **Eta squared (η^2)** to calculate the effect size (**d**). The value of η^2 was **0.1230**, and the calculated effect size (**d**) was **0.735**, indicating that the independent variable had a **moderate effect**, in favor of the **experimental group**, as shown in table (6).

Independent Variable	Dependent Variable	Eta Squared (η^2)	Effect Size (d)	Effect Magnitude
Smart Learning	Design Thinking	0.123	0.735	Moderate

Table (6). Effect Size of the Independent Variable (Smart Learning) on the Dependent Variable (Design Thinking)

Interpretation of the Hypothesis Results: This result may be attributed to the following reasons:

- 1- It is likely that the teaching method based on the smart learning strategy, which relies on collaboration between the school and the students, and among the students themselves, stimulates a spirit of competition and the pursuit of creative ideas for solutions. This opens up multiple research horizons for students and contributes to strengthening their mental habits.
- 2- It is likely that diversifying modern teaching methods, along with the use of multiple approaches to explaining topics, contributes effectively to developing students' design thinking skills.
- 3- It may open the way for students to freely express their ideas and express solutions to problems without fear or embarrassment of discussing them in front of their peers. This enhances students' self-confidence and supports an interactive learning environment.
- 4- Using various smart applications such as Desmos, GeoGebra, and PhotoMath can contribute to enhancing students' design thinking skills by supporting the generation, modeling, and testing stages through an interactive environment that enables solutions to be tested and analyzed visually.

Conclusions

1. Smart tools contributed to enhancing student engagement and increasing motivation, which positively impacted their test scores.
2. Students gained greater confidence in using smart applications, and their performance in solving mathematical problems using an analytical approach improved.
3. There was a noticeable improvement in the level of design thinking, through the enhancement of mental skills such as deduction and interpretation.
4. Skills such as problem perception and hypothesis formulation are fundamental to design thinking, and their development contributed to raising students' intellectual competence (Jawad, 2022, p. 428).
5. The diversity of content presentation enhanced design thinking skills by linking mathematical concepts to real-life situations and motivating students to generate creative solutions (Al-Mayouf et al., 2017, p. 3).
6. The modern educational strategy contributed to organizing ideas and presenting knowledge in an innovative manner, which activated design thinking skills such as understanding the problem and generating solutions (Karim and Jassim, 2013, p. 372).

Recommendations

1. Recommendation to the Preparation and Training Department in the General Education

Directorates to hold training courses for mathematics teachers on smart learning strategies and the use of interactive applications, given their direct impact on raising students' level of design thinking.

2. It is recommended that mathematics teachers adopt modern technological innovations, such as application programs and smart educational websites, which contribute to activating the role of the student as a primary participant in addressing problems based on design thinking skills.

Suggestions

1. The impact of smart learning strategies on improving academic performance and analytical thinking in mathematics among secondary school female students.

2. The relationship of smart tools to developing various types of thinking, including design and innovation, in mathematics education.

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