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# Effect of a Proposed Program Based on Artificial Intelligence in Developing Computational Thinking Skills in the Digital Skills Course for First-Grade Intermediate Female Students

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**Abstract**
The study aimed to identify the impact of a Proposed Program Based on Artificial Intelligence in Developing Computational Thinking Skills in the Digital Skills Course for First-Grade Intermediate Female Students. To achieve the study objectives, the researcher applied the experimental approach with its semi-experimental design, and she designed one data collection: The Computational Thinking skills scale in the digital skills course. The research population included all first-grade intermediate students enrolled in the first semester of the academic year (1444 AH) in the Olia district in Riyadh. The sample consisted of (48) students from (140) intermediate schools, divided into two groups: A control group and an experimental group. The results showed statistically significant differences at the level of ($\alpha \leq 0.05$) between the average scores of the experimental and control groups in the post-application of the computational thinking skills scale, favoring the experimental group. The study confirmed the positive impact of teaching using an artificial intelligence-based program in developing computational thinking skills in the digital skills course among first-grade intermediate students. The study recommended increasing the attention of digital skills course authors to incorporating AI-based educational programs in the course lessons and expanding their application to different educational stages and subjects.

**Keywords:** Chatbot, Self-Learning, Computer Education, Intermediate Stage, Curriculum Development

## Introduction

The 21st century is witnessing the rapid development of information and communication technologies, resulting in a knowledge revolution that is impacting various fields such as education, training, healthcare, and business. In line with this progress, educational institutions have increasingly integrated modern technologies into curriculum design and educational programs to improve the quality and efficiency of learning. One of the most notable developments is the investment in educational technologies to achieve sustainable goals and equip students with skills to become active contributors to society (Al-Abdallat, 2020; Al-Omari, 2019) [7, 9].

Studies show that integrating technology into education enhances the learning experience by promoting collaboration, teamwork, and the development of critical thinking and problem-solving skills, overcoming individual differences among students, and transcending temporal and spatial boundaries (Al-Balawi, 2020) [3]. In Saudi Arabia, the Ministry of Education has prioritized curriculum development to keep pace with technological advancements, particularly in computer science, a constantly evolving field. As part of this effort, the ministry initiated a curriculum development project aligned with CSTA standards, in which computational thinking is a cornerstone of curriculum innovation (Tatweer Company for Educational Services, 2014) [11].

Launched in 2006, computational thinking has become an essential skill in the 21st century, drawing on computer science concepts such as decomposition, abstraction, pattern recognition, and algorithm design. This type of thinking transforms individuals from passive users of technology into innovative creators (Phillips, 2009) [23]. Numerous studies have highlighted its importance in improving student achievement and fostering creativity, leading researchers to advocate for its inclusion in educational curricula (Wing & Stanzion, 2016; Al-Abdallat, 2020) [28, 7].

Artificial Intelligence (AI) has emerged as a key technology to support this trend. AI mimics human intelligence through advanced technological systems, providing innovative educational solutions and interactive learning environments. AI enables personalized learning tailored to the needs of individual students, accommodating differences and promoting active learning (Al-Balawi, 2020; Al-Saud, 2017) [3, 1]. Research has demonstrated the effectiveness of AI in improving academic performance and promoting self-directed and collaborative learning, as shown in studies by Ahmed (2022) [2] and Al-Abdallat (2020) [7].

Other studies highlight the importance of computational thinking in education, such as Al-Juwaid & Al-Obaikan (2018) [4] study on the need for computer science teachers to increase their knowledge of computational thinking, and Noh and Lee (2020) [20] study on how programming robots improves computational thinking and creativity.

This study aims to present an innovative methodology for designing an AI-based educational program that integrates pedagogical and technological design using tools such as chatbots. The program aims to promote active learning and blended education, address different learning styles, and enhance 21st century skills through intelligent and interactive learning environments.

## Search Problem

Integrating digital technology into education requires equipping students with computational thinking skills, which are essential for the digital generation (ISTE, 2016) [18]. However, the weak computational thinking skills of computer science teachers in Saudi Arabia have been identified as a challenge in computer science curriculum documents, which negatively affects students' abilities and turns them into consumers of technology rather than creators (Tatweer Company for Educational Services, 2014) [11]. Several studies have also revealed the ineffective teaching of these skills in both general and higher education (Al-Abdallat, 2020 [7]; Al-Obaikan & Al-Dhamsi, 2016).

In light of conference recommendations and studies highlighting the importance of adopting AI in education to support self-directed learning and address individual differences (Al-Yajzi, 2019; Al-Abdallat, 2020 [7]), an exploratory study was conducted on 20 first-year middle school students, which revealed weak computational thinking skills due to reliance on traditional teaching methods. Therefore, there is a need to design an AI-based educational program to enhance computational thinking skills in line with modern technological advancements and educational requirements.

## Research Question

What is the impact of a proposed AI-based program for developing computational thinking skills in the digital literacy curriculum for first-year middle school students?

## Research Objective

To explore the impact of a proposed AI-based program for enhancing computational thinking skills in the digital literacy curriculum for first-year middle school students.

## Significance of the Study

**Theoretical Significance:** This study contributes to the advancement of Arab educational research by keeping pace with AI developments. It provides a theoretical framework that highlights the role of AI in computer science education, its applications, links to learning theories, and its impact on pedagogical elements and adaptive learning in the digital literacy curriculum.

**Practical significance:** The study proposes an AI-based educational program that places students at the center of the learning process, taking into account individual differences. It aims to improve educational elements in Saudi Arabia and provides insights for policy makers and researchers to support educational development and conduct future studies in AI and computational thinking.

## Study Limitations

- **Temporally:** The research was conducted during the first semester of 1444 AH.
- **Spatial:** The study was conducted in a girls' middle school in Riyadh, Saudi Arabia.
- **Objective:** The research focused on the impact of an AI-based program on computational thinking skills, including decomposition, abstraction, algorithm design, and pattern recognition, as part of the third unit, "Introduction to Programming," in the digital skills curriculum (1444 AH) for first-year middle school students. Methods. The AI-based chatbot tool was used, and the variables were measured using a previously developed computational thinking skills scale.

## Study Terminology

**Artificial Intelligence (AI):**

- **Conceptual Definition:** As defined by Ulinwa (2008) [26], AI refers to the programming of computers using AI languages to perform tasks that mimic human intelligence.
- **Operational Definition:** AI is an intelligent educational program designed as a question-and-answer platform to deliver content to first-year middle school students in specific cognitive domains (recall, comprehension, application). It mimics human teachers by identifying students' prior knowledge and learning styles, diversifying teaching methods, and adapting interactions to individual differences, with the teacher serving as a guide and mentor.

**Computational Thinking Skills:**

- **Conceptual Definition:** Wing (2006) [27] defines computational thinking as mental skills that enable individuals to break down complex problems into solvable components through skills such as decomposition, abstraction, algorithm design, automation, data collection, analysis, and representation.
- **Operational Definition:** Computational thinking skills enable middle school students to simulate how computers process data and solve problems. These skills include decomposition, abstraction, algorithm design, and pattern recognition, as measured by the Computational Thinking Skills Scale.

## Study methodology and procedures

In accordance with the research problem and the questions derived from it, and based on a review of previous studies, the quasi-experimental method was adopted for its suitability to the nature and objectives of the research.

**Study Design:**
This study used a quasi-experimental design, specifically the pre-test and post-test design with both experimental and control groups.

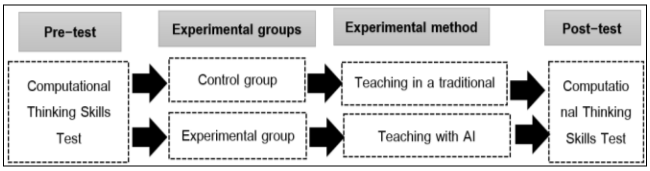


**Fig 1:** Quasi-Experimental Design of the Study

**Study Population and Sample:**
The study population consisted of all first-year middle school female students in the first semester of the academic year (1444 AH) in middle schools affiliated with the Al-Olya Education Office, totaling 1,354 students (Planning and Development Administration, personal communication via email at researches@riyadhedu.gov.sa, September 20, 2022). The study sample consisted of 52 students, divided into two groups: A control group and an experimental group, from the first-year middle school students at School 140 in Riyadh, enrolled in the first semester of the academic year 1444 AH. The sample was selected using a multi-stage cluster random sampling method from the study population.

**Study Materials:**
To achieve the research objectives, an educational program based on artificial intelligence technology was developed, capable of automatically adapting to users according to students' needs, while considering individual differences, using the AI-based tool (Chatbot). It utilizes Natural Language Processing (NLP) and Machine Learning (ML) to facilitate interaction between humans and machines in a human-like manner (Hassan, 2022) [5].
After reviewing the theoretical literature on designing educational software according to models, the educational program based on AI technology was designed according to the general model for instructional design (ADDIE) for the following reasons: It is one of the most comprehensive instructional design models, and all instructional design models revolve around these five stages. The difference lies in the focus and the extent of coverage of each stage. This model provides designers with a procedural framework that ensures the efficiency of educational outputs, achievement of objectives, clarity of its procedural steps, ease of implementation, and alignment with systems approach steps. The ADDIE model includes five stages: Analysis, Design, Development, Implementation, and Evaluation (Fitriani, 2016) [17].
To clarify the methodology, more emphasis was placed on the design phase, where the structure of the AI program and its educational scenario were developed before implementation. Therefore, the following aspects were detailed from a comprehensive perspective: Pedagogical design, technical design, and the integration of AI technology into the educational environment. The AI-based educational program was created through the AI-based chatbot tool, which uses NLP and ML to facilitate interaction between humans and machines in a human-like manner. It is worth noting that understanding human language by machines is a complex process; therefore, chatbot programs use several principles of Natural Language Processing (NLP) (Peart, 2020) [22], as illustrated in Fig 2**:**

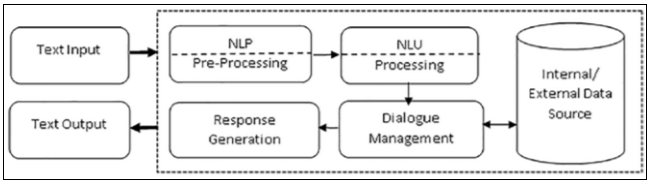


**Fig 2:** Chatbot General Pipeline (McTear *et al*., 2016)

The learning process begins by providing the student with the link to the AI-based educational program on her account in the Microsoft Teams application. The student then navigates to the main page of the AI-based educational program and clicks on the Chatbot link to begin learning. The Chatbot features a simple, user-friendly interface that makes it easy to access information, supported by a variety of variables such as images and colors tailored to the interests, content, and age group of the students. The font sizes, colors, and their placement in messages are also carefully considered. The content delivery is flexible, allowing students to revisit the screen multiple times to recall and review information, move to new content, or exit at any time.
The first lesson starts with an engaging introduction to the topic and a presentation of its objectives, followed by a pre-assessment ("diagnostic") to determine the student's prior knowledge and what she already knows about the lesson. Based on the test score, she is either provided with supplementary material using multimedia resources to enhance her knowledge or moved to the next stage, which is a learning style test through an online platform that assesses learning styles according to the global VARK model (Visual, Auditory, Reading/Writing, and Kinesthetic). The importance of identifying learning styles lies in the individual differences and variations among students in their learning approaches when interacting with educational content in a smart environment, related to their personal differences. This influences how they receive, organize, store, and retrieve knowledge, depending on each student’s needs in the adaptive environment (Fares & Ismail, 2017) [10].
The lesson content is then displayed, followed by a formative assessment through activities designed according to the student’s learning style, with appropriate feedback. At the end of the lesson, a final assessment is conducted, and if the student demonstrates mastery, she moves on to the next lesson, continuing until all sections are completed.
In the design of integrating AI technology into the educational environment, several educational concepts were applied technically, including personalized learning through interactive engagement with Chatbot messages, which are based on behavioral school principles, specifically Skinner's operant conditioning theory. This theory posits that learning occurs in small, consecutive steps forming behavior, provided that each step is based on previously learned behavior, with reinforcement provided immediately after the response, ensuring continuous learning. Active learning is also incorporated by encouraging student participation in the learning situation through various programs, such as Zoom, and applying strategies like problem-solving and inquiry via

the Chatbot dialogue. Additionally, differentiated instruction is used by adapting the lesson according to Howard Gardner's Theory of Multiple Intelligences, through multimedia, mind maps, and Zoom, as well as using the VARK model for assessing learning styles.

Learning theories are applied through dialogue with Chatbot, multimedia, mind maps, and flowcharts. Moreover, assessment for learning is carried out through detailed analytical reports of student responses, allowing teachers to identify areas of weakness based on AI techniques.

**Study Tool:**

To achieve the research objectives and answer the research questions, the Computer Thinking Skills scale used in Al-Othman *et al*. (2023) [8] was employed. The reason for choosing this scale was its suitability to the nature and goals of the research, its global reliability, and its use in several international studies. The scale is both accurate and powerful, as demonstrated by its validity and reliability, using expert reviews and precise mathematical formulas.

**Psychometric Properties of the Scale (Validity and Reliability of the Tool)**

**Expert Validity (Face Validity):** The scale was reviewed and its content and scientific accuracy, comprehensiveness, and ability to measure its intended purpose were validated by 11 experts in the fields of computer education, curriculum and instruction, and psychology. The experts' feedback influenced the refinement of the scale, the rewording of items, and adjustments to make it fit the research objectives.

**Internal Consistency:** After confirming the face validity of the scale, it was field-tested on a pilot sample of 36 students outside the current research sample. The Pearson correlation coefficient was calculated to determine the internal validity of the scale items. The correlation between the score of each item and the total score for the relevant dimension was computed. Table (1) presents the Pearson correlation results, showing that all correlation values ranged from 0.441 to 0.842, all statistically significant at the 0.01 level, indicating high consistency between the scale items and dimensions.

**Table 1:** Pearson Correlation Coefficients for the Computer Thinking Skills Scale

| Question | Correlation Coefficient | Question | Correlation Coefficient | Question | Correlation Coefficient | Question | Correlation Coefficient |
|---|---|---|---|---|---|---|---|
| 1 | 0.742** | 6 | 0.494** | 11 | 0.545** | 16 | 0.842** |
| 2 | 0.752** | 7 | 0.718** | 12 | 0.582** | 17 | 0.510** |
| 3 | 0.707** | 8 | 0.652** | 13 | 0.613** | 18 | 0.537** |
| 4 | 0.641** | 9 | 0.698** | 14 | 0.569** | 19 | 0.569** |
| 5 | 0.771** | 10 | 0.441** | 15 | 0.730** | 20 | 0.466** |

**Significant at the 0.01 level or less.

*Significant at the 0.05 level or less.

**Reliability of the Study Tool**

To verify the reliability of the Computer Thinking Skills scale, Cronbach's Alpha was used. The formula was applied to the pilot sample to measure construct validity, and the results showed that the tool has high statistical reliability, with the overall reliability coefficient reaching 0.844, which is considered a high reliability score according to (Nunnally, 1978) [21].

**Difficulty and Discrimination Coefficients**

The difficulty and discrimination coefficients were applied to the pilot sample to ensure there were no questions with excessive difficulty or questions that were too easy and did not measure what they were intended to. The difficulty coefficient was calculated using the following formula:

(Difficulty Coefficient = Number of incorrect answers / Total number of answers) * 100.

The results ranged between 0.11 and 0.83, which is acceptable for educational purposes. Additionally, the ability of the scale to distinguish between different student levels was verified by calculating the discrimination coefficient using the formula:

(Discrimination Coefficient = (Total number of high scores - Total number of low scores) / Number of individuals in the group).

The results for the discrimination coefficient for the questions ranged between 0.17 and 0.76, which is considered acceptable for educational purposes. Table 2 shows the details of all the questions.

**Table 2:** Difficulty and Discrimination Coefficients for the Computer Thinking Skills Scale

| Question | Difficulty coefficient | Discrimination coefficient | Question | Difficulty coefficient | Discrimination coefficient | Question | Difficulty coefficient | Discrimination coefficient |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.11 | 0.24 | 8 | 0.73 | 0.52 | 15 | 0.75 | 0.59 |
| 2 | 0.15 | 0.41 | 9 | 0.46 | 0.72 | 16 | 0.62 | 0.76 |
| 3 | 0.42 | 0.72 | 10 | 0.60 | 0.62 | 17 | 0.62 | 0.24 |
| 4 | 0.62 | 0.72 | 11 | 0.51 | 0.48 | 18 | 0.80 | 0.17 |
| 5 | 0.51 | 0.69 | 12 | 0.58 | 0.76 | 19 | 0.53 | 0.52 |
| 6 | 0.27 | 0.38 | 13 | 0.51 | 0.45 | 20 | 0.42 | 0.41 |
| 7 | 0.17 | 0.38 | 14 | 0.83 | 0.21 | | | |

**Procedures for Applying the Study**

The process of applying the research experiment to both the experimental and control groups went through three stages: preparation for the experiment, the experiment itself, and post-experiment. These stages are detailed as follows:

***Stage One: Preparation for the Experiment:***

- **Building the Study Material:** An AI-based educational program was developed, capable of automatically adapting to the needs and preferences of the students. The program was designed using AI techniques, with standards for AI-based educational programs based on the study by Al-Mohamadi (2020) [13]. The tool used was a chatbot, based on artificial intelligence. The educational program design was adopted according to the general instructional design model (ADDIE), as it was most suitable for this research. The program was implemented using the Flow XO platform's smart chatbot system, employing programming languages like JavaScript and Python, with the help of AI specialists. The program was then reviewed by a panel of experts to get their feedback on whether it adhered to the standards for AI-based educational programs, and adjustments were made accordingly.
- **Controlling the Study Variables and Ensuring Group Equivalence:** To increase the equivalence between the groups, in addition to the random selection of the groups;
  - which is one of the main methods for controlling external variables.
  - the researchers controlled important external variables that were expected to affect the research results. These included the following:
- **Teacher's Performance Level**: The same teacher taught both the experimental and control groups. The teacher provided the same effort and interaction to both groups, with the only difference being the independent variable.
- **Computer Thinking Skills**: The computer thinking skills scale was administered to the students before the experiment. An Independent Sample T-Test was used to verify that there were no statistically significant differences between the two groups (control and experimental) in terms of computer thinking skills, ensuring that both groups were equivalent in these skills.
- **Isolation**: The control group was isolated from exposure to the independent variable (the AI-based educational program) by not allowing them to view or experience it.

***Stage Two: Conducting the Experiment***

- **Pre-application of Research Tools**: The research tools were administered to both the control and experimental groups. Afterward, the data were processed statistically using the Independent Sample T-Test to compare the two groups in terms of the research tool, as shown in Table 3.

**Table 3:** Results of the Independent Sample T-Test for the difference between the mean scores of the experimental and control groups in the pre-test of the Computer Thinking Skills Scale

| Group | N | Mean | Standard Deviation | T-test | P-Value |
|---|---|---|---|---|---|
| Control group | 24 | 6.37 | 1.99 | 1.31 | 0.19 |
| Experimental group | 24 | 7.12 | 1.96 | | |

It is evident from Table (3) that the p-value of the T-test for the scale is 0.19, which is not statistically significant at the significance level (0.05 ≤ α), meaning that there is no difference between the mean scores of the experimental group and the control group in the pre-test of the Computer Thinking Skills Scale. This confirms the equivalence of the two groups (experimental and control) in the variable of computer thinking skills.

The study material, which is the AI-based educational program, was then implemented. During the experiment, students were observed to be enthusiastic from the first session, responding well to the instructions and interacting with the experience. They showed eagerness to learn the content of each part of the unit lessons and expressed their desire to continue the curriculum using artificial intelligence.

The control group was taught the new academic content using the traditional method within the classroom, through direct and interactive teaching methods such as lectures and discussions, with the use of Microsoft PowerPoint and a data show device.

The experimental group was discussed in every session regarding their new experience.

The post-test of the research tool was administered to both the experimental and control groups after the completion of the instruction.

***Stage Three: Post-Experiment Phase***

In this phase, the data were analyzed using the Statistical Package for the Social Sciences (SPSS), and the results were interpreted and discussed, leading to appropriate recommendations and suggestions.

**Statistical Methods**

The data were processed using the Statistical Package for the Social Sciences (SPSS) and Effect Size software as follows:

- Frequencies, mean scores, and standard deviations were calculated to make comparisons between the means.
- Independent Samples T-Test was used to determine the significance of the differences between the means of the experimental and control groups in the pre-test and post-test of the Computer Thinking Skills Scale, addressing the research question.
- Eta-squared ($\eta^2$) was used to calculate the effect size of the independent variable on the dependent variable, answering the research question.

**Study Results**

To answer the research question, the following hypothesis was formulated: There is no statistically significant difference at the significance level (0.05 ≤ α) between the mean scores of the experimental group and the control group in the post-test of the Computer Thinking Skills Scale in the Digital Skills subject.

To answer the research question and test the validity of the hypothesis derived from it, the Independent Sample T-Test was used to study the difference between the mean scores of the experimental group and the control group in the post-test of the Computer Thinking Skills Scale. Table (4) shows the results.

**Table 4:** Results of the Independent Sample T-Test for the difference between the mean scores of the experimental and control groups in the post-test of the Computer Thinking Skills Scale

| Group | N | Mean | Standard Deviation | T-test | P-Value |
|---|---|---|---|---|---|
| Control group | 24 | 9.08 | 3.13 | 2.66 | 0.01 |
| Experimental group | 24 | 12.41 | 5.27 | | |

It is evident from Table (4) that the mean score of the experimental group in the Computer Thinking Skills Scale is higher than the mean score of the control group. The p-value of the T-test for the scale is 0.01, which is statistically significant at the significance level ($0.05 \leq \alpha$), meaning that there is a statistically significant difference at the significance level ($0.05 \leq \alpha$) between the mean scores of the experimental group and the control group in the post-test of the Computer Thinking Skills Scale, favoring the experimental group, which has the higher mean (12.41). This result leads to the rejection of the null hypothesis and the acceptance of the alternative hypothesis, which states that there is a statistically significant difference at the significance level ($0.05 \leq \alpha$) between the mean scores of the experimental group and the control group in the post-test of the Computer Thinking Skills Scale in the Digital Skills subject. This result indicates the positive impact of the AI-based educational program in developing computer thinking skills in the Digital Skills curriculum.

After confirming the effect of the independent variable (AI-based educational program) on the dependent variable (computer thinking skills), the effect size was calculated using the formula ($\eta^2$) based on the T-test and degrees of freedom through the following equation (Abu Alam, 2011):

$$\eta^2 = \frac{t^2}{t^2 + df}$$

Both Abu Hatab and Sadiq (1991), and Cohen (1988) indicated that the effect size is considered weak if ($0.01 \geq \eta^2 < 0.06$), moderate when ($0.06 \geq \eta^2 < 0.14$), and large when ($0.14 \geq \eta^2$). Table (5) illustrates the value of Eta squared ($\eta^2$) and the effect size in computer thinking skills.

**Table 5:** Eta Squared ($\eta^2$) Results for the Effect Size of the AI-based Program on Computer Thinking Skills

| df. | T-test | $\eta^2$ | Effect size |
|---|---|---|---|
| 37 | 2.66 | 0.16 | big |

It is evident from Table (5) that the effect size of the independent variable (AI-based educational program) on the dependent variable (computer thinking skills) is 0.16, which represents a large effect size. This means that 16% of the variance in the students' scores on the computer thinking skills scale can be attributed to the AI-based educational program, while the remaining variations are attributed to other uncontrolled factors.

**Discussion of the Results:** The results of the first hypothesis test showed a statistically significant positive effect of the AI-based educational program on the development of computer thinking skills in the Digital Skills course for first-year middle school female students. There was a noticeable increase in the post-test mean scores of the experimental group, which studied using the AI-based program, compared to the post-test mean scores of the control group, which studied using the traditional method. In addition, the large effect size of the AI-based program on computer thinking skills was observed.

This result is in line with several studies that confirmed the positive role of e-learning environments in developing computer thinking skills. For example, Brachmann *et al.* (2017) [16] found that using various computer activities had a positive effect on developing computer thinking skills among elementary school students in Madrid, Spain. Similarly, Romero *et al.* (2017) [24] confirmed the effectiveness of creative programming materials in enhancing computer thinking skills, while Al-Muneer (2019) [14] highlighted the effectiveness of online programming games in developing certain computer thinking skills among kindergarten children in Ismailia. Tsai *et al.* (2019) [25] confirmed the effectiveness of problem-solving programs in enhancing computer thinking and logical intelligence, and Koivisto *et al.* (2019) [19] found that computer thinking skills can be developed through the game Minecraft. Furthermore, Noh and Lee (2020) [20] concluded that using robotics in education improves creative and computer thinking.

In the same context, this result agrees with the study by Al-Abdallat (2020) [7], which found a positive effect of AI-based educational software on teaching algorithms and programming in developing computer thinking among 10th-grade students in Jordan. Additionally, the study by Fares & Ismail (2017) [10] showed the positive effect of self-organized learning environments on computer thinking skills, while the study by Metwally *et al.* (2021) [12] highlighted the effectiveness of adaptive learning environments in developing computer thinking skills in secondary school students.

**Interpretation of the Results:** Based on the results above, the positive impact on the development of computer thinking skills among first-year middle school students in the Digital Skills course due to the implementation of the AI-based educational program can be attributed to several interacting factors:

The focus of the AI-based educational program on the student's role and interaction within the learning environment, designed according to their characteristics, led to consideration of individual differences among them. This approach motivated them to engage in the learning process. The program allows for personalized learning experiences based on each student's abilities, interests, and learning preferences. Students interact with the AI program by providing data such as their preferences, educational level, and preferred learning style. The AI program then responds with customized content, thus supporting students' strengths and addressing weaknesses. This system evaluates students' performance, identifies their strengths and weaknesses, and tailors lessons accordingly (Saadallah & Shatouh, 2019) [6].

As Afifi (2014) notes, the most prominent feature of AI-based learning is that there is no single approach that fits all students. Moreover, the findings of Omari's (2020) study highlight that considering individual differences through AI plays a significant role in enhancing students' cognitive learning and academic achievement.

This positive result can also be attributed to the design of the AI-based educational program, which simulates the human brain, helping students acquire cognitive aspects more easily and effectively. The researchers believe that learning within the AI-based educational environment aligns with the principles of behaviorism, which emphasizes the importance of the learning environment. This effect is evident in teaching practices such as goal-setting, providing feedback, and structuring content from easy to difficult. Additionally, the cognitive constructivist theory plays a role, as students build knowledge through interaction with experiences or activities that challenge their thinking, followed by cognitive processes like analysis, interpretation, and linking with prior knowledge to create new meaningful understanding. These processes are clearly reflected in the educational practices, such as the use of screen characteristics—colors, graphics, and text—to facilitate greater sensory perception and attention, thus enhancing the transfer of information. Furthermore, information is broken into smaller chunks to avoid interference during processing, with an emphasis on motivating students and recognizing what they already know about the topic. The communication theory is also relevant, integrating social networks and web applications into the educational process, which is essential for learning based on the communication theory (Yonkers, 2009) [29]. A study by Aparicio *et al*. (2016) [15] confirmed that the success and effectiveness of e-learning in any educational institution are not limited to the physical and spatial setup of the learning environment, or the presence of a learning management system (LMS), but must also include elements such as instructional design based on communication science principles, psychology of learning, and system theory, ensuring that the learning environment matches learners' characteristics and meets their needs, thus reflecting on the development of their computer thinking skills.

**Study Recommendations**

- Utilize various AI applications in teaching the Digital Skills course across all educational stages to enhance the development of computer thinking skills, as confirmed by the study's findings.
- Increase the focus of curriculum developers on employing AI-based educational programs in all Digital Skills course lessons, which will positively impact the development of computer thinking skills.
- Expand the application of AI-based educational programs to other educational stages and subjects.

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