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THE EFFECT OF EDUCATIONAL SOFTWARE ON ACHIEVEMENT IN MATHEMATICS AND THE DEVELOPMENT OF MATHEMATICAL THINKING AMONG NINTH GRADE STUDENTS IN JORDAN

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Abstract: The current study aimed at identifying the effect of an educational software on the achievement of ninth grade students in the analysis of algebraic expressions, and the development of mathematical thinking. It was randomly divided into two groups, the first was an experimental group, which amounted to (51) students, who studied using the educational software, and the second group was control, which amounted to (51) students who studied using the usual method. Two tests were applied and their psychometric properties were verified, and they were applied before and after. The study found that there were statistically significant differences in the achievement of ninth grade students in the analysis of algebraic expressions, the level of mathematical thinking between the control and experimental group due to the experimental group that studied using educational software. Study recommended that the Ministry of Education hold training courses for mathematics teachers regarding how to employ educational software in the educational process,
Keywords: Educational Software, Achievement, Mathematical Thinking, Ninth Grade Students.

Introduction

Today, we are experiencing a massive technological influx resulting from the information and communication revolution. This has led to a transformation in teaching methods and tools. The computer has emerged and become essential in all educational institutions. It has also become a valuable tool for creating a flexible and supportive learning environment for students within the educational setting, thus increasing the possibilities and diversifying learning methods, such as collaborative, individual, and self-directed learning.

Many developed countries have begun using effective educational programs, and teachers in many of these countries have started to rely heavily on computers. Some studies have shown that students learn more effectively through computer software than through traditional education, and that students can learn the required material in less time than traditional methods. Therefore, companies have competed to produce various educational programs, and students have increasingly embraced learning through these programs. However, there is an obstacle hindering the optimal use of computer software in education; This involves meeting the actual needs of students by providing educational programs that can deliver appropriate instruction in all subjects (Al-Rashid, 2007). Among these subjects is mathematics, which is characterized by its difficulty, cumulative structure, and complexity.

Computers are distinguished by their ability to store vast amounts of data, which is then translated into information and displayed quickly and in a logical sequence. They also provide learners with immediate feedback and offer an interactive learning environment that includes simulations and visual representations. The program can be controlled, guiding the learner from passively receiving information to actively interpreting it. Other features include the ability to handle text, images, audio and video clips, and color variations, among others. This facilitates the integration of these elements into educational software in an engaging and attractive manner (Muflih, 2011).

Shdeifat and Arshid (2007) indicate that modern digital technology—such as computers and the internet—has transformed the ways we access knowledge and has become a hallmark of the modern age through its integration into the educational system. Diversification in teaching methods is considered a key approach to improving learning and teaching, as educational technologies play a significant role in enhancing the quality of education, achieving mastery, and realizing educational goals with less time and resources. This also increases the return on investment in education and reduces costs without compromising quality. Computers play a crucial role in learning and teaching, being used to teach various subjects, prepare lessons and tests, evaluate students, and manage classrooms. There are numerous justifications for using computers and information technology in education and learning, including preparing students for a world centered on advanced technology, familiarizing them with information processing, improving the quality of learning and teaching, and keeping them abreast of the latest scientific advancements in various fields.

Mathematics can be described as a science born from the creativity of the human mind. It is a tool and method of thinking, focusing on ideas, methods, and intellectual patterns. Mathematics is also considered a special language, employing precisely defined symbols and expressions, and organizing its ideas logically and sequentially. Mathematics is generally viewed as structured knowledge, starting with undefined expressions and developing into theories, generalizations, and conclusions. It also focuses on studying patterns and sequences in numbers, shapes, and symbols (Abu Zeina, 2010).

Given the increasing need to create an effective learning environment that accommodates individual student differences, educators have concluded that computer technology is an influential tool in shaping human thinking patterns and assisting students in acquiring knowledge. The popularity of computers among students and their ability to accommodate individual differences have led to their rapid adoption in education (Al-Dayel, 2005) .Thinking, on the other hand, is a skill that can be learned and acquired. It is a holistic process through which an individual mentally and sensorily processes perceptions and translated information to form, reason, or judge ideas. It includes perception, prior experience, conscious processing, incubation, and intuition (Qatami, 2004).

Costa and Kellick (2000) point to the importance of acquiring thinking skills as a necessary means to meet all modern challenges and achieve progress in various fields. They emphasize that individuals need to develop communication and problem-solving skills, as well as the ability to absorb scientific and technological knowledge. In this context, modern education focuses heavily on training students in constructive thinking and developing problem-solving skills. This aims to prepare them to face the challenges of real life, and the school plays a fundamental role in teaching students thinking skills, as the ability to think is considered one of the main goals that modern schools strive to achieve in their students.

Study Problem

Mathematics is considered one of the school subjects that many students find difficult, as they struggle to understand and accept it. Teachers also face challenges in raising their students' achievement levels in this subject, which is evident through the low performance in mathematics across all educational stages, as well as parents' complaints about their children's consistently low results. This indicates that there are numerous factors contributing to students' general weakness in understanding and comprehending mathematics, among which are the teaching methods used in mathematics instruction.

The results of several studies have indicated that students in Jordan perform poorly in mathematics in general, and in problem-solving and mathematical thinking skills in particular. One such study is the Trends in International Mathematics and Science Study (TIMSS, 2015), where the average score in mathematics was 386, while the international average for all participating countries was 451. Jordan's performance was statistically significantly below the international average, ranking 36th out of 39 participating countries. Although Jordan's performance improved by three ranks in TIMSS (2019), achieving an average score of 489—equal to the overall average of all participating countries—the performance was still statistically significantly below the international benchmark, ranking 33rd out of 39 participating countries. This indicates that students' achievement remains below the desired level and highlights the need for improvement and reconsideration of the educational system. It also calls on educators, policymakers, decision-makers, and society at large to address this issue and take all necessary measures (Ababneh, Abu Labdeh, & Ababneh, 2021).

Through the researcher's analysis of a set of mathematics tests administered by teachers for ninth-grade students, it was observed that students demonstrated overall weakness in mathematics achievement, particularly in factoring algebraic expressions.

Therefore, the researcher recognized the need for appropriate instructional methods to teach factoring algebraic expressions to this group of students. Consequently, the researcher decided to investigate the effect of a computer-based program on developing the skill of factoring algebraic expressions among ninth-grade students.

Study Questions

The present study seeks to answer the following questions:

1. Is there a statistically significant difference at the level ($\alpha \leq 0.05$) in the achievement of ninth-grade students in factoring algebraic expressions in schools affiliated with the Directorate of Education of Qasaba Ma'an attributed to the teaching method (educational software vs. traditional method)?
2. Is there a statistically significant difference at the level ($\alpha \leq 0.05$) in the achievement of ninth-grade students in factoring algebraic expressions attributed to gender?
3. Is there a statistically significant difference at the level ($\alpha \leq 0.05$) in the development of mathematical thinking among ninth-grade students in schools affiliated with the Directorate of Education of Qasaba Ma'an attributed to the teaching method (educational software vs. traditional method)?
4. Is there a statistically significant difference at the level ($\alpha \leq 0.05$) in the development of mathematical thinking among ninth-grade students in schools affiliated with the Directorate of Education of Qasaba Ma'an attributed to gender?

Study Objectives

The study aims to identify the effect of an educational software program in mathematics on the achievement of male and female ninth-grade students in factoring algebraic expressions and developing mathematical thinking in schools affiliated with the Directorate of Education of Qasaba Ma'an, as well as to determine gender differences in these outcomes.

Significance of the Study

The significance of the current study lies in the following:

1. Introducing the role of digital educational software and its essential features of attractiveness, excitement, and engagement, in addition to the interactive environment it provides, and its ability to accommodate individual differences among students when teaching factoring algebraic expressions.
2. The application of this study to the basic stage of education underscores the importance of focusing on students’ skills in factoring algebraic expressions

at this level, as it forms the foundation for their learning in subsequent stages.

3. This study aligns with modern trends in the educational field that seek to digitize education by effectively integrating computers into educational settings. Consequently, educators can benefit from the results of this study. It can also support teachers by providing a practical model of how to use computer-based instruction in teaching students how to factor algebraic expressions.
4. The scarcity of studies addressing the impact of educational software in teaching mathematics, particularly in teaching factoring algebraic expressions—as far as the researcher knows.

Terminological and Operational Definitions

Computer-Based Educational Software: Defined by Al-Heila (2016) as instructional material prepared and programmed using computers for students to learn, based on the principle of reinforcement. Operationally, in the present study, it refers to structuring the ninth-grade equations unit using the computer, specifically through employing an educational software program to teach factoring algebraic expressions.

Traditional Method: The teaching method in which the teacher presents instructional content through any desired means (discussion, lecture, practical demonstrations, etc.) except for using computers.

Achievement: Defined as the level of success reached by the learner in a particular subject or educational/training field (Allam, 2000). Al-Jalali (2016: 10) defines it as "the learning accomplishment of a subject, meaning the attainment of a particular level of information and performing the required skills, determined through standardized tests or teachers' reports, or both." Operationally, it refers to the score obtained by the student on the test prepared by the researcher to measure students' achievement in factoring algebraic expressions.

Ninth Grade (Basic Stage): One of the grades within the basic education stage, with students typically around 14 years old.

Mathematical Thinking: efined as the process through which meaning is sought in mathematical situations or experiences, which may appear in the form of pictures, symbols, numbers, or mathematical concepts. It is considered one of the most comprehensive types of thinking (Abu Zeina & Ababneh, 2010). The researcher operationally defines it as a form of thinking used by the brain to mentally solve mathematical equations, determined by the following skills: induction, deduction, conjecturing, modeling, symbolic representation, and logical thinking. It is measured by the score obtained by the student on the mathematical thinking skills test used in the study.

Study Limitations

This study is limited to ninth-grade male and female students during the first semester of the 2025–2026 academic year in schools affiliated with the Directorate of Education of Qasaba Ma'an.

Theoretical Framework

First: Educational Software

The use of educational technologies is considered a fundamental component in the implementation of curricula in general, and mathematics curricula in particular. Interest in improving students' learning outcomes in science has increased through the employment of various instructional strategies and approaches in teaching to achieve integration between method and scientific knowledge (Edelson, 2001).

Al-Heila (2017) indicates that computers and their technological programs contribute to improving education, learning, media, culture, and even controlling human behavior in daily life. He emphasizes that the focus in the educational process should not be on the computer itself but rather on the educational program it contains. The computer serves merely as a tool for transmission, storage, and recording, whereas the embedded program is responsible for the actual educational process.

Bataineh (2006) explains that digital educational software enables learners to study independently without the need for deep knowledge of computer science. Computer-assisted instruction may be the most suitable approach for teaching various scientific subjects because of its advantages, such as rapid information retrieval, the ability to present content in multiple forms accompanied by visual and auditory stimuli that enhance the enjoyment of learning, the appealing presentation of information, increased learner motivation, and enhanced perseverance and engagement.

Definition of Educational Software

Educational software is defined as multimedia programs that combine techniques of presenting images, sound, text, videos, graphics, and more, controlled using computers and their software to achieve specific instructional objectives, with each medium used according to its effectiveness (Khmaisah & Arman, 2003, p. 122).

Mahdi (2006, p. 8) defines it as "instructional materials designed and programmed using computers, with which learners can interact at their own pace and ability, and which provide various multimedia alternatives such as images, sound, text, and motion that support the instructional content."

According to Khamis (2007), educational software are multi-functional electronic applications designed and used through computers to manage the educational process or deliver knowledge directly and comprehensively to students to achieve specific learning objectives tied to particular subjects as part of their formal curriculum.

Eshtayat (2017, p. 48) defines it as "a computer-programmed instructional unit developed using a programming language, which includes lessons presented in an engaging manner that incorporates objectives, content, examples, assessment, scientific simulations, videos, and websites supported by multimedia, enabling learner interaction and providing immediate feedback to achieve educational objectives."

Al-Heila (2017) also defines educational software as software developed via computers and used for instructional purposes, encompassing a diverse set of applications ranging from language learning programs to classroom management systems and programs intended to enhance the effectiveness and efficiency of the educational process.

Standards for Designing Educational Software

Although computers offer significant capabilities in education, these capabilities cannot be effectively utilized without well-designed educational programs. Therefore, certain general and specific standards must be considered in the design and production of such programs (Al-Hersh et al., 2003). These standards include ensuring the clarity and measurability of the program's objectives, providing content appropriate to learners' levels, and verifying mastery of prerequisite skills before introducing new skills or concepts. Additionally, learners should be granted some control over the program, and instruction should begin with attention-grabbing features such as fonts, graphics, sound, and color. Effective programs also provide practice opportunities after presenting each part of the content and adhere to sound principles of screen design to enhance learner interaction, motivation, and continuity.

Ayadat (2007, p. 277) notes several considerations in screen design: avoiding overcrowded information, leaving sufficient spacing between lines, enabling font resizing, using attention-grabbing elements (images, graphics, audio), avoiding excessive transitions that distract learners, and allowing customization of background and foreground colors.

Stages of Developing Educational Software

According to Al-Far (2005), the development of educational software involves a systematic and multi-stage process to ensure that the final product is both pedagogically effective and technically sound. The first stage, the **design stage**, focuses on establishing a comprehensive framework that includes defining the general objectives, selecting the content, planning learning activities, designing exercises, and outlining assessment methods. This stage serves as the blueprint for the subsequent steps. The **preparation stage** involves detailed planning and gathering of all necessary instructional materials, including objectives, scientific content, multimedia elements such as images and audio, as well as the formulation of operational objectives, the organization of content, and the planning of lessons along with feedback mechanisms. Following this, the **scenario writing stage** translates the design framework into concrete instructional events and activities, specifying how learners will interact with the material and how each learning objective will be addressed through the software. In the **execution stage**, the scenario is implemented using interactive multimedia programming, where technical functionality is tested, audiovisual elements are carefully selected, and interactive features are developed to engage learners effectively. Finally, the **testing and development stage** involves presenting the program to experts and educators for evaluation, followed by refinement and enhancement of both content and technical aspects based on feedback, ensuring the software is ready for adoption and practical classroom use. This structured approach ensures that educational software is not only technically functional but also pedagogically aligned with learning objectives.

Ayadat (2007) summarizes the importance of educational software by highlighting several key contributions to the learning process. Educational software facilitates learning through the use of diverse instructional models, enabling teachers to adopt different approaches tailored to students' needs. It allows the production of varied instructional materials, which can enhance lesson delivery and accommodate multiple learning styles. Furthermore, such software increases student interaction and promotes group collaboration, fostering a more engaging and cooperative learning environment. It also supports the execution of complex projects through simulations, providing practical and experiential learning opportunities. In addition, educational software can present stories and videos to enhance comprehension, integrate the internet effectively, and increase students' enjoyment of learning through multimedia features. Collectively, these aspects demonstrate how educational software can enrich both teaching and learning experiences.

Saraya (2006) notes that good educational software should align with the curriculum, enable learners to achieve objectives, be easy to operate, and provide appropriate feedback that aids retention and transfer of learning.

Mathematical Thinking

Developing thinking skills has become a pivotal focus in contemporary educational systems, reflecting a fundamental shift in educational philosophy from the traditional approach of mere knowledge transmission to one that prioritizes the cultivation of learners' cognitive capacities. In modern pedagogy, the goal is not only to equip students with information but also to develop their abilities to think critically, reason logically, and solve complex problems. This shift underscores the importance of fostering higher-order cognitive skills that allow students to analyze, evaluate, and apply knowledge effectively in various contexts (Marzano et al., 1988; Paul, 1993; Wilson, 1993; Houssart et al., 2005). In this light, education is increasingly seen as a process that prepares students to navigate a rapidly changing world, emphasizing learning how to learn, developing self-regulation, and promoting creative and analytical thinking.

Mathematics education, in particular, occupies a central role in nurturing cognitive development within basic education programs. Recognized as a discipline that inherently cultivates structured thinking, mathematics provides a fertile environment for the development of logical reasoning, problem-solving abilities, and abstract thought. Many countries have revised their mathematics curricula to align with 21st-century educational demands, emphasizing not only the mastery of content but also the cultivation of mathematical thinking skills and the ability to engage in rigorous reasoning and reflective thinking. Mathematics is no longer treated merely as a set of procedures and formulas to memorize; rather, it is approached as a mode of thinking that encourages students to identify patterns, explore relationships, and construct knowledge through reasoning and logical deduction.

The National Council of Teachers of Mathematics (NCTM, 1989, 2000) highlights the importance of fostering a wide spectrum of thinking skills, including mathematical, critical, deductive, and inductive thinking, alongside key competencies such as communication, algebraic reasoning, and problem-solving (Schielack et al., 2000). These standards stress that developing students' ability to think mathematically enhances not only their academic performance but also their ability to engage meaningfully with real-world challenges. Ibrahim (2007) emphasizes that mathematical thinking is the foundation and essence of mathematics, arguing that without structured reasoning, mathematical work becomes susceptible to errors, inconsistencies, and superficial understanding.

In Jordan, mathematics curricula at the basic education level explicitly aim to develop students' problem-solving abilities and cultivate higher-order thinking skills (Ministry of Education, 1988, p. 75). These curricula recognize that fostering mathematical thinking is essential for enabling students to analyze situations, make inferences, and apply knowledge creatively and effectively. The emphasis on thinking skills aligns with global educational trends that prioritize cognitive development, innovation, and lifelong learning, ensuring that students are not only consumers of information but also active constructors of knowledge.

Researchers have provided various definitions of mathematical thinking that emphasize its structured and purposeful nature. Hamada (2009, p. 69) defines mathematical thinking as "a continuous and organized mental activity occurring during instruction to solve mathematical problems using inferential and proof-based reasoning skills." Similarly, Al-Agha (2009, p. 8) describes it as "a mental process for solving mathematical problems using given premises, characterized by inquiry, induction, deduction, relational patterns, symbolic expression, and problem-solving." These definitions collectively highlight that mathematical thinking is an active, deliberate, and systematic cognitive process. It involves identifying patterns, generating hypotheses, making logical deductions, translating ideas into symbolic representations, and applying reasoning to solve problems. Developing such skills equips students with the intellectual tools necessary for understanding complex concepts, adapting to new situations, and engaging in reflective and independent thought.

Overall, the emphasis on mathematical thinking in educational systems reflects a broader pedagogical shift toward cultivating cognitive skills that are critical for success in the modern world. By integrating problem-solving, reasoning, and reflective thinking into mathematics curricula, educators aim to prepare students not only to excel academically but also to think analytically, creatively, and independently—skills that are essential for lifelong learning and effective participation in society.

Mathematical Thinking Skills

Since views on mathematical thinking and its skills vary according to educational stage and professional experience, researchers have proposed several classifications.

A skill is defined as the mastery of performance requiring practice and often accompanied by behavioral changes (Al-Hadi & Mustafa, 2001).

Ali (2009) suggests that mathematical thinking skills encompass induction, which involves deriving general concepts from multiple instances; deduction, which entails deriving specific cases from general principles; and symbolic expression, which refers to translating verbal statements into symbols. Similarly, Schielack et al. (2000) classify mathematical thinking skills into modeling, reasoning, symbolic expression, abstraction, and optimization. Based on a review of the related literature and consideration of cognitive appropriateness for students, the researcher identified six core mathematical thinking skills as suitable for ninth-grade learners, integrating the perspectives of both Ali (2009) and Schielack et al. (2000), graders:

Mathematical thinking skills encompass a range of cognitive processes essential for problem-solving and reasoning in mathematics. Induction involves moving from specific cases to general principles, including complete induction, which examines all cases, and incomplete induction, which derives rules from selected cases; its key components include identifying causal relationships, analyzing open problems, analogical reasoning, drawing conclusions, and identifying related information. Deduction, on the other hand, is the process of moving from general principles to specific cases, linking prior knowledge to reach logical conclusions. Symbolic expression refers to the ability to express mathematical ideas using symbols for abstraction and simplification, including translating verbal statements into symbolic mathematical expressions (Abu Al-Abbas, 1991). Modeling involves using mathematical representations such as tables, graphs, and diagrams to solve problems and identify patterns (Hussein & Fakhro, 2010). Conjecturing is the ability to propose reasonable hypotheses to solve problems and verify them, often associated with intuitive thinking (Eid, 2009). Logical thinking is a mental ability that enables students to move from the known to the unknown using objective principles and rules. Hamada (2009) emphasizes several educational conditions that promote the development of mathematical thinking, including encouraging dialogue and discussion, ensuring relevant and meaningful content, providing purposeful and appropriate activities, and allowing collaborative work with monitoring of individual progress. These considerations were incorporated into the design of the proposed program for developing mathematical thinking skills.

Previous Studies

The researcher benefited from previous studies in preparing the study instruments and in interpreting and discussing the results obtained. The previous studies were divided into two main themes:

1. Previous Studies Related to Educational Software

Muflih (2011) conducted a study aimed at identifying the effect of using computerized educational software on the achievement of ninth-grade students in mathematics compared with the conventional method. The quasi-experimental approach was used. The study sample consisted of (82) male and female students from the schools of Irbid First Directorate of Education. They were divided into two groups: an experimental group that studied using the software (41 students), and a control group that studied using the conventional method (41 students). The study concluded that using the software had a significant effect on students' achievement in mathematics, and no statistically significant differences were found in the experimental group's achievement attributed to gender or the interaction between gender and teaching method.

Eshtayat (2017) conducted a study aimed at identifying the effect of Flash Adobe software on developing fourth-grade students' attitudes toward mathematics in basic schools in Irbid Governorate. The quasi-experimental approach was used. The study sample consisted of (60) male and female students, divided equally into an experimental group (30 students) who studied using the Flash software, and a control group (30 students) who studied using the conventional method. An achievement test and an attitude scale were applied to both groups. The results revealed a positive effect of Flash Adobe software on students' achievement and attitudes toward mathematics.

Saleh (2017) aimed to investigate the effect of using the "Algebrator" software on the achievement of 11th-grade scientific stream female students in the unit of matrices and on their motivation toward learning mathematics. The study sample consisted of (64) female students from Nablus Governorate. They were divided into an experimental group that studied the unit using the software and a control group that studied the same unit using the traditional approach. The study concluded that the software was effective in improving students' achievement and motivation toward learning mathematics.

2. Previous Studies Related to Mathematical Logical Thinking

Al-Maliki (2016) conducted a study aimed at identifying the effect of a constructive educational software on developing mathematical thinking skills among second-intermediate grade students in Taif city. The study followed the experimental method, and its sample consisted of (48) students divided equally into experimental and control groups (24 students each). A pre-test of mathematical thinking skills was applied to both groups, after which the experimental group studied a geometry and spatial reasoning unit using the constructive software, while the control group studied using the conventional method. After applying the post-test, results showed statistically significant differences in favor of the experimental group in the skills of induction, deduction, relational perception, and spatial visual perception.

Shana'a and Abu Luhm (2021) aimed to explore the effect of a program based on smart mathematical applications on developing mathematical thinking among third-grade students in Jordan. The study followed a quasi-experimental design, with a sample of (60) male and female students from Al-Hassad Al-Tarbawi Schools, equally divided into experimental and control groups. A pre- and post-mathematical thinking test was applied. The study concluded that there were statistically significant differences in the post-test in favor of the experimental group which was taught using smart mathematical applications.

Omran (2022) conducted a study aimed at identifying the effect of using three-dimensional virtual reality software on mathematical thinking and attitudes toward mathematics. The sample consisted of (60) eighth-grade female students from Nablus Governorate, divided into an experimental group and a control group (30 students each). The study concluded that the virtual reality software was effective in improving mathematical thinking and students' achievement in its components, as well as enhancing their attitudes toward mathematics.

Methodology and Procedures

Study Method

The study followed the quasi-experimental method.

Study Population

The study population consisted of all ninth-grade students in the schools of Ma'an Directorate of Education, totaling (965) male and female students: (495) males and (470) females for the academic year (2025/2026), according to statistics from the Planning Department at the Directorate of Education.

Study Sample

The researcher purposefully selected two schools—one for males and one for females. The ninth-grade students in each school were divided into two groups: an experimental group and a control group. Each school contained two ninth-grade sections; section (A) was assigned as the control group, and section (B) as the experimental group. The total sample consisted of (102) male and female students: (50) males and (52) females, distributed across four sections—two for females and two for males. Table (1) shows the distribution of the sample according to group and gender.

Table (1): Distribution of the Study Sample by Group and Gender
Group Distribution According to Gender

Group	Gender	Number
Experimental	Male	24
	Female	27
Total		**51**
Control	Male	26
	Female	25
Total		**51**

Study Instruments

The following instruments were used in the study:

A. Computerized Instructional Material

The computerized instructional material on the topic of Factoring Algebraic Expressions for ninth-grade students was used.

B. Achievement Test

- An essay-type achievement test in mathematics (factoring algebraic expressions) was developed for ninth-grade students. The final form consisted of (7) questions. The following steps were followed:
- Analyzing the content of the Equations Unit in the ninth-grade mathematics textbook for the second semester.
- Deriving and formulating a set of behavioral objectives in light of Bloom's taxonomy in the cognitive domain.
- Constructing a table of specifications for the instructional content, determining the total number of test questions based on the time available, type of questions, and the characteristics of the sample, then specifying the number of items for each topic according to Bloom's levels.
- Writing the test items to match the specifications table and distributing them according to cognitive levels.
- Ensuring the test's validity and reliability.

Psychometric Properties of the Test and Its Items

1. Test Validity

A. Content Validity (Experts' Judgment)

The test was reviewed by (10) experts specialized in teaching methods, educational measurement and evaluation, and experienced mathematics supervisors from Jordanian universities. They evaluated the alignment of the test with content and Bloom's levels, as well as the clarity of its language.

2. Test Reliability

Test–retest reliability was used. The test was applied to an exploratory sample of (39) ninth-grade students—one male and one female section. The test was administered twice with a two-week interval (15 days). The correlation coefficient between scores of the two administrations was 0.87, indicating a high and acceptable reliability for such an achievement test.

Item Analysis

A. Discrimination Index

Item discrimination indices were calculated using corrected item-total correlation. The values ranged between (0.405–0.785), as shown in Table (2).

B. Difficulty Index

Item difficulty was calculated using the mean performance of the exploratory sample. Difficulty values ranged between (0.43–0.82). Table (2) presents the results.

Table (2): Discrimination and Difficulty Indices of Achievement Test Items

Item No.	Discrimination Index	Difficulty Index
1	.822**	0.36
2	.846**	0.33
3	.923**	0.35
4	.744**	0.30
5	.714**	0.34
6	.955**	0.34
7	.855**	0.30

- *Significant at (α ≤ 0.05)*

  *** Significant at (α ≤ 0.01)*

All discrimination and difficulty indices were found to be acceptable.

C. Mathematical Thinking Test

A test consisting of (4) questions was developed to measure students' mathematical thinking skills. Its validity and reliability were established as follows:

1. Validity

A. Content Validity (Experts' Judgment)

The test was reviewed by (10) experts in teaching methods, measurement and evaluation, and mathematics supervision to ensure content representation, alignment with Bloom's taxonomy, and linguistic clarity.

2. Reliability

A test–retest procedure was applied using the exploratory sample (39 students). After two administrations separated by 15 days, the reliability coefficient reached 0.77, which is acceptable for tests of this nature.

Item Analysis

Discrimination indices ranged between (0.405–0.785), and difficulty indices ranged between (0.43–0.82), as shown in Table (3).

Table (3): Discrimination and Difficulty Indices of Mathematical Thinking Test Items

Item No.	*Discrimination Index*	*Difficulty Index*
1	.85**	.64
2	.78**	.54
3	.71**	.53
4	.60**	.79

- *Significant at (α ≤ 0.05)*
  *** Significant at (α ≤ 0.01)*

Study Procedures

- The researcher developed the achievement test and the mathematical thinking test and designed the educational software.
- Official approval was obtained from the Directorate of Education to implement the study.
- Appropriate schools with available equipment and computer labs were selected. The researcher visited the schools to ensure the readiness of computers and software.
- Schools forming the study sample were identified, and students were randomly assigned into control and experimental groups.
- A pre-test was administered to both groups to verify equivalence. Means and standard deviations were calculated for achievement and mathematical thinking tests by group (control/experimental) and gender (male/female). Table (4) shows the results.

Table (4): Means and Standard Deviations of Pre-Test Scores According to Group and Gender

Test	*Group*	N	*Mean*	*SD*	*df*	*t-value*	*Sig.*
Achievement	Experimental	51	11.92	4.13	100	-0.269	.788
	Control	51	12.14	3.96			
	Male	24	12.00	4.67	49	0.127	.900

	Female	27	11.85	3.68			
Mathematical Thinking	Experimental	51	4.35	1.93	100	2.17	.032
	Control	51	3.43	2.32			
	Male	24	4.46	2.17	49	0.385	.717
	Female	27	4.26	1.72			

Results showed:

- No statistically significant differences between experimental and control groups in achievement pre-test (t = -0.269).
- Significant differences in the mathematical thinking pre-test in favor of the experimental group (t = 2.17).
- No statistically significant gender differences in either test.

Additional Procedures

6. The experimental program was implemented starting from 15/9/2021 for two weeks, at a rate of three sessions per day. The program ended on 29/9/2021.
7. After instruction, the post-tests were administered to both groups.
8. Statistical analyses were performed to determine the effect of the program and extract results and recommendations.

Study Variables

The study examined the effect of the independent variable, teaching method, on students' learning outcomes. The teaching method had two levels: the use of educational software and the traditional instructional approach. The dependent variables included students' achievement in factoring algebraic expressions and their performance on a mathematical thinking test. This design allowed for an assessment of how different instructional strategies influenced both academic achievement and the development of higher-order cognitive skills in mathematics.

Statistical Treatments

1. Means and standard deviations
2. Independent Samples t-test

Study Results and Discussion

This chapter presents the results obtained by answering the study questions, followed by a discussion of these results in light of theoretical literature and previous studies, and finally the corresponding recommendations.

Results and Discussion of the Study

Results Related to the First Research Question

"Are there statistically significant differences at the level ($\alpha \leq 0.05$) in the achievement of ninth-grade students in factoring algebraic expressions in schools affiliated with the Directorate of Education in Qasbah Ma'an attributable to the teaching method (computerized instructional program vs. traditional method)?"

To answer this question, means and standard deviations of students' performance on the post-achievement test were calculated according to group (experimental and control). Table (5) presents the results.

Table (5): Means and Standard Deviations of Students' Performance on the Post-Achievement Test According to Group

Test	*Group*	N	*Mean*	*SD*	*df*	*t-value*	*Sig.*
Achievement Test	Experimental	51	18.31	4.36	100	3.09	.003
	Control	51	15.21	5.75			

The results in Table (5) indicate statistically significant differences at ($\alpha \leq 0.05$) between the control and experimental groups on the post-achievement test, with a t-value of (3.09). This indicates the presence of an effect for the computerized instructional program on students' achievement in factoring algebraic expressions.

The researcher attributes this effect to several factors, including the ability of computer-based instruction to accommodate learners' pace and individual differences, and the fact that it introduces a novel, engaging learning environment. This likely increased students' interaction with instructional content, consequently improving their achievement. Students in the experimental group were exposed to continuous learning opportunities, which enhanced their learning competencies.

Furthermore, the effectiveness of the computerized instructional program may be explained by its features—colors, images, sounds, immediate feedback, and elements of stimulation and motivation—which increase students' engagement and reduce boredom associated with traditional instruction. It also provided a supportive learning environment that aligned with students' abilities, and encouraged participation and collaboration.

These findings agree with those of Ibrahim (2007), who reported statistically significant differences in student achievement in favor of the experimental group taught using computers. They also align with Muflih's (2011) study, which demonstrated the effectiveness of instructional software in improving ninth-grade students' mathematics achievement.

Results Related to the Second Research Question

"Are there statistically significant differences at the level (α ≤ 0.05) in the achievement of ninth-grade students in factoring algebraic expressions attributable to gender?"

To answer this question, means and standard deviations of students' post-achievement test scores were calculated according to gender. Table (6) shows the results.

Table (6): Means and Standard Deviations of Post-Achievement Test Scores According to Gender

Test	*Gender*	*N*	*Mean*	*SD*	*df*	*t-value*	*Sig.*
Achievement Test	Male	24	18.83	3.71	49	.798	.428
	Female	27	17.85	4.89			

Table (6) shows no statistically significant differences at (α ≤ 0.05) between males and females on the post-achievement test, as the t-value (.798) was not significant. This suggests that both genders were similar in their achievement levels in factoring algebraic expressions, indicating equal readiness and interest in learning through computers. This result may also be attributed to comparable learning conditions for both genders, the unified nature of the content, equal access to educational resources, and parallel cognitive developmental stages at this age.

This result is consistent with Muflih's (2011) findings, which indicated no statistically significant gender differences in the achievement of students in the experimental group.

Results Related to the Third Research Question

"Are there statistically significant differences at the level (α ≤ 0.05) in developing mathematical thinking among ninth-grade students attributable to the teaching method (computerized instructional program vs. traditional method)?"

To answer this question, ANCOVA was used. Table (7) presents the results.

Table (7): ANCOVA Results for Differences in Mathematical Thinking According to Teaching Method

Group	*N*	*Mean*	*SD*	*Source*	*Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*
Experimental	51	12.06	4.41	Pre-test	1.027	1	1.027	.066	.798
Control	51	9.12	3.40	Post-test	216.90	1	216.90	13.844	.000
				Error	1551.09	99	15.67		
				Total	1772.71	101			

The results in Table (7) indicate statistically significant differences at (α ≤ 0.05) in mathematical thinking attributable to the teaching method, where (F = 13.844). This demonstrates the effectiveness of the computerized instructional program in developing students' mathematical thinking.

This effect may be due to the motivational and stimulating nature of the computerized program, which caters to multiple learning styles, clarifies and simplifies concepts, and effectively utilizes instructional time—allowing students more opportunities for reflection and reasoning. Features such as the use of visuals, movement, sequencing, structured presentation, and numerous examples likely enhanced students' cognitive engagement. The program also allowed students to navigate through instructional material according to their interests and pace.These findings agree with those of Abu Al-Hutul (2011) and Najm (2012).

Results Related to the Fourth Research Question

"Are there statistically significant differences at the level ($\alpha \leq 0.05$) in developing mathematical thinking among ninth-grade students attributable to gender?"

Means and standard deviations were calculated, and an independent samples t-test was used. Table (8) shows the results.

Table (8): Means and Standard Deviations of Post-Mathematical Thinking Test Scores According to Gender

Test	*Gender*	*N*	*Mean*	*SD*	*df*	*t-value*	*Sig.*
Mathematical Thinking	Male	24	18.83	3.71	49	.798	.428
	Female	27	17.85	4.89			

Table (8) indicates no statistically significant differences at ($\alpha \leq 0.05$) between males and females in mathematical thinking, with a t-value of (.798). This result aligns with the findings of Al-Absi (2008) and Najm (2012), both of which reported no gender-related differences in acquiring mathematical thinking skills.

Recommendations

Based on the study findings, the researcher recommends the following:

1. Mathematics teachers should benefit from digital technologies and incorporate them into instruction, especially when teaching factoring of algebraic expressions.
2. The Ministry of Education should offer training programs for mathematics teachers on integrating educational software into teaching-learning processes.
3. Enriching mathematics content—particularly the unit on factoring algebraic expressions for ninth grade—with activities that foster mathematical thinking.
4. Conducting similar studies at other educational levels, especially higher grades, and in various subject areas.

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