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THE EFFECTIVENESS OF A PROJECT-BASED LEARNING EDUCATIONAL PROGRAM IN DEVELOPING MATHEMATICAL THINKING SKILLS AMONG GIFTED INTERMEDIATE STUDENTS

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Abstract

Objective: To investigate the effectiveness of project-based learning in developing mathematical thinking skills in mathematics among gifted intermediate-level students. **Design**: The researcher followed a quasi-experimental approach. The sample consisted of 24 gifted intermediate-level students in Al-Ahsa Governorate who had passed the Mawhiba Scale. The researcher designed a project-based educational program, based on the models of (Krajcik et al., 1999; Krauss & Boss, 2013). A mathematical thinking skills test tool was administered to the sample. **Results**: The study results revealed statistically significant differences between the mean scores of the experimental group students in the pre- and post-tests of the skills [logical thinking ($Z = 2.67$, $p = < 0.05$) - symbols and semantics ($Z = 2.41$, $p = < 0.05$) - mathematical deduction ($Z = 2.43$, $p = < 0.05$) - mathematical induction ($Z = 2.39$, $p = < 0.05$) - mathematical thinking skills as a whole ($Z = 2.61$, $p = < 0.05$)] in favor of the experimental group. **Conclusion**: Employing project-based learning in teaching gifted students aligns with the Kingdom of Saudi Arabia's Vision 2030, which emphasizes the importance of equipping students with the knowledge and skills of this era, and discovering their abilities and talents to nurture and support them, transforming them from an idea in the mind into a tangible object (tool) that can be used as a product that serves the nation and its people.

Keywords: Project-based learning - Mathematical thinking skills - Gifted students - Intermediate level

Introduction:

The world today is witnessing rapid growth in advanced cognitive and technological development. Educational institutions are facing enormous challenges that place a heavy burden on them. The tremendous knowledge explosion leads to a vast amount of information and data. With the growing beneficial role of mathematics in modern fields of knowledge, it has become necessary to prepare learners, especially gifted students who are the foundation of this progress, with strong mathematical preparation. Caring for these students has also become crucial to achieving the highest possible benefit from their abilities for the benefit of themselves and their society. From the perspective of many educators, mathematics is an important tool for organizing, understanding, and controlling the environment in which we live. Mathematics is the subject of science and the foundation of life. Therefore, it is imperative to teach it to students (Abu Zeina, 2010).

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Teaching mathematics requires positive interaction between the teacher and the learner in the learning situation. Students must evaluate and discuss mathematical concepts with their teacher and peers, and address them through modeling and realism to reach a level of mathematical understanding and develop a mathematical sense that they can use in their daily lives (Yamin, 2013). Recently, teaching strategies have gained increasing popularity and interest from researchers, theorists, and those working in the field of education, based on the belief that modern teaching strategies motivate learners to utilize their potential, abilities, and talents to the fullest. The best thing for teachers to do is to implement these strategies instead of filling learners' minds with information and knowledge that fades over time. Knowledge and skills they acquire through teaching-learning situations, remains with learners throughout their lives which are built within them through effective, activity-based learning (Awad, 2017).

A good teacher who is constantly researches and improves their teaching skills, maintains broad knowledge of new developments in education and teaching methods, and designs educational activities that ensure active participation of all students in the classroom. Project-based learning (PBL) is considered an alternative to rote learning. Proponents of PBL cite numerous advantages of implementing this strategy in classrooms, including greater depth of conceptual understanding, a broader knowledge base, improved communication, the development of personal and social skills, enhanced leadership skills, increased creativity, and improved writing skills. This enables students to develop a deeper understanding of science if they are given the opportunity to confront challenging, real-life problems (Tawalba et al., 2010).

Mowafi (2013) emphasized the importance of developing thinking, as it plays a significant role in the teaching and learning process. Educational institutions must provide appropriate opportunities that stimulate students to think, develop, and practice it in both classroom and extracurricular situations.

Because gifted students possess distinct skills and abilities, are identified by a specialized entity, and require educational programs different from their normal peers (Al-Qamish and Al-Imam, 2006), it is imperative to pay attention to this group and provide them with appropriate learning conditions. Gifted students represent the nation's precious wealth and the future of its prosperity, development, excellence, and progress if they are properly cared for (Omar, 2020). Giftedness is not solely dependent on an individual's mental capabilities; rather, it is the result of the contribution of many emotional, social, and economic factors. This means that an individual may possess the mental capabilities that qualify them to achieve a high level of intellectual performance, but fail to reach this level due to a lack of knowledge of the appropriate methods and techniques for making the best use of their potential. An individual's method of acquiring information and their ability to engage with various academic subjects represent important factors leading to giftedness (Al-Qamish, 2012).

The use of project-based learning in teaching gifted students aligns with Saudi Arabia's Vision 2030, which emphasizes the importance of equipping students with contemporary knowledge and skills, and discovering their abilities and talents to nurture and support them, transforming them from an idea in the mind into a tangible product (tool) that can be utilized as a product

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that serves the nation and its people. Therefore, the Ministry of Education has combined efforts to discover gifted male and female students and provide them with appropriate care, based on its belief in the importance of investing in people and transforming them into a knowledge-based society that achieves the sustainable development emphasized by Saudi Arabia's Vision 2030 (Al-Bukhat, 2021). Saudi Arabia's Vision 2030 aims to instill awareness of contemporary requirements by providing opportunities for students to participate in projects and activities that serve society and contribute to its development, with the participation of school personnel, parents, and the surrounding community, and to work to find solutions to the problems they face (Al-Shamrani, 2020).

Mathematical thinking is a modern topic, and many researchers and educators in this field emphasize its importance in improving teaching processes. Educational institutions also recommend the importance of developing other thinking skills in students (Hamza and Al-Suwaih, 2018). Several studies, such as Bakhti (2016), Karibasappa et al. (2015), and Al-Ghanimi (2010), have identified mathematical thinking patterns among primary school students and emphasized the importance of using mathematical thinking skills in teaching processes. Conversely, and to the best of the researcher's knowledge, there are few recent studies that focus on identifying mathematical thinking patterns among teachers of learning disabilities. However, these studies only focus on student teachers, such as Primasatya's (2016) study, which indicated a low level of mathematical thinking patterns among student teachers about to graduate. Tohir's study (2017) emphasized that one of the teachers' roles in teaching mathematics is to help students express how the learning process proceeds in their minds through the steps of mathematical thinking. Therefore, the current study aimed to reveal the effectiveness of a project-based learning program in developing the mathematical thinking skills of gifted female students in intermediate school.

Background:

Individuals differ in their abilities and capabilities. This fact cannot be ignored. In addition, their diversity in ways of thinking, learning styles, interaction with social situations and individuals, and reactions to problems are added. Al-Jughaiman (2018a) states that talent represents one of the abilities that distinguishes some individuals from others, making them different in the traits and characteristics that appear in their daily behavior. The degree of talent and the diversity of its fields also make a difference, which justifies the broad concept of talent and the lack of a specific definition. Accordingly, a concept can be defined for specific entities or individuals based on what they see as appropriate for the scientific and educational services and purposes for which this definition was developed. Furthermore, it is a concept that is subject to development and is influenced by environmental factors and societal culture (Al-Jughaiman and Melhem, 2021).

Talent is defined as: a naturally recurring pattern of thinking, feeling, or behavior that can be applied productively (Bowlin, 2013).

Al-Qaryouti et al. (2013) stated that gifted students are characterized by achieving high levels of achievement in one or more academic subjects, particularly mathematics, science, and languages. They often demonstrate outstanding talents in creativity, the arts, and scientific

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research. Gifted students are characterized by exceptional learning abilities across a wide variety of fields, and they can quickly acquire basic skills and concepts, enabling them to demonstrate a higher level of convergent and imaginative thinking. They are also characterized by independence, self-reflection, and a rapid pace of learning (Cheung et al., 2020). Kaya (2022) attributes the high level of academic performance among gifted students to the presence of several diverse characteristics, such as motivation to learn and innovate and high levels of cognitive skills, which enable them to outperform their average peers. Gifted students require unique educational needs due to a range of characteristics, such as vitality, sensitivity, memory strength, and long attention spans.

Gavin et al. (2023) noted that it is difficult to characterize students with mathematical talent because they display mathematical talent in different ways. Deal and Wismer (2010) described the characteristics of students with mathematical talent as (a) their ability to apply mathematical thinking to new, unplanned, or untested situations, and (b) their possession of analytical and inductive thinking skills without prior exposure to these types of skills. Heinze (2005) confirmed that students with mathematical talent were better able to verbally express and explain their solutions.

In the Kingdom of Saudi Arabia, the National Center for Assessment and Evaluation, with support from the King Abdulaziz and His Companions Foundation for Giftedness and Creativity, developed the Mawhiba Scale to identify gifted students. The scale aims to uncover students' latent academic abilities and skills in the fields of Arabic language, mathematics, science, and some aspects of creativity, examining them through several dimensions, sections, patterns, and images. This test consists of four main dimensions: flexibility Mental, scientific and mechanical reasoning, linguistic reasoning and reading comprehension, and mathematical and spatial reasoning. The General Administration for Gifted Students also uses the General Aptitude Test in various education departments in the Kingdom. This test was developed by a number of researchers (Al-Nafeh et al., 2001; Al-Jughaiman and Al-Yousef, 2022) as part of the national project to identify gifted students. The test aims to identify numerical, linguistic, spatial, and logical abilities. This test is administered when needed by gifted student care centers in various education departments spread across the Kingdom. The General Administration for Gifted Students uses the modified Wechsler Intelligence Scale for Children (Saudi version), which consists of 12 subtests, divided equally between verbal and scientific aspects. It measures overall general intelligence in children aged 6-16 years. The group of subtests is classified into two categories: verbal and practical. It was also noted that the General Administration for Gifted Students Talent is a set of tools, but this diversity is superficial, and what is widely applied is the talent scale (Al- Jughaiman, 2018b).

The Ministry of Education in the Kingdom of Saudi Arabia seeks to provide educational services to gifted students (identification, care, and enrichment) in public schools through a number of programs, projects, and initiatives. These include the Gifted Students Care Program in public schools, the Gifted Center programs, and several enrichment programs (follow-up, continuous care, and invention development) that rely on higher-order thinking strategies. The Gifted Classes Project in public schools also includes central programs implemented by the

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Ministry in cooperation with other government sectors, such as the National Olympiad for Scientific Creativity, the National Project for Gifted Identification, the Acceleration Project for Those Who Show Extraordinary Excellence, and the Twenty Students in Twenty Schools Project (Al-Wadani and Al-Malham, 2023).

Mathematical thinking is the type of thinking that an educated person performs when exposed to a mathematical situation, which is represented by one of the following aspects: induction, deduction, symbolic expression, mathematical proof, logical thinking, guesswork, modeling, reasoning and causation, criticism, and prediction (Al-Khatib, 2012). Zübeyde et al. (2023) define mathematical thinking as an individual's ability to deal with events encountered in daily life in an organized, rapid, and precise manner. This thinking is manifested in shedding light on a problem we often encounter in daily life, offering different solutions, or clarifying an observation that contradicts expectations for any event.

Although mathematical thinking skills are a primary goal of teaching mathematics to intermediate school students and are a necessity for nurturing mathematical talent, scientific studies indicate a decline in mathematical thinking skills, both in mathematics curricula and among female students. These studies include (Al-Rashidi, 2016; Al-Shalabi, 2017; Abidin et al., 2020; Zübeyde et al., 2023), which confirms the existence of shortcomings in mathematics teaching for intermediate school students in general, and gifted students in particular.

In light of the reasons revealed for the low levels of mathematical thinking among intermediate school students, which resulted in mathematics teachers relying on teaching strategies that are inconsistent with mathematical thinking skills and do not meet the needs of female students. For gifted students in intermediate school, project-based learning strategies are one of the strategies suitable for teaching mathematical thinking and aligning with the needs of gifted students. In project-based learning, students don't feel they are learning a single mathematical subject, but rather an educational subject that includes mathematics and other aspects. This demonstrates the highly flexible nature of mathematics and demonstrates the usefulness of mathematics for life, thus facilitating the enjoyment of learning for gifted students.

Project-based learning in mathematics is defined as an educational strategy based on a set of manual and intellectual activities that learners engage in in a socially interactive environment and under the guidance of the teacher to achieve specific goals (Bell, 2010). Project-based learning is a classroom activity that effectively develops basic knowledge in gifted students (Hongxing, 2017) and promotes the development of higher-order thinking skills (Weihong and Yinglong, 2019). The true value of project-based learning lies in its ability to enhance students' higher-order thinking skills, such as mathematical thinking, creative thinking, problem-solving, and integrated application skills, by exploring real-world problems in small groups as a means of acquiring the basic concepts and principles of knowledge. The topic is addressed by asking provocative questions about a topic based on real-life situations and engaging students with a talent for mathematical scientific inquiry.

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Methodology:

The study relied on a quasi-experimental approach based on designing equivalent groups (experimental group and control group). Two identical groups were selected.

A purposive sample of gifted female students who passed the Mawhiba test was selected (because it is a gifted school). (24) students who passed were selected: (12) for the control group and (12) for the experimental group. The students were selected based on their age and passing the Mawhiba test, whether they were classified as gifted, promising, or exceptionally gifted, at second-grade intermediate students in Al-Ahsa Governorate in KSA.

The Project-Based Educational Program

Mathematical thinking skills were identified after reviewing the content of the "Linear Functions" unit in the mathematics textbook prescribed for second-grade female students. They were also consulted by the study supervisors, specialists in mathematics curricula and teaching methods, and previous studies, such as those by Saada and Al-Aithawi (2016), Hamadneh and Al-Qateesh (2015), Subh (2014), Al-Qaisi (2014), Yamin (2013), and others. Skills appropriate for the "Linear Functions" unit in the mathematics textbook prescribed for second-grade female students were selected, including logical thinking, mathematical deduction, symbols and semantics, and mathematical induction.

The Project-Based Learning (PBL) educational program was designed around classroom projects related to the linear function's unit. These projects enriched the thinking of gifted students, developed their personal skills, and enabled them to solve problems and connect the scientific material to their real lives. These projects progressed through a series of different project-based learning steps, as follows:

- Phase I: Suggestions and ideas were received through brainstorming sessions, selection, questioning, and scientific information about the student's areas of interest and important learning elements. The project was then planned.
- Phase II: Students selected a problem and conducted research on it. They then analyzed and synthesized the information to solve the problem and included it in a research paper to arrive at the project idea.
- Phase III: Implementation of the project. The student selected project colleagues to advance with. They then followed up with the teacher to ensure the project was on track and implemented project criteria.
- Phase IV: Project Presentation: In this phase, each group presented their final product and wrote a report. The projects were judged by their peers, teachers, and supervisors.

- Timeline for implementing the educational program: The program was implemented over a period of three weeks, equivalent to 12 h.

Mathematical Thinking Skills Test

The aim of the test was to measure the mathematical thinking skills (logical reasoning, symbols and semantics, mathematical deduction, and mathematical induction) of gifted second-grade female students in the "Linear Functions" unit of the mathematics textbook prescribed for

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second-grade students, scheduled to be taught in the third semester. The test items were formulated as “multiple choice”, “true or false”, “completion”, and “essay questions” so that talented students could benefit from the advantages of the diversity of objective and essay questions and also to suit the different mathematical thinking skills. Thus, the initial form of the test consisted of (30) paragraphs. The questions were arranged randomly, where the mathematical thinking skills were alternated and varied in the targeted topics of the linear function's unit in the mathematics curriculum. The researcher also relied on the random arrangement of the alternatives for the multiple-choice questions, and determining the test scores by specifying (one score) for each paragraph of the objective test, while (one and a half or two scores) were allocated to the essay test paragraphs, so that the total test scores would be (40) points.

The pilot study was applied on Monday, 10/14/1444 AH, to a randomly selected sample of (10) gifted female students in the second intermediate grade, outside the study sample. This was done to determine the clarity of the test instructions, calculate the test time, verify the test's validity and reliability. The correlation coefficients of test items to calculate content validity which ranged from 0.588 to 0.890, and the overall test reliability coefficient using the split-half method reached (0.798) and using the Cronbach’s alpha equation it reached (0.856), which is a value that indicates that the test has an acceptable and appropriate degree of reliability.

Results:

The first hypothesis was: "There is a statistically significant difference at a significance level of ($\alpha \leq 0.05$) between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the logical thinking skill, in favor of the students in the experimental group."

Wilcoxon Test (Z) was used to investigate the extent of statistically significant differences between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the logical thinking skill, as shown in the following table:

Table (1) Wilcoxon Test (Z) to verify the existence of differences between the performance of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the logical thinking skill.

Group	N	Mean	SD	Mean Rank	Total Rank	Z-value	Sign
Control	12	4.54	2.291	6.64	73	2.670	0.008
Experimental	12	7.17	1.813				

Table 1 indicate that there are statistically significant differences between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the logical thinking skill. The calculated z-test value was (2.670), which is significant at a significance level of less than (0.05). These differences were in favor of the experimental group. Therefore, accept the hypothesis. To verify the effectiveness of using

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project-based learning in developing logical thinking skills, the researcher calculated Black's adjusted gain equation. Table (2) illustrates this:

Table (2) adjusted gain equation to determine the effectiveness of using project-based learning in developing logical thinking skills

Skill	Pre-mean	Post-mean	Final score	Adjusted gain
logical thinking	3.42	7.17	8	1.29

Table (2) illustrate that the use of project-based learning is highly effective in developing logical thinking skills among gifted female students in intermediate school. The adjusted gain ratio between the pre-post-test of mathematical thinking skills (logical thinking) was (1.29), which is higher than the value Black specified for effectiveness, which is (1.2).

The second hypothesis was: "There is a statistically significant difference at a significance level of ($\alpha \leq 0.05$) between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the symbols and semantics skill, in favor of the students in the experimental group."

Wilcoxon Test (Z) was used to investigate the extent of statistically significant differences between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the symbols and semantics skill, as shown in the following table:

Table (3) Wilcoxon Test (Z) to verify the existence of differences between the performance of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the symbols and semantics skill.

Group	N	Mean	SD	Mean Rank	Total Rank	Z-value	Sign
Control	12	4.75	1.323	7.50	60	2.408	0.016
Experimental	12	8.59	0.707				

Table 3 indicate that there are statistically significant differences between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the symbols and semantics skill. The calculated z-test value was (2.408), which is significant at a significance level of less than (0.05). These differences were in favor of the experimental group. Therefore, accept the hypothesis. To verify the effectiveness of using project-based learning in developing symbols and semantics skills, the researcher calculated Black's adjusted gain equation. Table (4) illustrates this:

Table (4) adjusted gain equation to determine the effectiveness of using project-based learning in developing symbols and semantics skills

Skill	Pre-mean	Post-mean	Final score	Adjusted gain

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symbols and semantics	3.90	8.59	10	1.24

Table (4) illustrate that the use of project-based learning is highly effective in developing symbols and semantics skills among gifted female students in intermediate school. The adjusted gain ratio between the pre-post-test of mathematical thinking skills (symbols and semantics skills) was (1.24), which is higher than the value Black specified for effectiveness, which is (1.2).

The third hypothesis was: "There is a statistically significant difference at a significance level of ($\alpha \leq 0.05$) between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the mathematical deduction skill, in favor of the students in the experimental group."

Wilcoxon Test (Z) was used to investigate the extent of statistically significant differences between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the mathematical deduction skill, as shown in the following table:

Table (5) Wilcoxon Test (Z) to verify the existence of differences between the performance of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the mathematical deduction skill.

Group	N	Mean	SD	Mean Rank	Total Rank	Z-value	Sign
Control	12	6.29	2.613	7.00	70	2.432	0.015
Experimental	12	10.58	1.942				

Table 5 indicate that there are statistically significant differences between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the mathematical deduction skill. The calculated z-test value was (2.432), which is significant at a significance level of less than (0.05). These differences were in favor of the experimental group. Therefore, accept the hypothesis. To verify the effectiveness of using project-based learning in developing mathematical deduction skills, the researcher calculated Black's adjusted gain equation. Table (6) illustrates this:

Table (6) adjusted gain equation to determine the effectiveness of using project-based learning in developing mathematical deduction skills

Skill	Pre-mean	Post-mean	Final score	Adjusted gain
mathematical deduction	4.13	10.58	13	1.22

Table (6) illustrate that the use of project-based learning is highly effective in developing mathematical deduction skills among gifted female students in intermediate school. The adjusted gain ratio between the pre-post-test of mathematical thinking skills (mathematical

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deduction skills) was (1.22), which is higher than the value Black specified for effectiveness, which is (1.2).

The fourth hypothesis was: "There is a statistically significant difference at a significance level of ($\alpha \leq 0.05$) between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the mathematical induction skill, in favor of the students in the experimental group."

Wilcoxon Test (Z) was used to investigate the extent of statistically significant differences between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the mathematical induction skill, as shown in the following table:

Table (7) Wilcoxon Test (Z) to verify the existence of differences between the performance of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the mathematical induction skill.

Group	N	Mean	SD	Mean Rank	Total Rank	Z-value	Sign
Control	12	3.77	1.618	7.72	69	2.394	0.017
Experimental	12	7.39	2.453				

Table 7 indicate that there are statistically significant differences between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the mathematical induction skill. The calculated z-test value was (2.394), which is significant at a significance level of less than (0.05). These differences were in favor of the experimental group. Therefore, accept the hypothesis. To verify the effectiveness of using project-based learning in developing mathematical induction skills, the researcher calculated Black's adjusted gain equation. Table (8) illustrates this:

Table (8) adjusted gain equation to determine the effectiveness of using project-based learning in developing mathematical induction skills

Skill	Pre-mean	Post-mean	Final score	Adjusted gain
mathematical induction	2.92	7.39	8	1.23

Table (8) illustrate that the use of project-based learning is highly effective in developing mathematical induction skills among gifted female students in intermediate school. The adjusted gain ratio between the pre-post-test of mathematical thinking skills (mathematical induction skills) was (1.23), which is higher than the value Black specified for effectiveness, which is (1.2).

To answer the main question of the study, which states: What is the effectiveness of project-based learning in developing mathematical thinking skills in mathematics among gifted female students in intermediate school in Al-Ahsa Governorate? To answer this question, the first main hypothesis is verified, which states: “There are statistically significant differences at a

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significance level of ($\alpha \geq 0.05$) between the average scores of the experimental group in the pre-post-teat of the mathematical thinking scale in favor of the post-teat." To verify the hypothesis, the non-parametric Wilcoxon 9+ Test (Z) was used. Table (9) illustrates this:

Table (9): Significance of the differences between the scores of the experimental group members in the pre-post-test of mathematical thinking skills

Skill	Group	N	Mean	SD	Mean Rank	Total Rank	Z-value	Sign
logical thinking	Pre	12	3.42	2.382	6.00	66	2.940	0.003
	Post	12	7.17	2.177				
symbols and semantics	Pre	12	3.90	1.469	6.00	66	2.950	0.003
	Post	12	8.59	0.707				
mathematical deduction	Pre	12	4.13	1.618	6.00	78	3.061	0.002
	Post	12	10.58	2.453				
mathematical induction	Pre	12	2.92	1.618	6.00	66	2.119	0.034
	Post	12	7.39	2.453				
Total	Pre	12	14.37	1.618	6.00	78	3.061	0.002
	Post	12	33.73	2.453				

Table 9 indicate that the mean scores of the experimental group students in the pre-test of mathematical thinking skills (logical thinking, symbols and semantics, mathematical deduction, mathematical induction, and total mathematical thinking) were (3.42, 3.90, 4.13, 2.92, 14.37), respectively. This is lower than the mean scores of the post-test, which were (7.17, 8.59, 10.58, 7.39, 33.73). This indicates a difference between the mean scores of the experimental group students in the pre- and post-tests of mathematical thinking skills.

To verify the significance of these differences, the researcher conducted a non-parametric Wilcoxon test (Z), which result that the Z values for the sub-skills and overall skills were (2.940 - 2.950 - 3.061 - 2.119 - 3.061), respectively. These are all significant values at a significance level less than (0.05). This confirms that these differences are statistically significant. Therefore, the hypothesis that states, "There are statistically significant differences at a significance level of ($\alpha \geq 0.05$) between the mean scores of the experimental group in the pre-post-test of the mathematical thinking scale in favor of the post-test" is accepted.

The following hypothesis was formulated: "There is a statistically significant difference at a significance level of ($\alpha \leq 0.05$) between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking skills test, in favor of the experimental group students."

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To test this hypothesis, the non-parametric Wilcoxon Test (Z) was used to investigate the extent of statistically significant differences between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking skills test.

Table (10) Wilcoxon Test (Z) to verify the existence of differences between the performance of the experimental group and the control group in the post-test of the mathematical thinking skills test.

Group	N	Mean	SD	Mean Rank	Total Rank	Z-value	Sign
Control	12	19.38	3.591	6.50	78	3.061	0.002
Experimental	12	33.73	4.048				

Table 10 indicate that there are statistically significant differences between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test. The calculated z-test value was (3.061), which is significant at a significance level of less than (0.05). These differences were in favor of the experimental group. Therefore, accept the hypothesis. To verify the effectiveness of using project-based learning in developing mathematical thinking skills, the researcher calculated Black's adjusted gain equation. Table (11) illustrates this:

Table (11) adjusted gain equation to determine the effectiveness of using project-based learning in developing mathematical thinking skills

Skill	Pre-mean	Post-mean	Final score	Adjusted gain
Total mathematical thinking	14.37	33.73	40	1.24

Table (11) illustrate that the use of project-based learning is highly effective in developing mathematical thinking skills among gifted female students in intermediate school. The adjusted gain ratio between the pre-post-test of mathematical thinking skills (total skills) was (1.24), which is higher than the value Black specified for effectiveness, which is (1.2).

Discussion:

The current research aimed to develop the mathematical reasoning skills of gifted female students in the second intermediate grade using an educational program based on project-based learning. The study was conducted on a group of gifted female students who had passed the Talent Scale. (24) students were selected, with (12) for the control group and (12) for the experimental group. The students were selected based on gender, age, and passing the Talent Scale, whether they were classified as gifted, promising, or exceptionally gifted. The study reached a set of results that will be discussed as follows:

The results indicated there was statistically significant difference at a significance level of ($\alpha \leq$ 0.05) between the mean scores of the experimental group and the scores of the control group in the post-test of the mathematical thinking test, specifically in the logical thinking skills, in

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favor of the students in the experimental group." The researcher attributes this result to the fact that the project-based educational program aimed to challenge the students' thinking, which increased the students' motivation to learn in order to arrive at correct solutions to problems and build correct conclusions. This requires logical thinking and following objective principles and rules that guide the student from the known to the unknown by utilizing premises, understanding relationships, and using logical linking tools to achieve the desired goal. The project-based learning educational program also contributed to providing students with more learning time, focusing on students' activity and positivity, and collaborating with peers to clarify the ideas and logical relationships that characterize the elements of a mathematical problem. This facilitated students' understanding of the relationships between them and developing solution strategies by following the rules of mathematical logic. Practical projects keep students constantly active, unlocking the horizons of thinking among gifted students. This meets the needs of gifted students. The researcher believes that developing an educational program based on project-based learning may achieve more effective results in developing the mathematical thinking skills of gifted students in intermediate school. The researcher also believes that project-based learning meets the needs of gifted students in the learning process. It is a student-centered teaching method, rather than using rigid and frustrating traditional lesson plans. It enables students to understand the problem and search for a solution, which makes learning meaningful and connects mathematics to reality and life skills. This is especially true since the project-based learning model enables students to confront interesting problems and allows for flexibility in learning and in proposing possible solutions to problems. These results are consistent with the results of Hazhouzi's (2016) study, which demonstrated the positive impact of using project-based learning on mathematical thinking in general and logical thinking skills in particular among seventh-grade female students in Jenin Governorate. This is in addition to many studies that have adopted the constructivist approach, which is the basis of project-based learning, in developing logical thinking and mathematical thinking in general, including the study by Kamarulzaman et al. (2022), which confirmed the impact of differentiated instruction on the mathematical thinking processes of gifted and talented students; the study by Al-Ali et al. (2023), which demonstrated the impact of using the school-wide optimal situation (SWOM) strategy on metacognitive thinking and the development of mathematical thinking skills among gifted tenth-grade students; the study by Al-Amir (2017), which confirmed the effectiveness of using an electronic mathematics lab in developing mathematical thinking skills among gifted female students in the first intermediate grade; the study by Al-Zaabi and Najm (2022), which confirmed the positive impact of using an interactive whiteboard in developing mathematical thinking and mathematics achievement among seventh-grade students; and the study by Qarshm (2012), which confirmed the effectiveness of a constructivism theory-based strategy in developing and maintaining mathematical thinking skills among Intermediate school students, and the study of Al-Sayyad (2020) which confirmed the effectiveness of a training program based on the theory of successful intelligence in developing analytical, creative, practical and mathematical thinking abilities among Intermediate school students, and the study of Basir (2019) which confirmed the effectiveness of enrichment activities based on habits of mind to develop mathematical

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thinking and communication among gifted children in the pre-school stage in Jeddah, all of which aimed to develop logical thinking skills as one of the mathematical thinking skills.

The results indicated there was a statistically significant difference at a significance level of ($\alpha \leq 0.05$) between the mean scores of the experimental group and the control group in the post-test of the mathematical thinking test, specifically in the skill of symbols and semantics, in favor of the students in the experimental group. The researcher attributes this result to the fact that the use of symbols and semantics is one of the most important mathematical thinking skills, as mathematical symbols are primarily used to denote and express verbal data and mathematical ideas, or vice versa. Symbols are one of the most important components of the "linear functions" unit targeted in the current study. Furthermore, translating linear functions and giving them meaningful meanings for students, this is achieved through practical projects provided by the project-based educational program. This provides students with time for all mathematical problems, access to immediate feedback, and the opportunity to ask questions from students in cooperative groups. They also seek assistance from the teacher, who typically serves as an educational facilitator and guide for students to benefit from each other in their cognitive development. They also use symbolic thinking to translate the symbolic formulas of linear functions into understandable verbal forms and recognize their significance. Project-based learning also focuses on enhancing opportunities for gifted students to repeatedly practice solving mathematical problems and express mathematical symbols without following stereotypes that follow a single solution method. The project-based learning program also sought to improve students' ability to use mathematical symbols and tools to analyze different situations by extracting information from the situation and representing it mathematically in the form of words, symbols, drawings, tables, figures, or equations, this then enhances students' ability to think symbolically. These results are consistent with the results of many studies that adopted the constructivist approach, which is the foundation upon which project-based learning was built, and which aimed to develop symbols and meanings as a framework. A mathematical thinking skill, including the study of Al-Amir (2017), which proved the effectiveness of using an electronic mathematics lab in developing mathematical thinking skills among gifted female students in the first intermediate grade, the study of Al-Zaabi and Najm (2022), which proved the effect of using an interactive whiteboard in developing mathematical thinking and achievement in mathematics among seventh-grade students, the study of Khabrani and Al-Ghamdi (2023), which confirmed the effectiveness of using the differentiated education strategy in developing mathematical thinking among fifth-grade primary school students in the Jazan region, the study of Al-Qaraleh (2023), which proved the effect of using the SWOM strategy on developing mathematical concepts and mathematical thinking among tenth-grade primary school students in mathematics, the study of Al-Kafween and Bani Domi (2023), which proved the effect of teaching using mathematical modeling and differentiated education in developing mathematical thinking in mathematics among fourth-grade primary school students in the Southern Mazar District, the study of Qarshm (2012), which confirmed the effectiveness of one of the strategies centered on constructivist theory in developing and retaining mathematical thinking skills among Intermediate school students, and the study of Al-Juma (2019) which revealed the effect of designing an adaptive e-learning environment on

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developing mathematical thinking skills among Intermediate school students, and the study of Al-Sayyad (2020) which confirmed the effectiveness of a training program based on the theory of successful intelligence in developing analytical, creative, practical and mathematical thinking abilities among Intermediate school students, and the study of Al-Shammari and Al-Sarhani (2021) which confirmed the effectiveness of using infographics to teach mathematics in developing mathematical thinking skills among second-year Intermediate school students, and the study of Basir (2019) which demonstrated the effectiveness of enrichment activities based on habits of mind to develop mathematical thinking and communication among gifted children in the pre-school stage in Jeddah, all of which aimed to develop the skill of expressing symbols as one of the mathematical thinking skills.

The results indicated there was a statistically significant difference at a significance level of ($\alpha \leq 0.05$) between the average scores of the experimental group and the scores of the control group in the post-test of the mathematical thinking test, specifically in the mathematical deduction skills, in favor of the students in the experimental group. The researcher attributes this result to the fact that the project-based educational program followed basic principles for developing mathematical thinking skills and developing mathematical deduction skills, starting with identifying the needs of gifted students, then allowing them to participate, present and discuss ideas and suggestions, and then encouraging and motivating gifted students to participate with questions and inquiries. While working in groups, they learned collecting, classifying, and analyzing information, identifying problems, and proposing appropriate solutions. The project-based learning educational program is based on the principles of constructivist theory, which is based on self-construction, positive learning, learner activity, and the linking of previous and current information in knowledge construction. This is consistent with mathematical deduction, which achieve specific conclusions based on sufficient, appropriate facts and evidence. This occurs when the students can link their observations and information about a mathematical problem to their previous knowledge. The process of drawing conclusions from the data and premises in the mathematical problem is carried out using deductive logic and logical arguments. It includes the use of mathematical principles, theories, and models to predict or explain observed phenomena. These results are consistent with the results of Hazhouzi's (2016) study, which demonstrated the positive impact of using project-based learning on mathematical thinking in general and on mathematical deduction skills among seventh-grade female students in the Jenin Governorate. The study by Nawar et al. (2021) confirmed the effectiveness of the project-based learning strategy in developing critical thinking skills, including deduction skills, for learning mathematics among elementary school students. This is in addition to numerous studies that have adopted this approach. The constructivist approach, which is the basis of project-based learning, is used to develop mathematical reasoning skills and mathematical thinking in general. This includes the study by Al-Ali et al. (2023), which demonstrated the effect of using the school-wide optimal situation (SWOM) strategy on developing mathematical thinking skills among gifted tenth-grade students. The study by Al-Amir (2017), which confirmed the effectiveness of using an electronic mathematics lab in developing mathematical thinking skills among gifted female students in the first intermediate grade. The study by Al-Zaabi and Najm (2022), which

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demonstrated the effect of using an interactive whiteboard in developing mathematical thinking and achievement in mathematics among seventh-grade students. The study by Khabrani and Al-Ghamdi (2023), which confirmed the effectiveness of using the differentiated instruction strategy in developing mathematical thinking among fifth-grade primary school students in the Jazan region. The study by Al-Qaraleh (2023), which demonstrated the effect of using the SWOM strategy on developing mathematical concepts and mathematical thinking among tenth-grade female students in mathematics. The study by Al-Kafween and Bani Domi (2023), which demonstrated the effect of teaching using mathematical modeling and differentiated instruction in developing mathematical thinking in the subject of mathematics among fourth-grade students in the Southern Mazar District, and the study of Qarshm (2012), which confirmed the effectiveness of one of the strategies based on constructivist theory in developing and retaining mathematical thinking skills among Intermediate school students, and the study of Al-Juma (2019), which demonstrated the effect of designing an adaptive electronic learning environment in developing mathematical thinking skills among Intermediate school female students, all of which aimed to develop the skill of mathematical inference as one of the mathematical thinking skills.

The results indicated there was a statistically significant difference at a significance level of ($\alpha \leq 0.05$) between the average scores of the experimental group and the scores of the control group in the post-test of the mathematical thinking test, specifically in the mathematical induction skill, in favor of the students in the experimental group. The researcher attributes this result to the fact that the design of the project-based educational program took into account the characteristics of gifted students in constructing individual and group educational activities and projects, which contributed to improving the gifted students' ability to think logically, observe and analyze mathematical relationships, and build connections between mathematical concepts and theories related to linear functions. Thus, the gifted students were able to discover quickly modeling and constructing general rules that apply to specific mathematical situations and formulas. The project-based learning program also enhanced opportunities for students to discuss and exchange questions, demonstrate mutual understanding of the properties of linear functions, their special cases, and the general rules that can apply to these situations. This enabled students to reach solutions to mathematical problems based on relationships established during the analysis of specific cases and examples presented, and in light of the students' previous experiences and knowledge of mathematical principles and theories. Mathematical induction is a skill that builds on other mathematical thinking skills, namely logical reasoning, the use of symbols, and deduction. It enhances students' ability to achieve inductions from the cases and examples presented in individual and group projects. This is further enhanced by immediate feedback from the teacher after students are given the opportunity to express their assumptions, justify their method, and extrapolate the proposed solution. Furthermore, project-based learning allows students sufficient time to practice solution-finding through extended tasks within the project. These results are consistent with the results of a study by Nawar et al. (2021), which confirmed the effectiveness of the project-based learning strategy in developing critical thinking skills for learning mathematics. Among them is the skill of mathematical induction among primary school students, in addition to many

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studies that adopted the constructivist approach, which is the basis of project-based learning, in developing the skill of mathematical inference and mathematical thinking in general, including the study of Al-Ali et al. (2023), which proved the effect of using the strategy of optimal situation at the school level (SWOM) on developing mathematical thinking skills among gifted tenth-grade students, the study of Al-Amir (2017), which confirmed the effectiveness of using an electronic mathematics laboratory in developing mathematical thinking skills among gifted female students in the first intermediate grade, the study of Al-Zaabi and Najm (2022), which proved the effect of using the interactive board in developing mathematical thinking and achievement in mathematics among seventh-grade students, the study of Khabrani and Al-Ghamdi (2023), which confirmed the effectiveness of using the differentiated education strategy in developing mathematical thinking among fifth-grade primary school students in the Jazan region, the study of Al-Qaraleh (2023), which proved the effect of using the "SWOM" strategy on developing mathematical concepts and mathematical thinking among tenth-grade female students in mathematics, and the study of Al-Kafween and Bani Domi (2023) which proved the effect of teaching using mathematical modeling and differentiated instruction in developing mathematical thinking in mathematics among fourth-grade students in the Southern Mazar District, and the study of Qarshm (2012) which confirmed the effectiveness of one of the strategies based on constructivist theory in developing and retaining mathematical thinking skills among Intermediate school students, and the study of Al-Juma (2019) which proved the effect of designing an adaptive electronic learning environment in developing mathematical thinking skills among Intermediate school female students, and the study of Al-Arini (2017) which confirmed the effectiveness of using differentiated instruction in developing some mathematical thinking skills among Intermediate school female students in Riyadh, and the study of Al-Shammari and Al-Sarhani (2021) which confirmed the effectiveness of using infographics to teach mathematics in developing mathematical thinking skills among second-grade Intermediate school female students, all of which aimed to develop the skill of mathematical inference as one of the mathematical thinking skills.

Recommendations:

The researcher proposes a set of recommendations that may benefit the target group, those responsible for caring for gifted students in the Kingdom, and mathematics teachers:

1. The need for teachers to employ a project-based learning strategy in teaching mathematics to gifted students in Intermediate School.
2. Conduct training courses for gifted teachers in Intermediate School on the use of project-based learning and mathematical thinking in teaching mathematics.
3. Direct those responsible for developing mathematics curricula for gifted students to the importance of incorporating mathematical thinking skills into Intermediate School mathematics curricula.
4. Work to design mathematics curricula for gifted students in Intermediate School in accordance with the project-based learning strategy.

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5. The need to provide a supportive environment that challenges the minds of gifted students and meets their needs.

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