MODESTUM EURASIA Journal of Mathematics, Science and Technology Education, 2026, 22(6), em2843
ISSN:1305-8223 (online)
OPEN ACCESS Research Paper https://doi.org/10.29333/ejmste/18637

The effectiveness of developing a proposed educational unit in mathematics on developing creative thinking skills among third-grade primary school students

Shaima A. Aldhafeeri [1], Essa A. Alibraheim [1*]

[1] Department of Curriculum and Instruction, College of Education, Imam Abdulrahman Bin Faisal University, Dammam, SAUDI ARABIA

Received 25 November 2025 ▪ Accepted 19 May 2026

Abstract

This study investigated the effectiveness of a mathematics instructional unit designed to enhance creative thinking skills among elementary students. Adopting a quasi-experimental one-group pre-/post-test design, the research involved 22 third-grade female students in Dammam, Saudi Arabia. Results indicated statistically significant improvements in students' performance on the creative thinking skills in mathematics test across fluency, flexibility, and originality, as well as in overall scores, favoring the post-test. These findings demonstrate the unit's effectiveness in fostering creative thinking. The study recommends revising elementary mathematics curricula to integrate enrichment activities that nurture creativity and emphasizing the teacher's role in creating an engaging classroom environment that encourages idea generation and innovation.

Keywords: instructional unit, creative thinking skills, curriculum development, mathematics, elementary education

INTRODUCTION

Given the rapid advancements in science and technology that characterize the present era, there is a growing need to accelerate development and foster creative, critical thinkers capable of keeping pace with such unprecedented scientific and technological progress. To achieve this, it is essential to improve the processes of teaching and learning, continuously develop textbooks, and employ modern instructional strategies and approaches to enhance learners' skills and competencies necessary for life amid ongoing change.

Saudi Arabia has taken significant strides toward educational development by exerting substantial efforts to improve textbooks in alignment with modern scientific and technological innovations and developments in educational sciences. These reforms aim to fulfill the requirements of Saudi vision 2030, which calls for advanced educational textbooks that focus on essential skills, nurture talent, and foster continuous character development (Vision 2030, n.d.). The Saudi Ministry of Education has prioritized developing mathematics textbooks from the elementary to the secondary levels, aspiring to elevate educational outcomes among students and align them with their peers in developed nations (Alyami, 2018). Mathematics textbooks play a vital role in equipping students with logical and scientific thinking skills that enable them to solve various problems, connect mathematical ideas, and develop fluency in proposing strategic solutions to mathematical challenges (Ismail, 2023). Therefore, textbook development is considered a central goal of modern education, as it enables learners to harmonize the inputs of the educational process with the demands of contemporary life (Al-Hussan, 2015).

At the same time, today's world is witnessing vast changes that require attention to all forms of thinking. Consequently, developing multiple thinking skills among learners—especially elementary students—has become a priority, as this stage represents a fertile foundation for cultivating essential cognitive abilities (Khayaya, 2020). The elementary stage forms the basis for comprehensive learner development—spiritually, socially, cognitively, emotionally, and physically—and

This article was derived from the master's thesis of the first author.

✉ Shayma92shayma@hotmail.com ✉ ealibraheim@iau.edu.sa **(*Correspondence)**

Contribution to the literature

- The study adds evidence that creative thinking can be strengthened through targeted mathematics instruction in the early grades.
- It offers a focused intervention built around a single mathematics unit and shows measurable gains in fluency, flexibility, and originality using a pre-/post-test design.
- The study contributes a clear instructional model that links creative thinking outcomes with specific curriculum design choices. It extends the literature by demonstrating the feasibility of integrating creativity goals into routine elementary mathematics content.

provides the foundation for subsequent educational stages (Al-Oufi, 2021). Mathematics occupies a central position in the curricula of the early grades, as students at this stage acquire essential knowledge and skill in computational operations (addition, subtraction, multiplication, and division). Through these, they learn to solve mathematical problems—whether numerical, symbolic, or verbal—and to propose solutions that develop their thinking skills. Thus, elementary mathematics plays a crucial role in teaching fundamental concepts, skills, and generalizations, which require diverse instructional strategies and specialized skills. Accordingly, many countries have reformed their mathematics curricula to align with 21st century learning by emphasizing the development of students' thinking skills, creativity, mathematical insight, and deep understanding (Al-Zahrani, 2024).

The principles and standards for school mathematics issued by the National Council of Teachers of Mathematics (2000) emphasized that developing creative problem-solving is one of the most important objectives of mathematics instruction across all grade levels. Creativity is a fundamental educational goal that necessitates revising mathematics textbooks to ensure that their content and components foster creative development (Al-Matrafi & Salem, 2023). Thus, the content of mathematics textbooks is a key pillar in nurturing creative thinking skills, as it includes numerous problems and tasks that stimulate students' abilities and provide opportunities to use prior experiences in generating multiple and original solutions. Furthermore, such content encourages students to apply mathematical concepts, skills, generalizations, and principles to real-life situations, fostering innovative ideas and creative solutions (Al-Ruwaili & Juwair, 2024). However, Al-Khrabsheh (2018) noted a marked weakness in students' achievement due to teachers' limited attention to creative thinking skills and their reliance on traditional, memorization-based instruction. Therefore, it has become essential to revise mathematics textbooks to integrate creative thinking skills as core components, enabling students—particularly girls—to engage effectively with the demands of the modern world (Kafafy & Nto, 2021).

Problem of the Study and Research Question

The problem addressed in this study emerged from the researchers' practical experience in education. They observed that creative thinking, despite its importance in developing learners' intellectual capacities and personalities, has not received sufficient attention in mathematics textbooks. This observation motivated the researchers to focus on the early elementary stage, a period marked by high receptivity and readiness for instructional methods that foster creativity. This need underscored the importance of developing a mathematics instructional unit designed to enhance creative thinking skills among lower-grade students.

To substantiate this issue, the researchers conducted interviews with several elementary mathematics teachers to explore the extent to which creative thinking skills are incorporated in the third-grade mathematics textbook and how well these skills are developed among students. The interviews revealed clear shortcomings: higher-order thinking skills were limited to a single question per lesson, and explicit emphasis on creative thinking was largely absent. Such findings highlight the need for systematic curricular intervention through developing enriched instructional units.

Moreover, strengthening creative thinking skills is vital to raising students' academic performance and improving outcomes in national and international assessments such as NAFS—a national benchmark assessing third graders' skills and knowledge—and Kangaroo Mathematics Competition, an international competition that promotes mathematical curiosity and problem-solving from grade three onwards. These initiatives align with the Kingdom's educational vision to provide globally competitive learning experiences. Supporting this direction, Al-Skaafi (2020) recommended designing interactive learning activities that stimulate creative thinking through educational applications. Similarly, Alanzi and Alanazi (2021) recommended developing enrichment programs in science and mathematics emphasizing creativity, while Alrowais (2016) advised integrating creative-thinking development activities across all school subjects.

Accordingly, this study seeks to design and implement a proposed instructional unit for third-grade mathematics (unit 2: addition) to develop creative thinking skills. It also aims to construct a test to measure these skills, contributing to achieving the intended educational objectives.

Main research question: *What is the effectiveness of the proposed mathematics instructional unit in developing creative thinking skills among third-grade primary students?*

Research Hypotheses

The study sought to test the following null hypotheses:

1. There are no statistically significant differences at the 0.05 level between the mean scores of students in the pre- and post- applications of the creative thinking skills test in mathematics for the fluency skill.
2. There are no statistically significant differences at the 0.05 level between the mean scores of students in the pre- and post- applications of the creative thinking skills test in mathematics for the flexibility skill.
3. There are no statistically significant differences at the 0.05 level between the mean scores of students in the pre- and post- applications of the creative thinking skills test in mathematics for the originality skill.
4. There are no statistically significant differences at the 0.05 level between the mean scores of students in the pre- and post- applications of the creative thinking skills test in mathematics.

Research Objectives

The current study aimed to achieve the followings:

1. Identify the creative thinking skills that should be developed among third-grade primary students.
2. Present a proposed design for developing the content of the second mathematics unit (addition) for third-grade students.
3. Examine the effectiveness of the developed mathematics instructional unit in enhancing creative thinking skills among third-grade students.

Research Delimitations

1. **Subject delimitation:** The study focused on evaluating the effectiveness of a proposed instructional unit in mathematics (unit 2: addition) in developing creative thinking skills among third-grade primary students, as addition represents a foundational arithmetic operation at this stage.
2. **Time delimitation:** The study was conducted during the first semester of the academic year 2025.
3. **Place delimitation:** The study was implemented at Riyadh Al-Ihsan Private School for Girls in Dammam, Saudi Arabia.
4. Human delimitation: The sample consisted of third-grade primary students in Dammam. This grade was chosen because it marks the transition from lower to upper elementary levels, forming a foundation for subsequent educational stages.

Definition of Terms

1. **Instructional unit:** Branch (2009) defined it as a specific organization of a subject and its teaching method that places learners in an integrated learning situation, stimulating their interest and requiring active participation to achieve desired educational outcomes. Mahmoud et al. (2022) described it as the systematic planning of content, experiences, and enrichment activities suitable for students' developmental characteristics.

   Operational definition: In this study, the "developed instructional unit" refers to a planned and organized unit on the topic of Addition for third-grade primary students, designed by the researchers, incorporating diverse objectives and activities to foster creative thinking skills.
2. **Creative thinking skills:** Defined by Guilford (1967) as fluency in generating ideas, flexibility in shifting thought processes, originality in producing uncommon responses, and the ability to elaborate and refine ideas. Similarly, Alshammari and Alanazi (2023) described it as an individual's activity characterized by novelty and originality, encompassing fluency, flexibility, originality, and problem sensitivity.

   Operational definition: In the present study, creative thinking skills are defined as mental processes through which a student demonstrates creative performance in various situations, contributing to generating innovative solutions. These skills include three key dimensions: fluency, flexibility, and originality.

   a. **Fluency:** Defined by Wang et al. (2024) as the quantitative aspect of creative thinking, referring to the ability to generate multiple ideas or solutions to an open-ended problem.

   b. **Flexibility:** Defined by Kılıç and Ercoşkun (2024) as a mental state enabling an individual to modify ideas and solutions according to changing contexts and to adapt thought patterns as required.

   c. **Originality:** Defined by Runco et al. (2005) as the ability to produce responses that are rare and unconventional, demonstrating novelty in ideas and solutions.

3. **Creative thinking in mathematics:** Defined as students' ability to solve non-routine mathematical problems in multiple ways, discover and establish diverse mathematical relationships, solve mathematical puzzles, and identify patterns—encompassing fluency, flexibility, originality, and elaboration (Shodiq et al., 2025).

THEORETICAL FRAMEWORK

The study of creativity in psychology began with Guilford (1967). He significantly influenced the field of creative and innovative studies by drawing researchers' attention to intensifying investigations into the nature of innovation and creative abilities, asserting that creative abilities are an integral part of general abilities, and emphasizing that creativity is a fundamental pillar in the individual's cognitive structure and in societal development. Torrance (1974) supports Guilford's (1967) position, Torrance (1974) is considered the pioneer of innovation in the 20th century and the second key figure in the development of creativity research, especially in establishing creativity measures that are still used today across diverse global contexts. In addition, many other authors have highlighted its importance as a necessary mental skill for the present and future of society. Undoubtedly, there are benefits to developing creativity at any age and at any educational stage. Both research studies and educational practice have revealed the importance of developing creative thinking skills, and strong academic performance and higher levels of learning are also associated with creativity.

From another perspective, creative thinking is one of the core learning outcomes targeted by curricula in general and mathematics education in particular. The focus on developing creativity as a mental ability has become an urgent necessity and a responsibility for school curricula. The role of the school is no longer limited to transmitting information and knowledge; rather, it is responsible for habituating students to creative thinking and developing their creative capacities. It is noteworthy that the contemporary role of the school is to prepare students to cope with life developments and to solve the problems they face by developing their creative abilities (Rusmin et al., 2024). As reported in Bron and Prudente (2025), creativity in mathematics does not follow routine procedures in the learner's work; a problem, exercise, or mathematical proof is not solved in a single way. The mathematically creative learner verifies new ideas, perceives what others may not, proposes solutions and ideas, and continually searches for what is new in mathematics.

Yildiz and Yildiz (2021) indicated that creative thinking comprises three fundamental skills: fluency, flexibility, and originality. Likewise, Gunawan et al. (2022) point to the most important creative thinking skills typically measured in creative thinking tests:

1. **Fluency:** Torrance (1974) views fluency as students' production of the largest possible number of ideas, acknowledging that some of these ideas may not be of high quality (Bouthelja & Ben Ziane, 2021). It is measured by counting the number of ideas a student generates within a specified time. Thus, fluency is the number of ideas that a creative learner can produce (Mahmoud et al., 2022). Fluency can be measured by the following tools:
   a. **Speed of thinking:** The student is given a set of words and asked to arrange them in a particular pattern or classify them into specific categories.
   b. **Classifying ideas:** The student recalls as many names or concepts as possible according to given requirements.
   c. **Linking concepts:** The student's ability to connect names, objects, or symbols to their meanings indicates the capacity for creative thinking (Mahmoud et al., 2022).

   In mathematics, fluency is the student's ability to produce the largest possible number of correct ideas when confronted with a particular mathematical problem within a set time frame. It relates to the speed and ease with which a student can propose more than one solution or method for solving a mathematical problem, while also generating additional new mathematical problems based on the given one. Fluency can be fostered by training students to provide multiple, different solutions for a given topic, problem, or issue, so they develop the capacity to retrieve numerous ideas when facing a specific mathematical or geometric problem and then choose the solution or idea they find most convincing.
2. **Flexibility:** Flexibility is the ability to generate ideas and redirect thought processes as the stimulus changes or as the situation demands (Dajani & Uddin, 2015). Accordingly, a creative person is characterized by distinctive mental flexibility that enables them to change their ideas freely and easily, producing ideas that are varied, diverse, and unconventional, and helping them find the best alternatives for each problem (Mahmoud et al., 2022). Dallah (2020) explains that flexibility takes two forms:
   a. **Spontaneous flexibility:** Producing the largest possible number of varied ideas related to a given problem. It is the student's ability to provide as many responses as possible to a particular stimulus in diverse patterns that do not belong to a single category, tending toward

initiative rather than merely automatic response.

b. **Adaptive flexibility:** Reaching a solution in light of feedback. It is the student's ability to change the mental perspective from which a specific problem is viewed and solved. As adaptive creative flexibility develops, the student's capacity to modify responses to fit the situation increases.

In mathematics, flexibility refers to the ability to produce numerous and varied solutions to mathematical problems. Flexibility can be stimulated by placing the student in a learning situation that requires changing mental perspectives, considering multiple diverse solution possibilities, and testing each until arriving at the correct one—provided the situation is intellectually engaging.

3. **Originality:** Originality is the skill most closely associated with creativity and creative thinking. It denotes novelty and uniqueness and is a common factor across most definitions that focus on creative products as the criterion for judging the level of creativity. It is reflected in a student's perception of things in new, unfamiliar forms, or in the production of an idea, relation, or scientific meaning that is unrepeated, unique, and generated within a specified time. The creative student exhibits rarity and uniqueness in behavior—one of the fundamental capacities in creative behavior—and, when paired with renewed imagination and any nontraditional, distinctive approach, it denotes originality. Guilford (1967) views originality as one of the factors most closely related to creative thinking, signifying uniqueness. It indicates an individual's capacity to produce a large number of unusual responses and to generate uncommon ideas rapidly, provided they are goal-related and acceptable (Canel, 2015). Originality manifests as the rarity of responses in a person's ideas and actions and a departure from the common and usual. It points to the quality, novelty, infrequency, and distinctiveness of ideas (Alsulaiman, 2017).

In mathematics, originality is the student's ability to offer new, nontraditional ideas and responses to mathematical problems, with such responses being infrequent within the student's community. When solving mathematical problems and applying rules, a student may initially perceive no alternative solutions. However, with careful effort and deep reflection, the student can generate multiple solution alternatives. This requires mental effort to overcome conventional tendencies in problem-solving and to reach distinct solutions—some of which may be original and unique. Accordingly, the teacher should encourage students to move beyond the first idea and search for other, novel, and different solutions.

LITERATURE REVIEW

Creative thinking is widely viewed as an important higher-order skill that helps learners generate different ideas, look at problems from more than one angle, and suggest solutions that go beyond familiar or routine approaches. In mathematics education, this skill has particular value because learning mathematics is not limited to memorizing rules or applying procedures. It also involves exploring relationships, identifying patterns, planning strategies, and justifying solutions. For this reason, developing creative thinking has become an important goal of mathematics instruction, especially in the elementary stage, when students begin to form their learning habits, attitudes, and basic cognitive skills. This has encouraged many researchers to move beyond traditional teacher-centered instruction and to examine learning environments that give students more opportunities to understand, explore, participate, and solve problems creatively.

A number of studies have examined how instructional programs and teaching strategies can support creative thinking in mathematics. For example, Alshuwaikh (2018) investigated the effectiveness of a program based on self-regulated learning in developing self-regulation skills, achievement motivation, and creative thinking in mathematics among fourth-grade elementary students in Egypt. The study used a quasi-experimental design with 50 students and found statistically significant differences in favor of the experimental group in the post-application of the creative thinking test. This suggests that when students are guided to manage their own learning and become actively involved in mathematical tasks, their creative thinking skills may improve. In a similar direction, Abdelkader and Albaraami (2019) developed a proposed strategy for teaching mathematics to elementary students in Oman. The strategy was based on problem solving, brainstorming, and cooperative learning, which are all closely connected to producing ideas, considering alternatives, and learning through interaction. Using a quasi-experimental design with 57 students, the study reported statistically significant differences in favor of the experimental group, with a high effect size. This finding supports the idea that active learning strategies can help students produce more varied and original mathematical responses.

Technology-supported learning environments have also received attention in the literature. Faraj et al. (2020) designed an instructional strategy that used tablet computers and the interactive whiteboard to develop creative thinking among third-grade elementary students. Their results showed statistically significant differences in favor of the experimental group in the creative thinking test and its dimensions. This indicates that interactive technological tools can make mathematical learning more engaging and can provide students with richer opportunities to represent ideas, explore relationships, and respond creatively. Similarly, Al-Skaafi (2020) examined the effect of using the iPad on developing creative thinking skills in mathematics among fourth-grade students in Jordan. The findings showed statistically significant differences in favor of the group taught using the iPad in fluency, originality, and flexibility. Taken together, these studies suggest that digital tools can support creative mathematical thinking when they are used purposefully and integrated into meaningful learning activities.

Other studies have emphasized concrete and model-based approaches to mathematics instruction. Mustafa (2020) investigated the use of manipulatives to improve mathematics teachers' understanding of mathematical concepts and examined its impact on students' creative thinking and achievement. The study included 180 students and found statistically significant differences in favor of the experimental group on the creative thinking test. This result suggests that manipulatives can help students visualize mathematical concepts, test ideas, and build meaning in ways that support creative thinking. Along similar lines, Elsayed (2022) examined the effect of using the Marzano model in teaching mathematics on developing creative thinking skills and attitudes toward mathematics among fourth-grade students in Oman. The study found statistically significant differences in favor of the experimental group, with a high effect size. This indicates that structured instructional models may contribute to creative thinking when they organize learning around active engagement and meaningful cognitive processing.

The literature also includes studies that explored enrichment and gamification as ways to develop creative thinking in mathematics. Mohammed (2022) examined the effectiveness of an enrichment program based on blended learning in developing creative thinking skills in mathematics among sixth-grade elementary students. The results showed statistically significant differences in favor of the experimental group in the overall creative thinking test and its subskills, as well as improvement between the pre- and post-applications within the experimental group. This suggests that enrichment experiences supported by blended learning can give students wider opportunities to practice creative mathematical thinking. More recently, Al-Ruwaili and Juwair (2024) investigated the effectiveness of a proposed instructional program based on gamification in developing creative thinking skills in mathematics among elementary students in Saudi Arabia. Their findings showed that the experimental group outperformed the control group, which points to the potential of gamification in increasing students' engagement and supporting creative thinking in mathematics learning.

Overall, the reviewed studies show a clear interest in developing creative thinking in mathematics through different instructional approaches. Most of these studies used quasi-experimental designs and focused on elementary or basic-education students, which reflects the importance of nurturing creative thinking during the early years of schooling. They also commonly measured creative thinking through skills such as fluency, flexibility, and originality. Across these studies, the findings consistently suggest that creative thinking in mathematics can be improved when learning experiences are carefully planned and when students are encouraged to participate actively, explore ideas, and produce varied responses. These interventions included self-regulated learning, problem solving, brainstorming, cooperative learning, digital tools, manipulatives, blended learning, and gamification. Despite the value of these studies, the reviewed literature also reveals a gap that the present study seeks to address. Most previous studies focused on testing the effectiveness of particular strategies, programs, or technological tools, while fewer studies have directly addressed the development of a proposed mathematics unit and examined its effectiveness in developing creative thinking skills among third-grade primary students. In addition, the third grade is a foundational stage in students' mathematical and cognitive development, yet it has received less attention than higher elementary grades in the reviewed studies. Therefore, the present study is distinguished by developing a proposed educational unit in mathematics that is suited to the developmental characteristics of third-grade primary students and by examining its effectiveness in developing their creative thinking skills. In this way, the study contributes to the literature by offering a curriculum-based model that links mathematics content development with the intentional cultivation of creative thinking in the early primary stage.

METHODOLOGY

This study measures the impact of an instructional intervention—independent variable (a developed instructional unit)—on a dependent variable (creative thinking skills), in order to determine whether the intervention produces a measurable difference in students' creative thinking. To achieve this aim, the study adopted the experimental approach using a quasi-experimental design to implement the developed unit and assess its effect on enhancing creative thinking skills among third-grade students. Specifically, a one-group pre-/post-test design was employed: students were assessed prior to the intervention (pre-test), then exposed to the independent variable (the instructional unit), and finally reassessed (post-test) to measure changes in creative thinking skills before and after the unit. The one-group pre-/post-test design is one of the quasi-experimental designs, in which a treatment is administered to only one group, and the effect of this treatment is measured by comparing participants' results before and after the treatment, without using a comparison group (Creswell, 2015).

Population

The study population comprised all third-grade primary students in the city of Dammam, Saudi Arabia, during the first semester of the 2025 academic year.

Sample

The study sample consisted of 22 third-grade female students at Riyadh Al-Ihsan Private School for Girls, on whom the developed instructional unit was piloted. The school was purposefully selected because it cooperated with the researchers in implementing the study instruments.

Study Materials

First. The developed instructional unit

The development of the unit proceeded through several stages (**Appendix A**). The Addition unit in the third-grade textbook was reviewed and analyzed to identify embedded learning aspects and to revise them to align with creative thinking. A student booklet was prepared after consulting educational literature, scholarly references, and numerous studies related to the topic. The unit included the lesson idea, lesson objectives, and revised unit lessons containing examples, exercises, and varied problems designed in light of creative thinking skills. The unit was reviewed by experts in mathematics education to elicit their opinions, benefit from their suggestions, and correct linguistic issues, which led to the final form of the instructional unit. **Figure 1** presents selected parts of the final version of the developed unit.

Figure 1. The developed instructional unit in its final form (Source: Authors)

Second. Instrument

A test was constructed to measure the effect of the developed unit on creative thinking skills in mathematics among third-grade students, based on a review of prior research and studies. Test items were then drafted to ensure coverage of the developed unit's content and suitability for students' cognitive levels, and to assess the three targeted skills (fluency, flexibility, and originality). The initial version of the test comprised 48 items: properties of addition (12 items), estimating sums (12 items), adding two-digit numbers (12 items), and adding three-digit numbers (12 items).

The test was then submitted to 11 specialists in mathematics curriculum and instruction to obtain their evaluations regarding item phrasing, alignment with the targeted skill, scientific accuracy, linguistic clarity, and curricular alignment. The reviewers recommended reducing the total number of items and decreasing the proportion of word problems, which might pose difficulty at this grade level; visual shapes and images were added so that items were not presented in a single format. After incorporating all suggested revisions, the final test comprised 24 items: properties of addition (6 items), estimating sums (6 items), adding two-digit numbers (6 items), and adding three-digit numbers (6 items). The total test score was 24 points.

Following finalization, the test was administered to a pilot sample of 20 students (outside the main study sample) to examine validity and reliability, and to compute item difficulty and discrimination indices.

Item difficulty indices: Item difficulty for the creative thinking test was calculated according to the Eq. (1) (Alabadi, 2015):

$$Difficulty\ index = \frac{Number\ of\ correct\ responses}{Number\ of\ students}. \quad (1)$$

Table 1 presents the difficulty indices of the creative thinking test items for third-grade students based on the pilot sample results.

Table 1. Difficulty indices for the test items

Question	Difficulty index	Question	Difficulty index
1	0.55	13	0.55
2	0.60	14	0.60
3	0.60	15	0.50
4	0.45	16	0.60
5	0.65	17	0.40
6	0.45	18	0.30
7	0.45	19	0.35
8	0.55	20	0.30
9	0.50	21	0.40
10	0.60	22	0.55
11	0.50	23	0.45
12	0.50	24	0.35

Table 2. Discrimination indices for the test items

Question	Difficulty index	Question	Difficulty index
1	0.50	13	0.70
2	0.60	14	0.60
3	0.40	15	0.60
4	0.50	16	0.40
5	0.30	17	0.80
6	0.50	18	0.40
7	0.50	19	0.50
8	0.90	20	0.60
9	0.60	21	0.60
10	0.40	22	0.70
11	0.60	23	0.50
12	0.40	24	0.50

Table 1 shows that item difficulty values range from 0.30 to 0.60. According to Alabadi (2015), any item with a difficulty index between 0.20 and 0.80 is acceptable and should be retained in the test. Accordingly, all test items were retained. The mean test difficulty was 0.49.

Item discrimination indices: Discrimination indices were computed by dividing the students into two groups: an upper group comprising 50% of students with the highest test scores, and a lower group comprising 50% of students with the lowest scores (10 students in each group). As noted by Alabadi (2015), measurement specialists provide reference values for judging items as follows:

(1) items with a negative discrimination index are deleted,

(2) items with discrimination below 0.20 are recommended for deletion, and

(3) items with discrimination of 0.20 or higher are acceptable.

The discrimination index was computed using the Eq. (2):

$$Discrimination\ index = \frac{T_u - T_l}{N}, \quad (2)$$

where, T_u is the sum of upper-group scores on the item, T_l is the sum of lower-group scores on the item, and N is the number of students in either the upper or lower group.

Table 3. Pearson correlation coefficients for the test

Question	Item-skill	Item-total
1	.666**	.612**
2	.628**	.664**
3	.666**	.546*
4	.457*	.544*
5	.589**	.552*
6	.759**	.630**
7	.759**	.630**
8	.824**	.793**
9	.682**	.694**
10	.627**	.552*
11	.628**	.656**
12	.588**	.630**
13	.743**	.754**
14	.579**	.520*
15	.682**	.694**
16	.620**	.520*
17	.914**	.945**
18	.850**	.713**
19	.815**	.689**
20	.919**	.882**
21	.856**	.819**
22	.680**	.741**
23	.778**	.694**
24	.815**	.689**

* $p < 0.05$
** $p < 0.01$

Table 4. Pearson correlations between skill scores and the total score

Skill	Correlation coefficients
Fluency	.929**
Flexibility	.961**
Originality	.932**

** $p < 0.01$

Table 2 reports the discrimination index for each item on the creative thinking test. **Table 2** indicates that item discrimination values ranged from 0.30 to 0.90. In line with Alabadi (2015), any item with discrimination 0.20 or higher is acceptable and should be retained.

Item-skill and item-total relationships (discriminative power): Pearson's product-moment correlation coefficient was used to examine:

(1) the relationship between each item score and the score on its corresponding skill (fluency, flexibility, originality) and

(2) the relationship between each item and the total test score.

This analysis was conducted using the pilot sample of 20 students (see **Table 3**). As shown in **Table 3**, item-skill correlations were statistically significant, ranging from 0.457 to 0.919. Item-total correlations ranged from 0.544 to 0.945, all statistically significant.

Pearson correlations were also calculated between each skill score on the creative thinking test and the total score (see **Table 4**).

Table 5. Expert agreement ratios on the suitability of test items

Question	Clarity of wording		Percentage of agreement
	Number of agreements	Number of disagreements	
1	11	0	100
2	11	0	100
3	10	1	91
4	11	0	100
5	11	0	100
6	11	0	100
7	10	1	91
8	11	0	100
9	11	0	100
10	10	1	91
11	11	0	100
12	11	0	100
13	11	0	100
14	10	1	91
15	11	0	100
16	11	0	100
17	11	0	100
18	11	0	100
19	10	1	91
20	11	0	100
21	11	0	100
22	11	0	100
23	10	1	91
24	11	0	100

Table 4 shows statistically significant correlations at the 0.01 level, ranging from 0.929 to 0.961, indicating that the test items possess high discriminative power.

Face validity: The test was reviewed by 11 experts to judge its suitability for measuring the intended construct in terms of item clarity and appropriateness, and the alignment of items with their respective primary skills.

Table 5 presents the agreement and disagreement ratios among the expert judges calculated using Cooper's formula (Eq. [3]):

$$Agreement\ ratios = \frac{Number\ of\ agreements}{Number\ of\ agreements + number\ of\ disagreements} \times 100. \quad (3)$$

Table 5 indicates that expert agreement ranged from 91% to 100%, reflecting a high level of consensus sufficient to adopt the test in its final form of 24 items, after making minor linguistic edits suggested by the reviewers.

Reliability:

Internal consistency (Cronbach's alpha): Cronbach's alpha was computed for the creative thinking test (see **Table 6**).

Table 6 shows an overall Cronbach's alpha of 0.94 for the test, with subscale alphas ranging from 0.81 to 0.93. These high coefficients indicate satisfactory reliability for the purposes of the study.

Table 6. Cronbach's alpha reliability coefficients for the creative thinking test

Skill	Item	Cronbach's alpha
Fluency	8	0.82
Flexibility	8	0.81
Originality	8	0.93
Total	24	0.94

Table 7. Guttman split-half reliability coefficients for the creative thinking test

Skill	Item	Guttman coefficients
Fluency	8	0.78
Flexibility	8	0.88
Originality	8	0.94
Total	24	0.95

Split-half reliability (Guttman): Split-half (Guttman) reliability coefficients were also calculated (see **Table 7**).

Table 7 shows an overall split-half (Guttman) coefficient of 0.95, with subscale coefficients ranging from 0.78 to 0.94. These high values indicate that the test exhibits strong and acceptable reliability for the study.

After verifying the validity and reliability of the instrument, the proposed instructional unit was implemented with the study sample, and the results were subsequently obtained. **Figure 2** presents a scene from the implementation of the unit with third-grade female students.

RESULTS AND DISCUSSION

To verify the effectiveness of the proposed instructional unit in mathematics in developing creative thinking skills among third-grade primary students, the study began by identifying creative thinking skills through reviewing literature and previous research related to the development of creative thinking, in addition to analyzing the content of the Addition unit in the grade 3 mathematics textbook (2024 edition). A specialized questionnaire was then constructed to assess creative thinking skills (fluency, flexibility, originality, elaboration, elaborative thinking, and problem sensitivity). This questionnaire was distributed to 197 mathematics teachers in the Eastern Province to determine which skills were most essential for third graders and to assess their relative importance. Based on frequency analysis, the majority of respondents agreed that the most essential skills for third-grade students were fluency, flexibility, and originality.

Accordingly, the final list of target skills—fluency, flexibility, and originality—was adopted as the basis for developing the instructional unit and constructing the accompanying assessment tool. The proposed unit was then designed, refined for scientific soundness, and presented in an engaging and age-appropriate format (see **Figure 1**).

Figure 2. Scenes from the implementation of the proposed instructional unit (Source: Authors)

Table 8. Paired-samples t-test results for differences between pre- and post-test scores in fluency

Skill	Application	Mean	SD	t	df	p	Effect size	Level
Fluency	Pre-	2.27	.631	13.239	21	.000**	2.81	Large
	Post-	5.73	1.162					

** $p < 0.01$

Table 9. Black's modified gain ratio for fluency

Skill	Pre-application mean	Post-application mean	Maximum score	Black's modified gain ratio
Fluency	2.27	5.73	8	1.30

To address the main research question—"*What is the effectiveness of the proposed mathematics instructional unit in developing creative thinking skills among third-grade primary students*?"—the study tested the research hypotheses sequentially, as follows.

First Hypothesis: Fluency Skill

The first hypothesis stated that "*there are no statistically significant differences at the 0.05 level between the mean scores of students in the pre- and post- applications of the creative thinking skills test in mathematics for the fluency skill.*" To test this hypothesis, a paired-samples t-test was used to determine the significance of the differences between the pre- and post-test means on the fluency subscale (see **Table 8**).

The results in **Table 8** show statistically significant differences at the 0.05 level between the pre- and post-test means in favor of the post-test. The pre-test mean was 2.27 with a standard deviation (SD) of 0.631, while the post-test mean was 5.73 with an SD of 1.162. The calculated t-value was 13.239 at a significance level of 0.00, which is below 0.05. The effect size was 2.81, indicating a large effect.

To further evaluate the instructional unit's effectiveness in improving fluency, Black's modified gain ratio was calculated (see **Table 9**).

As shown in **Table 9**, the gain ratio for fluency was 1.30, which falls within the standard value 1.2, confirming the unit's effectiveness in developing fluency among third-grade students. Therefore, the null hypothesis was rejected and the alternative hypothesis accepted: *There are statistically significant differences at the 0.05 level between the mean scores of students in the pre- and post-applications of the creative thinking skills test in mathematics for the fluency skill in favor of the post-application.*

This improvement can be attributed to the developed unit's activities, which enabled students to generate a large number of ideas within a limited time and solve problems quickly and confidently. The findings also indicate that the increase in fluency after the intervention was not merely quantitative (i.e., more answers) but reflected deeper, more active engagement with learning activities. For example, during the Properties of Addition lesson, students enthusiastically explored number relationships, which was evident in their multiple verbal responses and willingness to suggest more than one solution. This classroom environment encouraged freedom of thought and reduced fear of error, turning the classroom into a lively space for idea generation. Likewise, lessons on Estimating Sums offered opportunities for students to produce multiple reasonable approximations for the same problem, thus enhancing the volume of possible solutions and increasing fluency. As lessons progressed—from adding two-digit numbers to three-digit numbers—students demonstrated increasing ability to extend their thinking and generate successive solution chains, leading to notable fluency gains in the post-test.

Table 10. Paired-samples t-test results for flexibility

Skill	Application	Mean	SD	t	df	p	Effect size	Level
Flexibility	Pre-	2.32	.894	11.106	21	.000**	2.36	Large
	Post-	6.00	1.133					

** p < 0.01

Table 11. Black's modified gain ratio for flexibility

Skill	Pre-application mean	Post-application mean	Maximum score	Black's modified gain ratio
Flexibility	2.32	6.00	8	1.11

Table 12. Paired-samples t-test results for originality

Skill	Application	Mean	SD	t	df	p	Effect size	Level
Originality	Pre-	2.91	.868	13.035	21	.000**	2.77	Large
	Post-	6.77	.973					

** p < 0.01

Table 13. Black's modified gain ratio for originality

Skill	Pre-application mean	Post-application mean	Maximum score	Black's modified gain ratio
Originality	2.91	6.77	8	1.24

These findings align with prior research such as Elsayed (2022) and Al-Ruwaili and Juwair, 2024 (2024), which reported significant improvement in fluency through instructional strategies that allowed students to produce multiple ideas or solutions. They also concur with Faraj et al. (2020) and Al-Skaafi (2020), whose results showed marked increases in fluency due to active engagement with learning activities.

Second Hypothesis: Flexibility Skill

The second hypothesis stated that *"there are no statistically significant differences at the 0.05 level between the mean scores of students in the pre- and post-applications of the creative thinking skills test in mathematics for the flexibility skill."* A paired-samples t-test was applied to determine significance (see **Table 10**).

Table 10 shows statistically significant differences at the 0.05 level between pre- and post-test means in favor of the post-test. The pre-test mean was 2.32 (*SD* = 0.894), and the post-test mean was 6.00 (*SD* = 1.633). The calculated t-value was 11.106 with a significance level of 0.00 < 0.05. The effect size was 2.36, indicating a large effect.

To further evaluate the instructional unit's effectiveness in improving flexibility, Black's modified gain ratio was calculated (see **Table 11**).

The Black's gain ratio for flexibility was 1.11 as shown in **Table 11**, which falls within the standard range 1.2, confirming the unit's effectiveness. Thus, the null hypothesis was rejected, and the alternative hypothesis accepted: *There are statistically significant differences at the 0.05 level between the mean scores of students in the pre- and post-applications of the creative thinking skills test in mathematics for the flexibility skill in favor of the post-application*.

Students' progress in flexibility can be attributed to the unit's emphasis on encouraging multiple perspectives and adaptive reasoning. Observations during instruction showed that students displayed distinct mental flexibility, freely shifting between ideas and generating diverse and unconventional responses—a hallmark of creative individuals. During the estimating sums lesson, for instance, students accepted multiple possible solutions rather than seeking a single "correct" one. This capacity to entertain varied solution paths was reflected in their post-test performance, indicating improved cognitive flexibility.

These findings agree with the conclusions of Abdelkader and Albaraami (2019) and Al-Ruwaili and Juwair (2024), both of which reported enhanced flexibility through instructional strategies that encouraged varied thinking approaches and shifts between problem-solving strategies.

Third Hypothesis: Originality Skill

The third hypothesis stated that *"there are no statistically significant differences at the 0.05 level between the mean scores of students in the pre- and post-applications of the creative thinking skills test in mathematics for the originality skill."* A paired-samples t-test was used (see **Table 12**).

Results of **Table 12** revealed statistically significant differences in favor of the post-test. The pre-test mean was 2.91 (*SD* = 0.868), and the post-test mean was 6.77 (*SD* = 0.973). The t-value was 13.035 with a significance level of 0.00 < 0.05. The effect size was 0.88, indicating a large effect.

To further evaluate the instructional unit's effectiveness in improving originality, Black's modified gain ratio was calculated (see **Table 13**).

Table 14. Paired-samples t-test results for overall creative thinking skills

Skill	Application	Mean	SD	t	df	p	Effect size	Level
Overall	Pre-	7.50	1.535	16.316	21	.000**	3.47	Large
	Post-	18.50	2.956					

** $p < 0.01$

Table 15. Black's modified gain ratio for overall creative thinking

Skill	Pre-application mean	Post-application mean	Maximum score	Black's modified gain ratio
Overall	7.50	18.50	8	1.31

As shown in **Table 13**, the gain ratio for fluency was 1.24, which falls to the standard value 1.2, confirming the unit's effectiveness in developing originality among third-grade students. Therefore, the null hypothesis was rejected and the alternative hypothesis accepted: *There are statistically significant differences at the 0.05 level between the mean scores of students in the pre- and post-applications of the creative thinking skills test in mathematics for the originality skill in favor of the post-application.*

The significant improvement in originality can be attributed to the unit's design, which encouraged students to perceive mathematical problems in new ways, generate novel ideas, and propose unique, non-repetitive solutions. Originality—being the most closely linked skill to creative thinking—was notably enhanced. The unit provided ample opportunities for students to express personal ideas and generate unconventional solutions. Classroom discussions frequently involve students reformulating problems or presenting alternative interpretations, such as relating the problem to real-life contexts or inventing new solution representations. This dynamic learning environment fostered both intellectual courage—to think beyond norms—and value recognition—those unconventional ideas hold worth when they offer new insight. Consequently, students' elevated originality scores reflected not merely quantitative improvement but also a deeper creative mindset built on initiative and innovation.

These findings are consistent with Alshuwaikh (2018) and Elsayed (2022), both showing enhanced originality after training students to produce novel, nontraditional ideas, and with Al-Ruwaili and Juwair (2024), who found that stimulating out-of-the-box thinking significantly improved originality. Moreover, Mustafa (2020) demonstrated that originality can be cultivated even in early grades when open-ended activities are provided.

Fourth Hypothesis: Overall Creative Thinking Skills

The fourth hypothesis stated that *"there are no statistically significant differences at the (0.05) level between the mean scores of students in the pre- and post-applications of creative thinking skills in mathematics."* A paired-samples t-test was conducted (see **Table 14**).

Table 14 shows statistically significant differences at the 0.05 level in favor of the post-test. The pre-test mean was 7.50 (SD = 1.535), and the post-test mean was 18.50 (SD = 2.956). The t-value was 16.316 with $p = 0.00 < 0.05$. The effect size was 3.47, reflecting a very large effect.

To further evaluate the instructional unit's effectiveness in improving overall creative thinking, Black's modified gain ratio was calculated (see **Table 15**).

The Black's gain ratio for overall creative thinking was 1.31 as shown in **Table 15**, which falls within the standard range 1.2, confirming the instructional unit's overall effectiveness. Thus, the null hypothesis was rejected in favor of the alternative: *There are statistically significant differences at the 0.05 level between the mean scores of students in the pre- and post-applications of creative thinking skills in mathematics in favor of the post-application.*

This improvement can be attributed to the unit's holistic structure, which fostered the integration of fluency, flexibility, and originality rather than isolating each skill. The dynamic interaction between generating many ideas (fluency), shifting approaches (flexibility), and creating novel solutions (originality) made learning more engaging and cohesive, fostering both enjoyment and achievement in mathematics. The results thus confirm the unit's effectiveness in developing creative thinking skills overall and in each individual dimension. These findings align with Mustafa (2020), Mohammed (2022), Elsayed (2022), and Al-Ruwaili and Juwair (2024), all of which demonstrated that educational interventions can significantly enhance creative thinking as a comprehensive construct, though effect sizes varied by instructional strategy or technology used.

Moreover, several interrelated factors may explain the overall improvement observed among students across all creative thinking skills. First, the instructional unit was designed around authentic, real-life activities and problems that captured students' attention and heightened their motivation to learn. This approach not only made the mathematical content more meaningful but also encouraged the use of diverse cognitive processes. Moreover, the inclusion of varied examples and exploratory exercises enriched students' experiences and provided space for creative exploration and independent discovery. Active participation and collaborative learning further contributed to their progress, as students engaged in discussion, analysis, and problem-solving, developing perseverance and respect for multiple viewpoints. The teaching methods emphasized practice and application rather than rote memorization, linking mathematical problems to students' real-world experiences and prior knowledge—an approach that enhanced both general and creative thinking. The unit also employed diverse instructional strategies, including cooperative learning, open discussion, and a balance between individual and group activities, which cultivated an interactive and supportive classroom atmosphere. Integrating mathematics with other disciplines and life contexts helped students perceive its relevance and usefulness, fostering positive attitudes toward the subject. Additionally, the comprehensiveness of the unit's content—grounded in modern educational sources, expert feedback, and practical examples—ensured alignment with creative thinking objectives. Finally, the consistent use of constructive feedback and the creation of an interactive classroom climate encouraged freedom of expression, idea sharing, and mutual learning, leading to a positive, self-reinforcing cycle that enhanced creative thinking among all students.

CONCLUSION

The findings of this study demonstrate that the developed instructional unit in mathematics (addition unit) was highly effective in enhancing creative thinking skills—specifically fluency, flexibility, and originality—among third-grade primary students. The statistically significant differences between the pre- and post-test mean scores across all dimensions of creative thinking and the overall composite score provide strong empirical evidence of the unit's positive impact. These results confirm that when mathematical content is intentionally designed to foster divergent thinking, students are better able to generate multiple ideas, shift flexibly between strategies, and propose original solutions to mathematical problems. Theoretically, this study contributes to the growing body of literature emphasizing the role of mathematics instruction as a vehicle for cultivating creativity at the elementary level. By integrating creative thinking into the structure of a foundational mathematics unit, the research highlights that creativity is not an isolated talent but a skill that can be systematically developed through purposeful instructional design. Practically, the results underscore the importance of aligning elementary mathematics curricula with creative thinking objectives through enriching tasks, problem-based learning, and exploratory activities that engage students' curiosity and imagination. Moreover, the study reinforces the teacher's role as a facilitator of creative inquiry who encourages students to take intellectual risks and view mistakes as opportunities for learning. Despite its promising outcomes, the study's limitations include the relatively small, gender-specific sample and the use of a one-group pre-/post-test design, which may constrain generalizability. Future research should extend the implementation of similar instructional units to larger and more diverse populations, employ experimental designs with control groups, and explore longitudinal effects on students' creative growth.

Author contributions: Both authors sufficiently contributed to this study and agreed with the results and conclusions.

Funding: No funding source is reported for this study.

Acknowledgments: The authors would like to thank all participants in this study.

Ethical statement: This study was approved by the Ethics Committee at Imam Abdulrahman Bin Faisal University on 25 June 2024 with approval number IRB-PGS-2024-15-491. As the participants included children/minors, written informed consent was obtained from their parents or legal guardians prior to participation. Participants and their guardians were provided with clear information regarding the study's objectives, procedures, expected benefits, voluntary nature of participation, and the right to withdraw from the study at any time without any negative consequences. All personal and sensitive data collected during the study were treated as strictly confidential. The data were used solely for scientific research purposes and were accessible only to the research team. To protect participants' privacy, all data were anonymized or coded, and no identifying information was disclosed in the manuscript or any related publication. The study was conducted in accordance with the relevant ethical standards for research involving human participants.

AI statement: The authors stated that AI tools (ChatGPT) were used solely for proofreading the paper and not for any other purpose.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

Abdelkader, A., & Albaraami, Y. (2019). A proposed teaching strategy for developing creative thinking skills and attitudes towards mathematics among basic education students in the Sultanate of Oman. *Journal of Mathematics Education, 22*(8), 99-147. https://doi.org/10.21608/armin.2019.81253

Alabadi, R. (2015). *School tests*. Arab Complex Library for Publishing and Distribution.

Alanzi, S., & Alanazi, F. (2021). The effect of an instructional unit developed in light of STEAM (science, technology, engineering, arts and mathematics) on improving creative thinking skills in first grade middle school female students. *Journal of Educational Sciences, 33*(4), 677-698.

Al-Hussan, A. (2015). An analytic study of the inclusion of the trends in international mathematics and science study (TIMSS-2015) requirements 1st-4th grades science textbook in Saudi Arabia. *Zarqa Journal for Research and Studies in Humanities, 15*(1), 111-132.

Al-Khrabsheh, N. (2018). *The effect of using some creative thinking skills on the achievement of basic third grade pupils and information retention in teaching science in private schools in the Capital of Amman* [Master's thesis, Middle East University].

Al-Matrafi, S., & Salem, O. (2023). The effectiveness of a virtual training program in developing creative thinking skills in virtual learning environments for intermediate stage mathematics female teachers. *Journal Educational Sciences, 31*(1), 529-604. https://doi.org/10.21608/ssj.2023.292580

Al-Oufi, H. (2021). The external efficiency of primary education in schools affiliated to the North Madinah Education Office from the point of view of middle school teachers. *International Journal of Educational & Psychological Studies, 10*(3), 614-634. https://doi.org/10.31559/EPS2021.10.3.6

Alrowais, A. (2016). The development of an educational unit in light of Marzano's model for dimensions of learning and its influence on the creative thinking skills of the preparatory year program students. *The International Interdisciplinary Journal of Education, 5*(12), 101-116. https://doi.org/10.12816/0035739

Al-Ruwaili, A., & Juwair, A. (2024). The effectiveness of a proposed teaching program based on the gamification strategy in developing creative thinking skills in the mathematics curriculum for male and female primary school students in Al-Kharj Governorate. *Journal of the Faculty of Education, Al-Azhar University, 43*(203), 1-41.

Alshammari, M., & Alanazi, M. (2023). The practicing degree of early elementary grades' teachers for creative thinking skills from their point of view. *Journal of Educational and Psychological Sciences, 7*(11), 22-41. https://doi.org/10.26389/AJSRP.E291222

Alshuwaikh, S. (2018). A program based on self-regulated learning in developing self-regulation skills, achievement motivation and creative thinking in mathematics for primary stage students. *Journal of Scientific Research in Education, 9*(19), 79-122. https://doi.org/10.21608/jsre.2018.19766

Al-Skaafi, S. (2020). *The effect of using iPad on creative thinking skills in mathematics for fourth grades in private schools in the governorate Capital Amman* [Master's thesis, Middle East University].

Alsulaiman, N. (2017). *Mental excellence, talent and creativity*. Al-Faleheen Printing and Publishing.

Alyami, H. (2018). Future vision for the development of education in the Kingdom of Saudi Arabia in light of Kingdom's vision 2030. *Journal of Educational and Psychological Sciences, 2*(26), 32-49. https://doi.org/10.26389/AJSRP.E220718

Al-Zahrani, B. (2024). A proposed vision for developing mathematics curriculum of intermediate stage in the light of dimensions of sustainable development in KSA. *Journal of Umm Al-Qura University for Educational and Psychological Sciences, 16*(3), 52-73. https://doi.org/10.54940/ep59625206

Bouthelja, A., & Ben Ziane, M. (2021). Theoretical methods for teaching creative thinking in mathematics within the competency-based approach: Cooperative learning and problem-solving as a model. *Journal of Human Sciences, 32*(4), 359-373.

Branch, R. (2009). *Instructional design: The ADDIE approach*. Springer. https://doi.org/10.1007/978-0-387-09506-6

Bron, J., & Prudente, M. (2025). Enhancing mathematical creativity, self-efficacy, and problem-solving beliefs through heuristic instruction in preservice teachers. *Anatolian Journal of Education, 10*(2), 51-70. https://doi.org/10.29333/aje.2025.1025a

Canel, A. (2015). A program based on the Guilford model that enhances creativity and creative psychological counseling. *Sanitas Magisterium, 1*(2), 5-29. https://doi.org/10.12738/sm/2015.2.007

Creswell, J. (2015). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Pearson.

Dajani, D., & Uddin, L. (2015). Demystifying cognitive flexibility: Implications for clinical and developmental neuroscience. *Trends in Neurosciences, 38*(9), 571-578. https://doi.org/10.1016/j.tins.2015.07.003

Dallah, K. (2020). *Creative thinking and psychological adjustment*. Academic Book Center.

Elsayed, A. (2022). The effect of using Marzano's model in teaching mathematics on developing creative thinking skills and the attitude towards the subject among fourth grade students in Oman. *Journal of Studies in Curricula and Teaching Methods*, (255), 91-149. https://doi.org/10.21608/MJAT.2022.260362

Faraj, T., Mohamed, W., & Mahmoud, G. (2020). Developing an educational strategy based on the use of tablets and interactive whiteboards and measuring its effectiveness in developing creative thinking in mathematics among primary school students. *Studies in Higher Education*, (48), 77-161.

Guilford, J. (1967). *The nature of human intelligence*. McGraw-Hill.

Gunawan., Kartono., Wardono., & Kharisudin, I. (2022). Analysis of mathematical creative thinking skill: In terms of self confidence. *International Journal of Instruction, 15*(4), 1011-1034. https://doi.org/10.29333/iji.2022.15454a

Ismail, H. (2023). Employing artificial intelligence applications in the Egyptian educational system with reference to the experiences of the United Arab Emirates and Hong Kong: An analytical study. *Matrouh University Journal of Educational and Psychological Sciences, 4*(6), 1-90.

Kafafy, W., & Nto, R. (2021). Developing a mathematics curriculum for middle school students in Saudi Arabia in light of the twenty-first-century skills and its effectiveness in developing some skills. *International Journal of Curricula and Technological Education*, (2), 108-154. https://doi.org/10.21608/ijcte.2021.70553.1010

Khayaya, Y. (2020). Creative thinking skills for science teachers in the primary stage from the viewpoint of educational supervisors. *The Arab Journal of Educational and Psychological Sciences*, (12), 159-206. https://doi.org/10.21608/jasep.2020.117909

Kılıç, Z., & Ercoşkun, N. (2024). The mediating role of cognitive flexibility in the relationship between creative thinking tendencies and problem-solving skills. *South African Journal of Education, 44*(4), 1-16. https://doi.org/10.15700/saje.v44n4a2538

Mahmoud, A., Ali, M., & Hassan, F. (2022). A proposed unit based on integrated (STEAM) activities for developing creative thinking skills in mathematics for preparatory school pupils. *Journal of Educational and Social Studies, 28*(5), 83-128. https://doi.org/10.21608/jsu.2022.293201

Mohammed, D. (2022). An enrichment program based on blended learning to develop creative thinking skills in mathematics among primary school students. *Journal of Faculty of Education, 33*(132), 1-226. https://doi.org/10.21608/JFEB.2022.300246

Mustafa, A. (2020). The effectiveness of using the sensors in understanding mathematics teachers of mathematical concepts and its impact on the development of creative thinking and achievement among elementary school students. *Journal of Mathematics Education, 23*(8), 32-66. https://doi.org/10.21608/armin.2020.121924

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. NCTM.

Runco, M., Illies, J., & Eisenman, R. (2005). Creativity, originality, and appropriateness: What do explicit instructions tell us about their relationships? *The Journal of Creative Behavior, 39*(2), 137-148. https://doi.org/10.1002/j.2162-6057.2005.tb01255.x

Rusmin, L., Misrahayu, Y., Pongpalilu, F., Radiansyah, R., & Dwiyanto, D. (2024). Critical thinking and problem-solving skills in the 21st century. *Join Journal of Social Science, 1*(5), 144-162. https://doi.org/10.59613/svhy3576

Shodiq, L., Juniati, D., & Susanah, S. (2025). Teaching creativity through mathematical lateral thinking problems: A pilot study. *Eurasia Journal of Mathematics Science and Technology Education, 21*(2), Article em2574. https://doi.org/10.29333/ejmste/15913

Torrance, E. (1974). *Torrance tests of creative thinking*. Scholastic Testing Service.

Vision 2030. (n.d.). Human capability development program. *Vision 2030*. https://www.vision2030.gov.sa/media/pgid4z3t/2021-2025-human-capability-development-program-delivery-plan-en.pdf

Wang, W., Rezaei, Y., & Izadpanah, S. (2024). Speaking accuracy and fluency among EFL learners: The role of creative thinking, emotional intelligence, and academic enthusiasm. *Heliyon, 10*(18), Article e37620. https://doi.org/10.1016/j.heliyon.2024.e37620

Yildiz, C., & Yildiz, T. (2021). Exploring the relationship between creative thinking and scientific process skills of preschool children. *Thinking Skills and Creativity, 39*, 100795. https://doi.org/10.1016/j.tsc.2021.100795

APPENDIX A

The development of the educational unit went through several stages. First, the addition unit in the third-grade primary mathematics textbook was reviewed and analyzed to identify the learning aspects included in it and to determine how they could be developed in a way that supports creative thinking. After reviewing the relevant educational literature, scientific references, and a range of studies and research related to the topic of the present study, a student booklet was prepared. The unit included the lesson idea, lesson objectives, and the lessons of the developed unit, which contained examples, exercises, and varied problems designed in light of creative thinking skills. The unit was then presented to a group of experts in mathematics education, as well as mathematics supervisors and teachers, to obtain their opinions, benefit from their suggestions, and correct some linguistic errors. These procedures contributed to producing the educational unit in its final form.

Accordingly, and based on the above, the following procedures were adopted. The title of the unit was first determined as "the addition unit," after which the unit was developed according to the following steps:

1. Foundations and rationales for developing the educational unit.
2. Objectives of the developed educational unit.
3. Content of the developed educational unit and its organization.
4. Teaching strategies for the developed educational unit.
5. Tools and instructional materials used.
6. Assessment methods in the developed educational unit.
7. Validation of the developed educational unit.

A detailed description of these procedures is presented below.

1. *Foundations and rationales for developing the educational unit:* The development of the educational unit was based on the following foundations and rationales:
   - The educational philosophy of the Ministry of Education in Saudi Arabia, which gives considerable attention to mathematics curricula and emphasizes linking mathematics to other subjects and to students' practical lives.
   - The general objectives of teaching mathematics, which stress the importance of enabling students to acquire the mathematical knowledge necessary for understanding quantitative aspects of their environment and interacting effectively with society.
   - The extensive scientific and technological revolution, which calls for highlighting the role of mathematics in this development by connecting it to practical situations from students' lives and demonstrating its contribution to the advancement of other sciences.
   - The scarcity of studies and research concerned with developing creative thinking skills in mathematics among third-grade students by linking mathematics and integrating it with other school subjects and students' lives, in alignment with the requirements of teaching the new mathematics curriculum.
2. *Objectives of the developed educational unit:* The specific objectives of the addition unit for third-grade primary students were formulated in light of creative thinking skills as follows:
   - To perform addition operations accurately and quickly with two- and three-digit numbers, applying regrouping when necessary.
   - To understand the properties of addition, including the commutative property, identity element, and associative property, and to use them to solve mathematical problems in innovative ways.
   - To generate new methods for solving addition problems, such as using stories or representing numbers through visual aids, thereby developing originality.
   - To experiment with multiple addition strategies, such as rounding, decomposing numbers, or using compatible numbers, thereby developing flexibility.
   - To produce numerous ideas and solutions for a single addition problem using different methods, such as vertical addition or estimation, thereby developing fluency.
   - To apply addition skills in real-life situations, such as estimating costs, calculating distances, or determining the time needed to complete tasks.
   - To understand word problems involving addition operations, plan solutions, implement them, and verify their accuracy using creative strategies.
   - To use rounding skills and compatible numbers to estimate addition results quickly and effectively.

- To participate in group activities to solve addition problems creatively and collaboratively.
- To enhance students' self-confidence by enabling them to complete addition problems in innovative and independent ways.

3. *Content of the developed educational unit and its organization:* The educational unit was developed based on the proposed list of objectives. The lessons of "the addition unit" were presented in an innovative and effective manner that helps students develop their computational and thinking skills simultaneously. The unit reflects a focus on addition as an important foundation in mathematics by presenting clear concepts, systematic strategies, and interactive learning activities suited to students' needs and abilities.

   The unit was designed to begin with a simple introduction to attract students' attention, followed by a detailed explanation of addition concepts and techniques, and culminating in the enhancement of students' creative thinking skills, namely originality, flexibility, and fluency. These skills were selected based on a questionnaire prepared to identify the skills needed to develop creative thinking among third-grade primary students. The questionnaire was presented to male and female mathematics teachers at the primary stage. Through authentic, flexible, and varied activities, the unit also emphasizes connecting mathematical concepts to students' daily lives, making the learning process enjoyable and relevant to their reality.
4. *Teaching strategies for the developed educational unit:* The unit generally relied on teaching through multiple instructional patterns, including cooperative learning, whole-class instruction, and individual instruction. Dialogue and discussion, problem solving, and practical demonstrations were also used to strengthen students' constructive discussion skills and create a positive psychological impact on learners. In addition, brainstorming, guided discovery, and deductive discovery were employed to ensure students' active participation in the learning process.
5. *Tools and instructional materials used:* The following tools and instructional materials were used:
   - A printed educational unit.
   - An interactive whiteboard.
   - Colored number cards.
   - Short educational stories about addition.
   - Visual aids.
6. *Assessment methods in the developed educational unit:* The purpose of assessment was to determine the extent to which the educational unit achieved its intended objectives. The assessment methods were selected according to the nature of the objectives to be achieved. During the teaching of the educational unit, the following assessment methods were used:
   - **Pre-assessment:** This was conducted by asking questions at the beginning of each lesson to identify students' prior experiences, prepare them for learning, and stimulate their motivation toward the new content.
   - **Formative assessment:** This was conducted by asking questions during the teaching of the unit to determine the extent to which each objective was achieved in each lesson. It also aimed to activate students' roles, ensure their participation in the learning situation, and continuously stimulate their attention.
   - **Summative assessment:** This was conducted at the end of each lesson to verify the achievement of the learning objectives set for that lesson, as well as after completing the teaching of the entire unit.
7. *Validation of the developed educational unit:* To ensure the validity of the unit in terms of its scientific content and organization, its suitability for the objectives, students' level, and proposed activities, the list of unit objectives, its content, and proposed activities were presented to a group of specialists in mathematics and methods of teaching mathematics. This was done to verify the unit's appropriateness in terms of the comprehensiveness, clarity, and relevance of the objectives; the soundness, scientific accuracy, and suitability of the content for third-grade primary students; and the comprehensiveness, appropriateness, realism, and relevance of the activities to the unit objectives and content. The modifications suggested by the reviewers were implemented based on the principle of consensus among them. As a result, the final version of the developed educational unit became ready for implementation.