The Impact of Implementing a Graphics-Based Strategy in Improving Visual Thinking and Problem-Solving Skills in Geometry among Students with Disabilities

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Abstract

This investigation aimed to identify the effect of using a graphic-based strategy on improving visual thinking and problem-solving skills among eighth-grade students with disabilities in Irbid, Jordan. The study used the experimental approach and designed an objective test to measure visual thinking skills and problem-solving skills among the sample, which included 40 students divided into the two study groups, 20 students in the control group and 20 students in the experimental group. The findings showed that the effect of the program was large, which indicates that the strategy affected the students' achievement very significantly. The graphic-based strategy helped to enhance the students' commitment to the educational process so that it facilitates participation and reaching the goal on their own. The findings showed the importance of the graphics-based strategy in helping students with LDs overcome several challenges they face while learning mathematical and geometric problems.

Keywords: graphic-based strategy, mathematics, geometry, students with LDs, teachers.

1. Introduction

Mathematics is a basic pillar of academic progress. In academic subjects, it is considered a vital body that contains knowledge and skills that have major roles in life and fundamental contributions. Geometry is one of the disciplines of mathematics, as any subject that links it to the real world is through its application in various aspects of life (Herzberg et al., 2023). It is one of the basic branches of mathematics, as any subject that is taught to students in the intermediate stage, such as algebra. Geometry is the largest component of realistic mathematics (heuristics), as students can see and feel anything, unlike some other mathematics topics, which are considered highly abstract and difficult for students to learn and understand, especially algebra (Holloway & Barbareschi, 2022). Therefore, most of these topics are based on heuristics and physical phrases that are easy to teach and learn by students. Problem-solving is a very exciting activity, and it is the basic foundation for all types of mathematics activities. Art, skills, mathematical knowledge and definitions, and all other academic subjects are not lessons in and of themselves, but rather tools and means that help students solve problems (Gupta et al., 2021). In addition, mathematical problem-solving is a natural process of thinking in general, as there is no mathematics without thinking and no thinking without problems.

Visual activities and games are useful in solving theoretical questions, as this is the ability of attention to understand and comprehend the questions presented and insight into the passions of others (Park, 2022). Therefore, Piaget focused directly on the activities of visual thinking and did not focus on the steps. Visual thinking is a mental activity that has a big role in helping the student reach the meaning, where the ability to recognize and interpret the meaning relationships, and to seek the meaning and interpretation of the meaning (Kohnstamm, 2021). Brain research has helped in the field of neuroscience by revealing many secrets about how the brain performs functions, which sparked new trends and modern theories that began to invade the field of education and learning (Mosher, 2023). One of the emerging strategies in this regard is the graphics-based strategy, which is one of the strategies for formal reasoning that focuses on shapes and visual images. The graphic organizer is given to the student, which may precede the new lesson and help increase the effectiveness of the mental processing of information, especially the visual aspect, where formal reasoning increases in clarifying meaning and relationships through visual expressions and formal images, which are useful, i.e. still images, movement, drawings, plans, etc (Zhao et al., 2022). This strategy also helps to activate the soft side of the meaningful mind during the presentation of the formal structure before starting the new lesson to form a cognitive verse in the meaningful mind that helps me to understand the new topic or lesson.

Therefore, as the individual is exposed to these notions and keeps pace with the world in discoveries, knowledge, and theories, the student no longer memorizes and waits for all the concepts that he possesses for a long period, left within his cognitive environment. Human knowledge has focused on the comprehensive understanding of the individual, considering that knowledge is the essence of general knowledge in such a way that it arrives at meanings through research, investigation, and discovery, far from investigation and theorization. Visual thinking is a mental ability directly linked to the visual sensory aspects (Gorlewicz et al., 2020). This thinking occurs when there is mutual harmony between what the learner sees in terms of shapes, drawings, and relationships, and the mental connections and products that occur based on the vision and the displayed drawing. It is a mental ability in which images, shapes, and drawings are used, interpreted, and transformed from visual language into written, spoken language, which leads to the required understanding for the individual or student (Psycharis et al., 2022). It is a mental ability in which images, geometric shapes, and charts are used and transformed from the language of vision and drawn language into verbal, spoken, or written language and extracting conclusions and meanings from it to communicate with others.

1.1. Problem statement

In this regard, the researcher believes that the use of a graphic organizer that relies on visual shapes and images will improve the student's ability to solve the geometric problem, especially if the student is exposed to different geometric drawings and shapes, that are aimed at mastering the use of drawings or shapes, and teaching him how to use them and arriving at an artistic method for imagining geometric predicates. Students with learning disabilities need special care and attention from teachers. Using graphics is an effective method to teach this category of students mathematical problem-solving skills. All of this is intended to help the student in solving the geometric problem and how to imagine it, and in doing so it is consistent with the technological revolution and the contemporary knowledge revolution.

1.2. Questions of the study

1- What is the effect of using a graphic-based strategy on improving visual thinking among eighth-grade students with disabilities in Irbid?
2- What is the effect of using a graphic-based strategy on improving mathematical problem-solving skills among eighth-grade students with disabilities in Irbid?

1.3. Significance of the study

This study introduces mathematics teachers to the graphic-based strategy and the steps and how to use it in teaching mathematical concepts to improve students' ability to solve mathematical problems visually. The study helps in overcoming the difficulties of solving the mathematical problem by using visual shapes and drawings, creating a conscious awareness of the concerns of the heuristic problem, how to imagine the heuristic problems, and arriving at a peaceful solution. The results provide the ability to concentrate and pay attention, especially when it comes to the gaps that exist in the gifts of geometric questioning and distraction that prevent reaching the desired solution.

1.4. Limitations to the study

The study was limited to using the graphics-based strategy in teaching geometrical concepts and problem-solving to students with learning disabilities. The study included students from two schools in Irbid, Jordan during the academic year 2022-2023.

2. Literature review

Several scholars investigated tools to facilitate educational learning and help students achieve in academic subjects. Psychological research has focused on this area and created tools, such as formal structures, or graphic structures, and strategies consistent with this approach, organizers, and thinking maps, which are considered effective teaching and learning tools in general, and in particular (to teach critical and creative thinking) (Deveci Topal et al., 2023). The graphic-based strategy is one of the learning tools compatible with this trend in education, as it helps students understand, summarize, and synthesize complex ideas. Its basic aim is to find subtle ideas and details and discover missing meanings and unclear connections. It also encourages any activity that promotes non-linear thinking and summarization. The graphic organizers are graphic shapes, or visual plans that represent the meaning or the meanings related to its subject, in a way that clarifies the relationships between them (Chigbu et al., 2023; Khasawaneh & Arabia, 2016).

The graphic-based strategy helps in describing/theorizing the relationship between the facts and the ideas related to them in this learning process. Sometimes the graphic organizers are referred to as story maps, concept maps, knowledge maps, advanced and cognitive maps, organizers, and concept diagram maps (de Fátima Alvaristo et al., 2020). This strategy can be defined as a map, or a group of concepts, usually on a single sheet of paper, containing empty areas, to guide the student to fill it with interesting ideas. Some of these organizers are specific and others are intended to be used in several topics. The benefits of any of these are that they allow students to see the phrases explicitly (Nobel, 2021). This strategy focuses on the forms and visual images that are intended to be given to the interested person, and this may precede the new lesson, or be given to the learner in advance before the lesson. Scholars emphasized the effectiveness of this type of visual aid in bringing about learning in this regard, and any that contributes to increasing the effectiveness of the processing of the brain, especially the visually impaired side, as formative analysis helps in clarifying meanings and relationships through visual concepts and pictorial structures (Wei et al., 2019; Vanshina et al., 2021).

Using this strategy helps activate the right side of the cognitive brain during the presentation of the verbal tense before starting the new lesson to create a cognitive verse in the cognitive tone that will help in understanding the topic and thus facilitate learning about the subject (Fitzpatrick et al., 2018). The strategy is based on more abstract and conceptual meanings and visual concepts about the experiences and intellectual focus of the student and less abstract concepts that will be understood in the new lesson, and thus the importance of learning in this case, that is, dealing with quantities differently (Crowell, 2019). The strategy undertakes to provide advanced knowledge in the intellectual environment of the subject that facilitates the introduction of academic subjects. Therefore, the strategy achieves the greatest degree of closure and the end of deficiency in the intellectual environment of the subject, which most importantly helps the new subject. Thus, activating the weaker side of intelligence in preserving quantitative knowledge, which is intended to benefit the learner (Khasawneh & Khasawneh, 2023).

The views of educational researchers and scholars on the meaning of thinking varied, as they gave many different definitions based on numerous theoretical foundations and trends (Herzberg et al., 2023). There is no doubt that each individual has his style of thinking, which may be affected by his motivation, the way he was raised, and his cultural background. This has led to the absence of a unified vision among scholars and researchers regarding the meaning of thinking, its forms, characteristics, and methods (Gupta et al., 2021). This has created a wide space for research and investigation in this vast field among scholars and researchers. Visual thinking is an activity and a mental skill that helps the mind to obtain insights, interpret and organize words, create thoughts memorize words, and then express words and thoughts in a literal and verbal form (Kohnstamm, 2021). Therefore, visual thinking becomes clear in a way where vision, painting, and imagination come into active interaction. People who are accustomed to the method of visual thinking use imagination, vision, and drawing actively. They approach mathematical problems from many angles, and they may succeed in choosing the direct evidence that indicates vision to protect them (Mosher, 2023). These people then can imagine mathematical problems purely in the form of visual thinking and provide solutions to these problems.

The ability to visually visualize the essence of what surrounds a person is a way to acquire skills that help describe and understand it. This type of thinking develops the skills of studying forms, differences, and similarities in each other (Zhao et al., 2022). Whatever the method that students engage in while teaching mathematics, they must have visual abilities that are capable of describing an environment and a sense, as seeing things and imagining them is considered a source of thinking. Visual thinking is the individual's mental ability that helps translate what a person sees of visual stimuli (geometric shapes and drawings) into verbal connotations, which helps in describing the geometric shapes, understanding the relationships between them, understanding and interpreting the meaning in the geometric shapes, and extracting meaning from them (Gorlewicz et al., 2020). It is any activity or mental skill that helps obtain and understand concepts, interpret the meanings of my thoughts, memorize them, and express thoughts visually and verbally, to achieve communication with others (Psycharis et al., 2022).

Previous studies

Zebehazy and Wilton (2021) conducted a study where a total of forty students who have visual impairments performed tasks consisting of multiple-choice questions for five different kinds of images that were given in their preferred medium. They also offered assessments of the level of difficulty. Several aspects were taken into consideration when the instructors of pupils with vision impairments evaluated the students. To evaluate the association between disparities in performance and characteristics that were judged by teachers, statistical analyses were conducted. For the bar graph, the map, and the total correct replies on all activities, it was discovered that users of print graphics and users of tactile graphics performed significantly differently relative to one another. It was shown that the perceived difficulty of some activities among users of tactile graphics did not correspond with their actual performance. Significant differences in performance were found between total correct and most individual graphic results. These differences were attributed to the ratings that teachers gave to students who had Individualized Education Program goals for graphics, independence in using graphics, problem-solving ability, mathematics ability, and frequency of engaging with graphics.

Mustafa and Officer (2023) sought to fill a gap in our understanding by examining the intellectual framework of innovative assessment techniques for students with mental disabilities and autism disorders. Specifically, it sought to define the philosophy, objectives, justifications, and types of these techniques as they pertain to students with special needs in the context of the twenty-first century. Utilizing both a descriptive and forward-looking approach, the researcher adhered to research best practices. The research ultimately met some of the requirements for improving the effectiveness of these techniques in the context of the twenty-first century, to ensure their stability.

Ben-Haim et al. (2019) examined how elementary school students' performance with mathematical applets was affected by the visual design's appropriateness. Two sets of mathematical applets are compared in this quantitative study; the only difference between them is the visual style, namely the level of detail and the quantity of distraction. The mathematical problems are identical, however. Matific is a library of mathematical applets; the first applet uses its ideas for animated images. For this study, we created a second applet that replicates the first but in a more simplified, schematic form. The students in the group using schematic graphics were more efficient and finished the task faster than their animated graphics counterparts. Furthermore, the schematic group had more success than the other, even among pupils with inferior mathematical abilities. In terms of how much fun the kids had, there was no discernible difference between the two sets of data.

Indrawati et al. (2021) compared the effectiveness of MG learning with video-based learning to draw any conclusions about the relative merits of the two approaches to teaching English. Students from Bina Nusantara University made up the study's population in a quasi-experimental design. Two classes, each with forty students, served as the sample for this in-class experiment and control, respectively. According to the results, students' English proficiency was significantly enhanced by motion graphics-based learning due to its accessibility, motivation, stimulation, encouragement, informational content, and entertainment value. In addition, compared to video-based learning (VBL), motion graphic learning significantly improved students' English proficiency.

Tu (2021) sought to improve our understanding of visual thinking strategies and how graphic designers may better convey information to their audiences. This study investigates the spatial thinking of graphic designers and the information-receiving public via the lens of visual semiotics, combining Li Siqu's DIMT thinking style with Morris's symbolic context. At the formal level, you'll find things like important academic thinking and visual symbol research elements; at the entity level, you'll find things like the three-dimensional grasp of its theoretical concepts, a sketch of the interaction with the audience, and visual graphics. This article highlights the concepts of innovative graphic design and audience acceptability of information, and it uses semiotic theory to explore the connection between various graphics and ideographic approaches.

3. Methodology

The study used the experimental approach, which is appropriate to the subject of the study and is defined as any approach that reflects the changes affecting a phenomenon, except one change that the researcher can adapt and change. The purpose of this is to determine and measure its impact on the phenomenon.

3.1. Sample

The study group consisted of two divisions that were chosen purposefully from students in the resource rooms in two major schools in Irbid. The sample included 40 students divided into the two study groups, 20 students in the control group and 20 students in the experimental group. The selection of these students was based on their diagnosis of several disabilities. Their teachers were asked to assist in the implementation of the study.

3.2. Instrumentation

The study designed an objective test to measure visual thinking skills and problem-solving skills among the sample, which is the subject of choice. It consisted of 34 items, which were used to measure the equivalence of the two groups before applying the experiment and to identify the existence of differences between the two groups, control and experimental, after the end of the experiment. After preparing the test in its preliminary form, which consists of (34) items, it is presented in its preliminary form to ten experts in mathematics, curriculum, and methods of teaching mathematics. At some point, amendments were made to the test, the goal of the validity of the specific statements of the unit, and the goal of the end of the test paragraphs. The opinions of the judges were taken and done to the final version of the test. The test was also checked for internal consistency as presented in the following table.

Table 1. The internal consistency of the skills of the test

Visual thinking Skill	Correlation coefficient	Sig.
Identifying the shape and its features	0.574	0.01
shape analysis	0.775	0.01
Connecting relations to the shape	0.759	0.01
Recognizing vagueness and its analysis	0.713	0.01
Problem-solving skill		
Information analysis	0.734	0.01
Specifying requirement	0.560	0.01
Drawing the question and identifying the requirement	0.728	0.01
Putting a solving plan	0.750	0.01
Implementing the solving plan	0.558	0.01
Checking the correctness of the solution	0.889	0.01

Table 1 above shows that the items related to the skills of the test were consistent and significant, which indicates the reliability of the test to measure the students' progress after the implementation of the strategy in this study.

3.3. Data analysis

The study used the mean scores, frequency, standard definitions, and percentages to measure the students' progress and the t-test independent sample to detect the differences between the two groups.

4. Results and discussion

4.1. The first question

To answer the first question in this study, the t-test for the independent sample was calculated to identify the differences in the scores of the two groups before and after implementing the graphics-based strategy. The following table shows the results related to the visual thinking skill.

Table 2. Means, standard deviations, “t” value, and significance level to identify the differences between the scores of students in the post-visual thinking test

Skill	Group	Number	Mean score	Standard deviation	T value	Sig.
Identifying the shape and its features	Experimental	20	4.525	0.716	5.264	0.01
	Control	20	3.275	1.320		
shape analysis	Experimental	20	4.125	1.042	5.181	0.01
	Control	20	2.750	1.316		
Connecting relations to the shape	Experimental	20	4.425	1.279	3.904	0.01
	Control	20	3.075	1.774		
Recognizing vagueness and its analysis	Experimental	20	3.850	1.189	4.273	0.01
	Control	20	2.575	1.466		
Total	Experimental	20	16.925	2.093	7.073	0.01
	Control	20	11.675	4.202		

Table 2 shows that the mean score for the experimental group is equal to (4.525), and greater is the arithmetic mean for the control group, which is equal to (3.275). The calculated t value is greater than the tabulated value in all skills, which means the existence of statistically significant differences at 0.01 between the average of the experimental scores and the control scores in the visual thinking test. To find of impact of the applied program, the effect size was calculated as shown in Table 3.

Table 3. The effect size of the program on the visual thinking skill

Skill	T value	Et square	D value	Effect size
Identifying the shape and its features	5.264	0.262	1.192	Large
shape analysis	5.181	0.256	1.173	Large
Connecting relations to the shape	3.904	0.163	0.884	Large
Recognizing vagueness and its analysis	4.273	0.190	0.968	Large
Total	7.073	0.391	1.602	Large

The table above shows that the effect was large, which indicates that the strategy affected the students’ achievement very significantly. After applying the strategy, the students of the experimental group were inspired by perseverance, diligence, and social interaction. The strategy enabled all students to think without exception and pressure. This encourages thinking, communication, and presenting ideas, which increases their motivation and ability to comprehend and understand. This means studying the material and thinking about it thoughtfully. The strategy helped students recycle simple ideas making use of them and creating them. The strategy is having the continuity of the influence of cooperative learning due to the consideration that there are many types of cooperative learning. The strategy was able to attract interest and provoke thinking by asking questions that brainstorm ideas and rely on the interaction between previous experiences that interest you and expose you to new situations.

4.2. The second question

To answer the second question in this study, the t-test for the independent sample was calculated to identify the differences in the scores of the two groups before and after implementing the graphics-based strategy. The following table shows the results related to the problem-solving skill.

Table 4. Means, standard deviations, “t” value, and significance level to identify the differences between the scores of students in the post-problem-solving test

Skill	Group	Number	Mean score	Standard deviation	T value	Sig.
Information analysis	Experimental	20	7.825	2.286	5.079	0.01
	Control	20	5.050	2.591		
Specifying requirement	Experimental	20	3.275	2.136	3.054	0.01
	Control	20	1.925	1.803		
Drawing the question and identifying the requirement	Experimental	20	5.675	2.635	4.292	0.01
	Control	20	3.150	2.627		
Putting a solving plan	Experimental	20	3.450	0.959	3.120	0.01
	Control	20	2.550	1.552		
Implementing the solving plan	Experimental	20	5.175	1.647	6.043	0.01
	Control	20	2.150	2.704		
Checking the correctness of the solution	Experimental	20	10.550	3.273	6.427	0.01
	Control	20	5.700	3.473		
Total	Experimental	20	35.950	8.249	8.166	0.01
	Control	20	20.525	8.641		

Table 4 reveals that the calculated t value is greater than the value of the tabulation in all cases and the quantitative score, which indicates the presence of statistically significant differences between the average scores of the experimental group and the control group in the test of solving geometry problems. To find of impact of the applied program, the effect size was calculated as shown in Table 5.

Table 5. The effect size of the program on the problem-solving skill

Skill	T value	Et square	D value	Effect size
Information analysis	5.079	0.249	1.150	Large
Specifying requirement	3.054	0.107	0.692	Medium
Drawing the question and identifying the requirement	4.292	0.191	0.972	Large
Putting a solving plan	3.120	0.111	0.707	Medium
Implementing the solving plan	6.043	0.319	1.368	Large
Checking the correctness of the solution	6.427	0.346	1.455	Large
Total	8.166	0.461	1.849	Large

Based on the data presented in Table 5, the effect was large, indicating that the strategy affected the students' achievement significantly. The graphic-based strategy helped to enhance the students' commitment to the educational process so that it facilitates participation and reaching the goal on their own. The strategy helped students provide simple solutions for several tasks and encouraged them to solve the mathematical problem easily, without hesitation or complication. The strategy also allowed the students with LDs to overcome the challenges they have in recognizing geometric shapes and mathematical problems related to shapes. The teachers provided positive feedback on the use of this strategy.

5. Conclusion

The objective of this study was to identify the effect of using a graphic-based strategy on improving visual thinking skills and problem-solving skills among eighth-grade students with disabilities. The findings showed that the effect of the program was large, which indicates that the strategy affected the students' achievement very significantly. After applying the strategy, the students of the experimental group were inspired by perseverance, diligence, and social interaction. The strategy enabled all students to think without exception and pressure. The graphic-based strategy helped to enhance the students' commitment to the educational process so that it facilitates participation and reaching the goal on their own. The findings showed the importance of the graphics-based strategy in helping students with LDs overcome several challenges they face while learning mathematical and geometric problems. It was also noticed the inclination of teachers toward favouring this strategy when teaching these concepts to this category of students.

6. Recommendations

The study recommends the importance of using the graphics-based strategy in teaching mathematics to students with LDs to achieve general educational goals, which helps in circulating ideas internally and between them. The study also recommends holding mathematics courses to train teachers on employing graphic-based strategies in teaching mathematics and encouraging students to complete study units using the strategy. It is also recommended to use this theoretical strategy as a tool for strengthening students orally and in writing. It is also suggested to apply studies on the impact of using the graphics-based strategy in teaching other subjects and experiment with the strategy at different academic stages. It is important to conduct a study to determine the effect of the strategy on the achievement of slow-learning students in mathematics.

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