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Using The (4mat) Model in Teaching The Triangles Similarity Unit For The Ninth Grade

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Abstract

This study investigated the effectiveness of the 4mat model in teaching engineering and developing thinking skills and geometric tendencies among ninth-grade middle school students in "the triangles similarity unit". The study used a semi-experimental approach with 64 students divided into an experimental (32 students) and control group (32 students). The results revealed a statistically significant difference in the average scores of both groups for systemic thinking skills. Additionally, the post-application scores of the experimental group were higher than their pre-application scores. Therefore, the study concludes that the 4mat model is effective in enhancing thinking skills and geometric tendencies among ninth-grade students in "the triangles similarity unit". This study suggests that math teachers use 4mat model in their teaching practices and receive training on how to use it. The findings provide valuable insight into improving math education outcomes, and future studies could examine the 4mat model effectiveness in different contexts.

Keywords*:* 4mat, systemic thinking, geometric concepts, triangles similarity, geometric tendency, ninth grade pupils, learning styles.

1. Introduction

The researcher works as a guide for mathematics in middle and high schools where he conducts continuous talks with geometry teachers, counselors and students. Besides, he has access to the methods of teaching geometry, and is a lecturer in the Faculty of Mathematics which prepares teachers of mathematics and geometry for elementary and middle schools. These facts have made the researcher notice that students suffer from difficulties in learning geometry. Hence the idea of this research.

The world has witnessed rapid and successive developments in the field of knowledge and technology, especially in the fields of education, so the role of education in light of this tremendous development is no longer limited to acquiring information for students. Rather, its role has become directed towards building an advanced and integrated learner in various areas of life. Needless to assert, the teaching methods are one of the basic pillars in achieving the requirements of teaching and learning. The traditional teaching methods, which are still used in our schools and are often concerned with memorization and indoctrination, are no longer suitable for the nature of mathematics, especially geometry.

Fujita, and Jones (2003) mention in their article that the Modern teaching methods focus on the student's ability to understand, imagine, deduce, analyze, and practice thinking. These methods also help the student to organize ideas, to arrange them, and to reach the solution of problems. It is a fact that mathematics in its various branches, especially geometry, helps students to think. As a matter of fact, geometry is one of the materials that gives students an opportunity to solve problems, develop their thinking skills and increase their abilities to conclude and observe. Ubah (2022) mentions that geometry makes students able to organize, classify, and discover relationships between parts of the problem.

1.1. Theoretical Framework

1.1.1. Model (4mat)

There have always been different attempts and experiences that have a pivotal role in the learning process by creating an educational environment that takes into account the learners' styles and motivates them to learn. One of those efforts was made by McCarthy in 1987 when scholar created an integrated educational strategy that takes into account the four main learning styles (imaginary, analytical, logical and dynamic). This strategy caters to every learner's own stage and style, and then it was merged with the theory of learning according to the two hemispheres of the brain (preference for the right side of the brain or left) so that each stage consists of two steps, one which suits the learner's right side, and the other suits the learner's left side and the new technique was called the 4mat model; this strategy consisted of four educational stages that included activities appropriate to each stage (Şeker & Övez 2018).

Jang et al. (2022) wrote about it as a model built on David Kolb's theory that individuals learn new information and face new problems in one of two ways: how they absorb information (information perception) and how they process information.

In his book, Williamson (2017) mentions that the model (4mat) is one of the models that take into account the abilities and preparations of students who have the opportunity to learn at a level that suits their abilities. Put differently, it takes into account the superior, intermediate and weak students, and the differences between them, and allows the teacher to diversify the methods and means of education to suit their needs and tendencies. This model makes the educational situation more active and effective, since it also seeks to achieve several educational goals for students, including: the development of thinking of various kinds, especially systemic thinking, which focuses on developing their ability to organize, arrange and analyze ideas, as well as the ability to realize errors, think in an organized manner and stay away from memorization and indoctrination. Additionally, the student looks at problems and situations deeply and not superficially. In order for the educational process to achieve its goals and be successful, it is necessary to develop the systemic thinking of students.

B. McCarthy & D. McCarthy (2006) in their book, Teaching Around the 4mat Cycle: Designing Instruction for Diverse Learners with Diverse Learning Styles divided pupils' patterns into four styles.

Here I will try to give an accompanying example (Example 1) of each pattern related to the unit of similarity of triangles to be experimented. Suppose we are now in the ninth grade and the mathematics teacher for the first time gave the concept of two similar triangles and wants to pass to his students by defining the concept of similarity between two triangles, and there may be many definitions, including:

Definition 1: 'Two triangles are similar if one of them is an enlarged or miniaturized image of the other.'

Definition 2: 'If every angle in a triangle has an angle equal to the magnitude of another triangle, then the two triangles are similar.'

Definition 3: 'The situations that a triangle goes through if we stretch one or more of its sides without changing the amount of its angles are called similar triangles.'

Definition 4: 'Two triangles are similar if the corresponding angles in each of the two triangles are equal.'

a. The first type: the imaginative learner

It is the type where student tends to imagine and perceives information through direct experience, relying on his senses and interpreting information in the light of his personal experiences, and is motivated by the desire to know why he learns things. The type of students needs the initial definition at the beginning of this educational unit to imagine the concept of similarity in general before the similarity of triangles. He may need to imagine and compare the tree planted in the garden of his school and its image shown on the school's website on the Internet, (See Figure 1). He may find it difficult at first if we explain to him the concept of similarity of triangles as part of the similarity of polygons as in Figure (2), which shows similar pentagons, but he will inevitably understand the similarity of polygons after he understands the meaning of similarity from the example of the two trees.

Fig.1 Similar trees

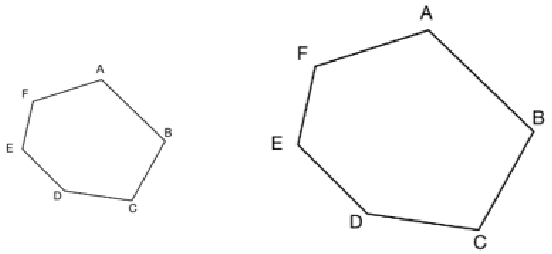

Fig.2 Similar pentagons

b. The second type: the analytical learner

Here the learner tends to know abstract facts and concepts, and needs to know what he learns. This student wants the second definition at the beginning, and he requests an example in which he can internalize the concept of similarity and see with his own eyes that each angle in one triangle has its equal in the other triangle. (See Figure 3).

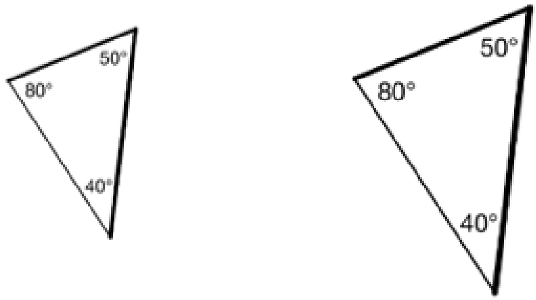

Fig.3 Showing equal angles

c. The third style: The common learner

This learner tends to try things, and wishes to know how he can apply what he learns. Here in the third definition the learner may need to touch or see (may be via a computer program application) a triangle built in a way that its sides can be lengthened or shortened in the same ratio, but its angles remain constant as in Figure (4). (Written-in-bold areas in Figure (4) mean that these are areas where the sides can intermingle).

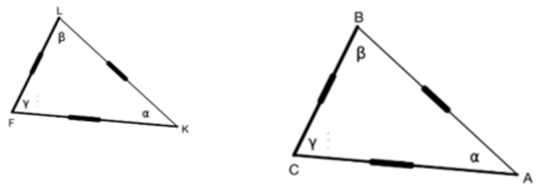

Fig. 4 lengthening-shortening in the same ratio

d. The fourth type: the dynamic learner

Here the learner perceives information directly and processes it in an active way, and tends to discover, apply and modify what he has learned, through the question: What if?

The follower of this pattern may benefit from the fourth definition and can manipulate the information 'corresponding angles are equal' to conclude that all angles are equal in the two triangles. He will quickly realize, for example, that congruent triangles (which he learned about earlier) are also similar, but the opposite is not true (see Figure 5).

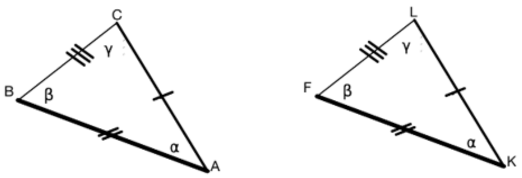

Fig. 5 congruent triangles are similar

He may also realize that the similarity between two triangles will not be faulted if the two triangles are drawn in different positions. (See Figure 6).

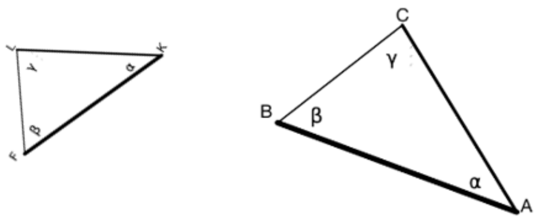

Fig. 6 similar triangles different positions

From the above, we note that these four patterns should be taken into account: we should allow the students to assimilate the concept by themselves, help students develop their ability to cope with problems in new and different ways, show them various geometric images and shapes to clarify the geometric meanings and concepts and discuss them with the students. We should also give students the opportunity to form an image or concept about the geometric shapes and their properties.

A. V. Martín-García (2020) divided the 4mat model in her Blended Education Systems into eight stages: (Here I will also give an example that accompanies these eight stages through the unit of congruent triangles and let's call it Example 2).

1. Connect

The teacher begins by activating the previous experiences of the students, and linking them to the new experiences, and the teacher paves the way to arouse the students' motivation to learn.

Here, for example, the teacher can review the concept of similarity between objects from daily life and discuss it with the students before introducing the new concept of similarity of triangles. He can also review the concept of congruence of triangles and their properties asserting that one of the ways to check if two triangles are congruent is that by displacing or rotating one of the triangles to make it completely apply to the other, on condition that the lengths of the sides in both triangles are equal so are the angles of both triangles.

Then he can wonder with his students, 'What can we say about two triangles that have the same angles, but their sides are not necessarily equal?'

In this mathematical discourse that opens the topic in class, we highlight the difference between the two concepts 'identical' and 'similar'. 'Identity' is a full equality or sameness in all possible parameters (identical twins, overlapping triangles...).

'Similarity' is equality in only some parameters (similar twins, similar siblings...). Teachers must do this because the study of the similarity of triangles is integrated into the study of ratio, proportion, scale and the overlapping of triangles. (Poon, Wong, 2017).

2. Attend

The teacher here presents the lesson (or the concept) to the students and directs the students to think carefully, organize their knowledge, analyze their personal experiences, and then judges their impressions on the first stage.

Here the teacher formally presents the definition of similar triangles: 'Similar triangles are triangles, in which each angle in one triangle has an angle equal to it in the other triangle; and there is an equal ratio between the three pairs of corresponding sides (the corresponding sides are opposite the equal angles) scale factor of the similar triangles'.

It is very important to present the advantages of similarity and to deduce them through dialogue with students, as each advantage may have its own students who will rely on it later. Among the important characteristics that distinguish the similarity of triangles that the teacher should discuss are the following:

- When a first triangle is similar to a second triangle, then the second triangle is similar to the first triangle, which in cases of triangle similarity is known as symmetrical.

- The congruence of two triangles implies they are identical but the opposite is not true.

- Every two triangles that have two equal angles means the third angle in both will also be equal, which will make them similar.

- All triangles resemble themselves, which is known as the reflexive property.

- If two triangles are similar, all opposite angles between them are equal.

- If a first triangle is similar to a second triangle and that second triangle is similar to a third triangle, then the first triangle is consequently similar to the third triangle, which is known as the transitive property.

3. Image

At this stage the used educational means such as, models, visual images, concept maps, and other sensory means are various and numerous. This helps students to link between what they know previously, and between what they are learning now.

Here the teacher can show his students many similar shapes from daily life or from the similarity of polygons, and focus on triangles in particular. This part of the lesson may be more successful if these shapes are presented through pictures or worksheets that the teacher has previously prepared; he can display them through a computer application, or even build them with his students, this is consistent with the opinion of Richard et al. (2016).

4. Inform

The teacher dialogues with the students and discusses their ideas and impressions of the lesson until the ideas become clear, and the teacher presents information and experiences in an organized way, and in a clear sequence. The teacher also diversifies the systems and means that help him reach the desired goal, and makes the students integrate into meaningful thinking.

Here is exactly the point for the teacher to stop giving new information about the similarity of triangles to discuss what has been passed so far, to gauge the students' understanding of the past material. That is, the properties of similar triangles are clarified and completed and linked together. The teacher can then outline the main similarities:

- Two triangles are similar if the parallel side lengths correspond with each other (side, side, side).

- Two triangles are similar if two angles of the first triangle are equal to two angles in the second triangle (angles).

- Two triangles are similar if the measure of an angle of one triangle and the measure of an angle of another triangle are equal and the lengths of the two sides containing this angle (side, angle, side) are correspondent.

- If the hypotenuse of a right triangle is equal to the hypotenuse of another right triangle, and the length of one side is equal to the length of the opposite side of the other triangle, then the two triangles are similar.

5. Practice

Students use their senses, and interact with practical activities until they can master them with high accuracy, at this stage there are many practical activities and various trainings. Here the teacher presents and does exercises that benefit what has been passed from the material so far and can help with worksheets or applications from the computer, this is a helpful way to learn geometry by the study of Santos et al. (2016).

6. Extend

The ideas of students increase at this stage, and become more profound. The teacher directs the students to link their knowledge and use it in new situations and problems, and the exercises are more difficult.

After the student has imbibed all of the above regarding the concept of similarity of triangles, the teacher must move this stage to the results of similarity (required according to the curriculum). These are:

- The ratio between the areas of two similar triangles is equal to the square of the ratio between the lengths of any corresponding sides in them.

- The ratio between the perimeters of two similar triangles is equal to the ratio between the lengths of any corresponding sides in them.

7. Refine

The students focus on the correct information they have acquired and address errors, i.e.: the student extracts and processes the wrong information through guidance and feedback, and the teacher provides the students with guidance and help.

Some common mistakes that some students make when passing this unit, due Haj-Yahya (2020):

- Distinguishing between the concepts of congruence and similarity,

- The concept of scale factor.

- Distinguishing between sides that give the value of ratio.

8. Perform

students begin to implement what they have acquired of information and theories, and apply them in practical life. Here, with the help of an imaginative attitude, the students will experience and know how to find values of sides and areas.

In this research, the eight stages were used to answer the nature and the needs of the ninth grade students. It is very likely that students at this level need clarification and diversity. Furthermore, the content of the unit 'similarity of triangles' contains many shapes and steps that need to be detailed so that the students can have the opportunity to implement them and discover these steps and shapes by themselves.

It is worth noting here that there is a need to use technology to pass the unit of similarity of triangles. In general, when teaching mathematical and geometric topics with computerized tools is fun and simulates students and is of great benefit to them (Erkek, & Bostan, 2019).

So, in this research we used technological tools such as: videos, PowerPoint presentations, applets and GeoGebra, which would make the topic more tangible and hence would attract the students. In this way, the students would have established the material in their mind without the need for memorization devoid of comprehension.

Some studies have been used to confirm the effectiveness of the 4mat program in education. Bılgın Aktas (2015) to start with, has examined the effect of the 4mat program on seventh grade students in science and found that the 4mat model took into account individual differences between students as well as their different learning styles.

Atasoy and Ergin (2013) studied the effect of the (4mat) program on tenth grade students in physics and confirmed that the 4mat model improves students' performance in experiments and has an overall positive effect.

Seider and Nicoll-Senft (2009) studied the effect of the 4mat model at higher education levels and recommended the use of the program in higher education, after six university faculty members from the following departments: Science, Business, Art, Education and Professional Studies, and Engineering and Technology implemented the 4MAT model in their classrooms.

Isreb et al. (2000), whom their paper presented a new learning paradigm in teaching finite elements in analysis and design. The goal was to train students and practicing engineers within the "University Without Borders" to think, learn and exercise competent judgment using techniques in engineering design and analysis. This is done using a special module which is built according to the 4mat model.

The study of Can (2009) which concluded that the academic achievements of science student teachers, their grade levels, were positively influenced after using 4mat.

Also, some studies have proven the effectiveness of the 4mat model in mathematics. Among these studies one might consider Dikici and Tatar (2009), whose study was meant to determine the efficiency of (4mat) method of instruction in which learning style and cerebral hemispheres are taken into account in teaching the binary operation and its properties in mathematics. The data have been obtained primarily from three scales, namely ‘mathematical knowledge test’, ‘mathematical attitude scale’ and ‘knowledge test on binary operation and its properties’. It has been determined that (4mat) method of instruction was more efficient than the traditional method in teaching of the binary operation subject in mathematics.

In addition, the study of Ovez (2012) aimed at finding out determine the learning difficulties in the scope and area of the circle and the cylinder and to determine the effectiveness of the (4mat) teaching model in overcoming learning difficulties. The study was conducted on 83 students (7th grade). The findings of this study indicated that the students had learning difficulties regarding the circumference and area of the circle and the perpendicular cylinder, and (4mat)-based teaching was effective in overcoming these difficulties, while the traditional method was not effective in overcoming learning difficulties.

1.1.2. Systemic thinking

Systemic thinking skills are the set of skills that help students to organize, analyze, synthesize, predict problem solutions, and have the ability to find errors. Educators have differed in identifying systemic thinking skills, including what was identified by Levin and Schrum (2013), which are: systemic classification, systemic analysis, systemic synthesis, perception of systemic relationships. Systemic thinking helps the student to re-analyze the educational situation, develops the student's ability to have a comprehensive view of the subject, develops the student's ability to analyze, and makes the student appreciate the opinions of others.

One of the recent trends that educators seek is the development of thinking of various kinds, which is also concerned with the mental processes of students. It helps students understand mathematics, especially geometry, and focuses on developing their ability to organize, arrange and analyze ideas, as well as obtain the ability to realize errors, think in an organized manner, and stay away from memorization and indoctrination. In addition, it motivates the student to look at problems and situations deeply and not superficially. In order for the educational process to achieve its goals and be successful, it must develop different types of thinking, including systemic thinking (Saxton et al., 2014).

Some studies confirmed that students have difficulties in systemic thinking, especially in mathematics and geometry. One chief study was conducted by Barcelos et al. (2018), who analyzed 42 studies between the years 2006-2017 from different places. What they found was that many of these studies were conducted with the aim of improving systemic thinking in mathematics. The majority of these studies suggested that systemic thinking is a sound scientific method of thinking that addresses problems through a holistic view in light of the interrelationships between the components of the problem.

Another study by Sinclair and Bruce (2015) reported a similar problem. Their article describes an immense change on geometric education at the elementary school level as a result of possible new opportunities, offering what elements would play a part in changing the typical attitude and highlight on vocabulary in teaching geometry, to work on composing-decomposing, classifying, comparing and mentally manipulating two- and three-dimensional figures.

According to Taylor et al. (2020), there are several classifications of systemic thinking skills. Here I, in turn, will accompany these classifications with an example of the unit of similar triangles. Let call it Example (3).

1. Systemic classification

It means: the systematic sorting of objects into groups or categories that have a common characteristic. Similar triangles are defined as a geometric system that occurs between two triangles, and this similarity is done according to the principle of proportion where all angles have the same measurement, but the side lengths differ between the two triangles by the same ratio between each two opposite sides.

2. Systemic analysis

It means systemic segmentation of the educational material given to it, the awareness of similarities, differences and relationships between parts, and identification of the principles that govern relationships in the unit of similar triangles. If similar triangles are successfully classified, systemic analysis can be considered as the search for properties resulting from similarity, which I have previously enumerated in item 2 of the stages of the (4mat) model.

3. Systemic synthesis

It means systemic collection of different parts of the content, main topic or ideas and using them to find something new that differs from the previous parts. After the analysis and synthesis of similar triangles, the search for similar triangles and the attempt to classify, group and enumerate the different ways begin to know if the two triangles are similar or not. This is what I have mentioned earlier in item 4 of the stages of the (4mat) model.

4. Understanding systemic relationships

It refers to recognizing relationships within the same subject or one though. After understanding the analysis and structure of the system of similar triangles, the peak of its realization is to use similarity theories successfully, which I have previously enumerated in item 7 of the stages of the (4mat) model and applied them in practical life. Through it, students can find side lengths and calculate perimeters and areas.

1.1.3. Geometric tendencies

Geometry includes a lot of ideas and geometric forms, which require accuracy, understanding, and concentration of students so that they can master it, and therefore many students do not have a positive inclination towards geometry. In fact, their comprehension is weak, so their inclination to geometry classes is typically low, as in light of the use of the traditional method and the non-use of various educational means that take into account all the differences between students; students are bored, do not understand the material, and naturally their motivation for geometry classes drops (Martínez and García, 2014), (Park and Kim, 2017).

Stoehr (2017) defines tendencies to mathematics and geometry as an internal feeling when the student is related to the emotional side and is manifested in his behavior. One main reason for the decline in tendency to mathematics is fear of it. This study concluded that teachers are able more than others to alleviate this fear in their students.

In an attempt to overcome the shortcomings in the usual methods of teaching, especially in geometry, the need to develop a tendency to it. In addition, the need for other types of learning to be more effective emerged. Of these methods one may consider active learning, used in the wake of confusion and bewilderment that students complain about after each educational situation in geometry. This condition may have occurred as the result of the lack of integration of new information and concepts in a real way in their minds after each traditional educational activity (Bronstein et al., 2017), (Emre et al., 2018), (Zapata-Grajales et al., 2017).

The current research seeks to develop some of the skills of systemic thinking, which develop the student's ability to sort objects and geometric shapes and know what is between them from their similarities and differences, as well as they improve the ability to analyze the geometric shape and extract other forms from it, and reach new ideas differently. This reasoning fits with the result of the study of Sinclair et al. (2016).

I also find that the (4mat) model is suitable for the similarity of triangles and also suitable for the diversity required by the skills of systemic thinking, so the current research seeks to find out the effectiveness of the (4mat) model in developing some systems thinking skills and geometric tendencies among ninth grade middle school students.

2. Methodology:

2.1. Goals of the research

1. Developing some systemic thinking skills among ninth grade students in the geometry curriculum through the use of the (4mat) model.

2. Developing the geometric tendencies of ninth grade students towards geometry through the use of the (4mat) model.

2.2. Research questions

1. What is the effectiveness of using the (4mat) model in developing some systemic thinking skills among ninth grade students in geometry?

2. What is the effectiveness of using the (4mat) model in developing geometric tendencies among ninth grade students?

2.3. Materials

A list of some systemic thinking skills for ninth grade students was prepared, and triangle similarity unit was reformulated to suit the (4mat) model (see examples 1, 2 and 3). Furthermore, directions were prepared for the teacher to teach the unit, including the objectives and the time plan with the number of classes necessary to teach the unit according to the (4mat) model and a method for preparing the lessons included in the unit.

Activities and tasks were also selected and prepared for the student to be carried out by him or in groups.

After preparing all these materials, they were presented to a group of teachers and counselors of mathematics, and the necessary adjustments were made after reviewing the materials with them, and the final image of the teacher's bulletin and the final picture of the student's activities were reached.

2.4. Tools

Systematic thinking test:

- A test of systemic thinking for ninth grade students. It was prepared through several steps: determining the objective of the test, and the content measured by the test, and analyzing the content of the trigonometry unit.

- Preparing a specification table, determining the type of test items, and choosing rubrics to calculate test scores.

After preparing the test, it was presented to teachers and counselors in mathematics, and it was agreed that the test in its initial form would include (15) items, and it was done on 18/2/2022 to a survey sample that included 40 students from the two schools, to settle on the final image of the test. The results as shown in Table (1) show the weakness of students in some systemic thinking skills.

Table 1: Results of the survey sample to examine the weakness of students in some systemic thinking skills

Dimensions	Mark above 50		Mark under 50	
	Number of Students	Percentage	Number of Students	Percentage
Systemic classification	12	30	28	70
Systemic analysis	6	15	34	85

Systemic synthesis	3	7.5	37	92.5
Understanding systemic relationships	5	12.5	35	87.5
Total test score	7	17.5	33	82.5

The researcher used the reapplication method to calculate the stability of the test after applying it to the survey sample, as he reapplied it with an interval of one month. Table (2) shows the coefficients of reapplication stability and their significance.

Table 2: Reapplication stability coefficients for testing systems thinking skills in geometry (survey sample).

Dimensions	Pearson Correlations	level of significance	Cronbach's Alpha
Systemic classification	0.866	0.01	0.850
Systemic analysis	0.875	0.01	0.845
Systemic synthesis	0.885	0.01	0.846
Understanding systemic relationships	0.865	0.01	0.815
Total test score	0.873	0.01	0.839

It is clear from Table (2) that the reapplication stability coefficients for the test of systems thinking skills in geometry are a function at the level of 0.01, which confirms the high stability coefficients of the test.

Geometric tendencies measurement:

The measurement of geometric tendencies has been prepared according to the following steps: determining the objective of the measurement, determining the dimensions of the measurement, determining the appropriate time to apply the measurement.

Then the initial image of the measurement was presented to a group of specialists in the field of curricula and teaching methods in mathematics from Sakhnin Teacher Training College, and it was agreed upon, and this image included (62) questions. It was applied to the survey sample on 16/2/2022, and the researcher also used here the re-application method to calculate the stability of the measurement after applying it to the survey sample and then re-applying it with an interval of one month. Table (3) shows the coefficients of reapplication stability and their significance.

Table 3: Reapplication stability coefficients and their significance for the scale of geometric tendencies.

Dimensions	Pearson Correlations	Level of significance	Cronbach's Alpha
Tendency towards the nature of geometry	0.836	0.01	0.810
Tendency towards the value of geometry and its importance	0.895	0.01	0.865
Tendency to learn geometry	0.875	0.01	0.836

Enjoying geometry	0.849	0.01	0.814
Tendency towards the geometry teacher	0.890	0.01	0.821
Total measurement score	0.869	0.01	0.829

It is clear from Table (3) that the coefficients of stability of the reapplication of the measurement of geometric tendencies are a function at the level of 0.01, which confirms the high coefficients of stability of the measurement, and the measurement was put in its final form.

2.5. Research procedures

The semi-experimental approach of two groups was used in the research: the experimental in which the research unit studied the similarity of triangles. Using the (4mat) model and the control that studied the same unit in the usual way, taking into account the identification of factors that may affect the dependent variables as much as possible to ensure the compatibility between the two groups. Al-Bashaer Comprehensive School was selected, Galilee District, from which the eighth grade was randomly selected; the number of its students was (32) to represent the experimental group, while Mar Elias Comprehensive School, Galilee District, was selected, from which the eighth grade was randomly selected; the number of its students was (32) to represent the control group.

Before applying the research, the materials and tools required to apply the experiment were defined from the teacher's guide according to the model (4mat), (See Examples 1, 2 and 3), as well as the application of the test of systemic thinking skills for the unit of similarity of triangles and the measurement of geometric tendencies to the participants in the experimental and control groups.

The experiment was conducted in the research period from 18/3/2022 to 11/4/ 2022 during which the unit of similarity of triangles was taught. This unit which is part of the material for the ninth grade students in the second semester was given to the experimental group using the (4mat) model, while the control group studied the unit in the normal way.

After teaching the unit to the experimental and control research groups, the researcher assisted the teachers in the two schools to conduct the test and measurement.

3. Results

First: The results of the application of the systemic thinking skills test.

To answer the first question, which states: 'What is the effectiveness of using the (4mat) model in developing some systems thinking skills among students of the first preparatory grade in engineering?' and to verify that there is a statistically significant difference between the average scores of the students of the control and experimental groups in the post-application of the test of systemic thinking skills in geometry, a test (t) was used for parametric samples of independent pairs through the statistical program SPSS, and Table (4) illustrates this.

Table 4: Test results of some dimensional systemic thinking skills for the control and experimental groups.

The skills	Group	Number	Arithmetic mean	Standard deviation	t-values	Significance
Systemic classification skills	Control	32	8.406	2.02	8.55	0.01
	experimental	32	12.66	1.96		
Systemic analysis skills	Control	32	7.75	2.66	8.67	0.01
	experimental	32	13.22	2.38		
Systemic synthesis skills	Control	32	7.28	3.32	12.33	0.01
	experimental	32	16.55	2.66		
Understanding systemic relationships skills	Control	32	7.53	3.36	12.98	0.01
	experimental	32	17.25	2.58		
Total test score	Control	32	30.97	18.54	8.889	0.01
	experimental	32	60.66	3.66		

It is clear from Table (4) that there is a statistically significant difference between the average scores of the students of the control and experimental groups in the post-application of all skills in the test of systemic thinking skills in geometry, at the level of significance (0.01), in favor of the average scores of students in the experimental group.

These results are consistent with the study of Salado et al. (2019), aimed to investigate the effect that traditional word problems have on a student's ability to use systemic thinking. The article presented results from three clinical interviews, and determined that the use of the (4mat) program would be effective in these cases.

Table 5: presents the results of the experimental group students in the pre- and post-application of the systems thinking test.

The skills	Application	Number	Arithmetic mean	Standard deviation	t-values	Significance
Systemic classification skills	Pre	32	3.28	1.49	21.21	0.01
	Post	32	12.66	1.96		
Systemic analysis skills	Pre	32	2.72	1.35	21.36	0.01
	Post	32	13.22	2.38		
Systemic synthesis skills	Pre	32	3.09	1.57	24.26	0.01
	Post	32	16.55	2.66		
Understanding	Pre	32	3.16	1.63	25.71	0.01

systemic relationships skills	Post	32	17.25	2.58		
Total test score	Pre	32	12.25	4.87	44.24	0.01
	Post	32	60.66	3.66		

Through Table (5), it is concluded that the pre-average of the total test reached (12.25) while the post-mean reached (60.66) and through that, the difference in the average of the test reached (48.41) in favor of the post-application in the test of systemic thinking skills in geometry. And by conducting a test (t) at the level of significance (0.01), it was found that (t) tabular has a value of (2.388), and by calculating (t) calculated its value is (44.24). That is, the calculated (t) is greater than the tabular (t), so there is a statistically significant difference between the average scores of the experimental group students in the pre- and post-application of systemic thinking skills in favor of the post-application at a significance level (0.01). This result is consistent with the study of Tatar and Dikici (2009), which aimed at finding out the effect of employing the (4mat) model in teaching binary processes and their properties in mathematics and the results showed statistically significant differences in favor of the experimental total in the test. The results also showed that the dynamism caused by such models is one of the reasons for openness to systematic thinking. This makes us link this result to the results of the study of Sinclair et al. (2008), which investigated the effect of introducing a dynamic engineering environment on mathematical thinking by identifying changes in the discourse resulting from its presentation in the high school engineering class. It found statistically significant differences between static and dynamic geometry in terms of the ways in which the teacher talks about geometric objects, uses visual artifacts and models of geometric reasoning.

Second: The results of measuring geometric tendencies

To answer the second question, which states: 'What is the effectiveness of using the (4mat) model in developing geometric tendencies among ninth grade students?' Table (6) presents the results that show the effectiveness of the model in the development of geometric tendencies of students.

Table 6: Dimensional application of geometric tendencies measurement

Tendencies	Group	Number	Arithmetic mean	Standard deviation	t-values	Significance
Tendency towards the nature of geometry	Control	32	36.47	4.43	9.87	0.01
	Experimental	32	45.66	2.69		
Tendency towards the value of geometry and its importance	Control	32	27.9	5.09	8.82	0.01
	Experimental	32	36.99	2.65		
Tendency to learn geometry	Control	32	32.8	5.76	11.57	0.01
	Experimental	32	46.22	2.96		
Enjoying	Control	32	27.6	4.36	10.55	0.01

geometry	Experimental	32	36.88	2.25		
Inclination towards the geometry teacher	Control	32	60.2	3.31	24.97	0.01
	Experimental	32	89.66	5.66		
Total measurement score	Control	32	185.71	14.6	23.94	0.01
	Experimental	32	256.33	7.56		

It is clear from Table (6) that there is a statistically significant difference between the average scores of the students of the control and experimental groups in the dimensional application of the total measure of geometric tendencies, at the level of significance (0.01), in favor of the average scores of students in the experimental group.

4. Discussion

Through the above, it is clear that the students of the experimental group who studied the unit of similarity of triangles according to the model (4mat) have outperformed the students of the control group who studied the same unit in the traditional way in the results of the systemic thinking measurement. It was also found that the students of the experimental group have been developing their geometric tendencies more than the students of the control group, and this is due to the use of the (4mat) model. It provided the opportunity for students to overcome many difficulties by giving them the opportunity to discover data for themselves, because it allowed them to recognize similar triangles through their own thinking patterns and transition as the information discovered remains more trace than the information that is taught to students in the traditional way. It is clear that the teacher's ability to recognize the different thinking patterns of his students is the impetus for the mathematical discourse, which in turn will dominate the general atmosphere in the classrooms, and this is in agreement with the study of Morgan (2016) through which he calls for the development of an analytical program to investigate the nature of mathematics discourse at home, and makes it possible to explore the potential of students to see a role for themselves as active, creative participants in mathematical practices.

The (4mat) model works on diversity in methods which take into account the differences between students in their learning styles. This diversity in teaching methods led to improving the thinking skills of students, as the use of multiple methods according to different stages helps students to realize the meaning and that the use of brainstorming in the stage of 'link' helped them to bring out all their information about similarity and their previous concepts about it.

The students' thinking, collecting information, organizing it, linking it to the information they retrieved, and discussing it with the teacher in the 'link' and 'brought' stages, such as the student contemplating a set of images from real life and determining which of them represents similarity or working on a computerized application, formed a good base for assimilating the concept. That certainly led to the success of the 'application' stage, and created an augmented reality atmosphere, and this aligns with the research of Abdul Hanid (2022), who conducted research that combines the application of augmented reality with computational thinking into geometry topics. Three variables were measured, computational thinking, visualization skills and achievements in geometry. The study was implemented with 124 students, the results showed that there is a positive effect of teaching methods using augmented reality applications with computational thinking for students in improving computational thinking, visualization skills and achievements in geometry.

Students were able to practice and consolidate the concept of similarity and its geometric definition. This positively influenced the continuation and 'expansion' in passing the unit material. And the student reaches with his knowledge the fact that the ratio between the areas of two similar triangles is equal to the square of the ratio between the lengths of any two corresponding sides in them. They also discovered the ratio between the perimeters of two similar triangles is equal to the ratio between the lengths of any two corresponding sides in them, this is really what significantly improved their 'performance' in application.

5. Recommendations

- Mathematics teachers should use the 4mat model in teaching mathematics, especially geometry.

- Conducting training courses and workshops for teachers to train them on how to use the (4mat) model.

- Integrating the (4mat) model within the models that are taught to students of faculties of education so that they can know how to use it in teaching mathematics.

- Adopting the strategies and methods which suit the students' needs and consider the differences between the types of students.

- Finding alternatives that help the students learn in an active and attractive environment.

- Establishing a mentor for the teacher in other geometry units to explain to him how to deal with the unit and teach it in the light of the model (4mat).

- Urging those in charge of the mathematics curriculum and its teaching methods to introduce contents and suggest strategies and methods that can advance learning.

Reference

1. Abdul Hanid, M. F., Mohamad Said, M. N. H., Yahaya, N., & Abdullah, Z. (2022). Effects of augmented reality application integration with computational thinking in geometry topics. Education and Information Technologies, 27(7), 9485-9521. https://doi.org/10.1007/s10639-022-10994-w.
2. Aktas, I., & Bılgın, İ. (2015). The effect of the 4MAT learning model on the achievement and motivation of 7th grade students on the subject of particulate nature of matter and an examination of student opinions on the model. Research in Science & Technological Education, 33(1), 1-21. https://doi.org/10.1080/02635143.2014.968536.
3. Barcelos, T. S., Muñoz-Soto, R., Villarroel, R., Merino, E., & Silveira, I. F. (2018). Mathematics Learning through Computational Thinking Activities: A Systematic Literature Review. J. Univers. Comput. Sci., 24(7), 815-845. https://www.academia.edu/download/96594322/jucs_24_07_0815_0845_barcelos.pdf.
4. Bronstein, M. M., Bruna, J., LeCun, Y., Szlam, A., & Vandergheynst, P. (2017). Geometric deep learning: going beyond euclidean data. IEEE Signal Processing Magazine, 34(4), 18-42. https://ieeexplore.ieee.org/abstract/document/7974879.
5. Can, Ş. (2009). The effects of science student teachers' academic achievements, their grade levels, gender and type of education they are exposed to on their 4mat learning styles (Case of Muğla University, Turkey). Procedia-Social and Behavioral Sciences, 1(1), 1853-1857. https://doi.org/10.1016/j.sbspro.2009.01.327.
6. Emre Akdoğan, E., Güçler, B., & Argün, Z. (2018). The Development of Two High School Students' Discourses on Geometric Translation in Relation to the Teacher's Discourse in the Classroom. EURASIA JOURNAL OF MATHEMATICS

SCIENCE AND TECHNOLOGY EDUCATION, 14(5). https://doi.org/10.29333/ejmste/84885

7. Ergin, S., & Atasoy, Ş. (2013). Comparative analysis of the effectiveness of 4mat teaching method in removing pupils' physics misconceptions of electricity. Journal of Baltic Science Education, 12(6), 730-746. Retrieved from https://www.proquest.com/scholarly-journals/comparative-analysis-effectiveness-4mat-teaching/docview/2343720515/se-2.
8. Erkek, Ö., & Işıksal Bostan, M. (2019). Prospective middle school mathematics teachers' global argumentation structures. International Journal of Science and Mathematics Education, 17, 613-633. https://doi.org/10.1007/s10763-018-9884-0.
9. Fujita, T., & Jones, K. (2003). The place of experimental tasks in geometry teaching: learning from the textbook designs of the early 20th century. Research in mathematics education, 5(1), 47-62. DOI: 10.1080/14794800008520114.
10. Haj-Yahya, A. (2022). Students' conceptions of the definitions of congruent and similar triangles. International Journal of Mathematical Education in Science and Technology, 53(10), 2703-2727. DOI: 10.1080/0020739X.2021.1902008.
11. Hibi, W. (2022). Attitudes and perceptions of lecturers at Sakhnin College towards the integration of online teaching and innovative teaching methods and innovative teaching technologies, Journal of Positive Psychology and Wellbeing. Vol. 6 No. 2 (2022): Vol. 6 No. 2, 2090-2105.https://journalppw.com/index.php/jppw/article/view/14118
12. Hibi, W. (2017). Beliefs and attitudes about mathematics among students and their relationship to their achievement in mathematics. Journal of Harbin Institute of Technology. Vol. 49 Iss. 11 (2017), 47-57. ISSN: 0367-6234.http://hebgydxxb.periodicales.com/index.php/JHIT/article/view/879
13. Hibi, W. (2022). Definitions of ratio and proportionality terms and their relationship to cognitive and meta-cognitive orientation in the proportional thinking of preparatory level students. Multicultural Education, Caddo Gap Press, 3145 Geary Boulevard, PMB 275, San Francisco, CA 94118 U.S.A. Vol. 08, No. 02, 2022, 12-34.https://academic-accelerator.com/Quartile/Multicultural-Education.
14. Hibi, W. (2023). Difficulties in teaching mathematics in the Arab sector in Israel, International Journal of Multicultural Education (IJME),United States. Vol. 25 No. 1, 1-14.http://ijmejournal.org/ijme/index.php/ijme/article/view/71122.html
15. Hibi, W. (2023). Language problems in mathematics studies Is there a link between difficulty solving mathematical verbal problems and reading deficiency among 7th graders? Onomázein hosts unpublished articles derived from scientific research, 9-31. http://www.onomazein.com/index.php/onom/article/view/9
16. Hibi, W. (2023). The effect of homework on the achievement of Arab students in mathematics in the Israeli Arab society, International Journal of Multicultural Education (IJME),United States. Vol. 25 No. 1, 15-32. http://ijmejournal.org/ijme/index.php/ijme/article/view/71222.html
17. Hibi, W. (2018). The effect of origami's educational and geometrical interaction on sixth graders. Journal of Harbin Institute of Technology. Vol. 50 Iss. 11 2018, 33-40. ISSN: 0367-6234.http://hebgydxxb.periodicales.com/index.php/JHIT/article/view/735. http://hebgydxxb.periodicales.com/index.php/JHIT/article/view/735
18. Hibi, W. (2022). The Positive Impact of Combining Daily Math with First-Class Equation Learning for Middle School Students, Yantu Gongcheng Xuebao Chinese Journal of Geotechnical Engineering. Vol. 44 No. 6 (2022), 31-44. http://ytgcxb.periodicales.com/index.php/CJGE/article/view/129

19. Hibi, W. (2022). The educational and geometric psychological impact of origami on sixth Graders. Journal of Positive Psychology and Wellbeing. Vol.6, No.1, January 2022,2031-2039. https://www.journalppw.com/index.php/jppw/article/view/2893
20. Isreb, M., Jarvis, J. R., & Khan, A. I. (2000). An Internet-4MAT-CAL system for adaptive finite element mesh refinement. Finite elements in analysis and design, 34(1), 1-24. https://doi.org/10.1016/S0168-874X(99)00024-4.
21. Jang, C. S., Lim, D. H., You, J., & Cho, S. (2022). Brain-based learning research for adult education and human resource development. European Journal of Training and Development, 46(5/6), 627-651. https://www.emerald.com/insight/content/doi/10.1108/EJTD-02-2021-0029/full/html.
22. Levin, B. B., & Schrum, L. (2013). Using systems thinking to leverage technology for school improvement: Lessons learned from award-winning secondary schools/districts. Journal of Research on Technology in Education, 46(1), 29-51. https://doi.org/10.1080/15391523.2013.10782612.
23. Martín-García, A. V. (2020). Blended Education Systems: In Search of Deep Learning. Blended Learning: Convergence between Technology and Pedagogy, 65-89. https://link.springer.com/chapter/10.1007/978-3-030-45781-5_4.
24. Martínez-Sierra, G., & García González, M. D. S. (2014). High school students' emotional experiences in mathematics classes. Research in Mathematics Education, 16(3), 234-250. DOI:10.1080/14794802.2014.895676.
25. McCarthy, B., & McCarthy, D. (2006). Teaching around the 4mat® cycle: Designing instruction for diverse learners with diverse learning styles. Corwin Press. https://books.google.co.il/books?hl=iw&lr=&id=8Rf1hTZvZs8C&oi=fnd&pg=PP9&dq=4mat+teaching+&ots=xWruceBGA4&sig=lNmrDe7qOX2LjhKrE3F_8Ik9mF0&redir_esc=y#v=onepage&q=4mat%20teaching&f=false.
26. Morgan, C. (2016). Studying the role of human agency in school mathematics. Research in Mathematics Education, 18(2), 120-141. DOI: 10.1080/14794802.2016.1176595.
27. Nicoll-Senft, J. M., & Seider, S. N. (2009). Assessing the impact of the 4mat teaching model across multiple disciplines in higher education. College Teaching, 58(1), 19-27. http://www.4mat.dk/media/1612/vcol_a_424736_o.pdf.
28. Ovez, F. T. D. (2012). The effectiveness of 4mat teaching model in overcoming learning difficulties in the perimeter and area of circle and perpendicular cylinder among the seventh year students. Procedia-Social and Behavioral Sciences, 46, 2009-2014. https://doi.org/10.1016/j.sbspro.2012.05.419.
29. Park, J., & Kim, D. W. (2017). How can students generalize examples? Focusing on the generalizing geometric properties. Eurasia Journal of Mathematics, Science and Technology Education, 13(7), 3771-3800. https://doi.org/10.12973/eurasia.2017.00758a
30. Poon, K. K., & Wong, K. L. (2017). Pre-constructed dynamic geometry materials in the classroom–how do they facilitate the learning of ‘Similar Triangles’?. International Journal of Mathematical Education in Science and Technology, 48(5), 735-755. DOI: 10.1080/0020739X.2016.1264636
31. Richard, P. R., Oller Marcén, A. M., & Meavilla Seguí, V. (2016). The concept of proof in the light of mathematical work. ZDM, 48, 843-859. https://doi.org/10.1007/s11858-016-0805-9.
32. Salado, A., Chowdhury, A. H., & Norton, A. (2019). Systems thinking and mathematical problem solving. School Science and Mathematics, 119(1), 49-58. https://doi.org/10.1111/ssm.12312.

33. Santos-Trigo, M., Moreno-Armella, L., & Camacho-Machín, M. (2016). Problem solving and the use of digital technologies within the mathematical working space framework. ZDM, 48, 827-842. https://doi.org/10.1007/s11858-016-0757-0
34. Saxton, E., Burns, R., Holveck, S., Kelley, S., Prince, D., Rigelman, N., & Skinner, E. A. (2014). A common measurement system for K-12 STEM education: Adopting an educational evaluation methodology that elevates theoretical foundations and systems thinking. Studies in Educational Evaluation, 40, 18-35. https://doi.org/10.1016/j.stueduc.2013.11.005 .
35. Şeker, B. S., & Övez, F. T. D. (2018). The integration of the 4mat teaching model with the interdisciplinary structure. Eurasia Journal of Mathematics Science and Technology Education, volume 14, Issue 5, 1767-1790. https://doi.org/10.29333/ejmste/82986.
36. Sinclair, N., Bartolini Bussi, M.G., de Villiers, M. et al. (2016). Recent research on geometry education: an ICME-13 survey team report. ZDM Mathematics Education 48, 691–719. https://doi.org/10.1007/s11858-016-0796-6.
37. Sinclair, N., & Bruce, C. D. (2015). New opportunities in geometry education at the primary school. ZDM, 47, 319-329. https://doi.org/10.1007/s11858-015-0693-4.
38. Sinclair, N., & Yurita, V. (2008). To be or to become: How dynamic geometry changes discourse. Research in Mathematics Education, 10(2), 135-150. DOI: 10.1080/14794800802233670.
39. Stoehr, K. J. (2017). Mathematics anxiety: One size does not fit all. Journal of Teacher Education, 68(1), 69-84. DOI: 10.1177/0022487116676316.
40. Tatar, E., & Dikici, R. (2009). The effect of the 4mat method (learning styles and brain hemispheres) of instruction on achievement in mathematics. International Journal of Mathematical Education in Science and Technology, 40(8), 1027-1036. https://doi.org/10.1080/00207390903121750.
41. Taylor, S., Calvo-Amodio, J., & Well, J. (2020). A method for measuring systems thinking learning. Systems, 8(2), 11. https://doi.org/10.3390/systems8020011.
42. Ubah, I. (2022). Pre-service mathematics teachers' semiotic transformation of similar triangles: Euclidean geometry. International Journal of Mathematical Education in Science and Technology, 53(8), 2004-2025. DOI: 10.1080/0020739X.2020.1857858.
43. Williamson, J. M. (2017). Teaching to individual differences in science and engineering librarianship: Adapting library instruction to learning styles and personality characteristics. Chandos Publishing. https://doi.org/10.1016/C2015-0-04361-1.
44. Zapata-Grajales, F. N., Cano-Velásquez, N. A., & Villa-Ochoa, J. A. (2017). Art and Geometry of Plants: Experience in Mathematical Modelling through Projects. Eurasia Journal of Mathematics, Science and Technology Education, 14(2), 585-603. https://doi.org/10.12973/ejmste/76958