Research Article

Topological concepts and their relation to engineering thinking among middle school students

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Abstract

The current research aims to investigate the topological concepts for intermediate stage students, engineering thinking among intermediate stage students, and the relationship between topological concepts and engineering thinking for intermediate stage students. The research sample consisted of (220) students from the first intermediate class / first Rusafa, where verification of validity and reliability were conducted for the topological test concepts as a first tool and a test for engineering thinking as a second tool. Accordingly, the two tests were ready to be applied to the basic sample and in their final form, which the topological concepts test items reached (16) items, while the engineering thinking test items reached (18) items, Furthermore, the statistical package for social sciences (SPSS) was applied to analyze the research results. and the results showed that first intermediate class students possess topological concepts and engineering thinking that exceeds the assumption average of the test and that there is a positive relation between topological concepts and engineering thinking. Finally, the researchers presented a set of proposals and recommendations based on the results of the study

Keywords: Topological concepts, Engineering Thinking, Intermediate stage school students

Introducing

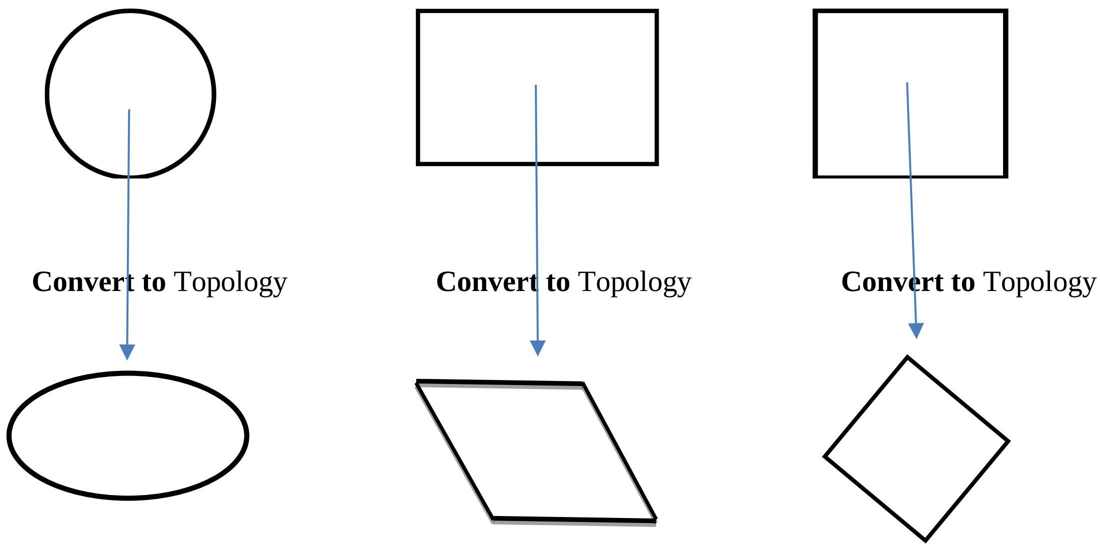
Learners acquire concepts through educational methods and activities that are consistent with the characteristics of their growth, needs, and inclinations, and from these activities, they are fond of geometric shapes with its two branches, Euclidean geometry, and Rubber geometry, which is one of the modern mathematics branches. As it deals with points, lines and shapes, and through which these forms can stretch or deviating in one direction, provided that there is no tear or hole in it. However, during the direct observation of the primary and intermediate school students, it can be found that they are practicing topological concepts while playing and dealing with things surrounding them that as adults do not care about and are not aware of, due to our insufficient knowledge or lack of good observation of these students. Moreover, the priorities of the students' experiences about the space are through the topological space and not the Euclidean, as the topological concepts such as (neighborhood, separation, arrangement, and surrounding) before the development of qualitative concepts related to Euclidean geometry such as (angle, distance) that concern straight lines and angles. Therefore, educators and experts have been concerned with the child of his early age on the necessity of working to develop his mental and cognitive capabilities, knowledge and concepts are acquired, most of their mental capacities are opened up and their sensory skills are integrated. According to the researcher's experience, the interviews with male and female teachers during supervision (practical application) and the question for them about their knowledge of topological concepts, and the answer came from not knowing these concepts. In addition, the lack of interest in providing them to learners despite their importance, the current research problem lies in answering the following questions; do intermediate class students have knowledge of topological concepts and engineering thinking?. As well as, is there a relation between topological concepts and engineering thinking for intermediate class students? Topological concepts are useful in enabling the learner to communicate and interact with others on the one hand and interact with the surrounding environment on the other hand. As well as organizing groups of facts and linking them with each other, where it helps to transfer the impact of learning as it becomes useful in dealing with the surrounding world, and it reduces the complexity of life (Al Omar, 1990: 205). Generally, topology deals with models and their conditions without looking at their size, and the topological form can be changed to other forms by stretching, folding, but without cutting the shape, which leads to the interest of learners at an early age in these forms. (El-Sherbiny and Yosrya, 2000: 18). The results of (Piaget, Anhalder, Shtern, and Poincare) confirmed that one of the priorities of the student's experiences about space is through the topological space and not the Euclidean, where young children cannot distinguish between simple geometric shapes such as triangles, circles, and squares, even if they can distinguish between these shapes and call them the correct name. They cannot know the characteristics of those shapes, where the square and circle cannot distinguish between them topologically because each of them is a simple closed surface; they distinguish between closed and open shapes before distinguishing between simple Euclidean curves such as the square and the circle and others. Also, develop their own biological concepts, such as neighborhood, contact, separation, and surrounding, before concepts related to Euclidean geometry such as the angle. (Qandil and Badawi, 2003: 9-10). Because of the rubber geometry, is inseparable from Euclidean geometry, engineering thinking, regardless of its many aspects, delivers results on shapes, ideas, mental processes, and engineering activities such as visualization, analysis, formal reasoning, and arriving at products that reflect mental treatments. The importance of the current research is determined in the field of education, especially after the cognitive developments that took place in the world, through which the student can identify the geometric shapes with their Euclidean and rubber branches. In addition to being a descriptive, research that deals with two definite definitions of variables and checking the correlation between the two variables and the proving of the effect of the independent variable (topological concepts) on the dependent variable (engineering thinking) for middle school students

- **Research hypotheses, Limits, Terms definitions**

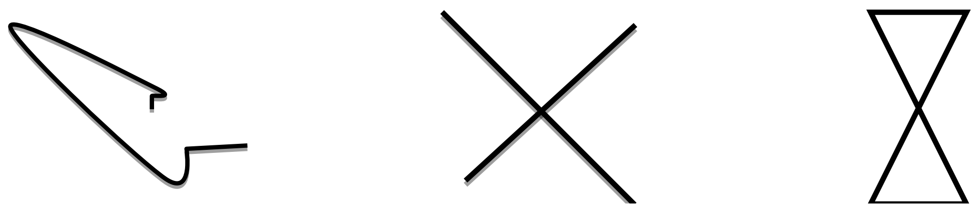
There was no statistically significant difference at the significance level 0.05 between the assumed average and the arithmetic mean for scores of students in the first intermediate class/education of first Rusafa in the topological concept test. Moreover, there was no statistically significant difference at the significance level of 0.05 between the assumed average and the arithmetic mean for scores of students in the first intermediate class/education of first Rusafa in the engineering thinking test. Finally, no statistically significant relationship at the significance level of 0.05 between the arithmetic means for scores of students in the first intermediate class in the topological concepts test and arithmetic mean for scores of students in the first intermediate class in the engineering thinking test. The current research is limited to the first intermediate class for the academic year (2018 - 2019), intermediate schools for boys, belonging to the education of first Rusafa. As well as, Topological concepts, Engineering thinking, and the second semester of the year (2018 - 2019). The study terms were elaborated in order to define features of the search, where (Arifaj and Nayef, 2010; 147) defined the concept: “The mental image formed by the individual as a result of generalizing qualities and characteristics (derived from similar things) on things that are identified later.” Additionally, it may be defined as " a mental spectrum of something, and this thing may mean an embodied goal or a kind of behavior or idea, and this spectrum has two dimensions which are the individual components of the concept, the relationship of these components to each other and their relationship to the whole." (Al-Khatib, 2011: 135). In the case of Topological concepts (Ibrahim, 1993: 12) defined it as the information and facts that make up the primary set of spatial relationships on the basis of which learners know the concept of where they live. From another point of view, it's defined as the forms in which one is able to cause other forms using distortion, contraction, tension (Al-fred & Jey, 2004: 488). While (Badawi, 2012) defined it as one of the mathematics branches that deal with points, shapes, and lines. It is also concerned with studying the main properties of shapes that are affected by tension, pressure, stretching, provided that there is no tear or puncture. (Badawi, 2012 : 83). The researchers adopted a definition (Badawi, 2012) as a theoretical definition of the topological concept and the degree that the first intermediate class student obtains by answering a topological concept test. Furthermore, (Al-Otoum et al., 2009: 19) defined thinking as "A cognitive activity that gives environmental stimuli meaning and significance through the cognitive structure to help the individual to adapt and adapt to environmental conditions. In the case of engineering thinking, (Shehata and Zeinab, 2003:128) defined it as "a mental activity that depends on a set of mental processes represented in students' ability to carry out a set of activities related to engineerings, such as visualization, formal reasoning, and analysis. In addition (Kinard, 2003:75) defined it as "a set of mental processes that discover relationships and represent them with symbols, meaning that it is a set of cognitive functions used to demonstrate engineering theories and solve life situations that deal with engineering facts and laws. Finally, the theoretical definition of engineering thinking is defined as mental activity related to engineering that depends on a set of logical mental processes represented in the learner's ability to recognize, infer, analyze, construct and read engineering shapes, while the degree obtained by the first intermediate class student by answering the engineering thinking test represent Procedural definition of engineering thinking

- **Previous Theoretical Background and Studies:**

Topology is one of the most prominent branches of modern mathematics, which deals with points, shapes, and lines, and in which the geometric shapes can be lengthened, contracted, or deviated in the direction of a certain condition, provided that no hole or tearing occurs in it (Elias and Murtaza, 2006: 294). Geometric shapes are of two types, the first type is traditional engineering, and one of which is rigid that does not move and change, it is fixed, the triangle, for example, has three sides that cannot extend, contract, buckle or bend, and if you want to move the triangle from one place to another, the size and shape remain constant. As for the second type, called rubber or topological engineering, they are mobile geometrical forms, not rigid, they are variable that can be expanded, contracted, buckle or bend, and give an engineering shape that rewards the first shape such as square, rectangle, and circle (Al-Sharif, 1996: 212). (Al-Menoufy, 2013:348) pointed out that the topology is the study of the essential qualitative engineering properties without regard to measurement, and these properties are independent of size, shape, and position, and these properties do not change, whether the shape was extended, shrinks or bends. This means that the topologies are not coherent and fixed in their form and shape rather, it is a rubber that can change its shape, for example, in the case of a rubber band, it can be circular or square in shape, extend, become in a shrinking shape, or be curved closed in different forms (



These shapes are called simple closed curves and they are those curves that start and end at the same point without any intersection at any other point than the following forms:



The first form intersects with other points than the starting point and the other two forms are open so these forms are not topological concepts.

However, there are many characteristics that characterize topology, including it is not correct to bend and break the straight line, and the circumference of the circle can be turned into a triangle, square, rectangle or any irregular shape. As well as, things that touch each other must be kept in contact with them, so it is not correct to cross or separate and anything that is outside must remain outside, and anything that is inside must remain inside. (El-Sherbiny and Yosrya, 2000: 20). Humans have lived in an age of information flow in the various fields of natural and human sciences, and the mere narration and accumulation of information in the learner's mind is not a successful way to achieve that objective. Therefore, it must direct our attention to how we can raise the level of thinking for the learner and help him to keep learning that information, In other words, we make the field wide for developing its thinking methods and means of obtaining knowledge and the fields of its application. Perhaps the most important material that plays a vital role in this field is mathematics, as it is one of the most important scientific subjects, which is indispensable to any individual in society, whether small or old, everyone needs it and uses it all according to its field and work. Therefore, it is necessary to take advantage of these wonderful advantages in this subject in order to put their fingerprints in the students' thinking and their capabilities, so that they learn from them that helps them face their lives with ability and efficiency. Mathematics has evolved over the ages and expanded very dramatically, so it has many branches related to each other, engineering is one of the most important branches of mathematics because it is more related to the ability to think, and it is considered an enjoyable subject. Moreover, its properties and components are related to our reality, if the learner notice the contents of his room, for example, he saw many engineering figures and shapes around him with different areas and sizes, he may not feel the presence of it around him and this is due to that engineering is not linked to real life. (Hindam, 1982 :3) pointed out that "engineering requires a specific logical method that is difficult for young pupils to understand, as it is above their mental level, where this method was taught to mature learners during the days of the Greeks as it was during the time of Euclid and Plato, and not to the young pupils as it happens now. (Aqeelan, 2000) determined that there are two levels of developing engineering concepts according to Piaget's conclusions, which are the level of perception through the senses of touch and sight, and The level of thinking or imagination (Aqeelan, 2000: 162). Additionally, (Al-Mawla, 2009) indicated that there are three main features of engineering ideas, Firstly, the shapes whether they are two-dimensional or three-dimensional, are found in different positions. Thus, the learner has to show the difference and similarity between these shapes in different ways, and that the best way to know these shapes is his understanding of these shapes, and here the learner thinks through a closer look at the shapes in front of him and learns about similarities and differences between them. Therefore, we have placed the learner in the first way of engineering thinking. Geometric shapes have properties that can be used by the learner in the analysis and description of these shapes, interest in these properties helps him to perceive them, and therefore such awareness requires thinking to find these properties. The properties of engineering shapes lead us to develop the learner's abilities in the deductive reasoning of the engineering environment so the learner can get to know the engineering shape through the environment in which he lives. This is a kind of non-school engineering, which the learner is accustomed to, but he can think through these shapes with different conclusions and learn about the characteristics and properties of different shapes (Al-Mawla, 2009: 157 – 158. Consequently, when teaching engineering concepts and shapes, it is preferred to focus on perceived things from the environment so that the student can think about the engineering shapes and solids to be learned. (Afaneh et al., 2012: 206). The advantages of educational activities that develop engineering thinking among students should be related to the lesson subject and can be practiced in the classroom, and not overly complicated and difficult. In addition to being related to reality and It is a stimulus for students' thinking and interesting for them (Zaytoon, 2003: 25).

Research Methodology and Procedures:

The two researchers used the descriptive research methodology according to the following procedures, where the research community was determined by first intermediate stage students/education of first Rusafa for the academic year (2018-2019), and the research sample consisted of seven randomly chosen schools as shown in Table 1

Table (1) Research sample of first intermediate stage students for the academic year (2018-2019)

Seq.	School name	Number of class students
1	Al-Harith intermediate school for boys	32
2	Al- Fatwa intermediate school for boys	28
3	Omar bin Abdulaziz intermediate school for boys	25
4	Khaled Bin Al-Waleed intermediate school for boys	35
5	Bilal Al Habashi intermediate school for boys	32
6	Al-Farazdaq intermediate school for boys	34
7	Al-Zahawi intermediate school for boys	34

	Total	220

Considering the book of the sixth primary stage and first intermediate stage and previous studies, items of the topological concepts test were prepared and consist of (16) items and engineering thinking test items, which consist of (20) items. While the Validity of the two instruments: was carried out to ensure the validity of the item, the items of the two tests were presented to a group of specialists in the field of mathematics and its teaching methods. The researchers applied the two tests to a first pilot sample consisting of (30) students of Al- Fatwa intermediate school for boys on Sunday 10/3/2019 to clarify the items and to calculate the time required to answer the two tests. The duration of the two tests was determined and reached (20) minutes for topological concepts test and (25) minutes for engineering thinking test. Moreover, the two tests were applied on a second pilot sample consisting of (100) students from three schools, namely Bilal Al Habashi intermediate school for boys, Al Farazdaq intermediate school for boys, Al-Zahwi intermediate school for boys, and divisions that differ from the basic sample divisions on Monday 11/3/2019 to perform the statistical analysis for two tests. The researchers arranged the scores of the second pilot sample members in descending order for the purpose of determining (27%) of the students who obtained the highest scores in the two tests and who got the lowest scores in the two tests, so the number of members of the higher group reached (27) students. The lower group (27) student, (Ebel, 1972) pointed out that the statistical analysis of test items is one of the basic steps in the good test and to confirm the validity of its items and to retain good items and delete the weak ones or modify or exclude them. (Ebel, 1972: 262). The following are the results of the statistical analysis of the items, where The researchers calculated the discrimination index for the topological concepts test items and found that it ranged between (0.22-0.63), while the difficulty index ranged between (0.37-0.77), thus all of the 16 test items were retained, as shown in Table 2

Table (2) the discrimination power and difficulty index of the items surveyed for topological concepts test

Item	Discrimination power	Difficulty index	Item	Discrimination power	Difficulty index
1	0. 48	0. 46	9	0. 59	0. 55
2	0.40	0. 72	10	0.33	0. 46
3	0.44	0. 44	11	0. 44	0.48
4	0.48	0.50	12	0. 22	0. 77
5	0.22	0.37	13	0.37	0.40
6	0. 22	0. 75	14	0.25	0. 68
7	0. 63	0. 68	15	0.25	0. 46
8	0. 22	0. 74	16	0. 55	0. 57

The researchers calculated the discrimination index for the engineering thinking test items, and found that it ranged between (0.11 - 0.66), and thus excluding item 19 because its discrimination index (0.11) while the difficulty index ranged between (0.05 - 0.83) and thus excluded the items (16, 19) as shown in Table 3.

Table (3) the discrimination power and difficulty index of the items surveyed for engineering thinking test

Item	Discrimination power	Difficulty index	Item	Discrimination power	Difficulty index
1	0.25	0.53	11	0.51	0.55
2	0. 22	0. 61	12	0.55	0.31
3	0.29	0.59	13	0.26	0. 61
4	0.51	0. 70	14	0.26	0.27
5	0.55	0. 64	15	0.37	0.51
6	0. 40	0. 42	16	0.26	0.83
7	0. 40	0. 68	17	0.40	0. 57

8	0.51	0. 66	18	0.22	0.29
9	0. 66	0.40	19	0.11	0.05
10	0.37	0.29	20	0.29	0.33

The two tests were applied on the second pilot sample of 100 from the first intermediate stage students of the three schools mentioned above on Sunday 24/3/2019, to calculate the Pearson correlation coefficient between the two test scores. For the two variables, where the correlation coefficient value for topological concepts reached (0.84), while the correlation coefficient value for engineering thinking reached (0.91). The items of the two tests were applied, the first, topological concepts test, as its number was (16) item, and the second, engineering thinking test, as its number was (18) on the research sample that consisting of (220) students and represented by the first intermediate stage students. The two researchers supervised the application of the two tests with explanatory explanations for them. Table 4 shows the day, date, and name of the schools in which the two tests were applied. Finally, to obtain their results, the researchers used the statistical package for social sciences (SPSS).

Table (4) the day, date, and name of the averages in which the two tests were applied

Day	Date	Intermediate school name
Monday	2019 / 3 / 25	Al-Harith Al- Fatwa
Thursday	2019 / 4 / 4	Omar bin Abdulaziz Khaled Bin Al-Waleed
Sunday	2019 / 4 / 7	Bilal Al Habashi Al-Farazdaq Al-Zahawi

- **Results and discussion**

The first hypothesis: There is no statistically significant difference at the significance level of 0.05 between the assumption average and the arithmetic mean for the scores of first intermediate stage students/education of first Rusafa in topological concepts test. Table 5 showed that the arithmetic means of the scores for first intermediate stage students in the topological concepts test were (9.31) compared to the assumption average of the test which amounted to (8). By using the T-test for one sample, it was observed that the calculated T value (7.65) is greater than the tabulated value (1.96). This indicates that there was a statistically significant difference at the significance level of 0.05 with a degree of freedom (219) and that the difference is in favor of the arithmetic mean, accordingly the first hypothesis was rejected.

Table (5) The calculated and tabulated T value of the topological concepts test for students in the first intermediate class

Individuals Number of the sample	Mean		Standard deviation	Minimum Response	Maximum Response	T value		Significance level
	Assumption	Arithmetic				Calculated	Tabulated	
220	8	9.31	2.55	15	4	7.65	1.96	0.05

The second hypothesis: There is no statistically significant difference at the significance level of 0.05 between the assumption average and the arithmetic mean for the scores of first intermediate stage students/education of first Rusafa in the engineering thinking test. Table 6 showed that the arithmetic means for the scores of first intermediate stage students in the engineering thinking test was (9.38), compared to the assumption average of the test, which amounted to (9). By using the T-test for one sample, it was observed that the calculated T value (2.04) is greater than the tabulated value (1.96), this indicates that there was a statistically significant difference at the significance level of 0.05 with a degree of freedom (219) and that the difference is in favor of the arithmetic mean. Accordingly, the second hypothesis was rejected.

Table (6) The calculated and tabulated T value of the engineering thinking test for students in the first intermediate class

Individuals Number of the sample	Mean		Standard deviation	Minimum Response	Maximum Response	T value		Significance level
	Assumption	Arithmetic				Calculated	Tabulated	
220	9	9.38	2.76	2	17	2.04	1.96	0.05

The second hypothesis: There is no statistically significant difference at the significance level of 0.05 between the arithmetic mean for the scores of first intermediate stage students in the topological concepts test and the arithmetic mean for the scores of first intermediate stage students in the engineering thinking test. Table7 showed that the relation between the arithmetic means for the scores of first intermediate stage students in the topological concepts test and the engineering thinking test. The researchers obtained the Pearson correlation coefficient between topological concepts and engineering thinking and its value was (0.37), and was used the T-test to identify the significance of the correlation coefficient, where the T value (9.92) was greater than the tabulated value (1.96).

Table (7) the value of the correlation coefficient between topological concepts and engineering thinking for students in the first intermediate class

Individuals Number of the sample	Correlation coeffici value between topological concep and engineering thinking	T value		Significance level
		Calculated	Tabulated	
220	0.37	9.92	1.96	0.05

Results interpretation

The results related to the first hypothesis showed that students in the first intermediate class possess topological concepts, due to the fact that curricula in the primary stages introduced many topological concepts in the form of various forms. Moreover, the results related to the second hypothesis showed that students in the first intermediate class have more engineering thinking beyond the theoretical average of the test, due to the fact that their teachers used various methods of teaching mathematics and this result was consistent with (Al-Sheikhly, 2014) study. While the results related to the third hypothesis showed that there was a relation between topological concepts and engineering thinking among students in the first intermediate class. It is a result indicates that students in the first intermediate class, whenever they acquire topological concepts, they can increase their engineering thinking, and this is due to their mental maturity and their understanding to a large extent of these concepts.

Conclusions and recommendation

1- The performance of students in the first intermediate class for topological concepts was moderate (higher than assumption average).
2- The performance of students in the first intermediate class in the engineering thinking test was medium (higher than the assumption average).
3- There is a positive correlation between topological concepts and engineering thinking among students in the first intermediate class.
4- Using the various teaching methods, modern techniques and electronic blackboard that help students possess topological concepts and develop their engineering thinking.
5- Merging topological concepts with life applications.

6- Studying the relation between topological concepts and other dependent variables, such as reflective thinking.
7- Studying the relation between engineering thinking and visual intelligence

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