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RESEARCH ARTICLE

THE IMPACT OF USING REPRESENTATIONS ON ACQUISITION OF MATHEMATICAL CONCEPTS AMONG 6TH GRADERS IN GAZA STRIP

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ABSTRACT

The aim of this study was to investigate the impact of using representations onacquisition of mathematical concepts among 6th graders in Gaza Strip. Two classes from Mustafa Hafez Elementary School in Khan Yunis Governorate were randomly chosen from sixth grade classes, where one of the classes was randomly assigned as an experimental group and the other as a control one. The number of students of every class was (40) students. The Quasi Experimental Design (pre-post test for two groups) was adopted. The study findings revealed that there are statistical significant differences between the scores mean of the experimental group and those of the control group in the concept acquisition test in favor of the experimental group.

INTRODUCTION

Mathematics is no longer just a material to be studied; instead, its applications engage in all our daily life aspects and everywhere we may go. In addition, students have different abilities, needs and interests, but each one should be able to use mathematics in his private life, work and educational levels. All students should get the opportunity to apply the mathematics processes in an accurate and brilliant manner for solving the mathematical problem in a creative way. They also should present the concepts they acquire in different ways. There are several variables that effectively affect the education process including, for example, the various learners' capacities for learning and their educational situations and types. Thus, the effective teaching of mathematics requires planning a group of the most important activities. Such activities are like selecting the suitable teaching strategy and the pure environment management (Obaid 2004:140). Generally, the use of words is essential within the classroom and is rather the base of the communication process through the printed books. However, the more one depends only on it, the lower its effectiveness is. Currently, using the language and the visual and tangible materials together is consistently increasing according to Zaitun (2005:591). There is a need for the multiple representations since the connection among the oral, visual and tangible information improves and strengthens the education process. Zaitun (2005) adds that the representations are considered as a way for organizing the information in a visual manner (p.592). So they can help the learner in converting a big amount of information or data into graphics or a simple structure to be read and which is connected in a certain way. Therefore, selecting various teaching methods decreases the phenomena in which the students memorize the information by heart. Instead, it increases the ability of students to understand and realize the ideas in various ways. It strengthens their expression ability of the concepts and ideas with which they are convinced. Educators and mathematicians in different countries agree on using the new measures which are adapted for developing the school curricula that take the students' needs and tendencies into consideration.

Communication in mathematics occurs through the symbols and the multiple representations of the concepts. The more the student is able to express the idea of the concept using different pictures, the more he is able to explain the idea to others. The concepts are formed by the imageries, reflections and the creative thinking. Each leaner's mind picture of the concept is different because of the different experiences and thinking ways. It should be noted that the students of the same grade may have similar concepts as they are exposed to the same experiences within the classroom. However, the extent of concept acquisition is different (Abu As'ad, 2010:163). Hence, the teacher should note forming the concept and the extent of

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students' acquisition of the concept. The teacher should decrease such gap using different ways to demonstrate the concept through the multiple representations which are proposed to the students and focus on the forming phases of the concepts such as defining the critical qualities of and explicit name for the concept. The modern educational view of mathematics teaching focuses on the conceptual knowledge. It represents the students' understanding of the mathematical ideas and the interrelations among these them and their ability to connect such ideas in a meaningful manner, reaching the final imagery (Abbas& Al Ibssy, 2007:21).The mathematical representations are effective tools which strengthen and support the mathematical ideas by helping students to focus on the main advantages of the mathematical knowledge, Also, they help students to define and understand the mathematical concepts (Fennel & Rowan, 2001:289).

The understanding is a realization of the idea beyond the different representations, the flexibility to deal with some of them and the conversion of the representations. For example, the student, who understands the function, realizes the relation between its inputs and outputs either in drawing the function, represented it in a table, or in its equation (Al Sawa'e, 2010:143). People who are involved in teaching mathematics are more aware of the role of the mathematical representations for acquiring mathematical concepts. The traditional claim which states that the student's brain is a blank sheet and it can be formed or filled with whatever the teacher wishes, is no longer persuasive for the educators. Instead, there are ideas that support the thinking way and help in knowing the common mathematical elements of the different mathematical cases.

Mathematical representations help students understand the mathematical concepts and procedures when they try to transfer the understanding of the same idea through different representations. Learning mathematical skills should go along with the real understanding of the mathematical concepts by feeling the same importance of the mathematical skills towards the mathematical representation.

When the student is able to find the correct answer to a problem, but he is not, meanwhile able to represent such an answer or mathematical idea, this is considered as anexplicit evidence that indicates the failure of the students' understanding of the mathematical idea (Al Sawa'e, 2010:158). The importance of the mathematical representations is shown through the call of the National Council of Teachers of Mathematics (NCTM) to pay attention to and concentrate on the mathematical representations and their importance in mathematics education as a main standard for school mathematics, which confirms that the mathematical representations help students to know the common mathematical elements of the various mathematical cases (NCTM, 2000).

The representations enhance the understanding of the mathematical concepts and the procedures and their uses. When the students are able to represent a mathematical case in a meaningful manner, solving such a problem becomes possible. Using the representations either by drawings, mind images, tangible materials, equations, or rules helps the students in organizing their thinking. They also enable the students to experiment different instructions that lead to a clear understanding and to solve the problems they face.

Mathematical concepts are considered the base of mathematics formation; all other elements of the mathematical knowledge as generalizations and skills are based on the concepts of their formation and understanding. Many studies are conducted about the best ways to acquire the mathematical concepts. Accordingly, several studies are made to investigate the impact of using the mathematical representation in teaching math (e.g.Al Balassy&Barhm, 2010; Abrahamson 2006; Barmby, *et al*. 2011; Grossman, 2010).These studies have proved that mathematical representations are effective to make the students acquire the mathematical concepts. However, the studies as (Al Khorusy(2008); Al Khteeb&Al'Atum(2008); Kuchemann *et al*. (2011); Ozmantar(2010); Barmby, *et al*. (2009); Cakiroglu&Akkus(2009); Hwang, *et al*. (2007) have proved that the use of mathematical representations is effective in developing what the students acquire and their mathematical thinking.

The two authors observed – as mathematics teaching experts- the low level of the students to acquire the ratio, proportionality and the percentagebecause it is difficult for them to understand the abstract concepts; the students may memorize the concept without getting its meaning. So the two authors desired to conduct this study to determine the impact of the mathematical representations on 6th grader's acquisition of the concepts because the concepts of ratio, proportionality and the percentage units need effective methods of teaching to teach the students and boost their tendencies to learning such concepts so that they can understand them well and lead to the correct meaning (NCTM, 2000).

Study Problem

Mathematical representation is an important skill in school mathematics. Using these representations, students can understand mathematics deeply and develop the flexibility to transfer the mathematical concepts into other situations. Despite the importance of mathematical representations, many mathematics teachers neglect to illustrate the concepts through the mathematical representations. So, the two authors wish to contribute to the development of the mathematics teaching in the elementary school by giving more care to the mathematical representations and building students' concepts. The study problem is represented in the following questions:

1. What is the suggested framework to teaching concepts using mathematical representations?
2. What is the impact of using representations on acquisition mathematical concepts among 6th graders in Gaza Strip?

Study Hypothesis

There are no statistically significant differences at ($\alpha \leq 0.05$) between the scores mean of the experimental group and those of their counterparts in the control group in the concepts acquisition test.

Study Objectives

The study seeks to investigate the impact of using representations on acquisition of mathematical concepts among 6th graders in the Gaza Strip

THEORETICAL FRAMEWORK

Mathematical Representations

Pape and Tchosnov (2001) define mathematical representation as internal abstracts of the mathematical thinking or a knowledge scheme that is developed by the learner using his/her experience. Numerical and algebraic representations, pictures, tables, plans, and lists are all considered as external illustrations of the concepts or representing the mind information building. It means that the students build the internal representations for organizing the mathematical ideas or solving the problem (p. 118). Kastberg (2002) also defines mathematical representations as "ideas in the learner's mind to be informed to the others through four types of representations: written, pictorial, tabular, and oral" (p.6). Hwang *et al*.(2007) define representation as " a modeling process of tangible things in the real world into abstract concepts or symbols"(p.192). Pape and Tchosnov (2001) consider representation as "a process in which there is an interaction between the inputs of the external representation and the brain picture" (p.118).

By reviewing the definitions of representations above, It can be found that some of them refer to the fact that there are internal mind representations which are formed in the learner's mind and difficult to be known, observed or measured, while the others focus on the external representations, describing the representations, which are more familiar and can be observed and measured. The internal and external representations integrate each other in illustrating the mathematical idea or concept. Depending upon the above, the two researchers will use the following definition of mathematical representations: using words, lines, drawings, pictures, and some computerized representations for expressing a mathematical idea or concept of the ratio, proportionality and the percentage.

The importance of the representations in teaching and learning mathematics

Abu As'ad (2010) states that concepts are the base of the Algorithms, the mathematical skills, and the mathematical problems (p.159).

Merrill *et al*. (1992) state that the definition process of the concept needs three activities to define the concept, which are as follows:

1. Define the content that can be used for the concept
2. Define the name or address that can be used for classifying the concept
3. Write a summary definition of the concept.

The concepts are formed from thoughts, reflections and the creative thinking. Each learner has a different mind picture for the concept according to the different experience they are exposed to and their different thinking ways. It should be noted that students of the same grade may have similar concepts as they are exposed to the same experiences within the classroom. However, the extent of concept acquisition is different (Abu As'ad, 2010:163). Hence, the two authors believe that the teacher should decrease such gap between concept teaching and students' acquisition of the concept using different ways to represent the concept through multiple representations which are proposed to the students. He should focus on the formation phases of the concepts such as defining the critical qualities of the concept and an explicit name for the concept.

Mathematical representations are significant to explain and use concepts to students. It is shown through the interest of the National Council of Teachers of Mathematics (NCTM, 2000) in the representation process.NCTM is an authority that is concerned with everything related to educational mathematics in USA. The mathematical representations are mentioned in the Principles and Standards for School Mathematics. These standards have stated that the educational programs from KG to the 12th grade should allow the student to:

A. Find and use representation in order to organize, register and transfer mathematical ideas.
B. Choose, apply and translate mathematical representation in order to answer the problems.
C. Use the representations to show and interpret the physical, social and mathematical phenomena.

Fennel and Rowan (2001) illustrate that students' thinking and representation may significantly vary even in discussing the same idea. One of the students can interpret the mathematical representation or idea in an oral manner. Still another student can show them on decennial basis. In addition, a third student can draw a picture to explain his understanding and solution of the problem. However, other student uses a computer application for representing and solving the problem. The computerized representation may be provided as a geometrical shape which is available in the computer. It may also be drawn and played by the students.

The representation is an important thinking tool. It makes the mathematical ideas more meaningful. It develops the argumentation through helping students in focusing on the important phenomena of the mathematical case. It also helps the student to realize the common main elements among different cases (Al Sawa'e, 2010:144). Huwang *et al*. (2007) confirm that the use of the multiple representations makes the students understand better and think creatively while they are learning, and the teachers should assess the student through problems solving activities by using different types of representation. Therefore, the teachers can know whether the students have misunderstanding of a certain concept. Ozmantar (2010) focuses on using the techniques for providing representations that increase the visual models and help the students in connecting among the different representations to understand mathematics well (p.20).

Delice (2010) mentions in his research findings that students prefer using mathematical representations while they are learning algebra equations and solving the problems. Salkind (2007) clarifies the importance of using mathematical

representations in teaching mathematics in school because they are tangible, imaginative, symbolic, verbal, visual, internal or external in developing communication and solving problems. He states that teachers should use representations in an effective manner while teaching the content to provide a deep knowledge of mathematics (p.11). Mathematical objects are used to represent mathematics like numbers, functions, limits and mathematical operations like summation, subtraction, and integrals (Al Sawa'e, 2010:143). Moulsey (2004) states that the increased use of the concepts of mathematical representations is aimed at developing the learning patterns of the students, which enables students to build knowledge relationships among the concepts. Also, representation is an important tool for thinking since it makes the mathematical ideas more meaningful (p7).

Suh and Moyer (2007) point out to the fact that the various representations boost the learners' understanding of mathematical ideas, When learners translate and reinterpret the ideas of different representations, they make the conceptual communication deeper for the learners (p215). Mousley (2004) shows that the mind is developed though the suitable learning tracks. It is also developed by using tools and activities that enable students to develop their mathematical understanding by increasing the representations of the mathematical concepts to build relationships and instructional scaffoldings and by developing the mathematical language of the students (p.7). The two authors add that concept learning is not just new information that is added to the learners' mind, instead, it aims at building an interaction between the mathematical and environmental knowledge. Within the learning process, the student needs to know how to learn mathematics meaningfully. Furthermore, students can represent the mathematical concepts in different ways such as words, pictures, symbols and tangible things, which can help them to enhance their mathematical thinking skills.

Accordingly, the two authors expect that if the student can express different representations using either verbal communication, pictures, drawings, symbols, or equations, they can understand mathematical concepts well, and transfer his/her understanding of using the concept in other applications, and can use it in solving mathematical problems.

METHOD

The Quasi Experimental Design (pre-post test for two groups) was adopted in the study. The two groups were randomly selected. One of them was assigned as an experimental group, and the other as a control one.

Participants

The sample of the study included (80) students in Mustafa Hafez Elementary School "B" which located in Khan Yunis Governorate during the second term of the school year (2012-2013).

The study sample consisted of two classes which were randomly selected from the school 6th grade classes, one of them was chosen as an experimental group and the other as a control group.

Study Tools

To achieve the study objectives, a framework of the mathematical representations and a concept acquisition test were developed and used. To develop these tools it required to analyze the content of the ratio, proportionality and the percentage units to determine the included mathematical elements and preparing the table of specifications.

The framework included an introduction, general objectives, procedural definition of mathematical representations, content, proceedings, suggested methods, proposed educational subjects and means, and lesson plans. Students' workbook was prepared; it is mostly based on the representations using drawings, pictures, and manipulatives. It consisted of the work sheet which was practiced by the student within the lesson activities. This framework was reviewed by a group of university professors, and then it was modified and written in final draft to be implemented in the study.

The concept acquisition test

To develop the concept acquisition test, table of specification was prepared as follows

The test was applied to Table 1 a group of (40) students as a pilot study; Accordingly, the difficulty coefficients of the test items ranged between (0.25 and 0.58), and the discrimination coefficients ranged between (0.45 and 0.91) . The correlation coefficient between each item of the test and the total score was significance at (0.05) or (0.01), and the correlation coefficients between the score of each domain (objectives levels) of the test and the total score was significance at (0.05) or (0.01) also. According to these results, it can be concluded that the concept acquisition test is highly consistent and valid as a tool for the study. The test reliability coefficient is calculated by Split – Half Method and Kuder–Richardson 20 (KR-20) Formula they were (0.96), (0.897) respectively. This confirms that the test was highly reliable.

Table 1 of Specification

Subjects	Domains	Knowledge	Comprehension	Analysis	Synthesis	Total
	Percentage	40%	36.7%	13.3	10%	100%
Ratio	23.3%	3	2	1	1	7
Ratio as Average	10%	1	1	1	0	3
Proportionality	23.3%	3	2	1	1	7
Scale Drawing	26.7%	3	3	1	1	8
Percentage	10%	1	2	0	0	3
Applications to the Percentage	6.7%	1	1	0	0	2
Total	100%	12	11	4	3	30

Study Findings and Discussions

The following results were achieved according to the study questions:

Table (2) reveals that the table 2 calculated (T) value is higher than the tabled (T) value. The calculated level of significance of T-test is lower than (0.05), so the null hypothesis was rejected and the Alternative Hypothesis was accepted.

Table2 Significant differences between the experimental and control groups In the concept acquisition test post-test

Group	N	Mean	SD	T	df	P value
Experimental	40	21.600	6.460	2.563	78	0.019*
Control	40	17.850	6.620			

*α = 0.05

Table3 Significant differences between the experimental and control groups In the concept acquisition test post-test

Domains	Group	N	Mean	SD	T	df	P value
Knowledge (12 Q.)	Exp.	40	8.175	3.161	0.904	78	0.369
	Control	40	7.525	3.266			
Comprehension (11 Q.)	Exp.	40	8.150	2.304	3.839	78	0.001*
	Control	40	6.175	2.297			
Analysis (4 Q.)	Exp.	40	3.225	1.074	2.080	78	0.041*
	Control	40	2.700	1.181			
Synthesis (3 Q)	Exp.	40	2.050	0.845	2.878	78	0.005*
	Control	40	1.450	1.011			

*α = 0.05

Table 4 References to determine the level of effect size (η 2) and (d)

Test	Effect Size		
	Small	Medium	Large
η 2	0.01	0.06	0.14
d	0.2	0.5	0.8

There are differences on the significant level at (α = 0.05) between the scores means of the mathematical concept acquisition in favor of the experimental group students. This finding may be attributed the great impact of mathematical representations on the acquisition of mathematical concepts.

Table 5 t value, η2 and d for domainsand the total degree

Domains	t	η2	d	Effect Size
Comprehension	3.839	0.1589	0.87	Large
Analysis	2.080	0.053	0.47	Medium
Synthesis	2.878	0.096	0.65	Medium
Total	2.563	0.078	0.74	Medium

The first question is: "what is the suggested framework to teaching concepts using the mathematical representations?". To answer this question, a framework was developed for implementing the mathematical representations in teaching the ratio, proportionality and the percentage units to 6th grade students.

The second question is: "what is the impact of using representations on acquisition of mathematical concepts among 6th graders in the Gaza Strip?" Toanswer this question, the study hypothesis, which is "There are no statistically significant differences at (α < 0.05) between the scores mean of the experimental group and those of their counterparts in the control group in the concept acquisition test."

For investigating such a hypothesis, the researchers firstly applied Levene's test to make sure of the conformity of the two groups, and the level of significance was (0.424). Accordingly, the researchers concluded that the two groups are similar as the level of significance is at (0. 424) is higher than the approved level of significance which is at (0.05). Then, the researchers calculated the means, standard deviations and significant differences between means, using Independent-Sample T-test for the concept acquisition test scores of the two groups (the experimental and the control). Table (2) illustrates the above:

This was obvious when students were able to express their awareness of concepts using different representations either by words, pictures, drawings, manipulatives, etc.

For determining the reason for such differences revealed by the test of concept acquisition between the two groups - experimental and control- , the means, standard deviations and T value were calculated. Moreover, the significant differences of each domain between the two groups are clarified in the following table (3).

Table (3) illustrates the table 3 effectiveness of the mathematical representations for high level objectives. The findings reveal statistically significant differences at level (α < 0.05) for each domain (Comprehension, Analysis, and Synthesis). This means that using the activities of mathematical representations is effective as they can help students to understand the mathematical concepts in a more comprehensive manner and in different aspects. They can also stimulate students and boost their self-confidence and relaxation while doing their assigned activities. Moreover, they facilitated individual and team work, and made students interact with each other using suitable representations to transfer their ideas without being confined to just one representation.

The findings of this table reveal that there are no statistically significant differences of the questions on the knowledge level. This may be because the level of knowledge does not need a high level of thinking. It may also be resulted by the fact that the questions of the knowledge level are literally directed in determining the concept, it is what is so-called the representation using words. This is so common in our traditional teaching manner of concepts. However, the other levels contain different representations of the concept on which the student can depend for a deep understanding while implementing the concept activities of the study experiment.

To calculate the effect size of e book, the researchers used Eta square "η2" by using the following equation: $\eta^2 = \frac{t^2}{t^2 + df}$, and (d) value: $d = \frac{2t}{\sqrt{df}}$ (Pallant, 2005,p. 209)

The following table 4 describes t value, η2 and d for each mathematical thinking sub skills and the total degree

In table (5) it can be seen that the table 5 results of" η2" and " d " were in a large level for comprehension domain, while in medium level for Analysis and Synthesis domains and the test in general. These levels of effect size indicate to the impact of mathematical representation on acquiring mathematical concepts, especially regards to the domains Comprehension, Analysis, and Synthesis. The results can be attributed to the following reasons:

1. The Students' interaction by using the mathematical representations for representing the concepts helped them to illustrate the concepts and use them to build their knowledge.
2. The students' interactions during the groups' activities and using manipulatives representations gave the opportunity for each group member to represent his ideas to the other groups' members.
3. The students' thinking level is highly developed by using the mathematical representations. The students could analyze the information and discover a method to represent the proposed concept. Then, they agreed on the suitable representation.
4. Such activities helped students to realize the mathematical ideas. When the concept is represented to students in a different manner, they can easily realize it.
5. The study results did not reveal any effect of the mathematical representation on concept acquisition at the knowledge level. The reason may be that the questions used for this level contain only the direct representation of the concept as mentioned in the school book and it does not depend on understanding or cognition.
6. This result reveals the impact of using the mathematical representations on the 6th students' acquisition of the mathematical concepts.

This illustrates the role of the mathematical representations in the elementary 6th students' acquisition of the mathematical concepts. This is a different teaching way from the traditional one and students promptly react to it. This finding is similar to that of the previous studies which discussed the influence of the mathematical representations on the acquisition of mathematical concepts. Some of such studies are the studies of Al Balassy and Barhm (2010) and Abrahamson (2006). Such studies confirmed the effectiveness of mathematical representations in acquiring mathematical concepts. This finding is similar also to the studies of Kuchemann *et al*., (2011) and Barmby *et al*., (2011), which confirmed that mathematical representations boost students' comprehension level and help them to have a deep knowledge of mathematics. The findings are in harmony with those of Grossman(2010), which revealed that the representations using drawings, pictures and manipulatives greatly supported solving the mathematical problems.

CONCLUSION

This study has aimed at determining the impact of mathematical representations on the elementary 6th students' acquisition of mathematical concepts. The findings have confirmed the superiority of the experimental group, who learned the ratio, proportionality and percentage units using representations over the control group. This means that the use of mathematical representations gives positive results in acquiring mathematical concepts. Depending on these representations students can integrate between mathematics and real life situations, which makes learning mathematics meaningful and overcome concept misunderstanding in elementary schools. For sure, this can contribute to reform in mathematics teaching reforming in Palestine that is because:

1. Using mathematical representations supports students' learning, enabling them to have instructional scaffoldings and knowledge connections among the mathematical concepts.
2. Types of mathematical representation are important for determining how students understand mathematical concepts and use them in different areas.
3. Moreover, when the student can express his ideas using the suitable and different representations, this will develop his positive attitudes towards mathematics and motivate him to learn it.

Study Recommendations

According to the present study and its findings, the two authors recommend that the teachers should effectively use the mathematical representations either they are manipulatives, pictorial, symbolic, verbal, or visual. Moreover, they can create methods to enhance the elementary students' learning of mathematics. Such methods should comply with the various mathematical representations and focus on the quality of performance. Teachers should train their students within classes in expressing their ideas using the mathematical representations and test the representation. The curriculums planners and developers should adapt the mathematical representations to explain a concept and give sufficient exercises to represent the mathematical idea in various ways.

The present study can be followed by several studies in teaching other subjects like geometry and solving the mathematical problems other studies can investigate the impact of the mathematical representations on other variables such as mathematical thinking skills.

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