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The effect of using computer games in teaching mathematics on developing the number sense of fourth grade students

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The purpose of this study was to investigate the effect of using computer games in teaching mathematics on developing the number sense of fourth grade students. To achieve this purpose a study sample of (81) students was selected from the fourth grade. This sample was divided into two groups. One group was randomly chosen to be the experimental group that studied mathematics using computer games; the other was the control group that studied mathematics using traditional method and without using computer games. The instrument of the study was a number sense test. Data analysis procedures using One-Way ANOVA revealed a positive effect of using computer games in teaching mathematics on developing the number sense of fourth grade students.

Key words: Computer games, teaching mathematics, number sense.

INTRODUCTION

Mathematics, being an abstract science, uses educational methods and aids that aim to make it a likable subject for the students. These methods and aids encourage to more learning and giving the students a part in discovering the mathematical knowledge instead of receiving it directly from the teacher. Among these methods and aids are the instructional games that are considered as an important element of mathematics' curriculum due to their many benefits in the educational process (Panoutsopoulos and Sampson, 2012; Leonard and Tracy, 1993).

Instructional games are suitable tools for teaching different subjects. Many games were developed in many areas to develop skills in languages, science, military and political sciences and many others (Bielaczyc and Kapur, 2010). There are varied forms and types of games that could be used in the educational process, such as: computer games, simulation games, instructional puppets and dramatization (Duatepe, 2005). The students and the teachers' roles differ in these games. The teacher is not the source of the information but the game. The students' failure or success depends on the appropriate strategies that they chose and followed to execute the game. The role of the teacher is limited to monitoring and directing the game execution processes to achieve goals. The teacher also evaluates the students' performances through participating in the game as an individual, then the student's performance in a group, in both cases he has to guide the learning process in the right direction.

Using instructional and computer games in the teaching process requires the teacher to possess special skills in preparing and designing, executing and evaluating games. The games must have the following characteristics: specific learning goals, rules to follow, and must be logical (do not depend entirely on luck). They must depend on good thinking and choosing playing strategies (solution) and not others. They must depend on the element of competition between one student and another

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student, or between a student and a specific criterion. It is important here to decide the result of the competition in the game (deciding who is the loser and who is the winner).

In mathematics, instructional and computer games are used to teach and learn concepts, generalizations, skills and mathematical problems solving. They are also used as an interesting introduction for a mathematical subject and to enhance students' motivation for learning mathematics and eliminate the elements of boredom that might affect students most of the time (Tan et al., 2010). Instructional and computer games play a very important role in discovery learning and in teaching mathematics for disabled students (Oldfield, 1991). Instructional and computer games have a positive effect on mathematics retention and help students in employing mathematics in new situations (Akinsola and Animasahun, 2007; Leonard and Tracy, 1993). The instructional and computer games help students to communicate and interact through learning mathematics, and work on the development of their social skills. Students are allowed in most games to work with their colleagues as a whole team; the students in these games works as a member in a team that enables him/her a lot of skills in dealing with others and in dealing properly with individuals outside school (Wanko, 2010; Nevin, 1992).

Using computer games in teaching mathematics help to offer mathematics in an interesting and fun way for students. Students will explore, through these games, the beauty and excitement underlying in mathematics subject. Using computer games in teaching mathematics have a positive effect on students' achievement in mathematics and improve their motivation to learn mathematics (Kebritchi et al., 2010; Wei and Hendrix, 2009; Huang and Ke, 2009).

Numbers and their arithmetic processes are the main subject in mathematics' curriculum in all educational stages in general and in the elementary stage in particular (Naylor, 2007). All of that come from the fact that numbers are the core of mathematics in all its different branches. Numbers and their arithmetic processes are presence in our life; we find that it occupies very important parts of our life in its different fields and in various daily activities. For that, we find that modern mathematics' curricula pay special attention to develop the number sense for students; especially for the elementary stage (Wiest, 2006). It aims to give students the numerical culture of understanding, writing, reading, and representing numbers. It develops their mental computation. It develops their ability to employ numbers and their arithmetic processes in real life situations and different applications (NCTM, 1989).

Number sense is an important part of mathematics and of the main goals of teaching mathematics; its importance for learning mathematics is equal in the importance of the writing and reading for learning language. Number sense is the way and the first step to learning mathematics (Naylor, 2007; Howell and Kemp, 2009). It is the main prerequisite for developing the mathematical ability for students and enhancing their achievement in mathematics (Bobis, 2008). The importance of developing the number sense for students in all different educational stages comes from here, and so it is necessary to work on giving the mathematics teachers the teaching skills and qualifications and providing all chances to help developing the number sense for their students (Muir, 2012; Der-Ching, 2007; NCTM, 2000; Cain, 2009; Faulkner, 2009; Griffin, 2004).

Although the researchers and educationalists working in the mathematical field agree on the importance of developing the number sense for students, there is multiple views on the concept of the number sense and specifying its components and skills accurately (Griffin, 2004; Howell and Kemp, 2009). On that point, Malofeeva and others specified the skills of number sense as follows: counting, number identification, addition and subtraction (Malofeeva et al., 2004). Naylor (2007) pointed out that number sense includes the following skills; size of numbers, meaning of numbers and relationships between numbers. Aunio et al. (2004) gave number sense the following skills: counting skills and relation skills.

Jordan and others defined the number sense skills as follows: counting, number knowledge, estimation, comparison, nonverbal calculation, number representation and transformation and story problems (Jordan et al., 2006; Jordan et al., 2007; Jordan, 2007). Faulkner (2009) pointed out the following skills for the number sense: estimation, mental computation, comparison, differentiation between a number of number's symbols and identifying unexpected outcomes. Bobis (2008) classified number sense skills as follows: numbers' relations, calculations, estimation and approximation, mental computation, place value and writing the number in different forms. Sood and Jitendra (2007) classified number sense skills as follows: counting, numbers' relations and connecting numbers to life. Wiest (2006) pointed out that the following skills are for the number sense: counting, representing numbers, number's relations and place value. Bay (2001) and Schneider et al. (2008) pointed out that number line estimation is a basic indicator to the development of the number sense for the students.

Based on the importance of developing the number sense for students, a number of researchers worked on developing the number sense for students in different educational stages by using several methods and techniques. Lee and others' study pointed out the positive effect of internet learning programs on developing the number sense for students (Lee et al., 2008). Der-Ching (2003, 2006) pointed out to the efficiency of using realistic settings and practical teaching strategies in teaching mathematics to develop the number sense for fourth and fifth grade students. In another study, Der-Ching (2005) pointed out to the efficiency of using the mathematical diary writing on developing the number

sense for students. And in another study, the results of Der-Ching (2010) study indicated that integrating technology into mathematics teaching and learning has a positive effect on promoting students' number sense, and also on towards learning number sense. Leonard and Campbell (2004) pointed out to efficiency of using commercial context (stock market) in teaching mathematics on developing the number sense for students in the middle schools in the United States. Aunio et al. (2005)' study aimed to improving the level of number sense and improving mathematical thinking for kindergarten students through preparing special programs for that. The results showed that the program succeeded in improving the number sense for students directly after finishing the implementation of the program. The results also showed that there was no effect of the program on developing the mathematical thinking of the kindergarten students. Ramani and Siegler (2008) in their study proved that linear number board games helped low income preschool children in enhancing their number sense. They made the children play for one hour every day on the following skills; number magnitude comparison, number line estimation, counting, and numeral identification. The study lasted for 9 weeks and there was an improvement in their skills in comparison to their classmates who were taught in school traditionally.

Problem of the study

Number sense is one of the most important aims of teaching Mathematics. It is considered the first step to learning mathematics. It is also a prerequisite for developing the mathematical ability and enhancing the mathematics achievement of the students. This shows the importance of developing number sense skills for students in all educational stages in general and in the elementary stage in particular.

The current study comes to participate on the development of number sense skills for the fourth grade students by using computer games in teaching mathematics.

Question of the study

The study tried to answer the following question: What is the effect of using computer games in teaching mathematics on developing the number sense of fourth grade students?

Hypothesis of the study

There is no statistical significant difference ($\alpha = 0.05$) in number sense test between the experimental group that studied mathematics using computer games, and the control group that studied mathematics using traditional method.

Terms of the study

Computer games

Mathematical games practiced through computer for specific educational goals. It has laws that governs it and must be followed. These games depend on the element of competition between one student and another student, or between a student and a specific criterion. These games introduce a mathematical lesson, leads to a discovery of a mathematical generalization, practicing a mathematical skill or solving a mathematical problem. These games were prepared and designed by the researchers, and were used in teaching the fraction unit from the fourth grade mathematics textbook.

Number sense

It is the general understanding of numbers and its arithmetic processes and that is through acquiring the following skills: reading and writing numbers, identifying numbers, comparisons and relations between numbers, arithmetic processes (addition, subtraction, multiplication, division), representing numbers in different forms, estimation and evaluating mathematical solutions and statements.

The study limitations

The number sense skills of the students were measured through a number sense test prepared by the researchers, so the results are connected to the test questions from its validity and suitability to the subject.

METHOD AND PROCEDURES

The study population

The population of the study included all of the fourth grade students in the governmental male schools of education directorate in the second Amman region in Amman city, who are attending the schools in the first semester of the scholastic year 2011/2012, their number is (3653) students.

The study sample

The study sample consisted of (81) fourth grade students. This sample was divided into two groups. One group was randomly chosen to be the experimental group (consisted of 39 students) that studied mathematics using computer games, the other was the control group (consisted of 42 students) that studied mathematics using traditional method and without using computer games.

The study instrument (the number sense test)

To answer the question of the study, the researchers prepared a test to measure the skills of number sense. The researchers

Table 1. Means and standard deviations of the control and the experimental groups in the number sense pre-test.

Group	Number	Mean	Standard deviation
Experimental	39	4.15	2.20
Control	42	3.97	2.16
Total	81	4.06	2.17

prepared it by referring to educational literature and studies about the skills of number sense. This test measured the following skills of number sense:

(1) Reading and writing numbers:
Example:
- Write the fraction three quarters in numbers.
- Write the fraction 7/9 in words.
(2) Identifying numbers:
Example:
- Find two fractions where the result of their multiplication is equal to the difference between them.
- Put the right number in the gab: 1/2, 2/3, 3/4, 4/5,…...
(3) Comparisons and relations between numbers:
Examples:
- Put the following numbers in the right order: 2/5, 3/4, 1/2, 7/8.
- Which of the following is bigger: (5/8) -1 or (3/8) -1.
(4) Arithmetic processes (addition, subtraction, multiplication, division):
Example:
Find the result of the following:
- (5/6 + 2/9) ÷ 1/4 =
- 2/3 × (4/7 – 1/8) =
(5) Representing numbers in different forms:
Example;
- Turn the following into a fraction 7 2/3.
- Represent the fraction 5/6 by using two numbers and one arithmetic process.
(6) Estimation:
Example:
- If the length of a boy of ten is 1 1/2 m, how much would he be on twenty?
(7) Evaluating mathematical solutions and statements:
Example:
What is wrong in the following?
- 3/8 +2/5 = (3+2)/(5+8) = 5/13
- 15/8 ÷ 3/2 = (15÷ 3)/(8÷2) = 5/4

The validity of the instrument

To ensure the test validity, the questions of the test were presented to several experts specialist in mathematics curricula and educational psychology from the professors in the Jordanian universities. The necessary changes were done according to the suggestions and the remarks of the judges, so the final form of the test has done. The total mark of the test was 40.

The reliability of the instrument

To ensure the test reliability, the researchers applied it to a pilot sample of (35) students excluded of the study sample with a three-week period between the first and second time it was applied. The reliability of the test was calculated using correlation coefficient and it was found (0.86) which is suitable for conducting such a study.

Procedure of the study

The study has been accomplished in the following steps:
- After choosing the study sample, the teacher was trained to do the procedures in executing the mathematical games through computer, and testing these procedures on a pilot sample to solve problems that might show during the execution.
- Before executing the experiment, the number sense pre-test was applied to both the control group and the experimental group and that is to check the equivalence of the two groups in the number sense skills before executing the experiment.
- The study was executed during the first semester of the scholastic year 2011/2012 were the experimental group studied using computer games and the control group studied using the traditional method and without using computer games.
- After finishing the experiment, the number sense post-test was applied on both groups to answer the question of the study and testing its hypothesis.

Statistical analysis

To answer the study question, SPSS statistical program for social sciences was used. The following statistical analyses were used: means, standard deviations and One-way ANOVA.

RESULTS

First) the results related to the number sense pre-test:

Before executing the experiment, the number sense pre-test was applied to both the control group and the experimental group and that is to check the equivalence of the two groups in the number sense skills before executing the experiment. Means and standard deviations were calculated and the results are shown in Table 1.

It is noticed from Table 1 that there is a difference between the means of the two groups in the number sense pre-test. The mean of the experimental group was (4.15), while the mean of the control group was (3.97). To know if the difference between the means has a statistical significance, One-way ANOVA was used, the following results have been reached and illustrated in Table 2.

It is noticed from Table 2 that the calculated value of F is not statistically significant at the level ($\alpha = 0.05$), and that shows that there is no significant difference between the means of the two groups in the number sense pre-test. We conclude that the two groups are equivalent in number sense skills before executing the experiment.

Secondly) the results related to the number sense post-test:

To answer the question of the study and to test its hypothesis, the number sense post-test was applied to both the control group and the experimental group.

Means and standard deviations were calculated and the

Table 2. The results of One-way ANOVA to compare between the means of the control and the experimental groups in the number sense pre-test.

Source of variation	Sum of squares	Degree of freedom	Average of squares	Value of calculated (F)	Statistical significance
Between the groups	0.638	1	0.638	0.133	0.716
Inside the groups	378.053	79	4.785		
The total	378.691	80			

Table 3. Means and standard deviations of the control and the experimental groups in the number sense post-test.

Group	Number	Mean	Standard deviation
Experimental	39	27.43	5.69
Control	42	22.64	7.71
Total	81	24.95	7.19

the results are shown in Table 3.

It is noticed from Table 3 that there is a difference between the means of the two groups in the number sense post-test. The mean of the experimental group was (27.43), while the mean of the control group was (22.64). To know if the difference between the means has a statistical significance, One-way ANOVA was used, the following results have been reached and illustrated in Table 4.

Table 4 illustrates that there is a significant difference between the means of the control and the experimental groups in the number sense post-test, where the calculated value of F was 9.997 which is of statistically significant at $\alpha < 0.05$. This difference is in favor of the experimental group that studied mathematics using computer games, where the mean of the experimental group was 27.43, while the mean of the control group was 22.64.

DISCUSSION

This study aimed to answer the following question: What is the effect of using computer games in teaching mathematics on developing the number sense of fourth grade students?

This question resulted in the following hypothesis: there is no statistical significant difference ($\alpha = 0.05$) in number sense test between the experimental group that studied mathematics using computer games, and the control group that studied mathematics using traditional method.

The results of the One-way ANOVA shows that there is a significant difference between the means of the two groups in the number sense post-test, where the calculated value of (F) was of statistically significant at $\alpha < 0.05$. This difference is in favor of the experimental group that studied mathematics using computer games. This result shows that the hypothesis of the study was rejected.

Previous result shows the positive effect of using computer games in teaching mathematics on developing the number sense of fourth grade students. The researchers found that this might be due to the following reasons:

- Computer games enhance the motivation of the students and draw their attention to learning mathematics by eliminating the elements of boredom that might occasionally face the student, all that is done by finding an educational environment full with fun, excitement and competition. Thus, putting a mathematical skill in a game help the students in acquiring this skill in a better and faster way than the traditional method they are used to. It is referred to the fact that most students want to play games in mathematics than doing it in the traditional method, which means they will receive what the game contains of mathematical knowledge.
- Computer games allow all students to participate according to their potentials and despite their differences. Discovery computer games certify the role of the student in the educational process and that is through making him think deeply and participate in producing mathematical knowledge and not only receiving it from the teacher, which reflect positively on developing the number sense skills for these students.

Recommendations

- Encouraging the educational administration to provide mathematics teachers with computer games websites and software that are suitable for the mathematical content of different grades.
- Encouraging mathematics teachers to use computer games in teaching mathematics for different grades.
- Doing more researches to reveal the effect of using computer games in teaching other subjects other than mathematics and for different grades.
- Doing more researches on the number sense such as; developing teaching methods and evaluation and assessment methods and techniques to develop the number sense skills for students.
- Working on analyzing the content of the mathematics scholastic textbooks to reveal their ability to develop the

Table 4. The results of One-way ANOVA to compare between the means of the control and the experimental groups in the number sense post-test.

Source of variation	Sum of squares	Degree of freedom	Average of squares	Value of calculated (F)	Statistical significance
Between the groups	464.570	1	464.570	9.997	0.002 *
Inside the groups	3671.233	79	46.471		
The total	4135.802	80			

*Of statistically significant at $\alpha < 0.05$

number sense skills for students.

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