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ScienceDirect

Procedia Social and Behavioral Sciences 15 (2011) 961–965

Procedia Social and Behavioral Sciences

WCES-2011

The effect of teaching the subject of Fibonacci numbers and golden ratio through the history of mathematics

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Abstract

This study aims to determine the influence of teaching Fibonacci numbers and golden ratio through history of mathematics on student achievement and the opinions of students regarding this issue. This study was carried out by case study method with 30 students who attended the 8th grade of an elementary school in Erzincan in spring term of 2009-2010 school year. Data were collected with performance test and a questionnaire form composed of 5 open-ended questions. The results showed that teaching Fibonacci numbers and golden ratio which was integrated with the history of mathematics had a positive effect on student achievement.

Keywords: Mathematics education; history of mathematics; golden ratio; Fibonacci numbers; primary school

1. Introduction

Augustus de Morgan, the first chairman of London Mathematical Society delivered the following speech at the opening ceremony on the 16th of January, 1865: "*Unless a field of science or art is related to human history, human being can not be free and broad minded. It is quite astonishing that mathematicians talk about mathematics though they do not know anything about the history of mathematics. Claiming that they know the realities, these people damage historical tendency. Every person has certain historical knowledge in his / her own mind and imagination."* (Weng Kin, 2008). In his speech, De Morgan points out that one needs to know the history of mathematics in order to have a noteworthy word about mathematics.

Recent studies in the history of mathematics lay stress on the fact that the history of mathematics is fundamental to mathematics teaching. Thanks to the vast culture and wide knowledge held within the history of mathematics, it becomes easier to understand the abstract concepts of mathematics which is thus longer a subject arousing fear and concern. According to Gulikers and Blom (2001), the history of mathematics can be applied in educational cases to create a lively classroom atmosphere and to add vitality to mathematics teaching. According to Perkins (1991),

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1877–0428 © 2011 Published by Elsevier Ltd.
doi:10.1016/j.sbspro.2011.03.221

through the history of mathematics, lessons can be taught in a more interesting way, which will thus bring about more achievement. Moreover, knowledge of the historical development of mathematics helps us to see the philosophical, scientific and social content of mathematics and to have a better understanding of mathematics (Grabiner, 1975).

Using the history of mathematics in classrooms does not warrant a great achievement in classes but it transforms mathematics learning into a meaningful and lively experience. Thus, it will become easier to learn and the student will have more profound understanding. A teacher, who is acquainted with the historical development of mathematics, will be more patient, humanist and less arrogant (Siu, 1997).

The goal of this study is to determine the influence of teaching Fibonacci numbers and golden ratio through history of mathematics on student achievement and the opinions of students regarding this issue. It is really sad that students do mathematical operations through numbers, symbols and concepts though they do not know what these operations serve for in practice. However, mathematics is an interdisciplinary science. It can influence other branches of science, as well. Mathematics is a subject that can be applied in daily life and that can be explained through examples from daily life. Another objective of this study is to take mathematics away from its traditional and entrenched structure and to demonstrate that mathematics is a lively branch of science with its real presence in nature. Actually, Fibonacci numbers can be seen in many places in nature such as in pine cones, daisies, sunflowers and tobacco plants...Similarly, the golden ratio can be seen in nature and even in alive beings. It can be seen on human face, teeth, fingers, arms, flowers, sea shells, snails, chairs, cars, works by Mimar Sinan and Anıtkabir... Through Fibonacci numbers and golden ratio, students will be able to see that mathematics is an entertaining and likeable course.

2. Method

Case study method was used in this study. Case studies enable in-depth investigation of a single or a number of cases, phenomena or events with a limited sampling (Çepni, 2007). During this process, the setting, individual or processes are investigated holistically and the roles and relations draw the main focus (Yıldırım & Şimşek, 2005).

2.1. Participants

The study was carried out with 30 students enrolled at the 8^{th} grade of a school in Erzincan in the spring term of 2009-2010 school year.

2.2. Data collection tools

The data of this study were collected through 5 open-ended questions and a performance test of 15 questions developed via the subjects of Fibonacci numbers and golden ratio. In order to ensure content validity, the questions of the performance test were shown to 3 primary mathematics teachers and 2 academicians studying on mathematics education. Also, the elementary mathematics curriculum of Ministry of National Education was taken as a reference to ensure that test questions were suitable to the level of the 8^{th} grade primary students. In order to calculate the reliability of the test, a pilot study was conducted. Thus, it was investigated whether students had any difficulty in understanding the questions in the test and the necessary time to answer the test. A total of 50 students studying in the 8^{th} grade classes of a primary school in Erzincan participated in the pilot study. As a result of the pilot study, reliability coefficient and discrimination index for every item included in the test are calculated using appropriate formulas. As a result of these calculations, the items whose discrimination index is under 0.30 are excluded from the study. The Cronbach's alpha reliability coefficient of the test was found as 0.91 by using SPSS 15. 4 worksheets of study were developed. In the 1^{st} worksheet, the life story of Fibonacci was told and open-ended questions were added to the end of this text. The 2^{nd} worksheet was about the rabbit problems determining Fibonacci number series in Fibonacci's book titled "Liber Abaci." The first 5 digits of the rabbit problem were depicted, and the students were asked to fill in the rest. The 3^{rd} worksheet of study was composed of an activity demonstrating the relation between Fibonacci number series and Khayyam's triangle. The 4^{th} worksheet was about the Fibonacci number series present in pine cones and achillea millefolium plant.

2.3. The implementation of data collecting tools

Students worked on the activities in two pairs throughout the performance. First, the activity of Fibonacci's life story was practiced. Then, the rabbit problem was presented to the students as a historical problem. After that, two activities which demonstrated the relation between Fibonacci number series and Khayyam's triangle were distributed. Lastly, the activity demonstrating the relation between Fibonacci number series and nature was applied to the students. Here, the goal was to examine the influence of pine cones and tree branches on the activity. Each student given a pine cone was asked to draw the spiral numbers on the pine cone and thus to reach Fibonacci number series on the pine cone. Moreover, students watched a video about Fibonacci number series and golden ratio. At the end of the application, a survey of 5 open-ended questions was distributed to receive students' opinions on the course. The performance test was applied to the study group, as a pre-test a month prior to and as a post-test immediately after the intervention.

2.4. Data analysis

The scores students got on the performance test were analyzed through a dependent t-test. The students' answers to the survey questions were analyzed by researchers according to their similarities and differences independent of each other. Then, the codes and themes composed by researches were analyzed and discussed to form common codes and themes (Yin, 1994).

3. Results and Discussion

This section includes the data collected through the performance test and the survey questions.

3.1. The findings obtained from the performance test

Table 1 shows the results of dependent t-test which was applied to determine whether there was a significant difference between the scores students got in the pre-and post-tests.

Table 1. The results of dependent t-test in relation to the pre-and post-tests

Tests	N	Mean	Sd	df	t	p
Pre-Test	30	53,111	16,186	29	-3,644	0,01
Post-Test		68,889	14,682			

It has been seen that there is a significant difference between the student scores on the pre-and post-tests with a level of $p < 0.05$ (Table 1). In the dependent t-test, teaching Fibonacci number series and golden ratio associating them with the history of mathematics increased the rate of student achievement ($t_{(29)} = -3.644$, $p < 0.05$). This case is in parallel with the study by İdikut (2007). In addition, it can be noted that the materials applied were effective on students to understand the subjects of Fibonacci numbers and golden ratio.

3.2. The findings obtained from the questionnaire form

Table 2 shows the responses of the students to the question *"How useful were the information taught during courses? Why?"*

Table 2. Remarks about the usefulness of the information taught during courses

Theme	Codes	Frequency	Supporting Sentence
Usefulness	Comprising useful information	18	The lesson was full of useful information in daily life.
	Understanding that mathematics exists in the nature	7	Because mathematics reminds me of not only calculations but also samples from the nature.
	That information is interesting	5	What the teacher said was very interesting and attractive. I liked it so much.

It can be seen that as to the usefulness of the course, students have such remarks as the existence of mathematics in nature, getting new and interesting information about subjects.

Table 3 shows the responses of students to the question *"How effective was the way the lesson was taught? Why?"*

Table 3. Remarks about how effective the way the lesson was taught

Theme	Codes	Frequency	Supporting Sentence
How the Lesson was Taught	Comprehending the lesson better	15	I comprehended the lesson better.
	Gaining new information	6	It was effective because I learned new themes.
	Ensuring active participation	5	I participate the class as I asked permission to speak.
	That the teaching was elaborate and illuminating	4	The lesson was very illuminating.

It can be seen from the remarks of the students about the way the course was taught that the code of understanding the lesson better comes to the forefront.

Table 4 shows the responses of the students to the question *"Did you find anything interesting about mathematics while doing the activity? If you did, why do you think they were interesting?"*

Table 4. Surprising points as to mathematics throughout the study

Theme	Codes	Frequency	Supporting Sentence
Surprising Points	Golden ratio	11	In Fibonacci number series, very similar values are obtained when the number is divided into the number before it.
	Fibonacci number series and areas of usage	4	I got surprised that pine cone and sunflower have the Fibonacci number series.
	The relation between the Fibonacci number series and Khayyam's triangle	4	That the Fibonacci number series exists in Khayyam's triangle.
	Pine cone activity	4	I got surprised about the spiral numbers in pine cone.
	The importance of M-mathematics in nature and daily life	2	That mathematics is profoundly related to the nature made me surprised.
	The life of Fibonacci	3	That Fibonacci was taught by a Muslim person and he introduced the numbers to Europe.
	The problem relating to the rabbits	2	Mathematical result of breeding of the rabbits was very interesting.

Concerning the study, what students found most interesting is golden ratio. They were also fascinated by the cone pine activity, and the usage places of Fibonacci number series in nature since these showed the place of mathematics in their daily life. Students found the life story of Fibonacci interesting since he was the person who conveyed what he learned from Muslims to Europe.

Table 5 shows the responses of the students to the question *"What do you think of the materials used in this study? Why?*"

Table 5. Remarks about the materials used

Theme	Codes	Frequency	Supporting Sentence
Content of the Materials	Being illuminating and helpful for comprehending	16	Activities made us comprehend better.
	Giving information about the history of mathematics	7	The history of the theme was given besides visual components as material.
	That visuality has priority	4	Everything was visualized.
	Supplying satisfying information	3	It was very effective, as I got enough information.

It can be seen that most of the students found the materials explanatory and understandable. Especially, it was very effective to have visuality at the forefront bringing a pine cone to the classroom and finding the Fibonacci numbers on it.

Table 6 shows the responses of the students to the question *"What do you think the differences between this class and your former classes are? Please explain."*

Table 6. Remarks as to the points making this study different than the earlier mathematics classes

Theme	Codes	Frequency	Supporting Sentence
Differences	That it was not dependent on only calculations	10	For mathematics classes are based generally on formulas and calculations, the materials made this class very different.
	Teaching historical developments of the themes	8	I have learned historical information about the themes in this class.
	That the lesson was thought in a concrete way	7	Mathematics class is considered as abstract, but this class was thought concretely.
	That different information was given	5	We have learned very different information from the mathematics classes.

It can be seen that it is not a course merely dependent on operations. Also, the history of mathematics came to the forefront during the courses. These are the most distinctive differences between this course and other courses.

4. Conclusion and Recommendation

In this study, how teaching Fibonacci number series and golden ratio through history of mathematics influenced the student achievement and what students think regarding this issue were determined. The conclusions drawn through this study and the suggestions offered are:

It has been concluded that mathematics teaching through materials developed with the history of mathematics increased the rate of student achievement. Moreover, it has been seen that students found history integrated courses entertaining. They said that they had never experienced such an application and the materials developed facilitated learning. Thus students found that mathematics was not based merely on operations or formulas, and mathematics had a historical background, as well. Based on these conclusions, it is suggested that more studies into the influence of the history of mathematics on student achievement should be carried out. Activities about the history of mathematics subjects should be prepared and practiced in classrooms. Furthermore, teachers should be informed about the importance of the history of mathematics through courses of in-service training and more participation in these courses should be encouraged.

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