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The effect of teaching using multimedia on mathematical anxiety and motivation

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ABSTRACT

In Iran and many other parts of the world, teaching and learning mathematics has confronted students and teachers with many challenges such as lack of motivation and increased anxiety. Thus, the current situation should be changed and shifted to active methods. One of the active methods is teaching with the help of multimedia. The purpose of this study was to investigate the effect of teaching using multimedia systems on the students' motivation and anxiety in mathematics. The method is a quasi-experimental with pretest and posttest design with a control group. Based on the available sampling, two classes were selected and a class was randomly assigned to the experimental group and the other to the control group. The tools were questionnaires on mathematical anxiety and motivation. In 8 sessions, using multimedia systems, the experimental group was taught, but in the control group, the same concepts were taught in a conventional way in Iran. In the end, Mathematical Anxiety and Mathematical Motivation Questionnaires were performed on both groups. The results showed that there was a significant difference between the two groups in each of the dependent variables and the use of multimedia systems has affected the students' motivation and anxiety in mathematics.

INTRODUCTION

Learning math depends on many factors such as time and quality of education. However, lesser-known factors, such as affective domains, also play a remarkable role (Foley et al., 2017). In other words, students' emotional characteristics such as interest, attitude, motivation, and anxiety are as important as cognitive characteristics of individuals in learning mathematics (Neslihan & Cagan, 2020; Ng & Teoh, 2019; Kpolovie et al., 2014).

Mathematical anxiety is one of these affective factors that interfere with mathematical academic achievement. Math anxiety refers to a kind of fear, tension, and apprehension that some people experience when dealing with math, and students who are math anxiety may feel worried or disgusted with math (Ramirez et al., 2018). According to research, math anxiety is negatively related to math performance, and students with above-average math progress have a math anxiety level below-average (Gunderson et al., 2018; Ramirez et al., 2018; Foley et al., 2017; Ramirez et al., 2016). Seemingly, the excessive amount of anxiety causes students to avoid learning mathematics, which has a negative impact on their mathematical progress and career future (Ramirez et al., 2016). Anxiety in general and mathematical anxiety, in particular, can increase the level of distraction, and irrelevant and disturbing thoughts in people. Anxiety can also disrupt a person's mental structures and make them hate math (Ramirez et al., 2018).

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According to Hassani-Zangbar and Livarjani (2017), people who are very anxious about math face negative feelings when engaging in math, which disrupts their performance. They often need more time to respond and also make more mistakes when solving the problem in the comparison with people who have less math anxiety. They are less likely to get involved in problem solving and answering math tasks, which causes learning not to be done properly. People who are very anxious about math face negative feelings when engaging in math, which disrupts their performance. These people usually need more time to respond and also make more mistakes when solving the problem in comparison with people who have less math anxiety. These people are less likely to get involved in problem solving and answering math tasks, which causes learning not to be done properly (Nolting, 2012; Beilock & Willingham, 2014). Also, anxious math learners with good math performance tend to lose their confidence due to anxiety and do not employ their maximum effort, which leads to distraction and error (Soltanlou et al., 2019). Therefore, strategies should be adopted to reduce the excessive anxiety of learners in mathematics.

Mathematical anxiety can be a result of weak math ability and performance. In other words, a student with low math ability refuses to do math homework and attend math classes, which leads to math avoidance and ultimately to mathematical anxiety (Ramirez et al., 2018). Of course, this can only be one of the effective factors. Due to individual differences, there is a wide range of factors that underlie this situation (Arem, 2010; García-Santillán et al., 2017). These factors include educational methods, genetics, environmental and social factors, such as teachers, math classroom (Ramirez et al., 2018), parents, and gender (Ramirez et al., 2018; Foley et al., 2017).

Ali and Hassan (2019) state that teaching and learning mathematics is a complex process and requires the creation of a mentally healthy environment to do math; a space that fosters mathematical thinking skills and meaningful understanding of mathematical concepts .To develop such an environment, in addition to reducing anxiety, other emotional factors must be considered as well. One of the most important factors is to create interest and motivation in learners (Ali & Hassan, 2019).

The driving force that triggers, maintains and directs behavior is called motivation (Saif, 2020). In other words, the external or internal forces that are exerted on a person and direct his actions are called motivation (Gonçalves, 2018). Motivating students to do math, which is called math motivation, is a critical element in the process of learning math, (Neslihan & Cagan, 2020) and can be the reason for pursuing math or related subjects. It can be said that mathematical motivation is a person's desire to learn, work with mathematics, and succeed in performing mathematical activities (Schukajlow, Rakoczy & Pekrun, 2017) which can have an essential impact on students' learning. Many psychologists confirm that motivation is a key factor in any action, and in particular, the learner's motivation to learn math is effective in the quantity and quality of learning (Gunderson et al., 2018). Students desire to learn topics that they are interested in and become more successful when they are motivated. On the other hand, very motivated students have more academic success than those who have low motivation (Karuniakhalida et al., 2019; Saif, 2020; Hannula et al., 2016). Also, according to research in this field, mathematical motivation is one of the most important factors in the development of mathematics over the years (Hannula et al., 2016).

The method and process of presenting mathematical content can be one of the most essential factors affecting the motivation and anxiety of learners. Not using appropriate teaching methods by teachers and uniformity of teaching methods is one of the factors impairing the students' motivation and increasing mathematical anxiety. Good learning requires the design of appropriate teaching methods and learning tools; in other words, attention to the two main components of appropriate teaching methods and learning media is of particular importance (Widodo, 2018). Teachers need to consider innovative methods and strategies. For students, math is a difficult subject that requires proper learning media to focus on their attention to learning math, increase interest, and deepen understanding. Teaching basic math concepts requires the use of amusing learning methods to enhance learners' understanding, one of which is the development of interactive multimedia learning (Pardimin et al., 2018). According to the research results, multimedia tools can be used as one of the appropriate teaching methods to decrease mathematical anxiety (Khaleji-Pirbalouti, 2015; Hadadian, 2013; Soewardini et al., 2018) and increase the motivation of students in mathematics

(Hosinzadeh et al., 2019; Anwari, 2018; Jangizehi, 2017; Khaleji-Pirbalouti, 2015; Arbabi, 2015; Ogochukwu, 2010) that should be further investigated.

Educational media includes tools and instruments that have an educational purpose and transmit the educational message from the sender to the recipient that can be used to implement instructions and facilitate students' achievement of educational goals. This tool can help create a more effective learning situation (Capuno et al., 2019). In this type of media, the message is delivered by the teacher and accepted by the students by stimulating thoughts and feelings along with their attention and concentration to encourage the learning process. The messages or information provided by the educational media are often prepared in form of messages to meet the learning and educational needs of students in a way that learners can actively participate in the learning process (Widodo, 2018). Educational media can be categorized into different categories: audio, visual, audio-visual, and multisensory media.

In the process of learning, human beings obtain the basic information they require through the five senses with the help of the environment. Each of our senses provides us with various aspects of the environment, whose deficiency interferes with adaptation to the environment. Some phenomena may be identified by only one or two senses, but sometimes more senses need to be used. Most learning occurs when the learner uses most of his/her senses and this is done through direct experience, manipulation, observation, and direct contact with the subjects (Amir-Teimuri, 2015). Today, educational media is very different from the past; today's students are born into the age of information technology and communication and the world of audio-visual media, so their education will not be fruitful using the old-fashioned educational methods and media. Teaching and learning with new technologies is one of the important, dynamic, and related issues of the educational system (GebreYohannes et al., 2016). With the advent of information technology and communication, the use of multimedia in education has also increased (Zaini et al., 2010). This type of media refers to any software and interactive program that integrates text, color, graphics, animation, audio, and video into a single application. Multimedia technologies are one of the modern innovations in the information age, the rapid growth of which has brought about fundamental changes in the education system (GebreYohannes et al., 2016).

Junior high school students are in the abstract stage of cognitive development, but many are not yet fully capable of formal thinking. At this level, they cannot completely think abstractly, and some of them are in the operational stage, so they need to use intuitive and objective examples to understand mathematical concepts (Widodo, 2018). One of the limitations of common teaching methods is the impossibility of displaying 3D graphics and images, which can solve this problem in multimedia education and is more effective than conventional methods (GebreYohannes et al., 2016). In addition, the use of multimedia in the classroom has other benefits. Studies have shown that learning in this way takes less time, is more enjoyable, increases understanding, enhances students' positive motivation toward math (Zaini et al., 2010), and reduces the anxiety of attending math classes (Khaleji-Pirbalouti, 2015). In general, it can be said that learning based on multimedia systems is more effective and successful than traditional and conventional methods (Capuno et al., 2019; Widodo, 2018; GebreYohannes et al., 2016).

Despite the great impact of this method in teaching and learning, so far little research has been done on teaching with the help of multimedia in the field of mathematics education in Iran. Due to the importance of being aware of the effects of using multimedia on students' mathematical anxiety and motivation in education, especially mathematics education, it is necessary to conduct more research in this field. The present study investigates the effect of teaching using multimedia on mathematical motivation and anxiety, so that educational designers, curriculum planners, education experts, teachers, and other researchers in this field implement the results to improve the process of mathematics education in Iran. To achieve this purpose, the research hypotheses are:

1. Teaching using multimedia influences math anxiety and math motivation of the seventh-grade students.
2. Teaching using multimedia decreases seventh-grade math anxiety.
3. Teaching using multimedia increases the math motivation of the seventh-grade students.

METHODS

The purpose of this study was to investigate the effect of using multimedia systems on students' mathematical motivation and anxiety by employing a quasi-experimental method with pretest and posttest design with a control group. Two classes respectively including 27 and 30 students were selected by the sampling method. One class was randomly assigned to the experimental group and the other to the control group. The experimental group students were aware of the research and expressed their willingness to collaborate and participate in the research. Mathematical anxiety and mathematical motivation questionnaires were used to collect data.

The Mathematical Anxiety Questionnaire was designed based on the Ferguson Questionnaire (1986) as well as the study of internal research questionnaires in Iran (e.g., Nowrouzi, 2014; Fathi, 2013). Finally, a questionnaire consisting of 22 items with a five-point Likert scale was scored (1 = very low anxiety, 2 = low anxiety, 3 = medium anxiety, 4 = high anxiety, and 5 = very high anxiety). The sum of the scores of the items indicates the level of students' mathematical anxiety, which can be a minimum of 22 and a maximum of 110. This questionnaire emphasized the factors of numerical anxiety, mathematics test anxiety, and abstraction anxiety. To determine the level of mathematical motivation, a researcher-made questionnaire with 16 items with a five-point Likert scale (strongly agree, agree, neither agree nor disagree, disagree, strongly disagree) was utilized. This questionnaire was designed by studying various studies (e.g., Butler, 2016; Salehpoor, 2012; Zadeh-Dabagh, 2010) and consulting with experts of mathematics education with a five-point Likert scale. In most items of questionnaire, the response scales use 1 = strongly disagree (very low motivation), 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree. But in three items, the scoring was reversed. The total scores of the items indicate the level of mathematical motivation of the students, which can be at least 16 and at most 80. This questionnaire emphasized the factors of external and extrinsic motivations and self-efficacy.

In designing and constructing the questionnaires, an attempt was taken to make the sentences and structure of the items as simple and understandable as possible for seventh-grade students. The face and content validity of these questionnaires has been confirmed by experts in mathematics education. Exploratory factor analysis was used to evaluate the construct validity of the questionnaires and the index of KMO (p-value < .05) and Bartlett (Bartlett > .5) were calculated. KMO is a test for multi-collinearity in factor analysis. “To ensure that multi-collinearity has been avoided, the KMO outcome should be greater than 0.5” (Mayers, 2013, p. 546). “Bartlett’s test confirms whether there is at least some good correlation between the variables” (Mayers, 2013, p. 552). To evaluate the reliability, the questionnaires were implemented in a class (pilot study) on 26 seventh-grade students. By examining the results, Cronbach's alpha was 0.814 for the Mathematical Anxiety Questionnaire and 0.785 for the Mathematical Motivation Questionnaire, which indicates the appropriate reliability of these questionnaires.

Before the treatment, to measure students' mathematical anxiety and motivation, both experimental and control groups completed mathematical motivation and anxiety questionnaires. Then, with the help of educational media such as PowerPoint slides, animation, educational videos, GeoGebra software, manipulative, and other educational media, the experimental group was taught the subject of the Volume of Geometric Objects for 8 sessions of 90 minutes. In the control group, on the other hand, the same concepts were taught in the conventional way. In the conventional learning way in Iran, the schools use conventional learning tools consisting of blackboards or whiteboards, books, and pencils. Finally, to compare and understand the effect of the independent variable, a posttest was performed on two groups.

Descriptive and inferential statistical methods were used to analyze the data using SPSS software version 26. At the descriptive level, indicators such as mean and standard deviation were used and at the inferential level and multivariate analysis of covariance (MANCOVA) was used. MANCOVA “examines two or more dependent variable outcomes across one or more independent variables, controlling for one or more covariates” (Mayers, 2013, p. 363). Because of the present study, the data collection method was based on a quasi-experimental research design of the pretest-posttest design with the control group and there were two dependent variables to prevent bias and eliminate the effect of pretest and multivariate analysis of covariance was used to analyze the data.

FINDINGS

Descriptive findings including mean and standard deviation of the variables of mathematical motivation and mathematical anxiety of the two groups of controls and experiments in pretest and posttest are shown in Table 1. The table reports the mean math anxiety of the students in the experimental group decreased in the posttest compared to the pretest, while in the control group this did not occur. On the other hand, the mathematical motivation of this group has increased, but for the control group, there was no increase. Then, to receive the research results and generalize them to the statistical population, inferential statistics and multivariate analysis of covariance or MANCOVA test were used. for the control group, there was no increase.

Before using the MANCOVA test, it is important to check the pre assumption of this test. The most important preconditions for this test include normality of data, equality of variances, homogeneity of variance-covariance matrices, and homogeneity of regression slope, which were examined as followed. To evaluate the normality of the data, according to the sample size of the research, the Shapiro-Wilk test was used. The results of the Shapiro-Wilk test to evaluate the normality of research variables showed that the level of significance for all variables in both control and experimental groups in the pretest and posttest is greater than 0.05. Therefore, the distribution of data in both variables in pretest and posttest in two groups is normal. Various statistics can be used to examine the equality of variances, one of the most important of which is the Levin test. The results of Levene's test showed the significance level of this test in mathematical anxiety is 0.066 (F = 3.53) and in mathematical motivation is 0.51 (F = 0.43). Therefore, the significance level of both dependent variables in this test is greater than 0.05 and the hypothesis of equality of variances between dependent variables was confirmed.

Box's M test was used to check the homogeneity of variance-covariance matrices. The results of this test showed that the significance level is 0.065 (F = 2.409) and greater than 0.05 and the assumption of homogeneity of variance-covariance matrices was also confirmed. Another main condition for using covariance analysis is that the slope of the regression graph for the two groups of control and experiment should be identical and parallel. To examine this condition, the interaction of pretest and posttest scores in the group is used. If the significance level is greater than 0.05, the homogeneity of the regression slope is confirmed. A significance level of group interaction and math anxiety test was 0.864 (F = 0.030) and group interaction and math motivation test were 0.849 (F = 0.036) and the regression slope homogeneity hypothesis was confirmed.

After confirming the preconditions of analysis of covariance, the MANCOVA test can be used to answer the research hypotheses. The results of multivariate analysis of covariance for the effect of multimedia teaching on math anxiety and students' math motivation are shown in Table 2. The table shows that by controlling the pretest, the significance levels of all tests (Pillai's Trace, Wilk's Lambda, Hotelling's trace, and Roy's largest root test) are less than 0.05 and even less than 0.01, which indicates a significant difference between the control and experiment groups in at least one of the variables of mathematical anxiety and mathematical motivation. Thus, in response to the first hypothesis of the research, it can be said with more than 99% confidence, the independent variable has affected at least one of the two dependent variables.

To investigate the effect of multimedia training on each of the dependent variables and response to the second and third hypotheses of the research, a univariate analysis of covariance is used on posttest means with pretest control in the control and experimental groups (Table 3). The table shows that according to the pretest, there is a significant difference between the means of the mathematical anxiety in the experimental and control groups in the posttest. Considering that its significance level is 0.02 (F = 0.09), it can be said with more than 95% confidence that teaching using Multimedia has an effect on mathematical anxiety. On the other hand, according to the pretest, there is a significant difference between the mean scores of mathematical motivation of the experimental and control groups in the posttest. Considering that its significance level is 0.03 (F = 4.63), it can be said with more than 95% confidence, it also impacts mathematical motivation. Therefore, teaching using multimedia systems increases the mathematical motivation of seventh-grade students and reduces their mathematical anxiety.

Table 1
Descriptive Findings of Mathematical Motivation and Mathematical

Dependent variable	Group	Pre-test		Post-test	
		Mean	SD	Mean	SD
Mathematical anxiety	Experimental	71.00	9.74	63.90	12.07
	Control	59.77	17.88	71.11	18.52
Mathematical motivation	Experimental	60.70	8.32	65.30	7.60
	Control	62.81	7.52	64.22	6.87

Table 2
Results of multivariate analysis of covariance

Effect		Value	F	Hypothesis df	Error df	sig	η^2	Observed Power
Group	Pillai's Trace	0.17	5.57	2	52	0.006	0.17	0.83
	Wilk's Lambda	0.82	5.57	2	52	0.006	0.17	0.83
	Hotelling's Trace	0.21	5.57	2	52	0.006	0.17	0.83
	Roy's Largest Root	0.21	5.57	2	52	0.006	0.17	0.83

Table 3
Results of univariate analysis of covariance in MANCOVA

Source	Dependent variable	Sum of squares	df	Mean square	F	sig	η^2	Observed Power
Group	Mathematical anxiety Post-test	1140.54	1	1140.54	5.09	0.02	0.08	0.60
	Mathematical motivation Post-test	124.93	1	124.93	4.63	0.03	0.08	0.56
Error	Mathematical anxiety Post-test	11862.20	53	223.81				
	Mathematical motivation Post-test	1428.43	53	26.952				

DISCUSSION

The results of multivariate analysis of covariance (MANCOVA) show that teaching using multimedia tools is effective in increasing math motivation and reducing students' math anxiety. When new teaching media such as PowerPoint slides, animation, educational videos, GeoGebra software, manipulative and educational videos, and other educational media are used while teaching, students learn the lessons better by intuitive observation and understanding. The research results showed that students were happier when using the tool in the classroom. They liked to be involved in the class process and they were very interested in responding to the teacher's questions and solving textbook activities and problems. Students' contribution and enthusiasm had reduced their anxiety about math lessons and created a dynamic and energetic environment for better education.

When in the classroom, using multimedia systems, students were shown photos and videos of important and historical buildings to identify the type of Geometric Shapes and their Volume, give other examples of this building, and express its type and shape. They no longer looked at math as a useless subject and their attitudes and motivations toward the subject changed slightly. Now, If students cannot be taken to nature or other real situations and shown real applications and examples of the subject, with the help of multimedia tools, a photo or video can be brought to the classroom which will increase students' motivation.

The results of most research that have been done on the effect of new media on students' mathematical motivation (e.g., Hosinzadeh et al., 2019; Anwari, 2018; Jangizehi, 2017; Khaleji-Pirbalouti, 2015; Arbabi, 2015; Ogochukwu, 2010; Zaini et al., 2010), show that this tool makes the learning process more attractive and enjoyable and increases the interest and motivation of students in mathematics. Other studies related to this study that examine the effect of multimedia systems on mathematical anxiety (e.g., Khaleji-Pirbalouti, 2015; Soewardini et al., 2018) indicate that multimedia education makes it easier to visualize objects and can help the students overcome anxiety and math difficulties. The results of the present study are in agreement with most of these studies, and they confirm the results obtained from the present study. Thus, in the era where the use of these media is increasing day by day, the education system and math teachers can also use this opportunity and facilities to improve the learning process and students' interest in math lessons to achieve their goals.

CONCLUSIONS

Based on the results of data analysis and reduction of post-test math anxiety scores compared to pretest in the experimental group, it can be concluded that the use of multimedia methods can reduce anxiety, making students more interested in learning math. Also, it is found that teaching using multimedia makes teaching and learning mathematics more attractive and students become more interested and motivated to learn mathematics.

In general, it can be said that during the process of teaching mathematics with the help of multimedia, students enthusiastically attend the math class, try with greater passion, interest, and excitement to get a higher score and mark, and work together in the teaching-learning process. Using multimedia will take the math classroom out of boredom and make students and the classroom more dynamic and active.

Because the present research has been done for a specific course and grade, it is recommended to conduct similar research in other courses and grades. It is also recommended that in future studies, the effect of teaching using multimedia as an active method be examined in comparison with other active methods such as discovery methods, expository teaching, project-directed. Since in this study the effect of multimedia on mathematical anxiety and mathematical motivation has been studied, it is also suggested that the effect of this method be investigated on other affective (emotional) aspects of the teaching-learning.

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