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IMPACT OF USE OF TECHNOLOGY IN MATHEMATICS LESSONS ON STUDENT ACHIEVEMENT AND ATTITUDES

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Technology use in classrooms in today's world is believed to have a positive impact on students' success and their attitudes towards lessons. In this study we investigated students' attitudes towards technology use in class and whether the use of technology improved their academic achievement. A quasiexperimental research design was used and we assigned 3 groups as experimental groups (n = 41) and 2 as control groups (n = 41). Mathematics was selected as the subject to be studied. All groups completed a pretest and a posttest. For the experimental groups, lessons were designed using several technological tools, whereas lessons for control groups were taught using traditional teaching methods. At the end of the study, the experimental groups completed a scale to investigate the preferences and attitudes of the students in regard to technology-based instruction. One-way ANCOVA was used to evaluate the differences in posttest results, which revealed that the mathematics posttest results of the students who were instructed using technology were significantly higher than the posttest results of the groups who were instructed without technology. Results showed that students had a positive attitude towards technology use. The implications for curriculum designers and teachers are discussed.

Keywords: achievement, attitude, quasiexperimental research design, mathematics, technology use.

Today in most developed countries technology is being used extensively in classrooms. As Bitter and Pierson (2005) and Wiske, Franz, and Breit (2005) have pointed out, the use of instructional technology in class enhances learning

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so that students can learn more effectively. In technology-implemented classes, interactive student involvement in the learning process is fostered, and learning becomes more fun and more attractive for the students (Smaldino, Russell, Heinich & Molenda, 2005).

As stated by numerous researchers (e.g., Alessi & Trollip, 2001; Ashburn & Floden, 2006; Bitter & Pierson, 2005; Egbert, 2009, Januszweski & Molenda, 2008; Jonassen, Howland, Marra, & Crismond, 2008; Kent, 2008; Lever-Duffy, McDonald, & Mizell, 2005; Wiske et al., 2005) and it is an inevitable fact that, in learning environments where educational technology is integrated into instruction, both students and teachers experience benefits from using it. As Smaldino et al. (2005) noted, the use of technology in instruction enhances not only the learning capabilities of students but also their motivation; thus, students are more engaged in the learning process.

Barron, Ivers, Lilavois, and Wells (2006) stated: “Technology provides an excellent avenue for student motivation, exploration, and instruction” (p. 17); it is also obligatory to consider the teachers who are the actual users of such technology and the groundwork that consists of the necessary aids, training, and equipment (Ashburn & Floden, 2005; Sandholtz, Ringstaff, & Dwyer, 1997). It has become evident that teaching, learning, and technology work synergistically to provide effective and efficient knowledge transfer because educational technology helps teachers create learning contexts that were not previously possible with traditional teaching methods (Wiske et al., 2005).

Bitter and Pierson (2005) stated: “A recent meta-analysis demonstrated that students using technology had modest but positive gains in learning outcomes over those students who used no technology” (p. 107). Likewise, Bates and Poole (2003) observed: “…technology does not reduce the need for imaginative, creative thinking about teaching and learning; indeed, it increases the need. Technology opens up a vast range of opportunities for imaginative, creative teaching …” (p. 178).

Additionally, it is believed that when technology is used appropriately in classroom instruction, it has a very positive impact on student achievement or success. Moreover, using technology in education or teaching helps teachers provide immediate feedback to students and motivates active student learning, collaboration, and cooperation. It also helps teachers provide individualized learning opportunities and flexibility for their students.

In this regard Kelly and McAnear (2002) stated:

> To live, learn and work successfully in an increasingly complex and information-rich society, students and teachers must use technology effectively. Within a sound educational setting, technology can enable students to become:
>
> - Capable information technology users

- Information seekers, analyzers, and evaluators
- Problem solvers and decision makers
- Creative and effective users of productivity tools
- Communicators, collaborators, publishers, and producers
- Informed, responsible, and contributing citizens. (p. 4).

Hawkes and Cambre (2001) stated: "Technology presents new opportunities for students and teachers that can be organizational, instructional, individual, procedural, and cultural…" (p. 1). The authors continued by stating that technology has an impact if learners understand and experience the main purpose of technology. They also pointed out that one of the main points that has to be taken into consideration by schools is the necessity to prepare students for the changing world in which technology plays an enormous part.

Baek, Jung, and Kim (2008) asserted that many researchers agree that using technology is an efficient cognitive tool and instructional media. They also suggested: "Technology can be helpful in classroom settings by encouraging inquiry, helping communication, constructing teaching products, and assisting students' self-expression" (p. 1). Thus, it has been suggested by scholars that using technology, or integrating technology into a classroom, enhances teaching and helps students learn how to broaden their perspectives, and provides a better learning environment by bringing the world into the classroom.

Educational technology can be defined in many different ways and many scholars have provided various definitions (Bates & Poole, 2003; Battista, 1978; Jonassen, Howland, Moore, & Marra, 2003; Newby, Stepich, Lehman, & Russell, 2006; Seels & Richey, 1994; Smaldino et al., 2005). However, the most comprehensive definition of *educational technology* has come from Seels and Richey (1994) who wrote: "Instructional technology is the theory and practice of design, development, utilization, management, and evaluation of processes and resources for learning" (p. 9).

In order to prepare students for the future and help them learn how to think, learn, and gain different perspectives, technology has to be integrated into the classroom. It is undeniable that technology has a great impact on every aspect of modern life. As Türkmen (2006) stated, children today need the learning media now available to become engaged in the learning process. Newby et al. (2006) contributed to this discussion and extended it, saying: "Educational technology includes tangible tools (high-tech hardware such as computers, and instructional media such as overhead transparencies and videotapes) as well as other technologies (methods, techniques, and activities) for planning, implementing, and evaluating effective learning experiences" (p. 22). Hence, for effective learning experiences and motivation educators now believe that using different, and appropriate, forms of technology in classrooms is necessary. Therefore, in this study we investigated whether or not the use of appropriate forms of educational technology had a positive effect on attitudes and enhanced the achievement of students. As a starting point, we chose mathematics as the subject to investigate this topic.

The Cyprus Turkish educational system has recently been updated, and, in addition to introducing learner-centered instruction, integration of technology in the teaching-learning process has also been prescribed (Cyprus Turkish National Education System, 2005). However, no experimental study has yet been conducted to provide local evidence that educational technology enriches learning experiences and student success in Cyprus. Although the basics of the new formal educational system seem clear, understandable, and appropriate on paper, it is unfortunate that most of the proposed procedures have not been completely accepted by schools and that the implementation of technology in schools is very limited. This could have resulted from the fact that the Ministry forced this program to be implemented without either preparing additional infrastructure or providing necessary in-service training to teachers who are the actual users of the technology; or it may have resulted from a lack of necessary aids, equipment, and resources. Above all, within this context there is no primary evidence that educational technology does, in fact, enhance achievement and have a positive effect on attitudes among students.

Considering the poor integration of technology into the updated educational system in North Cyprus, it is important to investigate the reasons that technology has not been implemented in classes as expected by society. But prior to an investigation of these reasons, it was vital to know whether or not the use of technology does improve student achievement. In addition, investigation of the attitudes of students towards the use of technology in this education system was also important as the perception of students has an influence on the effectiveness of technology use.

Therefore, in this study conducted in a private school in Cyprus, we investigated whether of not the use of technology in the classroom enhanced the achievement of seventh grade students in mathematics lessons, and whether or not these students had a positive attitude towards technology use in class. To investigate the effects on student achievement of using educational technology in mathematics lessons, we set the following research questions:

a) What is the effect of using educational technology in mathematics lessons on student achievement?
b) What is the attitude of students towards instruction in which educational technology is employed?

Method

We used a quasiexperimental design that involved selecting groups without any random preselection process to investigate the two research questions. In the private secondary school in which we conducted this study all seventh grade students had been placed in four heterogeneous classes and the school administration did not allow any changes in these groups for our study. For their mathematics lessons, we randomly selected three of these classes (n = 41) to form the experimental group and the remaining two classes (n = 41) were taken as the control group. Because of the method of assigning students to classes, it was evident to us that, across these classes as they had been formed, the aptitude levels of the students were different. Hence, our preference for a quasiexperimental design.

Design

We chose mathematics as the subject area to be investigated. In the classes, all groups completed a pretest at the beginning of instruction and a posttest after instruction. In the experimental groups, we provided the teachers with instructional technology to be used while teaching, whereas the control groups were taught by traditional methods, with no technology being used.

The topics being taught in the mathematics lessons were completely new to the learners. We provided teachers who regularly teach these lessons at the school with the lesson plans, all necessary materials, and pre- and posttests. We designed the lessons carefully, according to Gagne's nine instructional events (Gredler, 2005; Reigeluth, 1987). The only difference in the design of the lessons for the experimental and control groups was that technology was included in the lessons for the experimental groups, whereas no technology was used in the design of lessons for control groups. A laptop with multimedia and a data projector were used in experimental groups, and the lessons were transferred to PowerPoint slides and videos, pictures, flash cards, animations, and so on. These technological aids were provided with the aims of increasing student motivation, making learning more meaningful and enjoyable, maximizing visualization and maintaining students' attention on the lesson. Consequently, neither books nor the handouts prepared by the teachers were used during the lessons for the experimental groups.

Measures

Pretest and posttest. These tests were prepared by obtaining expert opinion. The pretest for mathematics, which was in an open-ended question format, comprised 10 questions, and it was used to assess the prior knowledge of students about the geometry topics that they would be studying during the lessons that formed our research. Students were asked to read each question and write their answers in the space provided below the question. The posttest had the same format and topics as the pretest.

Educational Technology Perception Scale (ETPS). We prepared a two-factor educational technology perception scale and the experimental group completed this in order to investigate the students' attitudes towards technology use in class and their preferences in this regard. The scale consists of 11 items, and the students were asked to state their opinions on a 3-point scale with *Yes* receiving a rating of 2, *Indecisive* = 1, and *No* = 0.

Sample items are: "The lessons are fun when the teacher uses a computer and data projector in the lesson," and "I participate in lessons when the teacher uses a computer and data projector in the lesson."

We analyzed the data by means of a principal component analysis (PCA), with direct oblimin rotation. Indicators of factorability were good. The Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was .88, which is greater than the cut-off value of .70. Furthermore, Bartlett's Test of Sphericity yielded a significant result, χ^2 (55) = 435.43, p = .000 < .01, which showed that the correlation matrix of measured variables was significantly different from an identity matrix; in other words, items were sufficiently correlated to load on the components of the measure. Two components with an eigenvalue of greater than 1.0 were found.

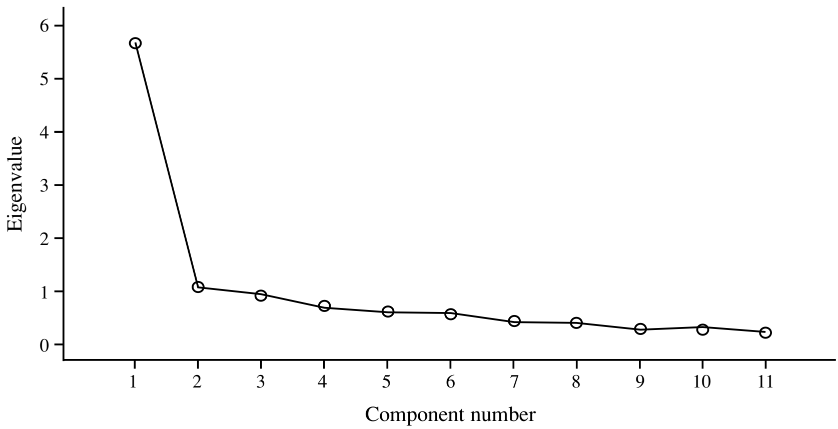

Figure 1. *Scree plot for components of the measure.*

In the scree plot there were two components in the sharp descending part of the plot (see Figure 1). The loadings of the two factors of Attitudes of Students and Preference of Students are presented in Table 1. Items 6, 4, 5, 7, 8, and 10 were loaded on the Attitude of Students factor and items 2, 11, 1, and 9 were loaded on the Preference of Students factor.

Table 1. *Items Representing Attitudes and Preferences of Students*

	Attitudes	Preferences
ITEM 6	.832	
ITEM 4	.779	
ITEM 5	.771	
ITEM 3	.755	
ITEM 7	.521	
ITEM 8	.513	
ITEM 10	.490	
ITEM 2		.917
ITEM 11		.755
ITEM 1		.639
ITEM 9		.426

For the measure, we computed the Cronbach's alpha (α) value for the internal consistency estimate of reliability, and the computed value was .91 for the whole scale, for the attitude items the Cronbach's alpha value (α) was .88, and for the preference items the Cronbach's value (α) was .77, indicating that the measure had good reliability.

Results

We conducted an analysis of covariance (ANCOVA) to find answers to the research question "What is the effect of using educational technology in mathematics lessons on student achievement?" The progress scores of students were calculated by subtracting their pretest scores from their posttest scores. Then, we used descriptive statistics to find out how the progress scores of the students were distributed. As shown in Table 2, progress scores satisfied the criteria for a normal distribution because both skewness (.257) and kurtosis (-.812) of the distribution were between -1.0 and +1.0 (Bluman, 2004). We took student report scores for mathematics from the previous term as the covariant in the ANCOVA and we analyzed these for skewness (-.100) and kurtosis (-.301), and the results of this analysis also satisfied the criteria for a normal distribution.

Table 2. *Students' Previous Term Scores and Progress Scores*

	n	Min.	Max.	*M*	*SD*	Skewness	Kurtosis
Previous term scores	82	24.25	90.50	63.29	15.01	-.100	-.301
Progress scores	76	-1.00	10.00	3.78	2.77	.257	-.812

We conducted a test of homogeneity of slopes in order to test the assumption about whether the relationship between the previous term scores and the progress scores differed significantly as a function of the independent variable of the group, $F(1, 72) = 2.39$, $p = .127 > .01$. As can be seen in Table 3, the result of this test was not significant; hence, it could be assumed that the slopes are homogeneous. Therefore, a one-way ANCOVA could be conducted.

Table 3. *Test of Homogeneity of Slopes Results*

Source	*SS*	*df*	*MS*	*F*	Sig.	Partial Eta Squared
Previous Term Scores	23.641	1	23.641	3.385	.070	.013
Group * Previous Term Scores	16.670	1	16.670	2.387	.127	.032
Error	502.785	72	6.983			
Total	1664.250	76				

Note. $R^2 = .128$ (Adjusted $R^2 = .092$).

We conducted a one-way ANCOVA, and the progress scores of the students were adjusted using the previous term's scores. As can be seen in Table 4, the effect of the covariate has effectively been removed from the data of the experimental and control groups. When the mean scores of the groups are examined, it is possible to say that the results of the experimental groups were better than those of the control groups.

Table 4. *Adjusted Mean of Progress Scores of Student Groups*

	n	Actual *M*	Adjusted *M*
Experimental Group	38	3.07	3.13
Control Group	38	4.49	4.43

As can be seen in Table 5, after adjusting the progress test scores, there was a significant difference between the experimental and control groups, $F(1, 73) = 7.12$, $p = .024 > .05$). In other words, the use of technology in the lessons with the experimental groups resulted in these students receiving higher scores in their mathematics tests.

Table 5. *ANCOVA Results for the Difference Between Experimental and Control Groups*

Source	*SS*	*df*	*MS*	*F*	Sig.	Partial Eta Squared
Previous term scores	24.972	1	24.97	3.509	.065	.046
Group	37.822	1	37.82	5.315	.024	.068
Error	519.456	73	7.12			
Total	1664.250	76				

Note. $R^2 = .099$ (Adjusted $R^2 = .075$).

Using the Educational Technology Perception Scale (ETPS), we analyzed data collected from the students who had been learning in an educational-technology-blended environment to find answers to the second research question, "What is the attitude of students towards instruction in which educational technology is employed?"

In order to assess students' attitudes and preferences we computed the mean score of each of these two components for every participating student. As can be seen in Table 6, nearly half of the students were indecisive in their attitude towards use of technology, nearly one third of the group liked using educational technology in class; but just over a quarter of the students expressed negative attitudes towards using educational technology. In terms of preference, nearly half of the students preferred the use of educational technology in class, only 16.5% of them did not prefer the use of technology, and just over one third of them were indecisive.

Table 6. *Descriptive Statistics of Data Collected by ETPS*

	Attitudes of Students		Preferences of Students	
	f	%	*f*	%
No	21	26.6	13	16.5
Indecisive	34	43.0	28	35.4
Yes	24	30.4	38	48.1
Total	79	100.0	79	100.0

Discussion and Conclusion

We expected that the use of educational technology in mathematics lessons would have a positive effect on student success and, after analyzing the collected data, it is possible to conclude that these expectations were met.

In addition, the students who took part in the study expressed quite positive attitudes towards the use of educational technology. According to the analysis conducted with the mean results of the performance of students, the use of educational technology had a positive effect on their performance, and the impact of the use of technology can be seen in the students' progress results. Although many researchers have investigated the understanding of learners in mathematics lessons, for example, Mji and Makgato (2006), Kotzé (2007), and Bansilal and Naidoo (2012), the effect of the use of educational technology has not been investigated extensively.

In the present study, we prepared a specific scale (ETPS) in order to gather information from the learners about their attitudes about, and preferences in regard to, the use of educational technology in mathematics lessons.

A significant number of students were indecisive about their preference. This might be attributed to the fact that, because technology was not used even occasionally in class, they were not familiar with this kind of instruction and, therefore, did not have negative perceptions about its use. As can be seen, a large percentage of the students were indecisive about whether or not they liked the use of educational technology in mathematics lessons. When educational technology is used, this is a tremendous change from the traditional method of teaching. People are resistant to change, and this was the first time these students had received instruction using educational technology; this may be the reason that they did not decide in favor of this kind of instruction. Hence, a longer period of time should be allowed for the use of technology, and this scale should be readministered at the end of this period to determine if there is then a reduction in the number of students whose response is that they are indecisive about use of technology. After getting used to this kind of instruction, we expect that most of the indecisive students and even some of the students who answered that they did not like the use of technology in our study, would be in favor of the use of educational technology in mathematics lessons. Thus, further research should be conducted to consolidate our findings.

According to our results, many of the students preferred to be in a class where educational technology was used, but they were not sure whether it would help them become more successful in the class. In addition, students' responses indicated that they did not have a negative perception of technology use in the class. We expect that, as the students had a positive perception of the use of educational technology in class, continuous use of educational technology would change their attitudes towards its use.

As education systems are not perfect, from time to time they are reviewed in order to provide better education for learners. Similar to the Turkish Republic of Northern Cyprus (TRNC) education system, the South African curriculum has recently been reviewed as set out in the South African National Curriculum Statement (Mwakapenda, 2008). The present situation in regard to the TRNC education system is not promising in terms of using technology in classrooms (İşman & Yaratan, 2004; Yaratan & Kural, 2010). One of the major constraints is the lack of necessary equipment in schools. Another important point to be considered is that teachers are not well trained in integrating technology into classroom instruction. To overcome these problems, it will be necessary to incorporate use of technology into teacher training and to supply teachers with the necessary information, aids, and equipment useful to the process of providing a better education by means of educational technology.

Our study exploring student success with the use of educational technology was conducted using mathematics as the subject, and it could be repeated with other school subjects. The findings in our study can shed light on the use of educational technology for teaching mathematics in similar education systems around the globe, in order to encourage education administrators to implement use of educational technology in mathematics lessons.

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