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The effect of active learning method on students' academic success, motivation and attitude towards mathematics

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ABSTRACT

One of the purposes of education and active learning is to promote a more engaging classroom that is both interactive and productive for the students. This study seeks to look at this purpose in a very holistic way by combining academic achievement, students' attitudes, and motivation in determining how much active learning has impacted the education process. By incorporating the Mathematics Achievement Test, the attitudes test, the motivation survey, and finally a more statistically reliable MANOVA test, this study seeks to find out the effect of active learning in classrooms. 10th-grade students from Nurorda school in Nur-Sultan Kazakhstan took part in the research and were divided into two groups, the experimental and the control group. The students were initially informed about the study and a pre-test was administered to both groups; the control group was taught using the normal lecture-based method while the experimental group was taught using active learning educational platforms. The study was then conducted for a period of 6 weeks, quizzes were being administered through a whiteboard and multiple-choice questions and a final test given to students. After the study period ended, a post-test was the administered to both groups and the results of the tests gathered for analysis using the MANOVA technique to test for significant difference between the two methods being tested. The study suggests that students in the experimental group from the active learning class had a more productive education process in terms of achievement, however, there was no significant difference found in attitudes or motivation between them and the control group.

KEYWORDS: Active Learning, Achievement test, Attitude, Motivation, Mathematics achievement

INTRODUCTION

The purpose of the study was to investigate the effect of the active learning teaching method on students' academic achievement, attitude towards mathematics, and motivation using the MANOVA test.

Active learning, in its most widely used definition, is "encouraging students to do something and think about what they do" (Bonwell & Eison, 1991). Active learning according to Shariff (2012); means that students actively participate in classroom activities throughout the lesson, rather than passively following the teacher who teaches the lesson. According to Jarvis (2005), it is a method for learners to participate actively in the learning process. According to Greene (2011), it is learning by doing, based on first-hand experiences. According to Kalem and Fer (2003), the learning method involves drawing the learners into the learning process and removing them from a dormant state. Gordon and Lawton (2005) on active learning; define it as learning that encourages a student to do more than take information from a teacher or a textbook, to memorize and reproduce information. Lohithakshan (2002) expresses it as learning based on student activity with minimal teacher intervention. Active learning is based on the constructivist learning theory, which states that learners actively create their own knowledge rather than passively absorb information from the environment (Cambridge International Examinations, 2015; Liu & Chen, 2010). Constructivism is a theory of meaning making and learning.

As active learning changed the learning conception, some changes occurred in the traditional roles of teachers and students. The role of the teacher in a student-centered learning environment based on active learning has changed in terms of facilitating, guiding, and supporting learning, not directing decisions about the learning process (Mills, 2006). The teacher has now come out of the traditional "teacher" role and becomes the "facilitator of learning" (Broad, Matthews, & McDonald, 2004; Ishii, 2017).

The role of students in the active learning process has changed from being passive receptors to being direct participants of the learning process (Aşiroğlu, 2014; Eugéne, 2006). In the traditional understanding of education, the student who receives the information readily discovers it by researching and derives new meanings from it (Güney, 2011; Ünal, 2004). active learning. Project-based learning and peer code reviews are part of active learning: students must actively participate, participate and respond. This is different from passive learning such as lectures, presentations or watching online videos.

Active learning requires students to analyze, evaluate and create. The majority of our curriculum consists mainly of projects with a problem of “building a solution for XYZ”. When students research, analyze, create, test and correct, their involvement goes through the roof compared to passive learning and the retention rate is close to 90% (compared to passive learning at 5-10%).

When these definitions are examined, it is seen that the main element that stands out is the active participation of students in the learning process because the essence of active learning is to present information with first-hand evidence and activities, rather than transferring it. Students also build on their own experiences, ask questions, develop hypotheses, and try to develop their own structures and understanding by testing them in an open, collaborative context (Herne, 2001). The creation and development of mental structures are also achieved through active participation. This means being active not only physically but also mentally. Through the mental activity, prior knowledge is expanded, improved, and shaped (Jessel, 2001). Today, studies in the field of cognitive psychology also show that active participation enables deeper levels of information processing and learning because it creates stronger connections (McGlynn, 2005). Considering all these, active participation of learners is deemed necessary for all kinds of learning to take place (Monk & Silman, 2013).

Purpose of The Study

The purpose of the study was to investigate the effect of the active learning teaching method on students’ academic achievement, attitude towards mathematics, and motivation using the MANOVA test.

In this study, it was aimed to find answers to the following questions.

1. Does active learning have any effect on students’ academic achievement?
2. Does the active learning method affect students’ attitudes towards mathematics?
3. Does active learning have any effect on students’ motivation?

LITERATURE REVIEW

Braun, Benjamin, et al. (2017) noted the various techniques and environments adopted in active learning in mathematics. Some of the methods they mentioned in their research include:

Think-Pair-Share method- In this method, students were given time (2 to 3 minutes) to come up with hypotheses or solutions to a given task independently. For an added two minutes, the students were allowed to consult with their classmates and their responses were checked and confirmed by the instructor.

Classroom Response Systems (Clickers) - This technique is a reinforcement of the think-pair-share method and seeks to promote student engagement within the classrooms and promote active learning. Students act in a team and take part in what is termed as ‘classroom voting’ and their answers are recorded.

Inverted or Flipped Classrooms – In this type of interaction, instructors present the lesson in a series of video presentations and usage of other educational software and technologies to increase student participation and engagement within the classrooms. The teachers present complex problems in audio-visual ways to enhance student understanding and comprehension of the topics.

Inquiry-based learning – This involves a series of discussions in small or large groups and mini-lectures that promote active learning and student engagement in the lesson.

Math emporium – A math emporium is similar to a flipped classroom where students engage with each other collaboratively using online platforms especially in easy topics such as college algebra and elementary mathematics. The students work together in a self-paced way and interact with the course content from various online sources promoting active learning in a mathematics lesson.

Modeling and Computer Laboratories – Usage of computer labs to enhance student engagement in mathematics through exploration programs such as Mathematica, MATLAB, and Maple has been used severally to promote active learning in mathematics lessons and in mathematics assessments.

Braun, Benjamin, et al. (2017) insist that more training should be provided to instructors and instant feedback and support should be provided to ensure the success of active learning mathematics classrooms.

Selvianiresa, D., and S. Prabawanto. (2017) encouraged the mathematics connection ability of students to be increased by providing them with more connection ways because they stated that this ability is still quite low and that learners cannot relate mathematical concepts to their daily lives. They did a comparison with 42 participants between contextual classrooms and direct learning classrooms and they concluded that there is a significant increase in mathematical connection ability of students in Contextual teaching and learning classrooms than in direct classrooms.

Demirci, C., (2017) in his study obtained a significant difference between the average post attitude scores of the experimental group towards science lesson while no change in attitude was found in the control group. He concluded that the active learning approach has a significant difference in the attitudes of students towards science lessons. He adds that active learning transforms the analytical thinking skills and cognitive skills of students by enabling them to create knowledge and be at the center of their studies.

Niemi, H., & Nevgi, A. (2014) state that the teacher’s role is radically changing and teachers are becoming more like researchers. The study was done on active learning in Finnish education with 605 student-teacher participants from two Finnish universities answering questionnaires on teaching and learning. They concluded that research studies were of great importance as well as active learning within classrooms. They insist on teachers becoming researchers and content creators with the future of education reliant on active learning.

Burke, Christian, et al. (2020) conducted a study on underrepresented minority (URM) groups in STEM education classes. They discovered a low performance of URM students in STEM classes and they noted that despite this challenge, active learning environments helped these URM students to increase their academic achievement. The study involved Hispanic students, the experimental group was put in active learning classrooms while the control group was put in traditional classrooms. Burke, Christian, et al. (2020) also noted that previous studies by (Hacisalihoglu, Gokhan, et al. 2020) discovered that active learning increases student learning by 43% and success rate by 16%. In this research, there was an observable increase of 21.4% in achievement of students’ performance in a Chemistry class. They insist on the deployment of the active learning method as a tool for closing the achievement gap between URM students and other students.

METHODS

The aim of this study is to examine the effect of active learning method on students' success, attitude and motivation. In the study that lasted 6 weeks, the effect of the active learning method was investigated by using various active learning methods with 10th graders randomly divided. The obtained data were analyzed with MANOVA using the SPSS 21 program.

INSTRUMENTS

Mathematics Achievement Test (MAT)

A mathematics achievement test is an assessment tool used to measure student performance. Morales (2009) argues that when making an important valuation of an assessment tool, two things have to be carefully considered; the reliability of the tool and the validity. Our mathematics achievement test was administered to 40 10th-grade students as a pilot study and comprised of 50 items. The items were systematically developed to test student knowledge and comprehension in the topic of Algebra. After data collection, Item difficulty, KR20, Item discrimination and Point biserial correlation was done on the data. It was checked by two experts after being developed who gave their own thoughts and suggestions regarding it.

As analysis was being done, the items were being grouped as good and acceptable or improper as per the standards of the test. According to Quaigrain and Arhin (2017) in Item difficulty, the standard items considered good and acceptable range between 0.2 and 0.9 while in Item discrimination, the standard items considered good and acceptable are those >0.19. When it comes to point biserial correlation, the items are grouped as either good or very good. The items ranging between 0.2 and 0.39 are considered good while those ranging between 0.4 and 0.7 are considered very good. Therefore, if an item had inconsistencies in two or more of the analytical statistical groupings, they were removed and grouped as improper and unacceptable. In our case, 30 of the 50 items were done away with because of inconsistencies after finding they had improper values with two or more of the statistical groups.

According to Rudner and Schafer (2002), Kuder-Richardson Formula 20 (KR20) was required to conduct an internal consistency check which focuses on the extent to which the items are correlated with each other. They report that for a more reliable test, the coefficients of the KR20 statistic should range between 0.8 and 0.9, which indicates a high reliability although a test with coefficients ranging between 0.5 or 0.6 may also suffice. In this study, our coefficient was initially found to be 0.850 but after eliminating the unnecessary items, it was re-calculated and determined to be 0.877. In the end, because of the high reliability, validity and consistency of the data, the final 20 items were used in the main study.

Attitudes towards mathematics test (ATM)

A 5-point Likert-type math attitude scale developed by Aşkar (1986) was implemented in this study to compare the attitudes of students from the experimental and control groups with regards to the mathematics lesson. The scale which was developed to determine attitudes of students contained 20 items which had 10 positive and 10 negative statements. The 20 items were further scaled in five different categories as " I Strongly Disagree ", " I Disagree ", " Neutral ", " I Agree " and " I Strongly Agree " (Appendix). Aşkar (1986) confirmed the credibility and reliability of this attitude scale towards the mathematics course with Cronbach Alpha and found it to be 0.96. The pilot application of the scale was not required in this study because the Cronbach Alpha Reliability Coefficient was high due to the application of the Mathematics Attitude Scale by other researchers hence it was applied to the study group. In the application process, the learners were first told about the mathematics attitude scale and allowed time to respond to the questions.

Motivation Survey

The study consisted of 16 statements on motivation in the process of learning mathematics and used the theory-based motivation questionnaire in mathematics learning. The questionnaire consisted of three main topics as follows: "use for activity," "want to result" and "want to overcome learning problems." It used a 5-degree Likert-type from "strongly agree" (1) to "strongly disagree" (5) for all statements.

DATA ANALYSIS

The data of the study were analyzed using the statistics program SPSS. First, it was checked whether the data meet the general conditions of parametric tests. Whether the data showed normal distribution was checked with the Shapiro Wilk test. It was determined that achievement, attitude and motivation tests showed normal distribution in the Shapiro Wilk test (= .073, .148, .333 p> .05). Descriptive statistics and multivariate analysis of variance

(MANOVA) were used to analyze the data. Some conditions must be met in order to perform MANOVA.

The first of these conditions is to examine whether the multivariate normality assumption is met (Tabachnick & Fidel, 2007). Multivariate normality was investigated with the help of Mahalanobis distance values in the study. As a result of the examinations, it was seen that the multivariate normality of the data was provided (Pallant, 2005). In the analysis of the data obtained in the study, the homogeneity of variances was also tested by using the Levene test (Can, 2013). As a result of the analysis, it was determined that the data provided homogeneity. Another assumption that MANOVA is applied is that there are no multiple linear connections between the dependent variables. (Field, 2009). According to Akbulut (2011), the high relationship between dependent variables (correlation coefficients above .80 or .90) causes problems in MANOVA. In the analysis, it was found that there is a medium level of relationship. Another assumption that must be met in order to apply MANOVA is the homogeneity of variance-covariance matrices. Of this condition

whether it is provided or not is determined by the "Box's M" test. The fact that Box's M test is not statistically significant indicates that the assumption of homogeneity of variance-covariance matrices is met, and its significance shows that this assumption is violated. Seçer (2015) suggests that the significance criterion for this test should be .05. In this study, the significance criterion for Box's M test was taken as .05.

PROCEDURE

To compare high technology active learning and low technology active learning classrooms, 10th-grade students were divided into 2 groups, experimental and control groups. For the research, a chapter named “Basic identities” was taken, the main goal of which was to apply the formulas, expand and factor expressions, and solve word problems. Two groups took a pretest of 20 questions lasting for 35 minutes. During a six-week period, from 25.01.2021 till 05.03.2021, the control group was taught by main materials in ppt format and activities by using papers with questions. The experimental group’s lessons were conducted via different educational platforms that included “Math Antics” which had explanatory videos with engaging animation, Kahoot, Quizzes, Quizlet, IXL and EduPage platforms which were used for individual assessment after each lesson, and these platforms are used for group work as well. The students were divided into groups and they constructed their own questionnaire and demonstrated their works with others. Also, lessons were performed by a presentation and Nearpod platform, in which after every new formula and example there was a questionnaire and mini-quizzes. Quizzes were held in two formats: multiple choice and whiteboard, where each student can draw by themselves, therefore as creative answers are stated, students can have fun learning new materials. Also in Nearpod teacher can control every student and see each of them working on the tasks during the lesson and share works with students in class, which is an opportunity for the teacher to interact with students individually.

Finally, after six weeks two groups took posttests lasting for 35 minutes during math lessons by the course teacher. After he research period was over, the questionnaires and the academic achievement of the students were analyzed using the MANOVA test to determine if the active learning technique had an impact on students’ achievement, attitude and motivation in education.

RESULTS

Table 1

Descriptive Statistics

	Groups	Mean	Std. Deviation	N
post achievement	Experimental	13,47	4,135	32

	Control	11,25	3,835	32
	Total	12,36	4,111	64
	Experimental	2,92	,263	32
postattitude	Control	2,85	,297	32
	Total	2,88	,280	64
	Experimental	3,41	,501	32
postmotivation	Control	3,28	,603	32
	Total	3,34	,554	64

It is a good sign that the group sizes are equal in terms of the results of MANOVA tests to be healthy.

Table 1 is a posttest scores analysis of mathematics achievement, attitude towards mathematics, and motivation retrieved from the study conducted in treatment and control groups. Looking at the table, the treatment group's posttest average score in the mathematics achievement test is 13.47 (SD = 4.135). On the other hand, the control group's posttest average score in the same test is 11.25 (SD = 3.835). As seen from this table, the treatment group's posttest average score in the attitudes survey test is 2.916 (SD = .263). On the other hand, in the exact same test, the control group's posttest average score is 2.845 (SD = .297). Lastly, the treatment group's posttest average score in the motivation survey test is 3.411 (SD = .501). On the other hand, in the exact same test, the control group's posttest average score is 3.276 (SD = .603).

The posttest mathematics accomplishment, attitudes, and motivation scores of the students in the treatment and control groups are shown in Figure 1.

Figure 1

Posttest Success, attitude and motivation Scores Average of Experimental and Control Groups

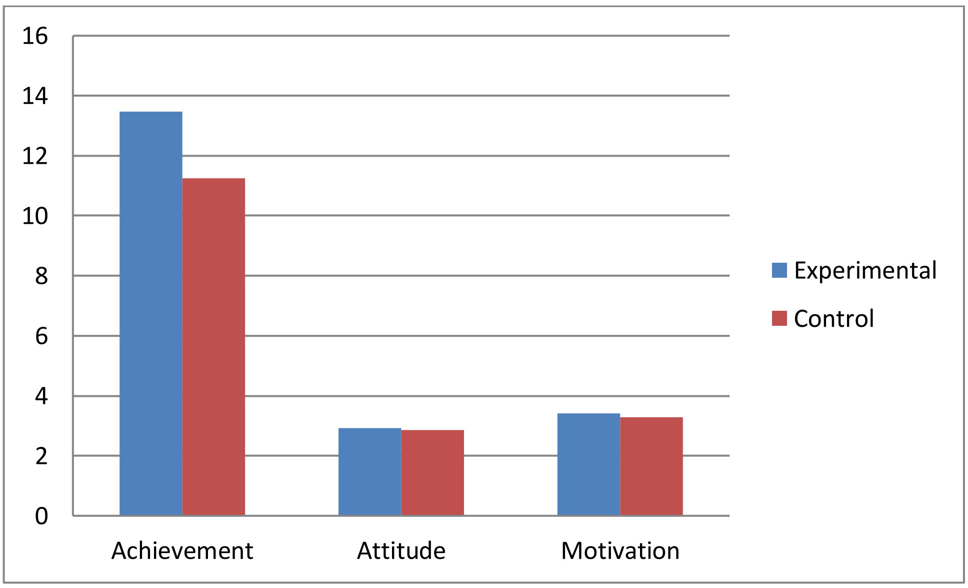

Table 2

Tests of Normality

	Shapiro-Wilk		
	Statistic	df	Sig.
Post achievement	,966	64	,073
Post attitude	,972	64	,148
Post motivation	,979	64	,333

Considering the results of the Shapiro-Wilk analysis performed in SPSS the p-values (.073, .148, .333) obtained as a result of Tests of Normality are higher than 0.05, we can say that the normal distribution was achieved in the tests.

Table 3

Extreme Values

			Case Number	Value
Mahalanobis Distance	Highest	1	49	11,64
	Lowest	1	29	0,07

Since the number of independent variables is 2, the critical value was taken as 13.82 (Tabachnick & Fidell, 2013). It was determined from the data of the study that Mahalanobis distances ranged between 0.07 and 11.64. The fact that all values are less than 13.82 shows that the data also meet the multivariate normality assumption (Pallant, 2015).

Table 4

Regration VIF values

	VIF
postachievement	1,337
postattitude	1,109
postmotivation	1,246

As VIF values were found to be less than 2.5 (Allison, 1999) as a result of the regression analysis we performed in SPSS, the analyzes were continued.

Table 5

Box's Test of Equality of Covariance Matrices[a]

Box's M	7,572
F	1,196

df1	6
df2	27850,868
Sig.	,305

Homogeneity of variance covariance matrix was tested. Box's M test has been done and the p-value (0.305) obtained as a result of Box's test is higher than 0.05, we can say that the covariance equality between the groups is ensured.

Table 6

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
postachievement	,935	1	62	,337
postattitude	1,080	1	62	,303
postmotivation	1,042	1	62	,311

All three variables included in the study as a result of the Levene test Since the value of p> 0.05, the analysis was continued.

As a result of the regression analysis performed in SPSS, VIF values were found to be 1.337, 1.109 and 1.246, respectively. When VIF values are below 2.5, regression homogeneity is considered to be achieved (Allison, P. D., 1999).

Table 7

MANOVA results regarding students' achievements, attitudes and motivations

Dependent Variables	Group	N	Mean	Std. Deviation	F	p
Achievement	Experimental	32	13,47	4,13	4,95	,030
	Control	32	11,25	3,84		
Attitudes	Experimental	32	2,92	,26	1,01	,320
	Control	32	2,85	,30		
Motivation	Experimental	32	3,41	,50	0,94	,336
	Control	32	3,28	,60		

In Table 7, MANOVA analysis results are given to measure the effect of the active learning method on students' academic achievement, attitude towards mathematics, and motivation. According to the results of the analysis, it is concluded that the active learning method has an effect on the academic success of the students and this effect is found to be significant.

DISCUSSION

From the study conducted, the posttest average scores of the experimental and control groups were 13.47 and 11.25 respectively in the mathematics achievement test. There is therefore an increase in academic achievement in the experimental group that utilised active learning methods in the classroom. Additionally, in the attitudes survey and the motivation survey, a similar trend was observed with the experimental group recording a more positive outcome.

In the attitudes survey done, the experimental and control groups average posttest scores were 2.916 and 2.845 respectively while in the motivation survey done the scores were 3.411 and 3.276 respectively. The data collected showed a positive increase in academic performance, attitudes and motivation among students who were taught in an active learning classroom compared to students who learned using the traditional education method.

However, to make a more conclusive analysis, the MANOVA test was conducted to test for significant differences between active learning classrooms and the traditional classrooms in all the three parameters tested; academic achievement, attitudes and motivation. The MANOVA test findings showed that there is a significant difference in academic achievement between the experimental group and the control group in favor of the experimental group because the value found (0.03<0.05). This means that in active learning classrooms, there is a significant increase in academic achievement or performance compared to traditional classrooms.

In attitudes and motivation, there were no significant differences between the experimental and control groups because the values found were (0.320>0.05) and (0.336>0.05) respectively. This indicates that the students were almost equally motivated and had same feelings towards learning in both environments despite having a better achievement in the active learning environment. This increase in achievement can be attributed to more involvement in the lessons hence more understanding and comprehension of the topics taught in class. This study is contrary to findings by (Demirci, 2017; Pundak, Herscovitz, & Shacham, 2010; Killian, & Bastas, 2015; Cicuto, & Torres, 2016), which concluded that active learning improved the attitudes and motivation of students. This may be due to the fact that the student curriculum-adaptation period is different for all learners.

CONCLUSION

Implementing new and innovative educational technologies might be costly in the beginning but has far reaching positive effects in the long run with both students and teachers seeking to benefit. Change can be costly and time-consuming but it is also an inevitable thing and in education, it is no different. Education is changing globally and the needs of both students and teachers have to be met to ensure there is productive engagement in classrooms and even outside classrooms because knowledge is more practical than theoretical.

Active learning opens the doors to practical learning enabling both students and teachers to do research, think outside the box and even come up with practical solutions to problems by themselves. This study seeks to increase student-teacher engagement through active learning and to encourage educators to make their classrooms more interactive because studies such as by (Shmidt, Cohen and Arends 2009), have shown a decrease in school dropouts because of incorporation of active learning in education.

Active learning has shown a significant increase in student achievement indicating efficiency and effectiveness of the teaching method in terms of academic performance. Compared to the traditional method, there is almost similar impact on students' motivation and attitudes hence this research concludes that active learning classrooms are more academically productive than traditional classrooms making students improve their grades and their passion in education. This study confirms other previous studies made by other researchers such as (Johnson & Johnson, 2008; Akınoğlu & Tandoğan, 2007; Sesen, & Tarhan, 2010) on how active learning increased student achievement. This study also aims to open the door to more future studies in this area for a more conclusive analysis of these methods of education.

LIMITATIONS AND SUGGESTION

The study was carried out for a very short period of time which may have not been enough to correctly and accurately determine the impact of active learning on students' achievement, attitudes and motivation. A longer study would however give more precise and clearer findings and results hence a more accurate conclusion because the curriculum adaptation period may be different for different learners. The study also focused on a few specific areas and methods of active learning however, instructors use different active learning implementation methods which have different impact on students. Therefore a standard method and implementation technique would give a clearer finding as well. We therefore, encourage more research and studies in this sphere to help learners and students in this modern era.

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