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THE EFFECT OF ACTIVE LEARNING ON STUDENTS' SUCCESS AND INFORMATION RETENTION IN ADVANCED MATHEMATICS

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Abstract

Mathematical analysis subjects are complicated and intricately related to each other. Hence, the retention skills of math topics and contents play a considerable role in the learning process. This study aims to examine the effectiveness of active learning (AL) on student academic achievement and information retention skills in the learning process of mathematical analysis course. The related hypothesis is that AL is more effective than regular conventional learning in success and keeping students' retention skills. AL implementation was conducted among first-year students (200) and lasted for 14 weeks during the spring semester of the academic year. We used an academic expert of the education faculty at a Kazakhstani University to instruct the lectures, and we used a pre-test and post-test design, and scores were interpreted statistically. Results indicated a significant effect of AL students' achievement and retention skills in mathematical analysis course.

Keywords: mathematical education, active learning, success in mathematics, information retention, knowledge.

Аңдатпа

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БЕЛСЕНДІ ОҚЫТУДЫҢ СТУДЕНТТЕРДІҢ МАТЕМАТИКА ПӘНІНДЕГІ ЖЕТІСТІГІНЕ ЖӘНЕ АҚПАРАТТЫ САҚТАУҒА ӘСЕРІ

Математикалық талдау пәндері күрделі және бір-бірімен тығыз байланысты. Демек, математика тақырыптары мен мазмұнын сақтау дағдылары оқу процесінде маңызды рөл атқарады. Бұл зерттеу математикалық талдау курсын оқу процесінде студенттердің оқу жетістіктері мен ақпаратты сақтау дағдылары бойынша белсенді оқытудың тиімділігін зерттеуге бағытталған. Тиісті гипотеза: белсенді оқыту жетістікке жетуде және оқушылардың есте сақтау дағдыларын сақтауда әдеттегі дәстүрлі оқытуға қарағанда тиімдірек. Белсенді оқытуды енгізу бірінші курс студенттері (200) арасында жүргізілді және оқу жылының көктемгі семестрінде 14 аптаға созылды. Тестілеуге дейінгі және кейінгі тестілеу схемалары қолданылды және ұпайлар статистикалық түрде түсіндірілді. Нәтижелер студенттердің математикалық талдау курсындағы жетістіктері мен есте сақтау дағдыларына белсенді оқытудың айтарлықтай әсері бар екенін көрсетті.

Түйін сөздер: математикалық білім, белсенді оқыту, математикадағы жетістік, ақпаратты сақтау, білім.

Аннотация

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ВЛИЯНИЕ АКТИВНОГО ОБУЧЕНИЯ НА АКАДЕМИЧЕСКИЕ ДОСТИЖЕНИЯ СТУДЕНТОВ И ИХ СПОСОБНОСТЬ ЗАПОМИНАНИЯ ИНФОРМАЦИИ ПО ВЫСШЕЙ МАТЕМАТИКЕ

Предметы математического анализа сложны и взаимосвязаны. Следовательно, навыки запоминания математических тем и содержания играют значительную роль в процессе обучения. Это исследование направлено на изучение влияния активного обучения на академическую успеваемость студентов и их способность запоминания информации в процессе обучения курсу математического анализа. Связанная с этим гипотеза состоит в том, что активное обучение более эффективно, чем традиционное обучение, в отношении успеха и сохранения навыков запоминания учащихся. Внедрение активного обучения проводилось среди первокурсников (200 человек) и длилось 14 недель в течение весеннего семестра учебного года. Были использованы схемы дотестового и послетестового тестирования, а результаты интерпретировались статистически. Результаты показали значительное влияние активного обучения на достижения студентов и навыки запоминания в курсе математического анализа.

Ключевые слова: математическое образование, активное обучение, успехи в математике, запоминание информации, знания.

Introduction

The high percentage of student failure in advanced mathematics has increased persistence among mathematicians for many years. Efforts to reduce failure have focused on successive mathematical analysis courses, mainly due to the prerequisites of which the courses' topics relate to each other. Most students who fail at advanced mathematics probably do so due to their experience in introductory mathematical analysis when they become first-year students because they have been unable to retain the knowledge of previous topics.

Many techniques are used in mathematical analysis courses to improve teaching and make mathematical analysis courses more informative and memorable than traditional ones.

AL could be one of the uses of learning methods to address performance and retention of the knowledge. Most of the learning effects can be increased in academic achievement if learning methods are used effectively in the classroom during the education process. AL is an approach to learning that makes students actively engaged in learning and has distinct grades of learning techniques, relying on student engagement. AL strategies help to engage learners in activities based on ideas about how the learning process can be operated [1]. AL may provide various techniques compared to traditional teaching (e.g., writing, reading), which have a difference, such as doing something rather than writing or regular learning. In this regard, students may actively participate in classroom activities and have an opportunity to establish new information and build new technical abilities. Sahin [2] categorized AL strategies in the framework of group discussions, whiteboard, one-minute paper, categorizing grids, concept maps, memory matrix, role-playing, think-pair-share, case study, panel, turn-and-talk, application cards, brainstorming, peer review, learning games, problem-solving and doing project. One of AL's tools is a class project that leads the students to participate in the form of activity through hands-on experiments or workshops in shape consisting of illustration, regression analysis, empirical style, and the settlement of change for the students.

AL plays a massive role in students' engagement in learning during class activities against passive listening to an expert. It underlines critical thinking and often consists of a group task [3]. Additionally, Prince [4] emphasized that AL helps students have meaningful activities for the learning process and be aware of what they are performing in a learning activity.

The Active Learners Institute [5] found that AL increases the education process's influence and performance. According to this research, the percentage of remaining knowledge in students' brains after months is as follows: "Lecture 5%, Reading 10%, Audiovisual 20%, Demonstration 30%, Discussion Group 50%, Practice by doing 75% and Teaching others 90%." Based on the result, it could be said that AL has a strong impact on lessons to support learners' academic achievement and retention.

Many experimental studies have authenticated humans' brains during learning. In addition, Ronaldo, T.; Lazaro P.T. [6] elucidated the influence over motor control memory and learning with respect to emotional social, and cognitive parameters. Researchers have studied the effect of retention that is dependent on AL which indicates evident events which are often better remembered because these events stand out from standard materials and consist of rich context hints. AL methods could support extraordinary materials to retain students' knowledge if the instructors persist in using unique activities in the education process.

Similarly, Riga et al. [7] found that AL raises students' learning desire and self-determination, giving them greater interest and control over their learning and giving them skills to increase life-long learning in the future. Lifelong learning examines situations where a student encounters several different works and develops methods of keeping and using task information to increase effectiveness. Thus, students start to improve their retention skills. Particularly, Tinto (1998) states that "Students who are actively involved in learning activities and spend more time on task, especially with others, are more likely to learn and, in turn, more likely to stay." By actively participating in the learning process – on the contrary, take passive – students view the material as pertinent, engaging, and absorbent. They improve and expand a sense of competence in using retention skills, construct, and connect to their comprehension through application, conversation, and consideration. Moreover, continuously improving retention knowledge requires instructors to center on different techniques to engage students in the education process actively. AL methods help to initiate learners and the entire faculty into practical ways to help learners engage in activities based on ideas about how people learn [1].

Hovelynck [8] and stated that AL promotes retention concepts, especially when the students instruct each other in the learning process. The barrier of feedback, students' passive listening, and improper situation for critical thinking education may create barriers to the impact of learning techniques. The interaction of the members of a group can decrease the limitation of the factors mentioned above. Light (1990) claimed that students' retention skills substantially impact the learning process concepts when they have engaged actively and can learn from training each other. Students can master each other; students can practice studying and collaborate with others; and students feel a warmer, more hospitable, and more exciting atmosphere. This last benefit can mainly play a vital role in the retention skills and achievement of the students.

Whittington [9] researched a massive measurement tool for students who were having difficulty getting through computer programming. He used a new curriculum to apply AL techniques, mainly designed for elementary computer programming courses in the classroom. The result showed that AL increased student retention skills, scores, and overall satisfaction. Furthermore, Kvam (2000) concluded that using AL methods on students' retention skills in an introductory engineering statistics class had significant benefits. It was scaled by re-testing immediately after the retention period and eight months later. The findings show that AL can help increase the retention rate for students with average or below average.

By the types of the literature analyzed, many factors affect AL on retention skills about mathematics topics sufficiently. One of the main factors is to use available measurement tools to reveal the significant impact of teaching mathematics methods.

Cherney et al. [10] have searched the effectiveness of AL by experimenting with open responses and without taking the same sizes and grades from several courses. Smith et al. [11] have also examined large lecture-based classes having 1091 students and found the effect of AL on student retention and engagement in Introductory Psychology by using a survey with three questions to find out the retention of content knowledge. Bullard et al. [12] investigated AL's effectiveness by experimenting with an engineering chemistry course every year from 2002 to 2006, instructing two groups (high-grade average and low-grade average) of students. They taught both groups actively and traditionally. The difference between achievement and retention among students was tiny, but students actively taught at the low GPA stage were much more likely to be successful and retain the traditional group. Mayer [13] revealed that pupils' assimilation of empirical knowledge through more accurate data about the distribution of practical information and testing results makes student retention stronger. Although there were many types of research about AL on achievement and retention skills, to our knowledge, no analysis has been carried out or focused on creating a specific measurement tool designed with the Bloom Taxonomy. The lack of relevant research makes it necessary to do more profound research about AL on achievement and retention skills using a measurement tool designed with the Bloom Taxonomy. Furthermore, Jonkovic, J. [14] elaborated on implicit or non-declarative memory in contrast to explicit declarative memory of episodic events. The article states that implicit memories have common storage and retrieval mechanisms that do not involve the hippocampal system; perhaps for this reason, the subject has no conscious knowledge of them. In the same line of arguments, Fillt, H. M. [15] discusses normal cognitive aging with regard to the dichotomy of declarative/ procedural memories stating that Implicit memory, often referred to as non-declarative memory, does not require the conscious or explicit recollection of past events or information, and the individual is unaware that remembering has occurred. Implicit memory is usually thought of in terms of procedural memory but also involves the process of priming. Procedural memory relates to skill learning and includes motor and cognitive skill learning, as well as perceptual or “how to” learning. Riding a bicycle, driving a car, and playing tennis are examples of procedural memory. Bouyeure, A.; Noulhiane, M. [16] in ‘factors affecting development in normal and adverse environments’, elucidated episodic memory as a particularly intricate phenomenon extending through long periods. They discussed the consequences of one’s cognitive and psychological development. They described normal episodic memory development during the infantile and childhood amnesia periods, with a focus on the relation between memory development and hippocampal maturation. They also explained how the concept of critical periods could explain pivotal aspects of infantile and childhood amnesia and how it could bring new insights to the study of disorders caused by adverse experiences during infancy and childhood. Similarly, Fereyduni, J, Baniadam, I, Rahimi, A. [17] in their article titled ‘The Effect of Turkish Lyrical Music on Foreign Language Vocabulary Acquisition and Long-Term Retention in a Turkish Language Course (TOMER)’ delineated the mechanism of information retention in a distinct discipline.

Unfortunately, researchers working in education have not yet thoroughly analyzed AL methods for retention skills in the field of advanced mathematics. Researchers should pay attention to the strategies of AL concerning retention skills in using advanced mathematics. However, the strategies are successful in medical sciences; AL should be used to investigate educational techniques in the new generation and help secondary and high school development. Therefore, this study aims to reinforce the effect of AL on students’ retention skills in mathematical analysis, a sample from Kazakhstan and Malaysia, which is an advantage of the current research that aims to the following research question:

How does AL impact students' achievement and retention skills by a measurement tool designed by Bloom's Taxonomy for mathematical analysis subjects?

Data Collection and Methodology

Data Collection

The data of the research have been collected through a measurement test about the Series subject and designed by the Levels of Bloom's Taxonomy. The measurement test scores showed the difference between AL and regular groups' success and retention levels.

Demographics of the participants

This study was conducted in the spring-fall semesters of academic years, with 100 participants at Suleyman Demirel University in Almaty and with 100 participants at University Malaysia Pahang. The implementation of AL lasted for 14 weeks, and each group separated 50 members in each university. The participants knew the English language at the level of intermediate in general.

Methodology

The study employs a quantitative method. First-year university students were chosen and had three hours of mathematics each week, and each hour of the lesson lasts fifty minutes. The experiment aims to reveal that a student in an AL group can keep the course information better in the long term (It was about four months) than a student in the regular learning group. More importantly, we examined to show the effectiveness of the methods that were AL and regular learning. As a result, students were tested twice; the first time was when immediately after a couple of chapters were finished, and the second was four months later. The first pre-test and post-test consisted of 200 students divided into equal groups for the used methods. The mathematical analysis-2 course consists mainly of series and convergence of the series. Two different classes having the same academic performance participated in the study. Both groups in the study took the same course knowledge with other techniques. Group sampling was random. The instructor taught the groups with the help of a teaching assistant during the academic year, and the participating students received no credit for completing the test.

While taking the pre-test at the beginning of the implementation, the lecturer received the post-test four months later. The instructor administered all tests and limited to fifty minutes to complete the test.

We used the t-test analysis for the small groups to reveal the difference between the AL and regular learning groups' post-test scores controlling their primary differences using a pre-test in the middle of the semester.

We ensured the process of study used by the instructor for the groups was AL in the lecture room. Before the implementation of AL, we monitored two regular lessons from the instructor by the first author. The strategies of AL were applied during the observation. The instructor carried out active learning methods by dividing the classes into three parts. The instructor used the active learning methods in the lessons given in Table (1). (Sahin, 2007)

Table 1. The AL Strategies Used in the Study

Strategies/weeks	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*Total*
One-minute paper	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*14*
Small-Group Discussion	*		*			*			*			*		*	*6*
Think –Pair-Share	*		*		*		*		*			*			*6*
Memory Matrix		*			*				*			*			*4*
Kahoot-play game	*		*		*		*		*		*	*			*7*
Whiteboard	*	*	*	*	*	*	*	*	*	*	*	*	*		*13*
Brain Storming	*	*						*		*					*4*
Problem-solving		*		*				*		*	*	*	*	*	*8*
Videos						*					*		*		*2*

One of AL's strategies in the study, think-share-pare, shows how to apply it in an advanced mathematics course' subject in the following manner:

Think–Pair-Share: An instructor asks students to think or write about an answer for one minute, then turn to a peer to discuss their responses for two minutes. The following question was one of the examples of the activity of think-share-pair.

A ball is dropped from an altitude of 100 cm. Each time it bounces, it takes to 1/2 of its previous height. What is the ball's total distance after hitting the surface of the ground for the fourth time? Activity: The instructor discusses the problem with the partners of the small group and, after two minutes, lets them show their solutions.

Results

Pre- and post-test means and standard deviations for AL and regular learning groups are given in Table (2).

Table 2. Group Statistics

Tests	Group	N	Mean	Std. Deviation
Pre-Test	Regular Learning	100	76.93	15.24
	AL	100	75.68	24.39
Post-Test	Regular Learning	100	47.50	17.12
	AL	100	65.31	15.75

Table (2) shows that the AL group (that is an experimental group) score is higher than that of the regular learning group (that is, the control group) for the post-test. Also, the groups' levels are closer to each other, utilizing the pre-tests of the groups.

After that, we used a t-test to evaluate whether the dependent variable varies between the AL and regular learning groups by the scores taken four months later. The results of the t-test analyses are shown in Table (3).

Table 3. Analyses of T-test

Tests	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig.	t	df	p
Pre-Test	3.75	.06	.17	30	.863
Post-Test	.052	.82	-3.06	30	.005

There is a significant result in students' retention for the post-test [p=0.005] of the AL group, as seen in Table (4).

Table 4. Independent Samples Test Results for Remembering, Understanding and Applying Levels of Bloom's Taxonomy

Level test of variance equality								95% Confidence Interval of the Difference	
Levels of Thought Actions	Variances	F	p	T	df	p	Mean D.	Lower	Upper
Remember	Equal variances assumed	.20	.65	-.63	30	.53	-4.68	-9.85	10.48
Understand	Equal variances assumed	2.51	.12	-3.93	30	.00	-28.60	-3.44	-13.75
Applying	Equal variances not assumed	6.05	.02	-2.26	25.58	.03	-17.87	-34.14	-1.60

As seen from Table 6, while the mean difference (-4.688) between remembering levels of regular and AL groups is not significant, the mean differences between understanding (-28.600) and applying (-17.875) are statistically significant. This result confirms Barnes's (1989) conclusion that AL helps students understand the subject through a query, collecting and determining data to solve higher-order cognitive problems.

Conclusions and Discussions

This study analyzed the difference between the AL group and traditional learning groups studying advanced mathematics. As predicted, students in the AL condition reported more excellent performance and retention in mathematical analysis courses. Based on the results, the study found the effectiveness of active learning methods through an accurate experiment for a group of students in success and retention skills. Interestingly, no student scored better results than the second exam, which shows consistency because the student's achievement and retention scores are less than the first exam scores.

It can be discussed with a well-written textbook and an active lecturer, and good students can get their course materials better. However, instructors may not be able to empathize with relatively mediocre students under guardianship and, as a result, may not understand the illustration and may have to do a repetition to teach the class concepts. This study is unique compared to other similar ones conducted on this topic in that it is the first study conducted in Kazakhstan, or maybe the first study in commonwealth nations. AL significantly affected students' retention in advanced mathematics when the groups of size, grade, and level of success were equal.

The result of this study promotes other research, which approves that AL keeps students' retention skills. For instance, Smith and Cardaciotto found a significant result that students in the AL environment showed higher retention and engagement with the course material in large classes. Similarly, Kvam (2000) accomplished an experiment to search the long-term impacts of AL instruction on student retention in an elementary engineering statistics class. Two groups of students took part in the study—one group was taught using traditional lecture-based learning, and the other group used AL methods. Retention was measured by examining the students immediately after the course finished and then again eight months later. The result proposes that AL is effective in increasing retention for students with average or below-average scores.

The meta-analysis done by Markant et al. [18] covering the studies published between 1961 and 2016, had a broad range of experimental evidence. It shows that such active control can lead to improvements in various forms of retention (including episodic retention) relative to passive conditions that lack the same opportunity for management, suggesting that enhanced retention may be a common AL outcome. Moreover, the analysis showed that these enhancements could appear from several different processes, depending on the kinds of control provided by an organized activity.

One of the main factors that make it difficult for instructors to use active learning in the classroom is that it requires a long time to prepare the activities, and the tools and resources are limited. The current study looked into AL's feasibility and advantages as a course method in small lecture-style classes to increase engagement with course material. This treatment may be used in other types of the classroom. For example, the AL environments based on technology may increase the use of meaningful learning that requires students to synthesize and analyze knowledge.

Future research with AL can be carried out to consider cultural conditions, using different software and feedback for the student to control new factors that enhance retention. We recommend that the instructors use various strategies of active learning in teaching advanced mathematics. Further research could also be conducted on AL's impact on student motivation, entrepreneurship, problem-solving skills, and meta-cognition in Kazakhstan.

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