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IMPACT OF THE ACTIVE LEARNING STRATEGIES ON STUDENT'S ACHIEVEMENT WITH RESPECT TO DOUBLE INTEGRALS IN MATHEMATICAL ANALYSIS

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Active learning is useful to engage and make an interest for the students in learning of mathematics, where the educators face many difficulties in teaching mathematics. This paper aims to address how to apply active learning strategies on the subject of double integral in advanced mathematics. We chose some suitable active learning strategies for using in the subject of double integral to show its designs. We also applied the active learning strategies which is shown in the introduction part for two groups from second year students in the faculty of science education at Suleiman Demirel University to reveal the of impact of achievement on the students. Comparing the achievement of experimental group to the control group, the authors deduce that the experimental group significantly outperform than the control group in the subject of double integral in mathematical analysis.

Key words: *Mathematics, Education of mathematics, Active learning, Strategies of active learning, double integral*

INTRODUCTION

Active learning is "a method of learning in which students are actively or experientially involved in the learning process and where there are different levels of active learning, depending on student involvement. (Bonwell & Eison 1991) [1]. Mathematics education changes based on constructivist perspective in this millennium suggest that the automation of abilities and passive educated interest should be replaced by active learning strategies. (Hiebert, 1992) [2]. Michael Prince explains, "Active learning is generally defined as any instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities and think about what they are doing". (Prince, 2004)[3]. Active learning strategies help to initiate learners and faculty into effective ways to help learners engage in activities based on ideas about how people learn. (Berkeley university of California, 2019) [4]. Active learning should transform students from passive listeners to active participants and helps students understand the subject through inquiry, gathering and analyzing data to solving higher order cognitive problems.(Barners, 1989)[5]. Some of the techniques that could be considered in the framework of active learning could be stated as follows: snowball, fish bowl, buzzing, writing poetry, mental maps, concept maps, creative groups, learning through research, role playing, case study, panel, debate groups, forum, card sorting, brain storming, explanatory learning, educational games, problem solving and decision making activities (Sahin M., 2007) [6]. Freeman and colleagues collected written definitions of active learning from three hundred people attending seminars on active learning, arriving at a consensus definition that emphasizes students' use of higher order thinking to complete activities or participate in discussion in class. (Freeman et al., 2014) [7]. Active learning supports the chance for advanced learning; however, student strength to this kind of learning requires hard level. Active learning clashes with student's traditional ways of teaching and learning. During the classrooms, students were told knowledge, kept in their minds it, and were then tested what they learned. But, active learning requires them to give a chance and try learning strategies that they have no fundamental structure with. Active learning coordinates with the principles of constructivism which are, cognitive, meta-cognitive, evolving and affective in nature. Studies have shown that immediate results in construction of

knowledge is not possible through active learning, the child goes through process of knowledge construction, knowledge recording and knowledge absorption. (Glenda A., 1996) [8]. The effectiveness of active learning in learning process revealed as following diagram:

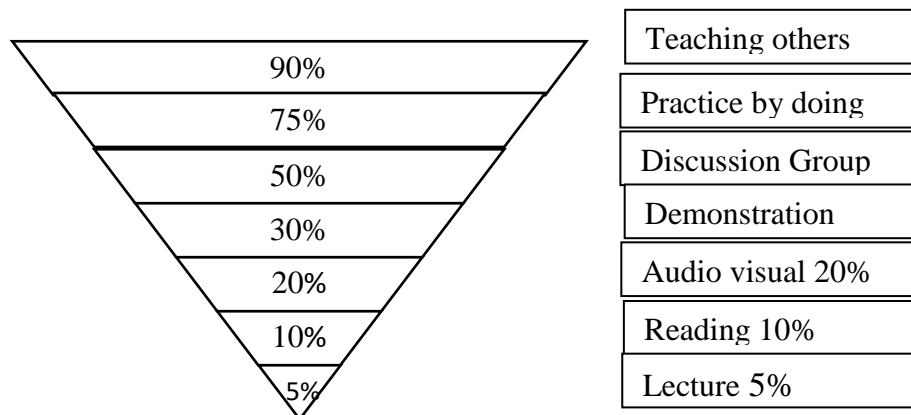


Figure-1

(The Active Learners Institute, 2011) [9]

STRATEGIES OF ACTIVE LEARNING

A . Group activities

1 . Case-based learning

Case-based strategy calls students to apply their knowledge to get a conclusion about real-world problem. Promote students with a case, asking them to check what they know that is relevant to the case, what extra knowledge they may demand, and what effect their decisions may have, impacting the wider applications of their decisions. It is formed by small groups of 3-4 students time to consider responses, circulating to ask questions and support help as requirement. It provides chances for groups to share reflects. This strategy helps students apply what they have learned through reading or didactic teaching. The greatest outcome from case-based strategy comes from the complexity and variety of answers that may be formed. The case-based learning can be done in pairs or groups.

Example:

Why the number of the rectangular solid are increased the volume of the total is getting greater as seen in the figure-2

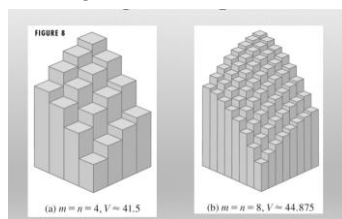


Figure-2

2. Group Discussion

When a question or case is posed, students discuss in groups of 3-4 for five minutes. It is important that the question or case is difficult enough that group members need to spend considering what they know (from readings, experience, or data) and multiple options could be determined before coming to a conclusion. If there is no time to discuss, and students are able to seem to a conclusion quickly, the

discussion will become flat quickly. Discussing concepts in groups allows students time to talk through their thinking, test their ideas with others, and receive feedback and alternative views from group members. Group discussion helps students clarify their understanding and aids in retention of knowledge.

Example:

If the base of a given solid has non-rectangular, how can one calculate the total volume of the solid as seen in the figure-3?

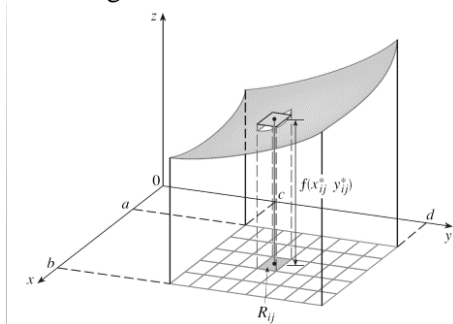


Figure-3

3. Jigsaw

In this strategy, two or three concepts are used, or questions around a single subject. Students are arranged in groups of 3-4 to study their related concept/question. After groups have some time to study it, they spend time teaching/explaining their ideas to the other group(s). This strategy is an efficient way to handle many concepts/questions at once, and gives students a chance to explain it to others.

Example:

Explain that if f happens to be a positive function, then the double Riemann sum is the sum of volumes of columns and approximates the volume under the graph of f . (After discussing time, the groups will explain their ideas.)

4. Working at the Board

When finding solution for a problem, (e.g. Critical thinking) students are given exercise the problems themselves, by asking them to go to the board in small groups to show their solution. This activity promotes students implement what they have knew through reading or instructive teaching. This strategy can reinforce students' logical thinking processes and check their mental model of an operation. The activity can be done in pairs or groups.

Example: Find the volume of the solid that lies above the square $R = [0, 2] \times [0, 2]$ and below the elliptic paraboloid $z = 16 - x^2 - 2y^2$.

B. Individual Activities

1. Application Cards

After students having a look or hearing about an important postulate, definition, theory, or axiom, share a piece of note paper and ask students to write down at least one possible, real-world example for repeated knowledge.

Example: Write at least one real-world example or application about finding volume by using double integral.

2. Direct paraphrasing

A statement is asked to the students from a part of a lesson of a specific viewer and aim, using their own words. Statement helps students practice their future interactions with patients. Students improve conversations skills of teaching to others helps students retain their knowledge as well.

Example:

Evaluate $\int_1^4 \int_0^{\sqrt{y}} e^{y/\sqrt{x}} dx dy$ by changing the orders of the double integration.

3. Minute Papers

A question is asked to the students that requires them to reflect on their learning or to engage in critical thinking. One minute is given to the students. It is asked to students to share responses to foster discussion. It also engages everyone in thinking and writing, not just for the minor students.

Example:

Evaluate $\int_2^5 \int_0^x xy dy dx$ by changing the orders of the double integration.

4. Muddiest point

A type of the minute paper, explaining for feedback about where students are still confused. I is asked a question such that non-clear remain at top in your mind during the lesson in the classroom. Students are allowed to reflect on what they know and don't know. It brightens where students may not understand so the facilitator can point them if they need

Example: Write the difficulties in the reversing of the borders of double integral.

C. PARTNER ACTIVITIES

1. Role-playing

Students are asked to activate a part of the statement of the subject or problem. In doing so, they get a better idea of the concepts and theories being discussed. Role-playing exercises can improve conversations skills of the students. They practice putting difficult concepts, and teaching to others helps students retain their knowledge as well.

Example: Perform the following integration and then discuss with your partner.

Evaluate $\iint_D (4x + 2) dA$ where D is the region enclosed by the curves $y = x^2$ and $y = 2x$.

2. Think –Pair-Share

It is asked to students a question that requires higher order thinking. Students are asked to think or write about an answer for one minute, then turn to a peer to discuss their responses for two minutes. Ask groups to share responses and follow up with instructor explanation if needed. By allowing students time to write first, they are able to initiate their own thinking before hearing someone else. By asking students to explain their answer to a neighbor and to critically consider their neighbor's responses, this approach helps students articulate newly formed mental connections.

Example: Find the result of the double integration $\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} e^{-(x^2+y^2)} dydx$

3. Turn-and-Talk

A faster version of think-pair-share, it is given a higher-order thinking question for students and asked them to talk about it with a neighbor for 1-2 minutes before asking pairs to share out their thinking to the total group. This is a quick process that can be put into a class session multiple times. By asking students to explain their answer to a partner and to critically analysis their partner's reply. This method helps students speak out newly formed mental connections.

Example:

What is the main purpose of the Fubini's theorem in double integral?

D. VISUAL ORGANIZING ACTIVITIES

1. Categorizing Grids

It is presented a grid made up of several important categories for students with and a list of scrambled terms, images, equations, or other items. Students answer quickly sort the terms into the correct categories in the grid. Willing students answer to share their grids and answer questions that arise. This method allows students to express and thus interrogate the distinctions they see within a field of related items. It can be particularly effective at helping instructors identify misconceptions.

Example:

2. Concept Map

Concept maps are visual representations of the relationships between concepts. Concepts are placed in nodes (often, circles), and the relationships between indicated by labeled arrows connecting the concepts. To have students create a concept map, identify the key concepts to be mapped in small groups or as a whole class. Students are asked to determine the general relationship between the concepts and to arrange them two at a time, drawing arrows between related concepts and labeling with a short phrase to describe the relationship. This activity helps students understand relationships between concepts, which promotes better understanding and retention. The activity can be done in pairs or groups.

Example: According to the figure-4, perform the double integration $\iint_D (x+y) dA$

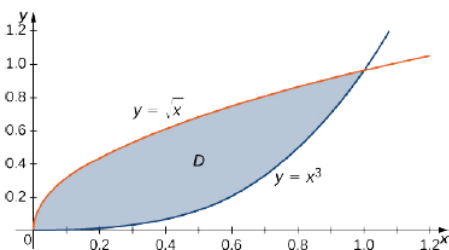


Figure-4

3. Demonstrations

Students are asked to foretell the result of a theorem of statement, briefly discussing with a partner. After the statement, they were asked to discuss the observed result and compare their conclusion by teacher's solution. This method asks students to test their understanding of a system by predicting a result. If their answer is incorrect, it promotes to learn from their mistakes.

Example: If $I = \iint_D \frac{1}{2+x^3} dx dy = \int_0^1 dy \int_{\sqrt{y}}^1 \frac{1}{2+x^3} dx$, then sketch the region D in the first form I appearing

here. Determine the value of I by changing the order of integration in the second form.

4 . Memory Matrix

This is a two-dimensional diagram, a rectangle divided into rows and columns used to organize information and illustrate relationships. In a memory matrix, the row and column headings are given, but the cells are left empty for students to fill out during class as they learn. This activity improves students apply what they have learned through reading or didactic teaching. This method can make strong students' relational reasoning. The strategy can be done in pairs or groups.

Example: Fill the empty parts the following matrix as seen in the table-1.

1. What is the Fubini's theorem?	?
2. What is the form of polar of double integration?	?
3. What is the formula of the mass of center by the double integral?	?
4. What is the Green's theorem?	?
5. $\int_2^5 \int_0^x e^{x^3} y dy dx$?

Table-1

METHODOLOGY

Purpose of the Study

The purpose of this study is to investigate how the strategies of active learning impact students' achievement in the mathematical analysis. Research question was asked as the following: How does the strategies of active learning impact student's achievement in mathematical analysis? The hypotheses assumed that the active learning strategies impact students' achievement positively. In this section, research model, data collection tools, data collection, comparison test method are included.

In this study, there were two midterms exams and a final exam formed by seven questions each. These exams were given two groups of the students which one of them were used active learning strategies and the other one were used regular method. We used post-test only control group design. The posttest-only control group design is a research design in which there are at least two groups, one of which does not receive a treatment or intervention, and data are collected on the outcome measure after the treatment or intervention (Frey, 2018) [10]. The-t test was applied for the posttest of the midterms. We took two midterms and final as exams and evaluated by the assesment of the student portal. Because of having many subtopics, it had to be taken. The questions about the double integral were chosen Calculus and Analytic Geometry written by Thomas- Finney were selected by the teachers.

Data Collection

The experiment was done with the participation of 32 students of the Faculty of Education and Humanities split into two groups 15 and 17. The students were asked about seven double integral questions, the mathematics lecturers chose the questions and prepared an exam for two groups.

The students in the first group (15) were informed about active learning strategies. As for the other group (17), the traditional method was implemented. The methods were extended along the first semester of the year and the achievements of the groups were compared.

Results

Group Statistics				
	Group	N	Mean	Std. Deviation
Grade	Active learning method	15	82.45	12.689
	Regular Method	17	59.88	21.106

Table -2

As seen in Table-2 for the three exam results, experimental and control groups' the averages are 82.45 and 59.88 respectively.

Independent sample t-test for equality of Means		t	df	p	Mean Difference	Std. Error Difference
Grade	Equal variances assumed	3.602	30	0.001	22.563	6.264
	Equal variances not assumed	3.713	26.677	0.001	22.564	6.078

Table-3

As seen from Table-3, the difference between groups' achievement is statistically significant ($p < 0.05$).

Findings

As seen in the tables of the results, the experimental group's mark average is 82.45 and greater than the mark average of the control group which is 59.88. Specially, in the average of the three exams, the difference between experimental and control group is approximately twenty three points.

Discussion

In this study, our alternative hypothesis was that the active learning strategies impact students' achievement positively. From our findings above we rejected the null hypothesis that the active learning has no positive impact on student's achievement as p-value is less than 0.05 and conclude that the experimental group performed significantly higher than the control group.

The results are important to show that methods are important to increase student's achievement. Of course, the purpose of the study was not to prove impacting the used method; it was just to discover the method's impact on the students. We had a short period and insufficient time which was two hours in a week. In a future study, it is recommended to plan the work for a longer period and to give a lot of contact hours with students. This similar result was found in the study by Grace Adebisi Fayombo (2013) [11]. Another point to keep in mind for the future research is to increase the number of students to change or not to change the achievement in math education.

Conclusion

In this study, there were chosen eleven active learning strategies and shown how to use in the subject of double integral in advanced mathematics for two groups of the faculty of education science. The experiment applied for the groups showed that there is statistically significant conclusion between regular method and active learning method. By the way the experimental group students engaged the lesson effectively rather than the control group. It is needed to show other strategies to use in mathematics to get diversity to engage the students into the mathematics to make it interesting to students. We hope that teachers in mathematics disciplines will be infused to develop active learning strategies to make their classroom environment more interesting and amusing.

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ВЛИЯНИЕ СТРАТЕГИЙ АКТИВНОГО ОБУЧЕНИЯ НА ДОСТИЖЕНИЕ СТУДЕНТОВ ПРИ ИЗУЧЕНИИ ДВОЙНЫХ ИНТЕГРАЛЛОВ В МАТЕМАТИЧЕСКОМ АНАЛИЗЕ

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В изучении математики где преподаватели сталкиваются со многими трудностями, активное обучение необходимо для того чтобы привлечь и заинтересовать студентов. Эта статья показывает, как применять стратегии активного обучения при изучении темы двойных интегралов в высшей математике. Мы выбрали несколько подходящих стратегий активного обучения, чтобы показать его конструкции. Чтобы выявить влияния достижений на студентов, авторы применили стратегии активного обучения, которые показаны во вводной части для двух групп студентов второго курса факультета естественнонаучных дисциплин в университете Сулеймана Демиреля. Сравнивая достижения экспериментальной группы с контрольной группой, авторы делают вывод, что экспериментальная группа значительно превосходит контрольную группу по предмету двойного интеграла в математическом анализе.

Ключевые слова: математика, математическое образование, активное обучение, стратегии активного обучения, двойной интеграл

МАТЕМАТИКАЛЫҚ ТАЛДАУДАҒЫ ҚОС ИНТЕГРАЛ ТАҚЫРЫБЫНА ҚАТЫСТЫ СТУДЕНТТІҢ ЖЕТІСТІКТЕРІНІҢ БЕЛСЕНДІ ОҚУТЫ СТРАТЕГИЯЛАРЫНЫҢ ӘСЕРІ

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Мұғалімдер математиканы оқытуда көптеген қиындықтарға тап болған кезде оқушылардың қызығушылығын ояту үшін белсенді оқыту тәсілін қолданғаны жөн. Бұл мақалада жоғары математикада қосарланған интегралдар тақырыптары бойынша белсенді оқыту тәсілін қолдануды қарастырады. Белсенді оқытудың тәсілдерін көрсету бірнеше қолайлы стратегияларды таңдадық. Белсенді оқытудің студенттерге әсерін анықтау мақсатында авторлар Сулейман Демирел атындағы университеттің жаратылыстану факультетінің екі курс студенттеріне арнайы зерттеу жұмысын өткізді. Эксперимент тобының жетістіктерін бақылау тобымен салыстыра отырып, авторлар эксперименттік топ математикалық анализде қос интеграл тақырыбында бақылау тобынан едәуір асады деген қорытындыға келді.

Түйін сөздер: математика, математикалық білім, белсенді оқыту, белсенді оқыту стратегиясы, қос интеграл

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