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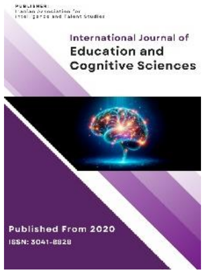

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The Impact of Active Learning Method on Academic Achievement, Motivation, and Attitudes Towards Mathematics

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ABSTRACT

Purpose: The present study aimed to examine the effect of the active learning method on students' academic achievement, motivation, and attitudes towards mathematics.
Methods and Materials: This quasi-experimental study employed a pre-test, post-test design with a control group. The study population consisted of fourth-grade students from the city of Babel in Iraq during the year 2023. Using Cochran's formula, 64 students were selected as the sample, chosen through convenient sampling, and randomly assigned into two groups of 32 students each: experimental and control. The experimental group received active learning instruction, while the control group was taught using traditional methods. The data collection instruments included the mathematical achievement motivation questionnaire by Aminefar and Saleh-Sadeqpour (2009) and the attitude towards mathematics questionnaire by Lim and Chapman (2013). Initially, both groups were informed about the study and a pre-test was administered. The control group was taught using lecture-based instruction, while the experimental group was taught using active learning platforms. The study lasted for six weeks. After the study period, a post-test was administered to both groups, and the results were analyzed using MANOVA to assess the significance of the differences between the two teaching methods.
Findings: The results indicated that students in the experimental group, who received active learning, showed greater academic progress. However, no significant differences in attitudes or motivation were found between the experimental and control groups.
Conclusion: The results indicated that active learning method can be used to improve students' academic achievement, motivation and attitudes towards mathematics.

Keywords: *Active learning, academic achievement, attitude, motivation, mathematical achievement*

1. Introduction

Undoubtedly, learning is at the center of activities that take place in educational environments, and the ultimate goal of any education is to achieve learning in a deeper, more desirable, and more sustainable way. Educational psychologists and learning experts have always strived to contribute to the realization of this goal by providing theories and scientific principles, aiming to offer more effective, enriching education and create productive learning environments. One of the relatively emerging learning methods in this regard is active learning (Mendonça et al., 2018). Active learning emerged in the 1980s and gained significant attention in the 1990s. It is a type of learning that engages students in the learning process through activities and class discussions, standing in contrast to passive listening. In its most widely used definition, active learning is described as "encouraging students to do something and think about what they are doing" (Ren et al., 2021). Active learning consists of methods that engage students in the learning process and refers to strategies that can enhance student activities and transform learning into a two-way interaction (such as problem-solving, group discussions, role-playing, case studies, essay writing, question formulation, etc.). In fact, active learning means that students actively participate in classroom activities, rather than passively following a teacher's instructions, and it is a method for encouraging learners to actively engage in the learning process (Vetter et al., 2020). In another definition, it is described as student-centered learning with minimal teacher intervention. Just as active learning has altered the concept of learning, changes have also occurred in the traditional roles of teachers and students. In a student-centered learning environment based on active learning, the role of the teacher has shifted from directing learning to facilitating, guiding, and supporting learning, rather than dictating decisions about the learning process. The teacher is no longer confined to the traditional role of "instructor" but has become a "learning facilitator" (Munna & Kalam, 2021). Therefore, students and their learning needs are at the core of active learning. When these definitions are examined, it becomes clear that the key element is the active participation of students in the learning process, as the essence of active learning involves presenting information with evidence and hands-on activities, rather than simply transferring knowledge. Students also construct their own experiences, ask questions, develop hypotheses, and attempt to refine and extend their understanding through testing material in an open and collaborative context (Muhammad et al., 2023). The creation and development of mental frameworks also results from active participation. Through mental activity, prior knowledge is expanded, enhanced, and shaped. Recent studies in cognitive psychology suggest that active participation facilitates deeper processing and learning of information, as it creates stronger connections. Considering all these factors, active learner participation is considered essential for effective learning in various domains (Lugosi & Uribe, 2022).

On the other hand, in the educational system, teaching mathematical concepts holds a special place, and it is one of the key areas in the curriculum. Today, the goal of teaching mathematics is not merely to cultivate elite mathematicians or individuals intending to pursue mathematics at the university level. The main objective is to enhance students' quality of life. Therefore, establishing connections between mathematics and daily life, acquiring mathematical modeling and problem-solving skills, developing thinking skills, linking various mathematical representations, interpreting and understanding them, connecting mathematics with other sciences, and generally applying mathematical concepts in the surrounding environment and interpreting and analyzing them are among the main objectives of this curriculum (Vale & Barbosa, 2023). Given the importance of mathematics across various educational stages, one of the objectives of the educational system is to incorporate mathematical topics into the curriculum in such a way that, in addition to fostering students' intellectual abilities and reasoning skills, it also prepares them to keep pace with scientific developments and technological advancements. Thus, the issue of students' academic achievement and the factors affecting it has been a topic of interest for psychologists and educators from the past to the present (Ofem et al., 2024; Omale, 2024). Researchers have always sought ways to improve academic achievement in mathematics and have identified multiple factors that influence students' progress in this subject. Various studies have shown that academic achievement in mathematics is related to motivational factors such as beliefs and attitudes. Attitude towards mathematics refers to the emotions students experience during mathematical activities or the automatic feelings they associate with mathematical concepts (Ajisuksmo & Saputri, 2017; Kaskens et al., 2020; Vale & Barbosa, 2023). Since attitude consists of three components, attitude towards mathematics also includes individuals' beliefs about mathematics (cognitive aspect), their feelings towards mathematics (affective aspect), and

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their behaviors towards mathematics (behavioral aspect), each of which can be positive or negative. Mathematics classes where teaching is conducted traditionally, and reasoning is not encouraged, lead to the development of negative attitudes among students (Kaskens et al., 2020). Teachers' emphasis on correct answers, a competitive classroom environment, students' lack of participation in their own learning, and parents' and teachers' negative attitudes towards mathematics cause students to experience anxiety and negative attitudes, leading to their disengagement from the learning process. Moreover, teacher-dependent learning in mathematics prevents students from engaging in direct and active learning, meaning that, in such situations, learning is heavily influenced by the teacher's personality, teaching style, and other characteristics, resulting in negative attitudes and, ultimately, poor performance in mathematics (Theobald et al., 2020). Furthermore, in educational theories, academic motivation is a fundamental concept and one of the most important elements for effective learning and teaching, especially in mathematics, and is considered one of the primary goals of education. Academic motivation is a tool for assisting in learning various subjects, promoting lifelong learning, and acquiring both professional and general skills (Lee et al., 2022{Enayati Shabkolai, 2023 #31226)}. Academic motivation refers to the needs, desires, and factors that prompt an individual to engage in educational settings and obtain a degree. Common behaviors indicating academic motivation include persistence in completing difficult assignments, working hard towards mastery learning, and choosing tasks that require effort (Kokabi Rahman et al., 2023; Sides & Cuevas, 2020).

Given the above and considering that mathematical problems and poor performance in mathematics are significant issues faced by a considerable number of students, with one of the factors related to this problem being students' academic motivation (in mathematics), attention to predictor variables such as necessary learning approaches is crucial and can help identify variables that predict motivation and academic achievement in mathematics. This, in turn, enables educational officials to design programs to improve students' mathematical performance and motivation. On the other hand, given the lack of research in this area (both domestically and internationally), conducting this research can fill this gap and strengthen the field of mathematics performance and motivation among students. Therefore, the present study aims to examine the impact of the active learning teaching method on students' academic achievement, attitudes towards mathematics, and motivation. In line with achieving this goal, the study seeks to answer the following questions:

1. Does active learning influence students' academic achievement?
2. Does the active learning method affect students' attitudes towards mathematics?
3. Does active learning influence students' motivation?

2. Methods and Materials

2.1. Study Design and Participants

The present study is applied in terms of its goal. The research method is a quasi-experimental design with a pre-test–post-test approach, including control and experimental groups. The statistical population of the study consisted of fourth-grade students from the city of Babol, Iraq, in the year 2023. Using Cochran's formula, 64 individuals were selected as the sample and chosen by convenience sampling. These individuals were randomly assigned to two groups: experimental (32 students) and control (32 students). The experimental group received active learning, while the control group received traditional teaching.

2.2. Measures

2.2.1. Mathematics Attitude

To measure students' attitudes toward mathematics, the questionnaire developed by Lim and Chapman (2013) was used. This questionnaire consists of 19 items that assess students' attitudes toward mathematics on a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). The authors of the scale calculated validity by correlating each item with the total score, with a correlation coefficient greater than 0.60 for each item. The reliability of the scale was reported as 0.93 using Cronbach's alpha. In the study by Ajisuksmo and Saputri (2017), the reliability of the questionnaire was reported as higher than 0.80. In the current study, the reliability of the questionnaire was calculated as 0.82 using Cronbach's alpha, indicating a good level of reliability (Ajisuksmo & Saputri, 2017).

2.2.2. Achievement

In this study, academic achievement in mathematics was measured by students' final exam scores in mathematics.

E-ISSN: 3041-8828

2.2.3. Motivation

The standard Mathematics Achievement Motivation Questionnaire, designed and developed by Amini Far and Saleh Sadeghpour in 2010, consists of 17 items. It has two components (approach motivation and avoidance motivation) and is scored based on a Likert scale (from strongly disagree to strongly agree). The reliability of the questionnaire was found to be 0.71 using Cronbach's alpha, indicating satisfactory reliability (Bahram Saleh & Fatemeh, 2013).

2.3. Intervention

2.3.1. Active Learning Method

This intervention protocol utilizes an active learning method designed to enhance students' engagement, understanding, and retention of mathematical concepts. The intervention consists of six sessions, each lasting between 60 to 90 minutes. Active learning is an instructional approach that emphasizes student participation, critical thinking, and collaboration rather than passive learning. During these sessions, students will engage in various activities that encourage problem-solving, group discussions, and hands-on practice, all of which are designed to foster deeper learning and develop positive attitudes toward mathematics. Each session will focus on a specific mathematical topic or concept, and the activities will be tailored to stimulate both cognitive and emotional engagement with the content (Aguillon et al., 2020; Lombardi et al., 2021; Lugosi & Uribe, 2022; Mendonça et al., 2018; Theobald et al., 2020; Vale & Barbosa, 2023).

Session 1: Introduction to Active Learning and Mathematical Problem Solving

The first session introduces students to the active learning approach and sets the expectations for the subsequent sessions. The session begins with a brief explanation of the importance of participation and collaboration in the learning process. The students then engage in a warm-up activity involving basic math problems, followed by a group discussion where they share different problem-solving strategies. The session emphasizes understanding mathematical concepts through real-life applications. Students will be divided into small groups, and each group will work on a set of problems that require them to collaborate, discuss different strategies, and arrive at a solution collectively. This session sets the tone for future learning, encouraging active participation and critical thinking.

Session 2: Collaborative Learning in Solving Algebraic Equations

In the second session, students will work in pairs or small groups to solve algebraic equations. The teacher will first explain the core concepts of algebraic equations, including variables, constants, and coefficients. Afterward, students will be given a series of algebraic problems that increase in complexity. The groups will discuss and solve the problems together, and each group will present their solutions and reasoning to the class. The teacher will guide the discussion, highlighting different strategies and encouraging students to explain their thought processes. This collaborative approach allows students to learn from each other and deepen their understanding of algebraic concepts.

Session 3: Inquiry-Based Learning in Geometry

Session three introduces inquiry-based learning through geometry. The teacher will present a series of geometric shapes and ask students to investigate their properties. Instead of giving direct explanations, students will explore the shapes in groups, formulate hypotheses, and test their ideas by constructing models or using geometry software. Each group will present their findings to the class, followed by a group discussion that emphasizes critical thinking and the development of problem-solving skills. The session encourages students to ask questions, explore different approaches, and arrive at their own conclusions, reinforcing the concept that learning is an ongoing process of inquiry.

Session 4: Group-Based Learning in Statistics and Data Interpretation

The fourth session focuses on statistics and data interpretation. Students will work in groups to analyze a set of real-world data, such as survey results or sports statistics. Each group will be responsible for organizing the data, calculating averages, and identifying trends. Afterward, students will present their findings to the class using charts and graphs. The teacher will guide the class through the interpretation of the results, explaining key statistical concepts like mean, median, mode, and range. The session will also emphasize the importance of data analysis in making informed decisions, helping students connect mathematical concepts to real-world situations.

Session 5: Active Participation in Problem-Based Learning (PBL) for Word Problems

In session five, the focus will shift to problem-based learning (PBL) with a focus on solving word problems. The teacher will present students with a complex word problem

E-ISSN: 3041-8828

that requires the application of various mathematical concepts. Students will work in groups to break down the problem, identify the necessary steps, and find a solution. The groups will present their strategies and solutions to the class, and the teacher will facilitate a discussion to explore the different approaches used. This session emphasizes the importance of critical thinking, teamwork, and applying mathematical knowledge to real-world challenges.

Session 6: Reflection and Application of Mathematical Concepts

The final session of the intervention will be dedicated to reflection and the application of mathematical concepts in real-life scenarios. Students will work on a final project where they apply the concepts learned throughout the intervention to a real-world situation. This could involve creating a budget, designing a simple architectural plan, or analyzing a dataset. The session will begin with a brief review of the key concepts covered in previous sessions, followed by group work on the final project. At the end of the session, students will present their projects to the class, reflecting on how their understanding of mathematics has evolved and how they can apply these skills in their daily lives. The session concludes with a group discussion on the benefits of active learning and the importance of continued engagement with mathematical concepts.

2.4. *Data Analysis*

The data collected in the pre-test and post-test stages were analyzed using Analysis of Covariance (ANCOVA) through SPSS version 24.

3. Findings and Results

Table 1 presents the post-test scores analysis for mathematics achievement, attitude toward mathematics, and motivation, as obtained from the study conducted in the experimental and control groups. Looking at the table, the mean score of the experimental group on the mathematics achievement test was 13.47 (SD = 4.35). On the other hand, the mean score of the control group on the same test was 11.25 (SD = 3.83). As observed from the table, the mean score of the experimental group on the attitude questionnaire was 2.92 (SD = 0.26). In contrast, the mean score of the control group on the same test was 2.85 (SD = 0.30). Finally, the mean score of the experimental group on the motivation questionnaire was 3.41 (SD = 0.50). In comparison, the mean score of the control group on the same test was 3.28 (SD = 0.60).

Table 1

Descriptive Statistics

Variable	Group	Mean	Standard Deviation	N
Achievement	Experimental	13.42	4.35	32
	Control	11.25	3.83	32
	Total	12.36	4.11	64
Attitude	Experimental	2.92	0.26	32
	Control	2.85	0.30	32
	Total	2.88	0.28	64
Motivation	Experimental	3.41	0.50	32
	Control	3.28	0.60	32
	Total	3.34	0.55	64

To test the normality of the data, the Shapiro-Wilk test was used. According to the results obtained ($p < 0.05$), it can be concluded that the data follows a normal distribution.

The study data indicated that the Mahalanobis distance ranged from 0.07 to 11.64. Since all values are less than 13.82 (the critical value), the data also meet the assumption of multivariate normality.

Since the VIF values obtained were less than 2.5, the analysis proceeded.

The homogeneity of variance-covariance matrix was further tested using M-Box's test. The result from Box's test showed that the p-value (0.305) is greater than 0.05, indicating that the assumption of covariance equality between groups is met.

Table 2 presents the results of the ANCOVA analysis, examining the effect of active learning on students' academic achievement, attitude toward mathematics, and motivation. Based on the results, it is concluded that active learning significantly affects students' academic achievement.

E-ISSN: 3041-8828

Table 2

ANCOVA Results for Students' Outcomes, Attitudes, and Motivation

Dependent Variables	Group	N	Mean	Standard Deviation	F	p
Achievement	Experimental	32	13.47	4.35	4.95	0.030
	Control	32	11.25	3.84		
Attitude	Experimental	32	2.92	0.26	1.01	0.320
	Control	32	2.85	0.30		
Motivation	Experimental	32	3.41	0.50	0.94	0.336
	Control	32	3.28	0.60		

An ANCOVA was conducted to assess the effect of treatment type (ACT, CBT, and control) on death anxiety and hope for life (Table 2), while controlling for pre-test scores. For death anxiety, the covariate (pre-test scores) was found to have a significant effect, $F(1, 41) = 25.73$, $p < 0.001$, with a partial η^2 of 0.387, indicating a large effect. The treatment type also had a significant effect on death anxiety, $F(2, 41) = 9.62$, $p < 0.001$, with a partial η^2 of 0.319, suggesting that the treatments significantly reduced death anxiety compared to the control group.

For hope for life, the covariate (pre-test scores) significantly influenced the results, $F(1, 41) = 21.02$, $p < 0.001$, with a partial η^2 of 0.337. The treatment type also significantly impacted hope for life, $F(2, 41) = 13.15$, $p < 0.001$, with a partial η^2 of 0.393, indicating a large effect of the treatments on increasing hope for life in comparison to the control group. These findings suggest that both ACT and CBT therapies had significant positive effects on the psychological outcomes of death anxiety and hope for life among breast cancer patients, relative to the control group.

4. Discussion and Conclusion

This study aimed to explore the impact of the Active Learning Method (ALM) on students' academic achievement, motivation, and attitudes towards mathematics. The results indicate that the ALM significantly enhanced students' performance in mathematics, increased their motivation, and positively influenced their attitudes towards the subject. These findings align with the body of research that emphasizes the positive outcomes of active learning strategies in various academic settings. Specifically, students who participated in the ALM showed higher levels of engagement, improved problem-solving skills, and a greater sense of ownership over their learning process. Moreover, the intervention led to a reduction in math anxiety and a stronger sense of self-efficacy in mathematics, which further contributed to their increased motivation and positive attitudes.

Previous studies have highlighted the importance of student-centered learning methods, such as ALM, in improving academic outcomes. Theobald et al. (2020) found that active learning strategies significantly reduce achievement gaps, particularly for underrepresented students, by fostering an inclusive and interactive learning environment. In line with this, the current study showed that students who actively participated in ALM tasks exhibited better academic performance, suggesting that these methods may help bridge gaps in understanding, particularly in challenging subjects like mathematics. The results of this study also support findings from Aguillon et al. (2020), who reported that active learning promotes equal participation among students, regardless of gender, further enhancing academic achievement (Aguillon et al., 2020). In our study, the gender differences observed in participation and academic performance were minimal, reinforcing the notion that active learning can create an equitable learning space for all students.

The positive impact of ALM on student motivation and attitudes towards mathematics is also supported by several studies. For instance, Kaskens et al. (2020) found that students with higher levels of self-efficacy in mathematics were more motivated and engaged in their learning, which subsequently led to better academic outcomes (Kaskens et al., 2020). The current study mirrored these findings, as students who participated in active learning activities reported increased confidence in their mathematical abilities. Furthermore, Vale and Barbosa (2023) highlighted that active learning techniques, such as collaborative group work and hands-on problem-solving, fostered a more positive attitude towards mathematics (Vale & Barbosa, 2023). Similarly, the students in this study expressed more enjoyment and interest in mathematics after engaging with active learning tasks, indicating that this approach may effectively combat negative perceptions of the subject.

E-ISSN: 3041-8828

Additionally, the findings of this study align with the work of Mendonça et al. (2018), who reported that active learning methods, especially those involving self-motivation and metacognitive awareness, positively influence student achievement in mathematics (Mendonça et al., 2018). In this study, students who participated in ALM showed an increased ability to reflect on their learning processes, which helped them develop better problem-solving strategies and deeper conceptual understanding. Moreover, Qureshi et al. (2023) emphasized the role of collaborative learning in enhancing student engagement and achievement (Qureshi et al., 2023), a factor that was evident in our study as students worked together to solve mathematical problems and support one another's learning.

The results of this study also resonate with the findings of Strelan et al. (2020), who conducted a meta-analysis on the flipped classroom model, a form of active learning, and found that it significantly improved student performance across various disciplines (Strelan et al., 2020). Although our study did not focus on the flipped classroom model specifically, it is clear that the principles of active learning—such as student engagement, problem-based learning, and collaborative tasks—resulted in significant improvements in mathematics achievement. The improvement in motivation observed in our study is consistent with the conclusions of Sides and Cuevas (2020), who found that goal setting and active participation in learning tasks positively impacted students' motivation and self-efficacy in elementary mathematics (Sides & Cuevas, 2020).

Despite the promising results, this study has several limitations. First, the sample size was relatively small, limiting the generalizability of the findings. A larger sample size would provide more robust evidence of the effectiveness of the Active Learning Method in diverse educational contexts. Additionally, this study was conducted in a single educational setting, which may not account for variations in teaching styles, student demographics, or institutional resources. Future studies should include a more diverse range of participants from different educational institutions and cultural backgrounds to examine the broader applicability of active learning methods in mathematics education.

Another limitation is the absence of a long-term follow-up to assess the sustainability of the improvements in academic achievement, motivation, and attitudes. While the results of this study suggest short-term benefits of the ALM, it is unclear whether these improvements will be maintained over time or if they are solely a result of the novelty of the teaching method. Longitudinal studies could provide insights into whether active learning leads to lasting changes in students' academic performance and attitudes toward mathematics.

Furthermore, this study primarily relied on self-reported data from students regarding their motivation and attitudes, which may be subject to biases such as social desirability or inaccurate self-assessment. Future research could incorporate more objective measures, such as standardized tests or behavioral observations, to triangulate the findings and provide a more comprehensive understanding of the impact of ALM on student outcomes.

Future research should explore the long-term effects of active learning on students' academic achievement, motivation, and attitudes. Longitudinal studies would provide valuable insights into whether the benefits observed in this study are sustained over time and whether active learning methods contribute to continued improvements in students' academic performance. Additionally, research could examine the impact of different active learning strategies on specific mathematical topics. For example, some active learning methods may be more effective in teaching abstract concepts, while others may be better suited for more procedural topics. Investigating these differences would help educators tailor their teaching methods to best meet the needs of their students.

Another avenue for future research is exploring the role of individual student characteristics in moderating the effectiveness of active learning methods. Factors such as prior knowledge, learning styles, and personality traits may influence how students engage with active learning tasks. For instance, students with a high level of intrinsic motivation may benefit more from active learning than those who are more extrinsically motivated. Investigating these moderating factors would allow for a more nuanced understanding of how active learning works for different types of learners.

Lastly, researchers could explore the potential of combining active learning with other innovative teaching methods, such as technology-enhanced learning or gamification. These hybrid approaches may further enhance student engagement and learning outcomes, providing additional tools for educators to effectively teach mathematics. By integrating new technologies with active learning, educators could create more dynamic, interactive, and personalized learning experiences for students.

In practice, the results of this study suggest that teachers should consider incorporating active learning strategies into

E-ISSN: 3041-8828

their mathematics instruction to improve student engagement, motivation, and achievement. Active learning fosters a more student-centered approach, where students are encouraged to take responsibility for their learning and collaborate with peers to solve problems. Educators can start by implementing simple active learning techniques such as group discussions, peer teaching, and problem-solving tasks during class. These activities can be adapted to suit various mathematical topics and can be easily integrated into existing lesson plans.

Teachers should also aim to create a learning environment that encourages participation and supports all students, regardless of their initial skill level or confidence in mathematics. By using active learning strategies, teachers can help students build self-efficacy in mathematics, which is a crucial factor in improving motivation and performance. Furthermore, incorporating diverse teaching methods, such as collaborative work and real-world problem-solving, can make mathematics more relevant and engaging for students, ultimately fostering a more positive attitude toward the subject.

Finally, professional development programs for teachers could focus on training educators in active learning techniques and providing them with the tools and resources needed to implement these strategies effectively. Teachers should be encouraged to experiment with different active learning methods and reflect on their effectiveness, allowing them to continually improve their teaching practices. By embracing active learning, educators can create more engaging and inclusive learning environments that promote long-term success in mathematics education.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Each participant received an informed consent form to understand the study's objectives.

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