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The Effectiveness of the 5E Learning Cycle Model in Students' Mathematics Engagement Learning

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ABSTRACT

Purpose – The goal of this research is to find out how well the 5E Learning Cycle Model works to increase students' interest in studying mathematics. The study specifically seeks to ascertain whether using this paradigm, as opposed to more conventional teaching techniques, results in statistically significant gains in students' behavioral, emotional, and cognitive involvement.

Methodology – This study looked at how the 5E Learning Cycle Model affected students' interest in learning mathematics using a quasi-experimental approach with a non-equivalent control group. The approach made it possible to compare a control group that was taught using traditional techniques with an experimental group that received the intervention.

Findings – The study's findings showed that students' engagement with mathematics learning was significantly improved by the 5E Learning Cycle Model. Students in the experimental group showed greater levels of engagement across all examined dimensions—behavioral, emotional, and cognitive—than those in the control group, according to an analysis of the post-intervention data. The observed improvements were not the result of chance, as statistical testing verified that these differences were significant at the 0.05 level. In terms of involvement, interest, and comprehension depth, the experimental group continuously performed better than the control group.

Novelty – By adapting the 5E Learning Cycle Model, which is often utilized in scientific instruction, to the field of mathematics learning with a particular focus on student involvement, this study makes a unique contribution to mathematics education. Although the 5E Model is well known for encouraging inquiry and conceptual understanding in scientific classes, little is known about how effective it is in math classes.

Significance – The findings of this study have important ramifications for a number of education stakeholders, including students, teacher training institutions, curriculum developers, educational leaders, and policymakers.

Keywords: 5E Learning Cycle Model, Behavioral engagement, Cognitive engagement, Emotional engagement, Engagement learning.

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1. Introduction

A variety of worldwide issues that cut across national boundaries and academic disciplines confront mathematics education in the twenty-first century. Global evaluations like UNESCO reports, TIMSS, and PISA (OECD) continuously point to a concerning pattern: dwindling student enthusiasm, low classroom participation, and inadequate development of higher-order thinking skills (HOTS). These problems are not limited to any one area; rather, they reflect a global crisis in the way mathematics is taught, understood, and experienced.

The foundation of STEM fields and the backbone of the digital economy, mathematics is more than just a school subject. Innovation, economic resilience, and global competitiveness are all supported by mathematical proficiency, from algorithmic thinking to data literacy. However, students in a variety of educational institutions find it difficult to relate to mathematics in a meaningful and inspiring way, despite its strategic significance.

Mathematical disengagement among students is now acknowledged as a global issue. Reduced engagement, superficial comprehension, and a growing discrepancy between curriculum objectives and student outcomes are some of its symptoms. Pedagogical innovation—tools and approaches that foster curiosity, critical thinking, and cognitive flexibility in addition to imparting knowledge—is necessary to address this challenge.

The changing living conditions in the world change the type of human being needed. For this reason, people who know themselves and their surroundings well, and how and what they feel about themselves, are required. The way of raising such individuals runs through the understanding of new education, aiming at resolving problems, seeing relationships within them, and establishing cause-effect relationships between events (NCTM, 2016). Today, every country trying to find effective solutions to the problems faced in the field of education and discussing how to solve these problems with new structures. We can often see that the problems encountered in teaching practice, especially in schools, are derived from traditional methods. However, in recent research, it has been shown that new teaching approaches are more effective than the traditional teaching approaches which have been pushed away, and thus the search for new and more effective teaching approaches. Unfortunately, it is not possible to ignore it, as many schools today use traditional teaching approaches. Such problems have prompted researchers and educators to develop more efficient and effective teaching practices (Huang and Shimizu, 2016).

Instructional designs are among the most prominent methods used by teachers in teaching. An instructional model is the specific instructional plans, which are designed according to the concerned learning theories. It provides a comprehensive blueprint for curriculum, instructional materials, lesson plans, teacher-student roles, support aids, and so forth. Additionally, the instructional model serves as a blueprint for teaching because it allows the teacher to be structured with an organized flow from the beginning to the end of the lesson. Teacher effectiveness starts with the teacher's ability to implement instructional models successfully (Smart & Marshall, 2013).

5E Learning Cycle Model (5E Model) is one of the developed instructional practices based on constructivism. The Biological Science Curriculum Study (BSCS) team, led by Rodger

Bybee, augmented the learning cycle model of Atkins and Karplus (1962), which had three stages: exploration, invention, and discovery. In the modified model (Turan, & Matteson, (2021). The 5E Model, which started its historical development with the question of "How People Learn", has become an exemplary model of education institutions, especially for science and mathematics education. These is Volusia Country Schools, that have Mathematics Florida Standards (Tezer & Cumhur, 2017).

The 5E Model is established on a framework called constructivist learning theory. This framework explains that the building of knowledge and meaning is a result of one's interaction with the environment. The fundamental framework that explains how learning happens in social interaction is the social constructivist perspective pioneered by Vygotsky (1978). According to this framework, social situations play an important role in learning. These situations include the exchange of information as a result of communication and collaboration between students. Moreover, the important role of prior knowledge in teaching and learning has been heavily studied (Scott, Asoko, & Leach, 2007). Teachers should be allowed to grow professionally in teaching mathematics to communicatevividly and efficiently in mathematical concepts. This will strengthen their mathematical communication skills and also imbibe in them the abilities to incorporate different kinds of collaborative learning techniques to aid students in making faster progress in their mathematical proficiency (Akendita et al., 2025).

The 5E model includes five successive stages, starting with the engagement stage, ending with the evaluation stage, and then repeating the stages (Bybee, 2006), shown in Figure 1:

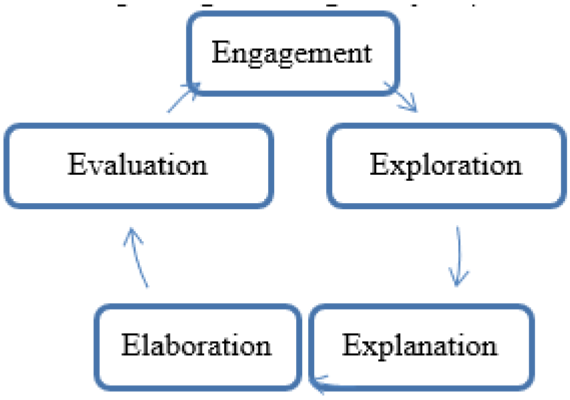

Figure 1. 5E Model includes Five Stages

1- Engagement phase: At this stage, the teacher should stimulate students to draw their attention, involving in the learning process, and make connections between pre and present learning experiences through varied interesting and meaningful activities; where raised questions concerning the pre-defined problem at this stage, have the students reveal their ideas and beliefs, compare students' ideas, let them work individually or in cooperative groups, then the students should become mentally engaged in the concept, process, or skill to be learned.

2- Exploration phase: At this stage, the student will interact with new experiences that arouse many questions that may be difficult to answer, and then doing activities and trying to find an answer to these questions will lead him to discover relationships that were not known to him before, and the teacher's role will be guidance, encouragement, and training to enhance continuing such activities until the clear image of scientific concept become apparent.

3- Explanation phase: At this stage, the student will benefit from the results of the previous two phases where he can correct his misconception, and the teacher's role is to collect information from students to help them organize summarize, and process it mentally until the concepts, operations, and skills become understandable and clear; then student, at this stage reach the new ideas offered by teacher and can scientifically re-formulated these ideas, and the teacher starts to draw and connect the student's interpretations with these experiences to make sure that the student can interpret the exploratory experiments using scientific terms correctly.

4- Elaboration phase: At this stage, teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.

5- Evaluation phase: At this stage, students receive feedback on the adequacy of their explanations and abilities, informal evaluation can occur from the beginning of the instructional sequence. It is an ongoing diagnostic process that allows the teacher to determine if the learner has attained an understanding of concepts and knowledge. Evaluation and assessment can occur at all points along the continuum of the instructional process. Some of the tools that assist in this diagnostic process are rubrics (quantified and prioritized outcome expectations) determined hand-in-hand with the lesson design, teacher observation structured by checklists, student interviews, portfolios designed with specific purposes, project and problem-based learning products, and embedded assessments.

There are some advantages of the 5E Model in education, namely: 1) encourages students to recall their previous knowledge, 2) helps develop students' scientific attitudes and their thinking abilities, 3) directs the students' focus on one problem to support conceptual understanding, 4) develops the students' potential, 5) trains students to express a concept verbally, and 6) engages students in exploring, expanding and evaluating the concepts (National Research Council, 2006). the effectiveness of 5E Model relies on the knowledge and skills students established from previous learning experiences. Students' background affects students' performance (Bahtaji, 2021). The 5E Method is thought to integrate the function of context throughout its stages, and it is preferred as a base in conducting life-based teaching applications and teaching scientific concepts (Aydin & Ates, 2019).

Through a review of previous literature, it was revealed that there are some studies that have investigated the impact of using 5E Model in teaching mathematics, such as: Bakri and Mazlini (2021) examined the benefits of the 5E model approach in teaching mathematics through a systematic review of research literature published from 2013–2021 producing a total of 20 interventions (20 studies) that satisfy this study's criteria. The results show that conceptual knowledge, procedural knowledge and flexibility of procedures for the implementation of greater interventions, which can improve mathematical learning when used appropriately. This study suggests that teachers may need additional support to complete the course of mathematics using the five phases of learning in the 5E Model, which in turn can assist in conducting teaching in an orderly and effective manner. In this way, it is important to implement the construction of learning modules for the fundamental topics of algebra based on the 5E Model.

Ozenc, Dursun, & Sahin, (2020) examined the effects of activities developed with WEB 2.0 tools based on the 5E Model on the multiplication achievement of 4th graders. Nonequivalent control group prescale-postscale quasi-experimental design was employed in the study. Two groups that were equivalent in terms of achievement were assigned as experimental group and one as control group. While multiplication activities developed with WEB 2.0 tools based on 5E model were used in the math classes of the experiment group. The control group math class was taught according to the 4th grade math textbook approved by the Ministry of National Education. A semi-structured interview form was used to determine student views on WEB 2.0 tools. According to the study results, there was no significant difference between the prescale achievement scores of the experiment and control groups. A significant difference was found between the postscale achievement scores between the groups in favor of the experiment group.

Nopasari, Ikhsan, and Johar (2020) aimed to determine the increase in the ability of mathematical understanding and the mathematical disposition learned though using 5E Model. The population of this study was the entire seventh-grade students in one of the junior high schools in Takengon, Indonesia. The two-class samples were randomly selected for the sampling purpose. The 5E Model was implemented at the experimental class, while the control class was utilized the conventional model. The instrument used to collect the data consisted of two types of scales, namely the mathematical understanding scale and the mathematical disposition questionnaires. Based on the t-scale analysis, it was found that the increase of the mathematical understanding and disposition of students who learned with the 5E learning cycle model was better than that of those who learned with the conventional model, Thus, the application of the 5E Model could improve students' mathematical understanding and disposition abilities.

The aim of Tezer & Cumhur (2017) study`s was investigation the effect of education on the mathematical achievement, problem-solving skills and the views of students on the 5E model and the mathematical modelling method for the "Geometric Objects" unit. The students were randomly selected from the 8th grade of a secondary school in Northern Cyprus. One group was the experimental group to which the 5E Learning Cycle Model applied, and mathematical modelling was applied to the other. As a data collection tool, the "Geometrical Objects Multiple Choice Achievement Scale" was applied to the experimental groups. As a result of statistical analysis, it was seen that the teaching provided by the 5E Instructional Model in Experimental group 1 and the Mathematical Modelling Method in the Experimental group 2 increased the academic achievement of the students.

Al-Shehri (2016) investigated the impact of using the 5E's model on achievement and retention of learning in mathematics among fifth-grade students. To achieve this, a semi-experimental design was employed with two groups: an experimental group of 30 students and a control group of 29 students. Pre- and post-scales were used to measure differences in mathematical achievement between the groups. The experimental group received instruction based on the 5E Learning Cycle Model, while the control group received traditional instruction. A t-scale revealed a significant difference in achievement scores between the groups in favor of the experimental group after the intervention. This suggests that using the 5E Learning Cycle Model may have a positive impact on mathematical achievement.

Through previous studies, it is clear that there is a positive impact of the 5E model in teaching mathematics. This is done by investigating the impact of the design in several fields such as academic achievement, mathematical creativity, learning retention, mathematical understanding, mathematical disposition, and problem-solving skills in mathematics. Most of these fields call on students to engage in learning mathematics, show their degree of involvement in the cognitive aspect of mathematics, express their feelings and emotions towards the learning process, and highlight the resulting impact on their behavior.

Engagement learning is defined as a function of the factors for example participation, need, emotions, intention, interest (Azevedo et al., 2012). Krause and Coates (2008) argue that engagement is a large phenomenon which is both academic and non-academic and which also has social aspects. It involves a multi-dimensional structure. Fredricks et al. (2004) consider it as three-dimensional labelled as cognitive, behavioral, and emotional engagement shown in Figure 2.

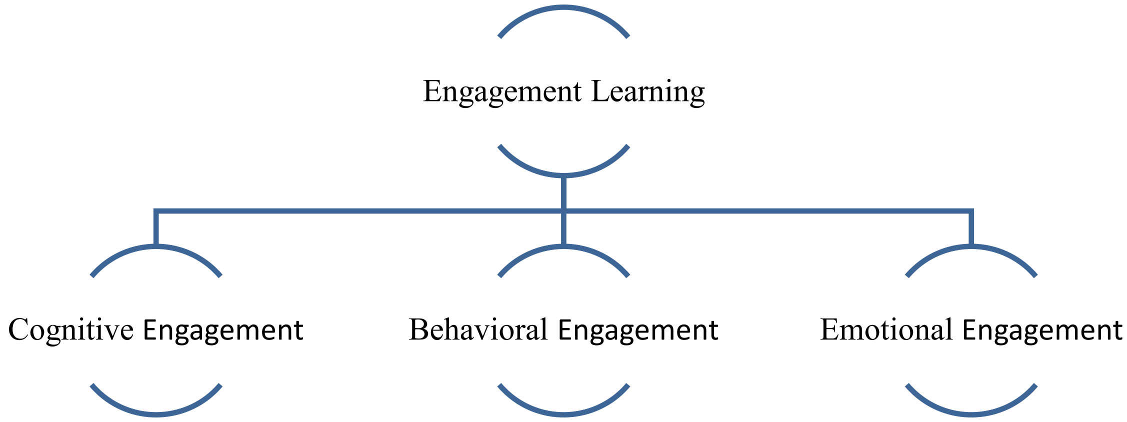

Figure 2. Engagement Dimensional's.

Cognitive engagement is closely related to academic involvement or approaches to learning involve the ideas of investment, recognition of the value of learning and a willingness to go beyond the minimum requirement (Fredricks et al. , 2004). There are three approaches to learning, namely; surface strategy (closely associated with lower levels of learning outcomes – memorization, practicing, handling scales), deep strategy (closely related to higher levels of learning outcomes – understanding the question, summarizing what is learnt, connecting knowledge with the old ways of learning), and reliance (relying on teachers) Behavioral engagement is closely related to student participation in the classroom. Active participation in the classroom is demonstrated by compliance with classroom procedures, taking initiative in the group and classroom, becoming involved in classroom activities, asking questions, regularly attending class, and comprehensively completing assignments (Chapman, 2019). Emotional engagement is closely related to students' reactions to the learning environment (school, teachers, peers, and academic curriculum) that influence willingness to become involved in school activities (Chapman, 2019).

Academic engagement happens when students dive deep into learning activities, when they are emotionally and mentally fascinated by the study materials, and often when interacting with peers, Positive interpersonal relationships enhance individuals' enthusiasm for learning (Carmen & Clara, 2021). Game-based mathematics interventions may be a powerful way to improve students' engagement and learning outcomes (Gao& Sun, 2020).

Teaching and learning mathematics should enable students to acquire a variety of experiences through various sources and activities so that students have more opportunities to increase their engagement in the teaching and learning process. Evidence shows that the focus of the teaching and learning process must be the students as in student-centered learning instruction. Hence, the lecturer must function as a facilitator and her or his main role is to encourage students to be actively involved in their learning so that they are able to construct understanding through their own active engagement and their own previous knowledge (Syarifuddin, & Atweh, 2022).

Insights into student mathematical knowledge and engagement at important stages in their mathematical trajectories can inform enriched, enduring outcomes for students as they continue to navigate through the education system (Deieso & Fraser, 2019). Student engagement in mathematics and attitude is directly related to the supportiveness of the teacher and the classroom environment (Lazarides, Buchholz, & Rubach, 2018).

By reviewing previous literature, it became clear that there are studies that have verified the importance of engagement in learning. Such as Mohammad, Nica, Levere, & Okner (2023) purposed to understand students' preferences and attitudes towards "Engaged Mathematics Labs" in which professors and teaching assistants assisted students in completing an assignment during lab time. They analyzed both qualitative and quantitative survey responses from 200 first year students participating in "Engaged Mathematics Labs" across two different levels of mathematics classes at a large Canadian public university. Results indicate that students enjoy being able to work in groups. Moreover, students learned to effectively use resources available in the course to solve questions that deepen their understanding of course concepts.

The paper of Aliyu, Osman, Kumar, & Jamil, (2023) presented an evaluation viewpoint of the learning strategy (LS) with cooperative learning strategy (CLS) and GeoGebra (GG) integration to support Student engagement in solving simultaneous equations SSE. The discussion of the preliminary mathematical achievement scale (MAT-scale) from pre-and post-scales with 41 students who have learned SSE using the developed LS is also presented. Semi-structured interviews were conducted with three experienced lecturers to provide feedback and recommendations on interacting with LS. The themes that emerge from those lecturers include the connection between LS phases, specific material, cooperative activity, playfulness in the discovery process, and thinking. Experts' feedback on the LS's content reasoning and content learning strategy through a questionnaire, and showed good inter-rater reliability and agreement between them. The estimated marginal means covariate of the ANCOVA scale was then examined, and the results supported the necessity for a learning strategy to be developed. The findings revealed that the LS, with CLS and GG integration, has the potential to be educationally effective in enhancing SE in SSE.

Sin (2022) investigated the effects of middle school students' learning approaches and their attitudes towards mathematics on their engagement in mathematics course. The research cross sectional survey design was used in the quantitative research model. The research was conducted with the participation of 5th-8th graders who attended schools located in a city in the Central Anatolian region of Turkey. Thus, 383 students in total, 209 of whom were female and 174 of whom were male, were included in the research. Three different data collection instruments were used in the study: student engagement in mathematics scale, approaches to learning mathematics scale, and scale for assessing attitudes towards mathematics in secondary education. The data were analyzed on structural equation modelling. As a result, significant correlations were found between participants' engagement in mathematics course and their learning approaches while no significant differences were found between their engagement in mathematics and their attitudes towards the course.

The purpose of Alpaslan & Ulubey (2021) research was to examine the relationship between achievement emotions, motivation, and classroom engagement in mathematics among Turkish middle school students, and to determine how these three variables predicted academic achievement in mathematics. 549 seventh grade students in a province located in the south-west region of Turkey participated in the study. Relations among variables were examined by utilizing structural equation modeling. Results of this study provided evidence for the theoretical model that explained the relations between achievement emotions, motivation and classroom engagement and their contributions to a significant amount of mathematic achievement in Turkish contexts. In addition, it was found that the contributions of achievement emotions to engagement depend on whether they were activity- and outcome-focused or deactivating and activating emotions.

It is clear from reviewing previous studies that students engage in learning mathematics and enjoy working in groups within the classroom, in addition to the importance of focusing on the cognitive, emotional, and behavioral aspects in the process of teaching mathematics. It is also clear that previous studies used teaching methods to increase students' engagement in learning. Therefore, this study try to investigate The Effectiveness Of The 5E Learning Cycle Model In Students' Mathematics Engagement Learning.

While the 5E instructional model—Engage, Explore, Explain, Elaborate, Evaluate—has been widely studied and adopted across educational systems, the existing literature remains disproportionately focused on its impact on academic achievement. Numerous studies have demonstrated its effectiveness in improving test scores and conceptual understanding, particularly in science and mathematics. However, this narrow focus overlooks a critical dimension of learning: student engagement.

Engagement, as conceptualized by Fredricks et al. (2004), is a multidimensional construct encompassing cognitive, affective, and behavioral domains. Yet, few studies have examined how the 5E model fosters these interrelated aspects of engagement. The affective responses of learners, their sustained behavioral participation, and the depth of cognitive involvement remain underexplored within the 5E framework.

Moreover, the majority of empirical investigations into the 5E model have been conducted in Western or high-income educational contexts. There is a notable scarcity of research examining its relevance, adaptability, and impact in non-Western or developing-country settings—contexts where linguistic diversity, resource constraints, and cultural pedagogies may significantly influence learner engagement.

Finally, there is a theoretical disconnect between constructivist learning principles, which underpin the 5E model, and contemporary engagement theory. The lack of integration between these frameworks limits our understanding of how inquiry-based, student-centered instruction can holistically support learner motivation, persistence, and emotional investment in learning. This study addresses these gaps by investigating the relationship between the 5E model and multidimensional engagement in a bilingual, non-Western educational context. It seeks to bridge constructivist and engagement theories, offering a more nuanced and culturally responsive understanding of how instructional design can transform mathematics learning.

Based on the importance of mathematics in the educational process in Jordan, and the role of mathematics in many modern sciences, mathematics is still considered one of the subjects that is difficult for many students to learn, and this may be due to the fact that many teachers continue to use traditional methods in teaching mathematics, which It leads to poor academic achievement and students not being engaged in the learning process. Unless there is continuous renewal and updating of teaching strategies to increase student engagement and raise their academic achievement. Hence the problem of this study arose in verifying the effect of using the educational model (5E's) on students' engagement in learning. What is the effectiveness of the 5E model in Students' Mathematics Engagement Learning?

Study hypotheses

2. Methods

Constructivist theory is considered one of the most important cognitive learning theories in the field of education and has influenced the research movement to clarify and apply new and diverse models and strategies to innovate learning and teaching methods. Following a constructivist strategy, such as non-traditional learning and teaching models, would give students the opportunity to increase their involvement in learning mathematics. The most prominent of these models is the educational model (5E), which consists of five successive stages, and is considered one of the models that helps students build concepts and knowledge through, linking it to the cognitive, behavioral and emotional aspects of students.

The importance of this study comes from the following considerations: using a modern strategy in teaching mathematics. The assistance provides teachers with deeper knowledge and understanding of the using 5E Learning Cycle Model in the teaching process. The results of the study provide curriculum designers and educational supervisors with feedback and a real vision of how students engage in the educational process, and the importance of including it within the mathematics curricula and classroom practices accompanying the curriculum.

2.1 Study Delimitations

The results of the study were determined by a set of determinants: ninth grade students in schools affiliated with the Directorate of Education, Bani Ubaid District, Irbid Governorate - Jordan, for the academic year 2023/2024 AD. The study was limited to a scale of engagement in learning consisting of (15) items, prepared by the researcher after teaching the relative conjunctions unit in the mathematics curriculum for the ninth grade. The study used 5E Learning Cycle Model and the usual method of teaching

2.2 Study Approach

The study adopted the semi-experimental approach, pre-post, for two groups, one experimental and the other control, and applying a scale to answer the study questions:

G1: O1 X O1

G2: O1 - O1

Where:
G1: the experimental group, G2: the control group
x: processing (using 5E Learning Cycle Model), O1: Engagement Learning.

2.3 Participants

Two groups (experimental and control) were intentionally selected from the study population to represent the study population. The method of selecting individuals was according to the following procedures: Participants were selected from Musab bin Omair Basic School. The school was chosen in an Purposeful sample, because the school agreed to conduct the study, and provides the necessary capabilities to implement the educational model, because it is conveniently available to the researcher, low in cost and easily available, and therefore fast and effective. The number of classes for ninth grade students was two classes. One classroom was randomly selected as the experimental group, and its students were assessed using 5E Learning Cycle Model. It consisted of 29 students. The second class was chosen as a control group, and its students were taught in the usual way. It consisted of 28 students.

2.4 Equivalence of groups:

To verify the equality of the groups, the arithmetic means and standard deviations of the dimensions and the total score of the students' pre-scale scores were extracted according to the group variable (experimental, control), and to show the statistical differences between the arithmetic means, and using "t" scale, table (1) shows this.

Table 1 - Students' Scores on the Engagement Learning Scale

	Group	Number	Arithmetic Means	Standard Deviation	T-Value	Degrees of Freedom	Sig
Pre-scale	Experimental	29	38.72	3.96	0.24	55	0.62
	Control	28	38.71	3.41			

It is clear from Table 1 that there are no statistically significant differences (α = 0.05) attributed to the group in all dimensions of the pre-scale of engagement learning, and this result indicates the equality of the groups.

2.5 Research Instrument

The “Proportional Thinking” unit was relied upon to conduct this study, which is the second unit of the ninth grade mathematics curriculum, according to the Ministry of Education in Jordan. The unit consists of (49) pages. The study includes tools to scale the role of students’ engagement in learning mathematics. This unit is dominated by the cognitive aspect as it is related to the subject of algebra, and the scale consists of (15) multiple-choice items to determine the effect of using the 5E learning cycle model on students, and the researcher relied on classifying engagement learning by association into: behavioural engagement (5 items), emotional engagement (5 items), and cognitive engagement (5 items).

2.6 Validity and Reliability of the Study Tools

To verify the validity of Engagement Learning scale, it was presented to a group of arbitrators who hold doctorates in mathematics curricula and teaching methods. They were asked to judge the scale items in terms of knowledge classification, learning outcomes, linguistic integrity, and output. In light of the arbitrators’ observations and suggestions, the necessary amendments were made. . To ensure the reliability of the study instrument, it was verified using the scale-rescale method by applying the scale, and re-applying it after two weeks to a group of (25) individuals outside the study, and then the Pearson correlation coefficient was calculated between their estimates the two times, as it was (0.85). The reliability coefficient was also calculated using the internal consistency method according to the Kuder Richardson-20 equation, reaching (0.79), and these values were considered appropriate for the purposes of this study.

2.7 Difficulty and Discrimination Coefficients

Using the SPSS program, the responses of a group from outside the study population, consisting of (25) students, were analysed to calculate the difficulty and discrimination coefficients for the scale items. The percentage of students who answered the paragraph incorrectly was taken as the difficulty factor for each scale item. The difficulty coefficients for the items ranged Between (0.20-0.68), and discrimination coefficients ranged between (0.40-0.70). Based on what Odeh (2010) indicated for the acceptable range of paragraph difficulty, which ranges between (0.20-0.80).

2.8 Study Procedures

The study subjects were identified, and two classes were selected from Musab bin Omair School, taught by one teacher. The classes were randomly distributed into an experimental group and a control group. The equality of the groups was verified before conducting the study by relying on the pre-scale scores. The teacher who teaches the two groups (experimental and control) was trained on the use of 5E learning cycle model and the method of its implementation while teaching the experimental group, and teaching the control group in the usual way. The Two groups were taught all the topics included in the “Proportional Thinking” unit. The application period took two weeks, which is equivalent to (10) class sessions. After completing the implementation of the study, the scale of engagement learning in mathematics in the unit was applied to the study individuals as a post-scale, the scale was corrected, and the results were transcribed to analyse the data and answer the study question.

2.9 Study Variables

This study includes the following variables:
1- Independent variable: teaching method.
2- Dependent variables: engagement learning by association into: cognitive engagement, behavioural engagement, and emotional engagement.

3. Results and Discussions

3.1 Results

To extract the answer. calculating the arithmetic means, standard deviations, and adjusted arithmetic mean of the students' scores in the Engagement Learning scale in the pre- and post-measurements according to the group (experimental, control), as shown in Table (2).

Table 2 - Pre- and Post-test Engagement Learning Scores

Group	Numbers	Pre- measurements		Post measurements	
		Arithmetic Means	Standard Deviation	Arithmetic Means	Standard Deviation
Experimental	29	38.72	4.2	59.75	4.20
Control	28	38.71	3.7	48.48	3.70

Table 2 reveals a notable increase in the post-measurement scores of the experimental group (M = 59.75, SD = 4.20) compared to the control group (M = 48.48, SD = 3.70), despite both groups starting with nearly identical pre-measurement means. This suggests that the intervention applied to the experimental group may have positively influenced student engagement. However, to confirm the statistical significance of these differences, the use of one-way ANOVA is essential and appropriately applied.

One way ANOVA for the post-measurement of the Engagement Learning scale as a whole according to the group (experimental, control), and the following is a presentation of these results as shown in Table 3.

Table 3 - One-Way ANOVA Results for Post-Test Engagement Learning Scores

Source of variance	Sum of Squares	Degrees of Freedom	Mean sum of Squares	F- value	Sig
Between group	980.04	1	980.04	62.22	0.00
Within group	866.27	55	15.74		
Total	1846.31	56			

The results presented in Table 3 demonstrate a statistically significant difference in students' post-measurement scores on the Engagement Learning scale between the experimental and control groups, with an F-value of 62.22 and a significance level of 0.00. This strongly indicates the effectiveness of the 5E learning cycle model in enhancing student engagement.

One way ANOVA for the effect of group on the post-measurement of each dimension of the Engagement Learning scale. The means, standard deviations, and adjusted arithmetic mean were also calculated for post-measurements of the dimensions of Engagement Learning scale according to the group (experimental, control), as shown in Table 4.

Table 4 - Descriptive and Adjusted Means of Engagement Learning Dimensions

Groups	Numbers	Dimensions	Arithmetic Means	Standard Deviation	Standard Error
Experimental	29	Cognitive	18.82	1.94	.36
		Behavioral	18.70	2.12	.39
		Emotional	19.31	2.10	.40
Control	28	Cognitive	16.46	1.34	.25
		Behavioral	15.78	1.79	.33
		Emotional	16.21	1.64	.31

Further analysis in Table 4 shows consistent superiority of the experimental group across all dimensions—cognitive, behavioral, and emotional—with higher mean scores and comparable standard errors. These apparent differences warrant deeper statistical examination to confirm their significance, which is addressed through the one-way ANOVA results in Table 5.

Table 5 - One-Way ANOVA Results for Post-Test Engagement Learning Dimensions

Source of variance	Dimensions	Sum of Squares	Degrees of Freedom	Sum of Means Value	F value	Sig.
Corrected Model	Cognitive	79.56	1	79.56	28.21	0.00
	Behavioral	128.84	1	128.84	33.19	0.00
	Emotional	121.76	1	121.76	32.48	0.00
Group	Cognitive	79.56	1	79.56	28.21	0.00
	Behavioral	128.88	1	128.88	33.19	0.00
	Emotional	121.76	1	121.76	32.48	0.00
Error	Cognitive	155.1	55	2.82		
	Behavioral	213.47	55	3.88		
	Emotional	206.16	55	3.74		
Total	Cognitive	18025	57			
	Behavioral	17433	57			
	Emotional	18189	57			

Table 5 shows that there are statistically significant differences at the significance level ($\alpha \leq 0.05$) according to the effect of the group experimental in all dimensions, and the differences were in favour of the members of the experimental group who studied using 5E learning cycle model.

3.2 Discussions

The results of this study clearly demonstrate the effectiveness of the 5E Learning Cycle Model in enhancing students' engagement in mathematics learning. This aligns strongly with the theoretical framework emphasizing student-centered instruction, emotional involvement, and active participation.

3.2.1 Student-Centered Learning and Constructivism

The 5E model is rooted in constructivist theory, which posits that learners build knowledge through active exploration and personal experience. Syarifuddin & Atweh (2022) emphasized that in student-centered environments, the teacher acts as a facilitator, guiding students to construct understanding based on prior knowledge and active engagement. The significant improvement in the experimental group's scores across cognitive, behavioral, and emotional dimensions supports this theory, showing that when students are given opportunities to explore, explain, and elaborate, their engagement deepens.

3.2.2 Cognitive, Emotional, and Behavioral Engagement

The multidimensional nature of engagement—cognitive, emotional, and behavioral—is well-supported in the literature. Alpaslan & Ulubey (2021) found that achievement emotions and motivation significantly predict classroom engagement and academic success. In this study, the experimental group showed statistically significant gains in all three dimensions, suggesting that the 5E model effectively activates students' emotions, encourages participation, and promotes deeper cognitive processing.

3.2.3 Collaborative and Interactive Learning

The findings also resonate with studies highlighting the importance of collaborative learning environments. Mohammad et al. (2023) showed that students enjoy working in groups and benefit from interactive lab settings. The 5E model's phases—particularly "Explore" and "Elaborate"—naturally foster peer interaction and cooperative problem-solving, which likely contributed to the experimental group's higher engagement scores.

3.2.4 Playfulness and Discovery in Mathematics

Aliyu et al. (2023) emphasized the role of playfulness and discovery in mathematical engagement. The 5E model encourages curiosity and experimentation, especially during the "Engage" and "Explore" phases. The significant differences in post-measurement scores suggest that students in the experimental group experienced mathematics as a dynamic and enjoyable process, rather than a static set of procedures.

3.2.5 Learning Approaches and Attitudes

Sin (2022) found that students' learning approaches are more predictive of engagement than attitudes alone. The 5E model promotes active learning strategies—such as inquiry, reflection, and application—which likely shifted students' approaches toward deeper learning. This may explain the substantial gains in engagement observed in the experimental group. Figure 3 shows this.

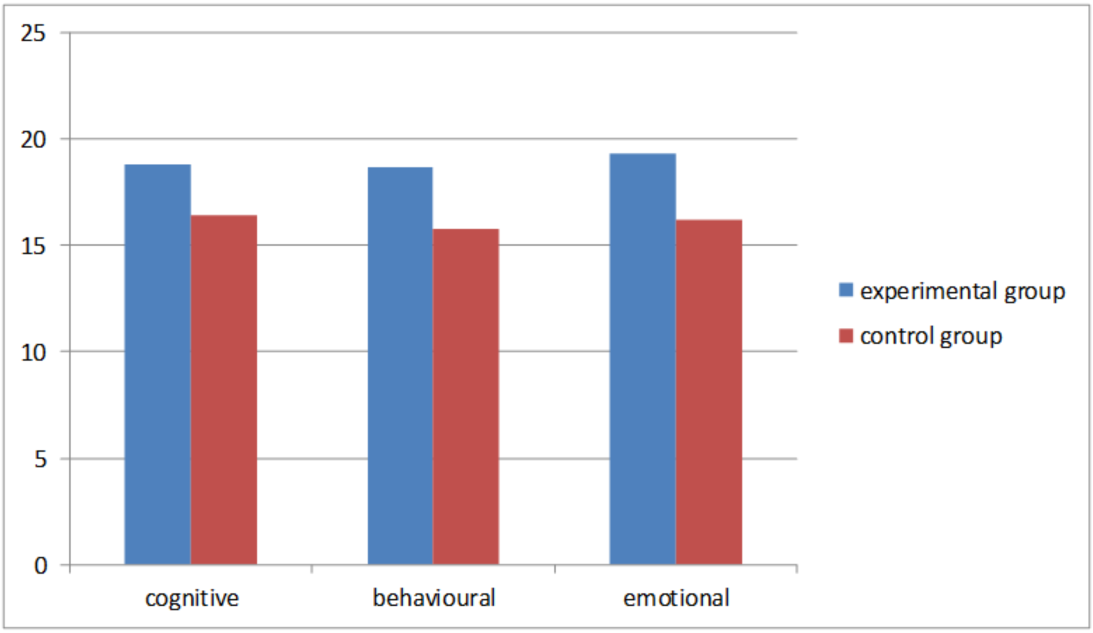

Figure 3. Comparison Between in Two Groups in Dimensions of Engagement in Learning Mathematics

It is clear from the finding of the study that the educational model has a positive effectiveness in engaging students in learning mathematics, and the order of these dimensions according to the arithmetic averages of the experimental group, as indicated in Table 4, is as follows (highest to lowest): emotional, cognitive, behavioural. It is also noted from Table 4 that the experimental group excelled in all Dimensions of engagement in learning mathematics compared to the control group.

4. Conclusions

The results of this study provide compelling evidence for the effectiveness of the 5E Learning Cycle Model in enhancing students' engagement in mathematics learning. Statistical analyses revealed significant differences between the experimental and control groups in overall engagement scores, as well as in the cognitive, behavioral, and emotional dimensions. These differences were consistently in favor of the experimental group, which was taught using the 5E model.

The findings suggest that the structured phases of the 5E model—Engage, Explore, Explain, Elaborate, and Evaluate—create a dynamic and student-centered learning environment that fosters deeper understanding, active participation, and emotional investment. The model's emphasis on inquiry, collaboration, and reflection appears to support students in constructing meaningful mathematical knowledge while remaining motivated and involved throughout the learning process. In light of these results, the 5E Learning Cycle Model can be considered a powerful pedagogical approach for improving student engagement in mathematics, and its integration into classroom practice is strongly recommended.

Declarations

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