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Academic Achievement in Chemistry Based on the 7E Learning Cycle Model in Jordanian High Schools

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ABSTRACT

This study seeks to investigate the impact of implementing the 7E learning cycle model on the academic performance of high school students in Jordan. This study employed a quasi-empirical design. A sample size of 106 students enrolled at Ahmed Toukan Secondary School, a school located in Amman and affiliated with the Directorate of Education for Marka District, was employed in this study. The study sample consisted of two distinct groups:52 students in the empirical group, and 54 in the control.A teacher's guide was developed based on the 7E learning cycle model, and an achievement test was created following the guidelines outlined in the good test specification table. Researchers have confirmed the validity and reliability of the subject matter. The results indicate a statistically significant difference between the two groups, with the empirical group being favoured. The study proposed several recommendations, including the necessity for chemistry teachers and supervisors to undergo training workshops focused on the planning, implementation, and evaluation of chemistry lessons using the 7E learning cycle model.

Keywords: 7E Learning Cycle Model, Academic Achievement, Twelfth-Grade Students, Secondary Level.

INTRODUCTION

The rapid change and development in various aspects of life, particularly in the scientific and technological fields, such as science, the information revolution, and technological and technical progress, are considered crucial characteristics of the twenty-first century (Alsalhi et al., 2019). Globally, there is a significant increase in interest in science literacy and science education due to the rapid changes occurring. In addition, there is a need for ongoing development to align with the characteristics of the scientific and technical era as well as meet the demands of the twenty-first century and its future challenges (Aiginger & Rodrik, 2020). The emphasis in the study of science should be on scientific investigation rather than relying solely on a recipe-based approach (Fang, 2021).

The National Science Education Standards (NSES) highlight that scientific literacy encompasses activities such as communication, reading, discussion, and critical evaluation of arguments supported by data (Schwartz et al., 2023). There is a significant overlap of process skills between reading comprehension and scientific inquiry, presenting an ideal opportunity for their integration. Karplus and Thier (1967) highlighted the learning cycle enhancement in the Science Curriculum Improvement Study (SCIS). According to the figure1, the inquiry- teaching approach depending on inquiry requires three different learning steps.

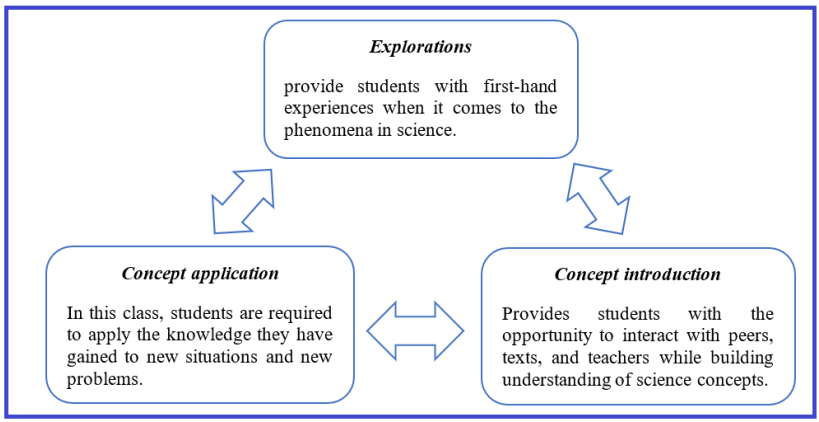

Figure 1. Inquiry-based teaching approach stages.

Since Karplus and Thier (1967) introduction of the learning cycle, several models have emerged. The learning cycle has retained its original exploration basics since its inception, despite the availability of numerous models. However, the introduction of new models has led to an increase in the number of phases (Santi & Atun, 2021). Keup et al. (2023) noted that textbooks can support all phases of the learning cycle to enhance teaching and learning effectiveness.

The 7E Learning Cycles emphasise the utilisation of prior knowledge to facilitate the acquisition of new knowledge or understanding within a constructivist learning framework. This model employs a constructivist approach to instruction and learning, rendering it a highly effective method for facilitating students' active acquisition of new knowledge (Rahman & Vikram, 2017). The main aim of this model is to demonstrate the importance of eliciting prior knowledge to apply a concept to unfamiliar situations. Figure 2 illustrates the organisation of teaching and learning according to the 7E model, which includes the following stages: elicit, share, explore, explain, elaborate, evaluate, and extend.

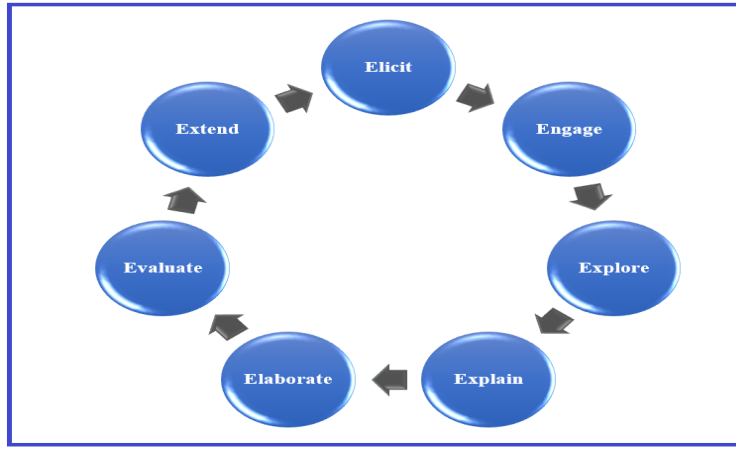

Figure 2. Sequential steps of the 7E model

Chen et al. (2020) indicated that the 7E model has multiple features that are summarized in Figure 3.

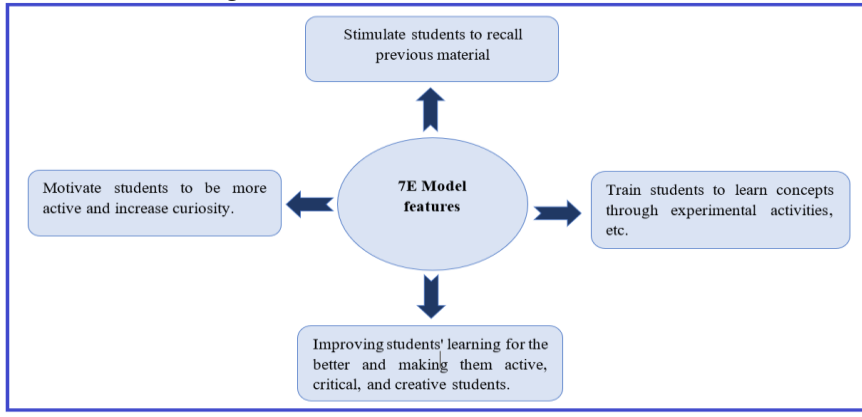

Figure 3. 7E model features

Researchers, including Ramadhani et al. (2019), have conducted numerous studies on the integration of the 7E model of learning. Research has demonstrated that educators widely embrace the use of 7E learning cycles in various subjects, such as chemistry. Furthermore, implementing 7E learning cycles significantly improves students' academic performance. This study investigates the academic performance of twelfth-grade students in Jordan following the implementation of the 7E learning cycle model. This study investigates whether there are disparities in chemistry academic performance among Jordanian high school students when using the 7E learning cycle model.

The present study holds significance from various angles. Firstly, it aligns with the current educational trend of promoting student engagement by encouraging research, investigation, reflection, observation, critical thinking, problem-solving, and knowledge acquisition. Additionally, curriculum developers and designers may find the results of this study intriguing as the 7E learning cycle model has the potential to offer a novel approach to science education. This study is significant as it explores the effectiveness of the 7E learning cycle, a contemporary teaching approach. The findings have the potential to inspire science educators to adopt this method. This study holds significance as its findings can be valuable to educational institutions beyond Jordan.

REVIEW OF LITERATURE

Various scholars have made significant contributions to the understanding of the significance of the 7E framework in student learning and engagement. Scholars extensively debate the impact of this approach on students' learning and comprehension of course material. Lestari and Wahyudin (2020) employ the 7E approach to foster student motivation and involvement in their academic tasks. It is imperative to guide individuals towards delivering consistent and dependable performance. Low student motivation negatively impacts academic performance. Student engagement in the learning process has been found to be advantageous for promoting progress (Demina et al., 2022). Furthermore, mentally engaged students exhibit enhanced performance compared to those who lack active involvement in improving their work performance.

Similarly, instructors encourage students to explore the educational materials provided to them. This approach also promotes effective learning (Dwijayani, 2019). Teachers must oversee their students' academic progress. This will foster a robust teacher-student relationship, thereby enhancing student performance. Students should adopt a critical approach to their learning (Bdair, 2021). Exploring content at a high level promotes critical thinking skills and enhances students' working approach (Rasmitadila et al., 2019). Therefore, self-exploration serves as a problem-solving approach that enhances students' learning.

Additionally, providing a clear explanation of content is an essential aspect of student learning (Hayat et al., 2020). Teachers must provide

explanations of the subject matter to facilitate students' comprehension and enhance their learning experience. Tailoring the content to match the comprehension level of individual students is crucial for facilitating effective learning (Wu & Wu, 2020).The learning approach is beneficial for teachers and students alike in enhancing comprehension. The most reliable method for students to comprehend information is through the provision of clear explanations. The accurate interpretation of content is crucial for students' learning.

Teachers must also offer students opportunities to expand upon their content. This approach benefits students as it allows their teachers to assess their progress (Rasmitadila et al., 2020). Content elaboration is a critical method that aids teachers in assessing students' learning levels. This collaborative approach between teachers and students is effective in enhancing student comprehension. In addition, teachers should prompt students to enhance their performance by effectively elaborating on the content using real-life examples (Hwang et al., 2019). Therefore, students find it comprehensible to grasp new concepts from different perspectives.

The evaluation process is crucial in the context of learning. This process enhances students' understanding by updating their knowledge through evaluation (Puspitarini & Hanif, 2019). Assessing teachers' attentiveness to students aids in the accurate evaluation of instructional content. This approach is more effective in enhancing students' knowledge and learning.The evaluation of students is necessary to motivate them to improve their learning outcomes (Cheng & Tsai, 2019). Reliable methodology and advanced learning are necessary for successful student learning. Teachers have the responsibility of imparting reliable knowledge to their students.

Teachers are not only responsible for imparting basic information to students, but they also play a crucial role in introducing new information (An et al., 2021). This facilitates knowledge development and is suitable for students. Improving students' task management is crucial for enhancing their learning outcomes. Teachers need to employ a problem-solving approach in order to effectively motivate their students and enhance their learning outcomes (Sun & Wang, 2020). In this manner, students exhibit self-motivation and demonstrate enhanced efforts towards improving their comprehension. The acquisition of knowledge by students is essential for expanding their understanding of the subject matter.

However, it is essential to conduct a final evaluation of the students to enhance their knowledge. Teachers must engage in critical work to promote student learning (Encarnacion et al., 2021). The evaluation of students by their teachers enhances the relationship between students and their knowledge. Evaluation is an important technique that facilitates effective learning. A more effective learning strategy involves thorough evaluation. Access to information is crucial for students to enhance their learning (Caena &

Redecker, 2019). Evaluation is an essential and suitable process for enhancing learning. This evaluation approach aids teachers in comprehending students' learning levels.

Additionally, it is advisable to foster a positive teacher-student relationship. Cheng et al. (2019) propose a method to enhance mutual understanding and advance learning approaches. Understanding the process of learning requires adopting an effective learning approach. Both students and teachers should work in accordance with established guidelines and adopt a strategic approach to enhance their performance (Quezada et al., 2020)Reliability is crucial for students to gain a comprehensive understanding of their work. Fostering student success and enhancing their knowledge acquisition is a more effective strategy for progress. Students should develop strategies and adhere to their teachers' instructions.

Modern developments are crucial for the learning process. Teacher training is necessary to ensure that educators possess the necessary attitude and knowledge to effectively instruct students (Putri & Sari, 2021). Motivated students can effectively enhance their work ethic and knowledge. Educational institutions should provide teachers with reliable resources to ensure they have the necessary tools for effective teaching (Alqurshi, 2020). This facilitates the effective implementation of teaching strategies. This approach is crucial for enhancing student learning. Teachers' involvement in active learning can enhance students' learning process over time.

Improving educational institutions with modern facilities is crucial, as the availability of resources significantly impacts the learning process (Mahmood, 2021). Student success and learning outcomes contribute to improved performance. Motivating teachers and students is crucial for facilitating successful learning (Tohara, 2021). Motivated teachers play a strategic role in advancing their practices by actively seeking opportunities for learning and improvement. In contrast, less motivated students may experience discomfort regarding their advanced performance (Lapitan et al., 2021). Effective teaching and reliable resources greatly influence student performance.

METHODOLOGY

The study's approach

This study employed a quasi-empirical methodology to investigate the impact of the 7E learning cycle model on learners' academic achievements. Figure 4 illustrates the study's design. Figure 4 depicts the control group, who received traditional instruction, studying the chemistry topics outlined in Table 1.

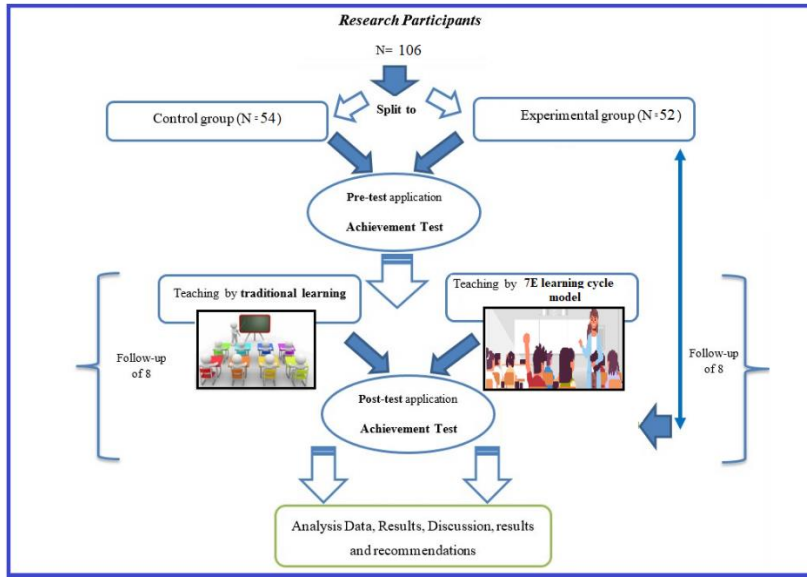

Figure4. Designing the analysis (Designed by the researcher)

Table 1. 7E Learning model stages in science which is Instructional Design Model recommended by the NSTA.

Name of Stage	Description
Elicit	Asking a question stimulates students' thinking and activates their previous knowledge to extract their concepts, knowledge, and trends about the lesson topic.
Engage	To motivate a student and to excite his curiosity, encourage his attention, and develop his thinking skills through performing one or more activities onthe topic of the lesson to reveal the prior knowledge and experiences the student already has.
Exploration *(investigating)*	The teacher does not give direct instructions or directions, students caneither work in team or independently. By manipulating, observing, verifying, and collecting data, students can come to preliminary conclusions about the topic.
Explanation *(explaining)*	Students should be encouraged by their teachers to illustrate concepts with examples and explain definitions of the lesson's topic.
Elaboration	The Learners apply the symbols, concepts, definitions, and skills in learning to problem solving relating to the topics.
Evaluation	The teachers evaluate the learning outcomes. Formal and informal evaluation strategies are both helpful in this stage.
Extends	Students are asked to apply new concepts and skills learned through thinking, research, discovery, and explanation.

Source: Balta and Sarac (2016)

The empirical group students in the autumn semester of 2021/2022 learned the same chemistry topics as presented in Table 2. The empirical group students in the autumn semester of 2021/2022 were taught the same chemistry topics as reported in Table 2 using the 7E learning cycle model over a period of eight weeks.

Table 2. 12th-grade chemistry textbook topics.

Topics	Week
Concepts of Acids and bases.	1
Self-ionization of water.	2
Acid and base solutions	3
pH Scale	4
Equilibrium in solutions of weak acids	5
Equilibrium in solutions of weak bases	6
Acidic and basic properties of salt solutions.	7
Common ion effect.	8
Total week	8

The sample of this work

The study involved 106 twelfth-grade students from secondary schools in Jordan. Out of 120 students, we randomly selected two groups: the empirical group (n = 54) and the control group (n = 52). The study was conducted during the 2021–2022 academic year. Table 3 presents the comprehensive data for the sample.

Table 3. Participants of the Study

Group	Frequency (f)	Percentage (%)
Empirical	52	%49.06
Control	54	%50.94
Total	106	100%

Study Tools

The researcher conducted a comprehensive review of the pertinent literature. Additionally, the researcher employed the following instruments.

Achievement test

The examination encompasses the unit on Acids and Bases from the twelfth-grade chemistry textbook. There were 20 multiple-choice questions. Each question has

four answer options, with only one being correct. The maximum score for the test is 20 points. The test was created using Bloom's cognitive domain taxonomy. The testing period lasted for 45 minutes. This study utilised a specification table for its achievement test, as indicated in Table 4.

Table 4. Test specifications table

Topics	The number of teaching sessions	The relative weight of topics	Questions of Lower-level thinking	Questions of Higher-level thinking	Total of questions
Concepts of Acids and bases.	2	9%	1	1	2
Self-ionization of water.	2	9%	1	1	2
Acid and base solutions	3	13%	2	2	4
pH Scale	3	13%	2	1	3
Equilibrium in solutions of weak acids	4	17%	3	1	4
Equilibrium in solutions of weak bases	3	13%	1	1	2
Acidic and basic properties of salt solutions.	3	13%	1	1	2
Common ion effect.	3	13%	1	0	1
Total	23	100%	12 (60%)	8 (40%)	20 (100%)

The virtual validity of the achievement test was assessed by obtaining feedback from eight university lecturers who hold doctoral and master's degrees in curriculum and instruction methods in science. Following their recommendations and suggestions, certain questions were removed, and new ones were included. Reliability was assessed using test-retest methods. The Pearson correlation coefficient was computed to assess the relationship between the two approaches. Data was collected from 24 students attending nearby schools. The test was then repeated after a two-week interval with the same group of 24 students. The obtained reliability coefficient (0.861) was deemed suitable for the present study.

3.4 Equivalences of the two groups

The study employed two groups: an empirical group and a control group. The empirical group consisted of 52 respondents, with a mean of 12.62 and a standard deviation of 2.097. In addition, the control group consisted of 54 respondents, with a mean of 12.26 and a standard deviation of 1.320. The findings are presented in Table 5.

Table 5. presents the relevant data.

Group	N	M	SD
Empirical	52	12.62	2.097
Control	54	12.26	1.320

The pre-test scores of the two groups are compared. A t-test was conducted to assess the equivalence of the two groups, as presented in Table6. Based on the data presented in Table 6, the p-value (0.148) exceeds the significance level of 0.05, suggesting a lack of statistical significance at the 0.05 threshold. Table 6 indicates that there were no significant differences in the mean or standard deviation between the students in the empirical group and those in the control group. The participants in both groups were initially identical.

Table 6. Empirical versus control group t-test results

	Levene's Test for Equality of Variances		t-test			
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Equal variances assumed	4.473	0. 370	1.050	104	0.148	0.3561
Equal variances not assumed			1.042	85.384	0.150	0.3561

* The statistical significance level is 0.05 ($p<0.05$)

RESULTS AND DISCUSSION

A T-test was conducted to compare the outcomes of the experimental group, who learned the chemistry unit topics (acids and bases) using the 7E model, with the control group, who learned the same topics using the traditional method. Tables 7 and 8 display the results of the T-test. According to table 7, students of the empirical group (They were learned via the 7E learning cycle model) have a mean value of (17.15, SD = 1.673) compared to control group students (They were learned via traditional method) who have a mean value of (13.2, SD = 1.554).

Table7. Post-test Means and SD

Group	N	Mean	SD
Empirical	52	17.15	1.673
Control	54	13.02	1.654

Table 8 indicates that the P value of 0.000 is significantly lower than the predetermined significance level of 0.05, suggesting a statistically significant difference in favour of the empirical group of students. According to the data in Table 8, the average post-achievement test score for the empirical group was 17.15, while the control group had

an average score of 13.02. The empirical group, taught chemistry topics using the 7E learning cycle model, outperformed the control group, taught using the traditional method, in the post-test.

Table8. The post-test independent sample t-test.

	Levene's Test for Equality of Variances		t-test			
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Equal variances assumed	1.824	0.180	12.796	104	0.000	4.1353
Equal variances not assumed			12.793	103.744	0.000	4.1353

According to the author, the experimental group students who participated in the eight-week model 7E learning course likely have a superior comprehension of chemistry topics. Their proficiency in chemistry positively impacts their academic performance, leading to improved scores in the subject. In summary, the implementation of the 7E learning cycle model in teaching chemistry topics resulted in improved academic performance. This model offers several positive features in education, such as enhancing student motivation, facilitating conceptual learning through practical activities, fostering active and creative student engagement, promoting the recall of prior knowledge, and encouraging effective communication between students and teachers while considering individual differences.

Previous studies have also verified that the 7E learning cycle model has a positive impact on academic achievement in comparison to traditional learning models. Mahmood (2021) suggests that the use of the 7E strategy promotes student motivation and active engagement in academic tasks. It is crucial to provide individuals with guidance to ensure consistent and reliable performance. An et al. (2021) found that low levels of motivation among students have a detrimental effect on their academic achievement. Active student involvement in the learning process leads to beneficial outcomes, facilitating their progress. Demina et al. (2022) found that students who display cognitive engagement tend to achieve higher academic performance compared to their less engaged peers.

Whereas, Dwijayani (2019) states that students receive guidance to explore the relevant subject matter in their education. This strategy also has advantages in terms of promoting successful learning outcomes for individuals. Putri and Sari (2021) argue that teachers have a responsibility to monitor and evaluate the academic advancement of their students. This measure will promote strong relationships between teachers and students, leading to improved academic performance. Pupils must adopt a critical approach to their learning. Wu and Wu (2020) found that deep engagement with knowledge improves critical thinking skills and cognitive processes in students. This method is crucial for improving one's problem-solving and decision-making skills. Using a problem-solving approach that promotes self-exploration accomplishes the improvement of students' learning.

Hwang et al. (2019) argue that clarifying the subject matter is a crucial stage in students' educational progress. Educators have a responsibility to offer thorough explanations of course material to enhance student understanding and improve learning outcomes. Sun and Wang (2020) emphasise the importance of customising information to align with students' individual comprehension levels to enhance learning outcomes. Lestari and Wahyudin (2020) found that active learning, as a pedagogical technique, has advantages for educators and learners by promoting improved comprehension. Clear and comprehensive explanations are an effective way for students to understand information. Therefore, it is essential to offer students precise explanations of subject matter to enhance their learning experience.

Alqurshi (2020) states that educators must provide students with opportunities to improve their comprehension of the subject matter. This approach facilitates teachers' assessment of students' academic progress. Encarnacion et al. (2021) highlight the importance of topic elaboration in evaluating students' comprehension and acquisition of knowledge. This collaborative approach between educators and students is considered reliable for improving students' understanding. Cheng et al. (2019) recommend that teachers encourage students to actively elaborate on academic topics by using real-life examples to improve their academic performance. Pupils can comprehend new concepts from various perspectives.

Likewise, Caena and Redecker (2019) emphasise the significance of the assessment procedure in the field of education. This approach benefits students' comprehension by facilitating ongoing evaluation to update their knowledge. Assessing teachers' commitment to student engagement is crucial for evaluating instructional content comprehensively. Bailey and Rakushin Lee (2020) found that this strategy effectively improves students' knowledge acquisition and learning outcomes. Assessing students is crucial for effectively motivating them to achieve improved learning outcomes. The successful education of children requires the implementation of reliable techniques and a commitment to advanced learning. Teachers are responsible for providing reliable information to their students.

In the similar vein, Hayat et al. (2020) argue that teachers have a dual responsibility of imparting foundational knowledge and introducing new information to students. This promotes the dissemination of knowledge and is conducive to student participation. Bi et al. (2019) emphasise the significance of students acquiring knowledge while also highlighting the need for improvement in their task management abilities. Research suggests that problem-solving strategies used by teachers can effectively motivate students and improve learning outcomes. Puspitarini and Hanif (2019) found that students display intrinsic motivation and increased efficacy when striving to improve their comprehension. The acquisition of knowledge by students is crucial for expanding their understanding of the subject matter.

Likewise, Li et al. (2019) emphasises the importance of assessing students at the end of their academic pursuits for their intellectual development. Teachers have a responsibility to actively participate in critical work that supports the advancement of students' learning. Lawson et al. (2019) found that educators' evaluation practices

positively influence the correlation between pupils and their knowledge acquisition. Evaluation is essential for promoting effective learning. A more effective learning method involves conducting comprehensive evaluations. Providing information to students is essential for promoting improved learning outcomes. The assessment is an essential procedure that is considered effective for improving the learning experience. Bdair (2021) suggests that this evaluation approach assists teachers in understanding students' knowledge levels and learning progress.

In another study, Jdaitawi (2019) emphasises the importance of a positive rapport between educators and students. This method seeks to improve mutual understanding and enhance the learning approach of both participants. Mohamad Nasri et al. (2020) argues that comprehending the learning process requires an analysis of its occurrence. Both students and teachers must follow established guidelines and employ a strategic approach to improve their performance. Lapitan et al. (2021) emphasise the importance of reliability in student work for enhancing academic understanding. A more effective approach to fostering progress is to prioritise the academic achievement and educational advancement of students to enhance their knowledge. Students must develop strategies and follow their instructors' guidance diligently.

While Rasmitadila et al. (2020) emphasise the significance of contemporary advancements in knowledge acquisition. It is crucial for instructors to receive training to acquire the necessary mindset and expertise for effective instruction of their students. Cheng and Tsai (2019) found that student motivation positively influences work ethics and knowledge acquisition. Educational institutions must provide reliable resources to their teaching staff to equip them with appropriate instructional aids. Quezada et al. (2020) suggest that this enhances the successful implementation of educational strategies. This strategy plays a crucial role in promoting students' learning progress. Active learning strategies, when facilitated by teachers, can enhance students' learning.

Similarly, Rasmitadila et al. (2019) argue that incorporating contemporary amenities into educational institutions is crucial for enhancing the learning process, as the availability of resources greatly impacts its effectiveness. The academic achievements and educational advancements of students can have positive implications for improving overall performance. Promoting motivation among teachers and students is crucial for facilitating positive learning outcomes. Tohara (2021) suggests that educators who possess intrinsic motivation to enhance their professional development play a strategic role in improving their pedagogical approaches. Students with low motivation may feel uncomfortable with their ability to perform at a high level. The effectiveness of teaching and the reliability of educational resources are significant factors that impact students' academic achievement.

CONCLUSION

The educational landscape in Jordan is currently experiencing notable progress in diverse domains, reflecting the swift transformations and advancements transpiring within the nation. Science and technology represent intrinsic and

indispensable attributes of the contemporary era, specifically the 21st century. The primary objective of the Ministry of Education in Jordan is to augment academic proficiency throughout various tiers of education, encompassing primary, intermediate, and secondary levels. The model employed in this study exhibited a favourable impact on the academic performance of students. The experimental cohort, instructed by the computational model, exhibited a statistically noteworthy edge over the control cohort in relation to their grasp and assimilation of chemistry academic performance.

THEORETICAL AND PRACTICAL IMPLICATIONS

The present study has contributed to the existing corpus of knowledge through its empirical discoveries. This study has made a significant contribution to the existing body of knowledge by highlighting the importance of the 7E learning cycle. It is worth noting that this particular cycle holds significant importance for students enrolled in educational institutions, particularly with regards to their pursuit of advanced academic accomplishments. Previous research has extensively examined the significance of the 7E learning cycle across various contexts. However, it is worth noting that there exists a dearth of literature pertaining to its application within the educational landscape of Jordan, specifically among students attending schools in this region. The present study elucidated the significance of critical literature in facilitating the progress of students' educational development. Henceforth, this study has elucidated the significance of employing the 7E instructional model in facilitating the acquisition of knowledge and enhancing the scholastic achievements of students in the domain of literature. As a result, we have effectively rectified the identified gaps in knowledge, thereby significantly enhancing the existing corpus of knowledge.

Consequently, the present study yields practical implications derived from its empirical findings. The present study elucidated the pragmatic significance of the 7E learning cycle in enhancing the learning outcomes of science students. The present investigation elucidated the provision of suitable laboratory facilities for students to enhance their learning outcomes and critical aptitude. The optimal strategy for guiding students towards critical performance would involve implementing a systematic approach. In a similar vein, the investigation underscored the necessity for educators to cultivate a suitable curriculum to enhance the learning trajectory of their students. Undoubtedly, the progression of students and their aptitude for acquiring knowledge have exhibited improvement over the course of time. However, it is worth noting that the dependable ramifications associated with the implementation of the 7E framework possess the potential to significantly enhance their academic accomplishments. Therefore, students should not disregard the significance of 7E and are strongly advised to enhance their performance critically to effectively achieve their objectives.

RECOMMENDATIONS

Based on the findings, the researcher has provided recommendations. It is advisable for science teachers to use the 7E learning cycle in their teaching due to its effectiveness in enhancing students' academic achievement. Additionally, it is advisable to conduct training programmes for science educators to enhance their proficiency in implementing the 7E learning cycle model. Additionally, it is advisable to supply the necessary tools and science laboratories required by the 7E learning cycle model in Jordanian schools.

LIMITATION OF THE STUDY

In addition to its theoretical and practical significance, this study has certain limitations. The initial focus of the curriculum for the 2021–2022 academic year was on the introductory unit of the chemistry textbook, specifically covering the topic of acids and bases. Furthermore, this study is limited to twelfth-grade students in Jordanian secondary schools. The Ahmed Toukan Secondary School, an educational institution affiliated with the Amman Directorate of Education, is the specific focus of this study. This study is limited to the first semester of 2010–2020. Therefore, it is imperative to address the limitations of this research in future studies. Future research should employ a Likert-scale questionnaire to gather data from students. This would aid in addressing the limitations of this study and obtaining significant findings. Furthermore, it is crucial to acknowledge that the data collection for this study is limited in scope as it solely pertains to a single school's population. The generalization of research findings poses a concern. Future research should aim to gather data from a more diverse population in order to enhance the generalizability of the findings beyond the scope of this particular study. This approach would facilitate scholars in accessing the research findings.

DECLARATIONS

Consent andethics approval

The Research Ethics Committee/Deanship of Graduate Studies and Research of Ajman University, the United Arab Emirates approved this work.

Consent statement

All participants of this study completed a consent form introduce to them online.

Data availability

The data is available with the corresponding author upon request.

Conflicting interests

The author declares no conflicting interest.

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