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Effectiveness of 7E Instructional Model in Teaching Factors Affecting Rate of Chemical Reaction for Grade Nine Chemistry

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ABSTRACT: *This study was designed to explore the effectiveness of the 7E instructional model in teaching the concept of factors affecting the rate of chemical reaction to ninth-grade chemistry students in one of the schools in Bhutan. The research design was quasi-experimental, and the study was conducted over a month. Quantitative data was collected from 62 students using convenience sampling, with 31 students each in the experimental and control groups. In addition, a purposeful sampling method was used to gather qualitative data from six students specifically chosen from the experimental group. Quantitative data for the study was obtained using the test and survey questionnaires, whereas qualitative data was collected using semi-structured interviews. The test scores underwent descriptive and inferential analysis, while the survey questionnaires were subjected to mean and standard deviation calculations. Thematic analysis was used to analyze the semi-structured interviews. The study found a significant mean difference in the academic scores of students in chemistry when taught using the 7E instructional model compared to the lecture method. Likewise, the study found students exhibited positive attitudes toward chemistry when exposed to the 7E instructional model. Moreover, the study revealed a significant strong correlation between students' attitudes and test scores. The findings suggest that the 7E instructional model enhances students' academic performance and fosters a more positive attitude toward learning chemistry. The researchers recommend adopting the 7E instructional model, as it offers a more engaging learning experience that enhances students' understanding and application of scientific concepts.*

KEYWORDS: 7E instructional model, academic achievement, quasi-experimental, student attitudes, chemistry, Bhutan.

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1. Introduction

Science is considered an important subject as it builds knowledge and helps to understand the world better. According to Sewanu (2022) chemistry plays a vital role in the progress of a nation, where the country's economic foundation relies heavily on natural resources. Considering the importance, chemistry teachers, make an effort to improve academic success in Chemistry despite understanding the subject is difficult for learners due to its abstract concepts. The studies conducted by Jusniar et al. (2020a) and Fahmi and Irhasyuarna (2020) highlighted the difficulties faced by both learners and educators in comprehending scientific reasoning and concepts related to reaction rates. Similarly, a study by Jusniar et al. (2020b) revealed that learners encounter difficulties in comprehending concepts associated with the rate of reaction in chemistry. Likewise, the Pupil Performance Reports for Bhutan Council for Secondary Examinations and Assessment (BCSEA) (2019-2023) also revealed that student performance in chemistry in Bhutan was consistently low compared to other subjects in the Bhutan Certificate of Secondary Education (BCSE).

To address the challenges in learning chemistry, teachers should adopt a variety of alternative teaching strategies. The study conducted by Turgut et al. (2017) reported that the 7E instructional model, developed by Eisenkraft (2003) as an extension of the 5E instructional model introduced by Bybee (1997), is more effective in teaching. The 7Es model represents a sequence of learning stages, namely Elicit, Engage, Explore, Explain, Elaborate, Evaluate, and Extend, which provide a comprehensive framework for guiding students through the learning process. Studies conducted by scholars such as Santi and Atun (2021) and Maskur (2019) reported that the 7E instructional model enhances students' conceptual understanding and improves academic performance compared to the lecture method, primarily because it emphasizes hands-on practices that enhance learning at each stage. Moreover, the 7E instructional model has shown effectiveness in removing misconceptions and improving students' performance and retention capacity (e.g., Adam et al., 2022; Gyampoh et al., 2020; Istuningsih, 2018; Masker et al., 2019; Shaheen et al., 2015). However, there is limited research conducted to examine the effectiveness of the 7E instructional model for teaching Chemistry in Bhutanese classrooms. Therefore, this study aspires to answer the following research questions in the Bhutanese context.

Is there a statistically significant difference in the academic scores of students in chemistry between those taught using the 7E instructional model and those taught using the lecture method?

What is the attitude of students towards chemistry when exposed to the 7E instructional model?

Is there a significant correlation between the academic scores of students and their attitude towards the 7E instructional model when learning about the factors affecting the rate of chemical reaction?

2. Literature Review

2.1. The 7E Instructional Model

Arthur Eisenkraft's 7E instructional model is an extension of Robert Bybee's 5E learning cycle, incorporating "elicit" at the beginning and "extend" at the end. These modifications were made by Eisenkraft to ensure that teachers do not overlook essential components of learning. The 7E instructional model plays a vital role in activating learners' prior knowledge and experiences, emphasizing the importance of knowledge transfer, a key aspect of science education. According to Senuwa (2022), it is grounded in Vygotsky's Social Constructivist theory and Jean Piaget's Cognitive Development theory. This model enhances student engagement in the learning process and aligns with their expectations. Additionally, it emphasizes students' exploration of new concepts and their connections to prior knowledge. It encourages active participation through various learning phases, allowing students to activate their prior knowledge of a concept, engage in class or group discussions, investigate topics, derive definitions based on their experiences, acquire further information about their learning, and evaluate their understanding.

2.1.1. Elicit Stage

This is the first stage of the 7E instructional model, where the teacher aims to elicit or draw attention to students' prior knowledge. According to Shaheen and Kayani (2015), during the elicit stage, the teacher assesses students' existing understanding of the subject to be discussed. At this point, the teacher highlights students' prior knowledge to reinforce their comprehension. This stage also encourages knowledge sharing among students regarding the topic they are about to learn.

2.1.2. Engage Stage

The Engage phase is specifically designed to cultivate students' interest in the upcoming learning acivities. In this stage, the teacher provides opportunities for all students to express their opinions to their peers using various techniques. According to Balta and Sarac (2016), using cartoons, animations, movies, or films, as well as demonstrations of material concepts, can inspire students during this stage. The objective of this stage is to establish a foundation for the subsequent activities that will take place.

2.1.3. Explore Stage

The exploration phase provides students with opportunities to observe, record data, identify variables, conduct experiments, create graphs, interpret results, and draw conclusions. During this phase, learners collaborate to develop skills and concepts, and the teacher ensures their active participation in constructing new knowledge (Chenoro, 2021).

2.1.4. Explain Stage

In this stage, students present and demonstrate their group outputs to the class, and they are allowed to explain their work using the provided materials (Gonen & Kocakaya, 2010). The teacher observes and evaluates the students' presentations using a rubric. The teacher corrects any misconceptions about the topic and supplements the discussion with additional points (Gonen & Kocakaya, 2010; Tecson et al., 2021). During this phase, students are allowed to connect their experiences to any concept being explored.

2.1.5. Elaborate Stage

During this stage, students are given a chance to put their newly acquired knowledge into practice. According to Chenoro (2021), students can transfer their acquired knowledge from one context to another in this stage.

2.1.6. Evaluate Stage

In this stage, the teacher assesses whether students have understood and applied the topic correctly in a scientific context through the evaluation step (Wilder & Shuttleworth, 2005). The evaluation can be conducted using formal or informal techniques. Assessments are used to demonstrate students' constructed knowledge during this phase. The teacher assesses the degree to which learning objectives have been accomplished. This can be done through tasks, tests, and questioning.

2.1.7. Extend Stage

The extended phase ensures that teachers facilitate the transfer of learned concepts, enabling students to apply their knowledge in new contexts and in their everyday lives (Kajuru & Kauru, 2014). While the initial goal is to retain knowledge, the ultimate goal of this phase is to apply that knowledge to problem-solving in various contexts.

2.2. The 7E Instructional Model and Academic Achievement

In a constructivist setting, students can construct their understanding by using prior information to generate new concepts. Within the 7E instructional setting, the teacher assumes the role of a facilitator, guiding active learners in reaching their conclusions. According to Sewanu (2022) modern instructional methods help improve students' academic achievement compared to a stable traditional education approach.

The studies such as Adam et al. (2022), San Miguel (2021), and Shaheen et al. (2015) revealed that the 7E instructional model improves students' performance in science. Similarly, Shaheen and Kayani (2017) conducted research in Pakistan involving 122 ninth-grade students and found that the 7E instructional model yielded superior academic achievements compared to the lecture method. Similar findings were reported by Adesoji and Idika (2015) and Naade et al. (2018), where students taught using the 7E instructional model outperformed those taught through traditional lecture methods. Furthermore, Gyampoh et al. (2020) asserted that students instructed using the 7E instructional model demonstrated higher performance levels and better conceptual understanding compared to students taught through the lecture method. Additionally, Vick (2017) found that the 7E instructional model could potentially improve students' academic achievement compared to the lecture method. The findings from scholars show the efficiency of the 7E instructional model in teaching chemistry. Thus, this 7E instructional model is the solution to narrow down the gaps created by the traditional means of teaching science.

Several studies, including those conducted by Adak (2017), Kunduz and Secken (2013), and San Miguel (2021), observed a notable disparity in achievement test scores when learners were taught using the 7E instructional model compared to the lecture method. Likewise, the research conducted by Suardana et al. (2018) in Indonesia found that the 7E instructional model boosts the students' critical thinking skills and test achievement. Furthermore, research conducted by Komikesari et al. (2020) and Bucayong (2022) noticed that the 7E instructional model improves conceptual understanding for lowperforming students. Additionally, Nasbey et al. (2022) claimed that the 7E instructional model is effective in planning an online learning tool, and lesson plan for the learners.

Several studies have been conducted to compare the academic achievement of students taught using the 7E instructional model and traditional lecture methods in various subjects. The majority of these studies have favored the effectiveness of the 7E instructional model. For example, a study by Sarac and Tarhan (2017) in Turkey, involving 92 fifth-grade students, found that multimedia learning materials prepared according to the 7E instructional model positively influenced academic achievement and enhanced learning retention. Similarly, a study by Widarti et al. (2021) in Indonesia revealed that activities designed based on the 7E instructional model contributed to improved academic achievement and retention of students in English. Abdullahi et al. (2021) and Chenoro (2021) also found that the adoption of the 7E instructional model enhanced students' achievement in Biology. Furthermore, the study focusing on the topic of magnetic fields by Şahin and Yağbasan (2022) demonstrated that integrating the 7E instructional model with creative drama enhanced the success of physics teacher candidates. Additionally, Adam et al. (2022) discovered that the 7E instructional model positively impacted students' achievement in ecology. Moreover, a study by Tecson et al. (2021) in the Philippines revealed that inquiry-based teaching using the 7E instructional model had a favorable impact on student performance and enhanced the teaching-learning process. These findings collectively indicate that the 7E instructional model is effective in teaching various subjects. However, it should be noted that the 7E instructional model was unable to bridge the achievement gap between low and high achievers, as reported by Quainoo (2019). Scholars are in favor of the 7E instructional model having a positive impact on the academic achievement of learners in different subjects. Yet there is a dearth of literature in the Bhutanese context. This study would add to the academic literature on the 7E instructional model and academic achievement in the Bhutanese context.

2.3. Students' Attitude towards Chemistry When Exposed to the 7E Instructional Model

Learning is significantly influenced by attitude. The attitude of the individual determines whether they feel positively or negatively about a given situation. According to Welch (2010), attitude encompasses emotional behaviors, preferences, acceptances, and values. Moreover, Slavin (2019) claimed that students perform better academically when they have a positive attitude toward an instructional strategy.

The study conducted by Adesoji and Idika (2015) reported that students exhibited favorable attitudes toward chemistry when exposed to the 7E instructional model compared to the lecture method. Similarly, Naade et al. (2018) claimed that the 7E instructional model was more effective in cultivating and stimulating students' interest and enthusiasm for learning compared to the lecture method. Additionally, an action research study conducted by Turgut et al. (2016) involving 52 participants in Turkey, found that the majority of participants enjoyed the lessons when the teacher employed the 7E instructional model compared to the traditional lecture methods. Furthermore, Chenoro (2021) asserted that students displayed a more positive attitude toward the lesson when the teacher utilized the 7E instructional model rather than traditional methods. Gonen and Kocakaya (2010) also asserted that the "7E model promotes scientific understanding and thinking abilities among students" (p.3). The 7E model is an instructional approach that places students at the center of the learning process, promoting peer interaction and fostering collaborative discussions to facilitate a deep understanding of concepts (Rahman & Chavhan, 2022; Abdullahi et al., 2021).

The study conducted by Shaheen and Kayani (2017) in Pakistan revealed that the 7E instructional model-based instructions enable students to connect what they have learned in biology and transfer this knowledge later. Similarly, Sarac and Şekerci (2018) highlighted that the 7E instructional model sparks curiosity among students and enhances their learning experience. Moreover, instruction based on the 7E instructional model was found more effective in improving students' attitudes toward a school subject compared to the conventional way of teaching (Bulbul, 2010). The study conducted by Quainoo (2019) also asserted that students had positive perceptions of the 7E instructional models of teaching. Additionally, Sewanu (2022), Abdullahi et al. (2021), and Adesoji and Idika (2015) found that the 7E instructional model had a notable impact on students' achievement and attitude towards chemistry.

3. Methodology

3.1. Research Design

This study employed a quasi-experimental, mixed-method design, combining both quantitative and qualitative approaches to gain a comprehensive understanding of the impact of the 7E instructional model on students' knowledge of the factors affecting the rate of chemical reaction. The quasi-experimental design was chosen to include entire classes without randomization, minimizing disruptions to regular classroom activities. A pre-test was administered to assess students' initial understanding of the factors affecting the rate of chemical reaction. The 7E instructional model was then used as an intervention for the experimental group, while the control group received traditional lecture-based instruction. Both groups were taught for an equal duration. Following the intervention, a post-test was administered to evaluate the effectiveness of each teaching method in improving students' understanding of the rate of reaction.

3.2. Participants

A total of 62 students from two sections of grade nine classes participated in the quantitative portion of the study. The researcher selected one section as the experimental group and the other as the control group. Purposeful sampling was used for qualitative data collection, selecting six students from the experimental group who demonstrated strong language and academic skills to ensure insightful feedback. Convenience sampling was employed for the quantitative data collection, as participation was based on students' availability and willingness.

3.3. Instrument

The study used both quantitative and qualitative instruments. Quantitative data were gathered through the achievement test which assessed students' knowledge of the factors affecting the rate of chemical reaction, and the 18-item Likert-type scale survey questionnaires capturing students' attitudes toward the learning experience. The test questions were aligned with the content covered and formatted similarly to the Bhutan Council for School Examinations and Assessment (BCSEA) standards. The survey questionnaires used a five-point scale, ranging from "Strongly Agree" (5) to "Strongly Disagree" (1), with items grouped under three primary themes. For qualitative data, semi-structured interviews were conducted with six selected students from the experimental group to gather deeper insights into their experiences.

3.4. Data Collection

Quantitative data were collected through pre-tests and post-tests, administered to all participants before and after the instructional intervention. Additionally, survey questionnaires were completed by the experimental group following the intervention. The quantitative data provided objective measures of academic achievement and student attitudes. For qualitative data, semi-structured interviews were conducted post-intervention with the six selected participants, focusing on their experiences with the 7E instructional model.

3.5. Data Analysis

Quantitative data were analyzed using Microsoft Excel and SPSS, employing both descriptive and inferential statistics. Descriptive statistics, including mean and standard deviation, were calculated to compare pre-test and post-test results for both groups. Inferential analyses, such as independent sample t-tests, assessed statistically significant differences in academic performance between the experimental and control groups. Attitudinal data from the survey questionnaires were analyzed descriptively, focusing on mean scores and standard deviations. Thematic analysis of qualitative interview data followed Creswell and Creswell's (2018) approach to identify patterns in students' perceptions. The raw data were organized, read, and coded for key ideas. Themes were then generated, defined, and interpreted to present a cohesive, insightful narrative. Additionally, correlation analysis examined the relationship between students' test scores and their attitudes toward the 7E instructional model.

4. Results

4.1. Demographic Information

Table 1. Demographic information of the research participants

Group	Total Students	Grand Total
Experimental Group	31	62
Control Group	31	

This study involved 62 grade nine students, 31 from each of the experimental and control groups.

4.2. Normality Test for Continuous Data

Normality tests are crucial in research, providing insights into suitable statistical methods for data analysis. In this study, the normality of the continuous data was evaluated through the Shapiro-Wilk test. The p-values were found to surpass the predetermined alpha level of 0.05, suggesting that the dataset adhered to normality, as presented in Table 2. Based on the outcomes of the normality tests, it was apparent that the researcher could employ parametric tests to analyze the continuous data.

4.3. Comparison of pre-test and post-test scores between the groups

One of the objectives of this study was to determine if there exists a statistically significant difference in the academic scores of students in chemistry those taught through the 7E instructional model and those taught through the lecture method.

The descriptive analysis was conducted for the post-test scores of the experimental and control groups. Furthermore, an inferential analysis was performed to determine the significant mean difference between the post-test scores of the experimental and control groups. Statistical terms such as mean, standard deviation, t-value, df-value, and p-value were utilized in the data analysis process.

4.3.1. Comparison of post-test between the groups

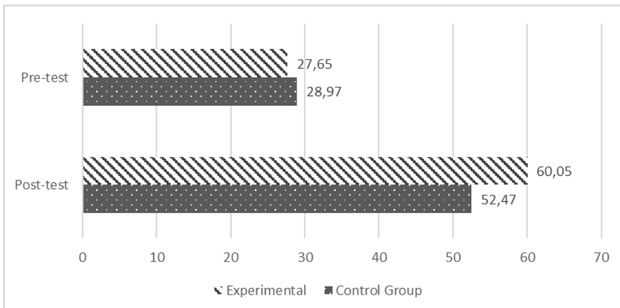

Figure 1. Comparison of Pre-test and Post-test between the groups

Figure 1 depicts that both the experimental and control groups have improved from the pre-test to the post-test. However, the experimental group exhibited a higher mean score in the post-test compared to the control group. This indicates that the experimental group has outperformed the control group.

Table 3 shows the mean pre-test score of

Table 2. Tests of normality based on the Shapiro-Wilk test

	Test	N	Statistic	Sig.
Experimental Group	Pre-Test	31	.964	.408
	Post-Test	31	.955	.253
Control Group	Pre-Test	31	.945	.137
	Post-Test	31	.977	.759

Table 3. Comparison of mean Pre-test scores between the groups

	Section	N	Mean	Mean Difference	Std. Deviation
Pre-test	Experimental	31	27.65	1.32	10.22
	Control	31	28.97		9.87

Table 4. Independent sample t-test for pre-test between the groups

	Groups	t-test for Equality of Means			Cohen's d
		t	Df	Sig. (2-tailed)	
Pre-Test	Experimental Control	.517	60	.607	.132

Note: 95% Confidence Interval of the Difference

Table 5. Comparison of mean Post-test scores between the groups

	Section	N	Mean	Mean Difference	Std. Deviation
Post-Test	Experimental	31	60.05	7.71	12.51
	Control	31	52.34		12.05

the (N=31) experimental group was 27.65 (*SD*=10.22) and the (N=31) control group was 28.97 (*SD*=9.87). The mean pre-test score difference between the experimental group and the control group was 1.32.

An independent-sample t-test was conducted to determine if the mean pre-test score of the experimental group was more than that of the control group. The results showed the mean pre-test score of the experimental group was (M = 27.65, SD = 10.22) and the mean post-test score of the control group was (M = 28.97, SD = 9.87). This mean difference was found not significant [t (60) = .517, p = .607]. Moreover, the calculated Cohen's d was .132 indicating the effect size is relatively small.

4.3.2. Comparison of post-test between the groups

The purpose of the posttest was to evaluate the effectiveness of the 7E instructional model versus the lecture method in teaching the factors affecting the rate of chemical reaction in grade nine chemistry.

Table 5 shows the mean post-test score of the experimental group was 60.05 (*SD*=12.51) and the control group was 52.34 (*SD*=12.05). The mean post-test score difference between the experimental group and the control group was 6.79.

Similarly, an independent-sample t-test was conducted to determine if the mean post-test score of the experimental group was more than that of the control group. The results show the mean post-test score of the experimental group was (M = 60.05, SD = 12.51) and the mean post-test score of the control group was (M = 52.34, SD = 12.05). This mean difference was found significant [t (60) = 1.84, p = .016]. Moreover, the calculated Cohen's d value of .653 indicates a moderate effect size.

4.4. Students' attitudes toward chemistry when exposed to the 7E instructional model

Another objective of the study was to investigate the students' attitudes toward chemistry when taught using the 7E instructional model. So, the researcher administered 18-itemized questionnaires based on three themes to the students from the experimental group. The items were developed based on a five-point Likert-type rating scale, which are; Strongly Agree = 5, Agree = 4, Neutral = 3, Disagree = 2, and Strongly Disagree = 1. The

Table 6. Independent sample t-test for Post-test between the groups

	Groups	t-test for Equality of Means			Cohen's d
		t	df	Sig. (2-tailed)	
Post-Test	Experimental Control	1.84	60	0.016	.653

Table 7. Participants attitudes based on three themes when exposed to the 7E instructional model

Sl No.	Themes	N	Mean	SD	Attitude descriptions
1	Liking for chemistry	31	4.32	.424	Very Good
2	Evaluative beliefs about chemistry	31	4.12	.403	Good
3	Behavioral tendencies to learn chemistry	31	4.16	.532	Good

mean, standard deviation, and level of students' attitude descriptions were assessed for the items, as depicted in Table 1. Furthermore, thematic analysis was conducted on data obtained through semi-structured interviews with four participants from the experimental group.

Table 7 shows, that the participants have a "very good" attitude description for liking chemistry and a "good" attitude description for evaluative beliefs about chemistry and behavioral tendencies to learn chemistry when exposed to the 7E instructional model.

Additionally, the responses from the semi-structured interview revealed that students like the lesson taught based on the 7E instructional model. The students feel that the lesson based on the 7E instructional model was interesting and interactive, and learning the concepts better. For instance, P1 said, "*I learned most of the concepts while discussing with friends and while trying to find out possible ways to apply the concepts.*"

Likewise, participants also reported in the semi-structured interviews that the 7E instructional model in teaching chemistry offers opportunities for exploration, elaboration, group activities, and teamwork, which foster a deeper understanding of the subject matter and enhance their confidence in their chemistry knowledge and skills. According to P2, "The activity, which involves discussion, investigation, and explanation, enhances my learning, fosters teamwork, and facilitates the exploration of various concepts."

The participants' responses, from the semi-structured interviews also showed that there is a positive behavioral tendency toward learning chemistry at a higher institution using the 7E instructional model. The participants expressed their interest in using this model because it allows them to explore new things and understand complex concepts more easily (e.g., P1, P2, P4). Additionally, the model was seen as a way to improve participation and gain confidence in class (e.g., P3).

4.5. Correlation analysis between the attitudes of the participants and their test scores

A Pearson Correlation was used to examine the relationship between the attitude of participants towards chemistry when taught using the 7E instructional model and the achievement test scores of the participants.

Table 8. Correlation between attitude and post-test scores

	N	Pearson Correlation	Sig. (2-tailed)
Attitude and Test	31	.891	.001

Table 8 shows there was a strong positive correlation between the two variables and it was found statistically significant (r (31) = .891, $p < .05$).

4.6. Regression Analysis

A simple linear regression was calculated to predict the test scores of the students based on the attitude of students towards chemistry when taught using the 7E instructional model, b = .816, t (*31*) = -3.495, $p < .05$. A significant regression equation was found F (*1,29*) = 57.716, $p < .05$, with an R^2 of .666. This indicates the variation in test scores is 66.6% because of the attitude of the students toward the 7E instructional model.

5. Discussion

5.1. Comparison of Pre-Test and Post-Test Scores between the Groups

The study was to explore the difference in academic scores of students in chemistry who were taught using the 7E instructional model and the lecture method. The descriptive analysis of pre-test scores showed that the experimental and control groups were nearly identical at the beginning of the study with a mean difference of 1.32. Furthermore, the independent sample t-test results indicated that there was no significant difference in the mean scores between the two groups with a p-value of .607 (Table 4). However, the post-test scores revealed that participants in the experimental group, who were taught using the 7E instructional model, achieved a higher mean score compared to those in the control group, who were taught using the lecture method. The results demonstrated a positive impact on students' learning through the use of the 7E educational model. A similar study conducted by Shaheen and Kayani (2017) reported that the 7E instructional model was more effective than the lecture method in terms of academic achievements. Likewise, Adesoji and Idika (2015), Gyampoh et al. (2020), Naade et al. (2018), Subcounty et al. (2021), and Vick (2017) also found that students taught using the 7E instructional model perform better than those taught through the lecture method. Based on the descriptive findings of this study and past research, it can be inferred that the 7E instructional model had a beneficial effect on students' academic performance, regardless of

Table 9. Model Summary for Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.816a	.666	.654	7.36

a. Predictors: (Constant), Total Attitude

Table 10. ANOVA[a] for Regression Analysis

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3126.694	1	3126.694	57.716	<.001b
	Residual	1571.043	29	54.174		
	Total	4697.737	30			

Dependent Variable: Post-Test, b. Predictors: (Constant), Total Attitude

Table 11. Coefficients [a] for Regression Analysis

Model B		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		Std. Error	Beta			
1	(Constant)	-51.532	14.746		-3.495	.002
	Total Attitude	1.480	.195	.816	7.597	<.001

Dependent Variable: Post-Test

the geographic location and diverse curriculum approaches employed.

Moreover, the independent sample t-test confirmed that there was a statistically significant mean difference in post-test performance between the two groups, with a p-value of .016 (Table 6). The significant mean difference indicates that the intervention positively impacted the performance outcomes of the experimental group, setting it apart from the control group. The findings of this study were consistent with the studies conducted by Adak (2017), Kunduz and Secken (2013), and San Miguel (2021) where they observed a significant difference in the achievement test when the learners were taught using the 7E instructional model than the lecture method. The findings of this study and past research suggest that the learners in the experimental group have achieved higher scores on the achievement test because the 7E instructional model might have promoted active learning, critical thinking, and student engagement by providing a structured framework that incorporates various strategies and activities throughout the learning process. In this study the students were actively engaged in each phase of the 7E, thereby helping them to construct knowledge through various activities conducted both individually and in groups, stimulating their curiosity and enthusiasm for learning, ultimately resulting in the more effective acquisition of knowledge and skills.

5.2. Students' Attitudes toward Chemistry When Exposed to the 7E Instructional Model

The study explored the students' attitudes toward chemistry when taught using the 7E instructional model. The descriptive analysis of the survey questionnaires revealed that the participants have a positive attitude towards liking chemistry when taught using the 7E instructional model. The results were in line with the research carried out by Adesoji and Idika (2015) and Chenoro (2021) where they utilized survey questionnaires to investigate students' attitudes toward science when taught using the 7E instructional model. Their findings indicated that students exhibited a favorable attitude towards science lessons when the teacher employed the 7E instructional model instead of traditional lecture methods.

The thematic analysis of the semi-structured interview also revealed that participants like chemistry when exposed to the 7E instructional model. In this study the participants' liking for chemistry, when exposed to the 7E instructional model, could be attributed to the presence of an engaging and interactive learning environment that fosters excitement, interest, interaction, confidence, and improved learning abilities in every step of the 7E instructional model. Studies conducted by Naade et al. (2018), Sarac and Şekerci (2018) and Turgut et al. (2016) are in alignment with this research findings. In general, students likely found the 7E instructional model appealing for several reasons. Firstly, the 7E model encourages active engagement and participation, replacing passive listening with hands-on activities such as exploration, experimentation, and discussion. This approach empowers students and fosters a sense of ownership in their learning. Secondly, the 7E model promotes collaboration and peer interaction, allowing students to work in groups, exchange ideas, and engage in meaningful discussions, which enhances comprehension, simplifies complex concepts, and builds social skills. The model also emphasizes practical knowledge application by integrating real-world examples, problem-solving tasks, and hands-on activities, making learning more relevant and impactful.

Both the survey questionnaires and semi-structured interviews showed that the participants have a positive evaluative belief towards chemistry when exposed to the 7E instructional model. The findings were parallel with the study conducted by Abdullahi et al. (2021) and Adesoji and Idika (2015) who reported that the 7E instructional model was found to have a significant effect on students' achievement and attitude toward chemistry. The results of this study, along with past research, suggest that participants evaluated the 7E instructional model positively in learning chemistry. This positive sentiment likely stemmed from the model's emphasis on active engagement, hands-on activities, and collaborative learning experiences facilitated by the teacher. Additionally, the 7E instructional model may have helped bridge the gap between theoretical concepts and real-life applications, creating a more meaningful learning experience and increasing motivation and interest in chemistry.

The survey questionnaires and semi-structured interview questions also revealed that the participants have positive behavioral tendencies to learn chemistry when exposed to the 7E instructional model. The present findings were supported by Slavin (2019) who claimed that students perform better academically when they have a positive attitude toward a teaching strategy. Similarly, the research conducted by Bulbul (2010), Siribunnam and Tayraukham (2009) and Quainoo (2019) found that students had a positive perception of learning when exposed to the 7E instructional model compared to the conventional technique. The findings suggest that the instructional model might have effectively influenced participants' behaviors and attitudes toward learning the subject, and are likely to continue learning the subject in a higher institution setting. One possible reason is that the 7E instructional model provides learners with opportunities to master skills at each phase, fostering intrinsic motivation that boosts their interest and improves academic performance.

To sum up, the data from survey questionnaires and thematic analyses of the semi-structured interviews provide strong evidence that the 7E instructional model positively influences students' attitudes, behaviors, and perceptions toward chemistry. These positive results are likely due to the 7E model's ability to foster intrinsic motivation by allowing students to actively engage with content, collaborate with peers, and apply knowledge to real-world contexts, thereby enhancing both academic performance and interest in the subject.

5.3. Correlation between the Attitudes of the Participants and Their Test Scores

A Pearson Correlation was used to examine the relationship between the attitude of students toward chemistry when taught using the 7E instructional model and the achievement test scores of the students. The analysis revealed a significant and strong positive correlation ($r = .891$, $p < .05$) between the two variables. The results suggest that the 7E instructional model can enhance students' attitudes toward chemistry, leading to improved academic performance in the subject. The finding supports the study conducted by Abdullahi et al. (2021), Adesoji and Idika (2015) Chenoro (2021), Naade et al. (2018), Sewanu (2022), Turgut et al. (2016) who reported that the 7E instructional model was found to have a significant effect on students' achievement and attitude toward chemistry. One possible reason is that the positive attitudes of students toward the subject when taught using the 7E instructional model, may have fostered curiosity and a desire to learn. This increased curiosity, in turn, likely led to greater engagement and motivation, ultimately resulting in higher test scores.

5.4. Limitations of the Study

This study faced several limitations that may have affected the generalizability of its findings. Firstly, the study was conducted over a short duration, which may not have allowed sufficient time to observe the long-term effects of the 7E instructional model on students' attitudes and performance in chemistry. Secondly, the study focused on a specific topic within the chemistry curriculum, which may not fully represent the 7E model's impact on other topics or subjects. Finally, the research was conducted within a single school with a relatively small sample size, which limits the ability to generalize the results to a broader population. These limitations suggest that future studies could benefit from a larger, more diverse sample, a longer duration, and a broader range of topics to provide a more comprehensive understanding of the 7E instructional model's effectiveness.

6. Conclusions and Recommendations

The findings revealed that students who were taught using the 7E instructional model achieved a higher mean score compared to those taught using the lecture method. The independent samples t-test also demonstrated a statistically significant difference in academic scores between students in chemistry who were taught using the 7E instructional model and those taught using the lecture method. The findings from both the descriptive analysis of the survey questionnaires and the thematic analysis of the semi-structured interviews revealed that the students had a positive attitude towards learning chemistry when taught using the 7E instructional model. They enjoyed the interactive and collaborative nature of the model, which fostered their liking for chemistry and improved their evaluative beliefs about the subject. Further, the participants showed positive behavioral tendencies to learn chemistry when exposed to the 7E instructional model. The findings also revealed a significant and strong positive correlation between students' attitudes toward chemistry when exposed to the 7E instructional model and their academic achievements.

This study demonstrated that implementing the 7E instructional model in teaching factors affecting the rate of chemical reactions in grade nine chemistry positively impacted both academic performance and student attitudes. Therefore, the study recommends that school principals, dzongkhag education officers, and the Teacher Professional Support Division (TPSD) organize targeted professional development programs to equip in-service teachers with the knowledge and skills required to effectively implement the 7E instructional model. The study further suggests future research to explore the use of the 7E model across different subjects to assess its broader effectiveness. To strengthen evidence of the model's impact, future studies should consider including students from diverse academic levels, increasing the sample size, and extending the study duration. Additionally, this study encourages future researchers to examine long-term retention in students taught with the 7E instructional model, as the limited timeframe of this study did not allow for an assessment of sustained retention.

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