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Effects of the 5E Learning Model on Physics Students' Academic Achievements

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Abstract

This study aims to determine the effects of the 5E learning cycle model at the bachelor level physics students' academic achievement. Null hypotheses were examined to accomplish this study. The population included all students studying science education at the bachelor's level on Tribhuvan University's constitutional campuses. The sample of the study consisted of sixty (60) physics students from two constitutional education campuses in Kathmandu and Bhaktapur districts, who were in their second year of bachelor's degree. A quasi-experimental research method was adopted for this investigation. There were 30 students in each of the control and experimental groups. The instrument was validated by university professors and lecturers, and the Kuder Richardson -21 formula was used to determine the reliability coefficient which was found to be 0.78. The experimental and control groups were taught for fifteen hours on the topic "Electrostatic Force, Field, and Potential" using a learning cycle model and conventional teaching methods. The results of this investigation demonstrated that students taught using the learning cycle model were shown to be more successful learners in physics than those taught using the conventional teaching technique.

Keywords**:** achievement, bachelor's level, constructivist learning, conventional method, 5E model, physics

Introduction

With the rapid advancement of science and technology, science education has become extremely relevant. The development of methodologies, techniques, and approaches that enable students to be active, curious, and build knowledge has resulted from this growth in interest. One of them is the 5E learning model, which has been the subject of numerous research in literature. These independent investigations were conducted in a variety of study regions, with a variety of study groups, and yielded a variety of outcomes.

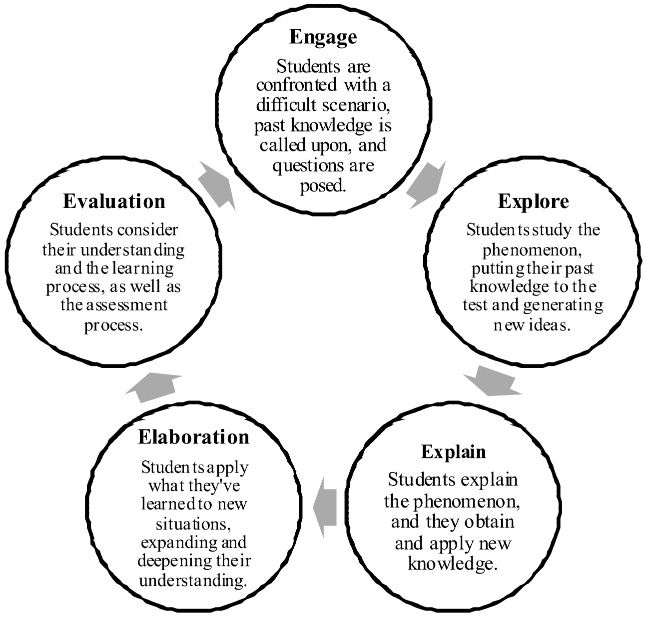
Constructivism has progressively had a significant impact on various fields of education and has emerged as one of the key influences on modern science and mathematics teaching. Its core premise can be summed up in the statement that persons who seek knowledge cannot exist in a vacuum. In this way, it can be considered a human creation that acknowledges the active ability of the subject engaged in cognition (Olssen, 1995).

The proponents and practitioners of the constructivist paradigm in scientific education stressed the importance of a student's or individual's accumulation of knowledge at any one time in responding to new information or stimulation (Burhberger, 2000; Lewis, 2001). For the purpose of applying the constructivist learning method, different teaching and learning models have been created. The 5E learning model is one of these models that has recently been validated with various process phases in the educational process. Bybee (1993), a prominent figure in the Biological Science Curriculum Study (BSCS), introduced this model in 1967. The 5E Instructional Model(Bybee & Landes, 1990) is based on constructivist learning theory, cognitive psychology, and the most effective methods for teaching science, and it may be utilized to create a science lesson. The 5E model is based on the findings of studies conducted in accordance with national scientific education requirements (Newby, 2004). Engage-Enter, Explore, Explain, Elaborate, and Evaluate are the five steps that constitute up the model (Carin et al., 2005). The 5E approach allows students to properly understand a new topic or learn a previously learned concept (Ergin et al., 2007).

The 5 Es Learning Cycle Model, according to Ozmen (2004), is the most widely used constructivist learning system (Bybee et al., 2006). This model is predicated on the notion that learners must create their own understanding of novel concepts and information by examining, testing, and purging their prior assumptions and perspectives. Instead,then only hearing, students apply concepts and realities during practical learning. Students' perspectives, knowledge, abilities, interest, and reasoning change for the better. The quantity of learning that occurs is mostly determined by the quality of the experience (McElhaney & Ann, 1998). This model is often used in the science education paradigm (Soomro et al., 2010) and can be applied to any subject. The student can gain additional information about science topic, science process, and critical thinking abilities by using this approach (Buntod et al., 2010; Yalcin & Bayrakceken, 2010). The 5Es learning model piques students' curiosity and encourages them to be more creative (Rasul et al., 2019).

Constructivism is a learning paradigm that asserts that students must construct their own knowledge of new concepts. The 5E process of learning involves discovering or attempting to comprehend something familiar in a new way. It isn't a straightforward procedure. In an effort to make sense of events, students draw on both their existing knowledge and firsthand information learned from fresh explorations (Newby, 2004). Engagement, investigation, explanation, elaboration, and evaluation are the five phases of the 5E Instructional Model (Carin & Bass, 2000; Lorsbach, 2006; Tinker, 1997). It encourages students to develop their own notions at all levels (Martin, 2000) and is interconnected as presented in Figure 1 below.

Figure 1. 5E's Learning Cycle Model Adopted from Northern (2019)



Note. This model was adopted by Northern in 2019, summarizing 5Es that enhance the cognitive level of students.

Every part of the 5Es is deliberately shaped to help students build their knowledge and information construction skills. The first step, Engagement, is utilized to encourage students by inducing mental dissonance or re-enacting real-life scenarios. Prior knowledge is accessible during the engagement phase by involving learners in short activities that generate interest in the new topic. Students form personal connections with the content and the pedagogical activity in order to establish connections between educational strategies. The learners' interest in the subject is piqued. Teachers explain a topic or a problem, offer questions or demonstrate an event about the subject at this stage, and then encourage learners to debate the subject in order to recognize learners' initial information (Bybee, 1997; Wilder & Shuttleworth, 2005).

Students then move on to the second stage, Exploration, when they make observations, gather the data, test assumptions, and refine hypotheses in light of the first phase's heightened interest. During the exploring phase, the students efficiently generate ideas to address the problems.The teacher facilitates and provides the necessary resources to aid the students in becoming more receptive (Carin & Bass, 2000; Newby, 2004). With this knowledge, they can begin responding to questions posed during the Engagement phase. In order for students to recognize their misconceptions about the concept, the teacher promotes safe, guided or open inquiry activities and inquiries throughout the Exploration stage. During the third phase, Explanation, the teacher builds a scientific justification for the students' findings using their observations and data.This is when suitable scientific jargon is introduced and linked to the pupils' previous experiences. The lecturer encourages students to pay off misplaced knowledge or replace it with new material if they are unable to do so. The instructor employs extra excellent approaches such as verbal clarification, film, movie, and demonstration (Bybee & Loucks-Horsley, 2002; Campbell, 2006).The goal of the fourth step, Elaboration, is to provide pupils increasingly difficult applications, answers, choices, and/or logical conclusions to make. The instructor encourages students to apply their newly gained information in a variety of situations and to take on responsibilities (Morse et al., 2004). This usually takes the form of a new investigative activity or a continuation of the Exploration phase. Finally, the fifth phase, Evaluation, is critical for determining whether students grasped the concept scientifically and were able to generalize it to other situations. This might be done in a formal or informal manner (Wilder & Shuttleworth, 2005). The instructor's preparation for the next lesson is guided by the knowledge obtained at this stage (Khan et al., 2020).

Numerous studies have indicated that students are unable to retain knowledge acquired through conventional methods (Ahmad et al., 2019). The 5Es learning cycle model is a cutting-edge, active learning strategy that is essential for optimal learning. Many studies have been conducted to demonstrate the impact of the 5Es model on students' academic results in science in general and physics in particular (Madu & Amaechi, 2012). In a study by Ihejiamaizu et al. (2018), it was discovered that teaching with the 5Es method improved learners' active involvement in Physics. Furthermore, Lee (2003), Pulat (2009), Acish et al. (2011), Yalcin and Turgut (2011), Ajaja and Urhievwejire (2012), and Jack (2017) conducted empirical investigations on the usefulness of the 5Es learning cycle model for improving student accomplishment in other countries.

As a teacher in Nepal, the researcher encountered numerous issues in the teaching and learning of physics at the higher levels. Without any debate, collaboration, or contact with kids, learning in a pin drop silence classroom is believed to be the finest in Nepalese schools. Science teachers rarely encourage students to participate in classroom discussions. Students are expected to be passive recipients of a teacher's content knowledge (Shrestha, 2011). As a result, low science proficiency among students in Nepal is due to a highly deductive and teacher-centered pedagogical approach to teaching and learning science at the campus level (Acharya, 2016). Furthermore, a teacher-centered approach does not provide appropriate support for classroom talk, discussion, and reflection. In the classroom, students sit in tidy, organized, and well-arranged rows. Students are forced to memorize methods because a dogmatic approach to teaching science makes them feel boring.

A variety of issues have been highlighted in this respect as contributing to students' low achievement in science in general, and in physics in particular. Teaching science subjects, particularly physics, has numerous obstacles, including an ineffective teaching strategy, a lack of science resources, and a big class size (Mekonnen, 2014). Because of these difficulties, students regard physics as a difficult and abstract science. Previous research has demonstrated that students have difficulty understanding and interpreting physics concepts such as diffraction, polarization, and interference effect (Ambrose et al., 1999). Learning optics and related phenomena have lately been researched for similar issues, which have been largely linked to instructional tools and teaching methodologies (Ndihokubwayo et al., 2020). Furthermore, in Nepal's campus education, the 5E's constructive learning cycle model for science teaching and learning has yet to be linked with classroom pedagogy. As a result, I decided to conduct research into the effectiveness of the 5 E's constructive learning cycle model on students studying physics, an approach that has yet to be investigated in Nepal's science education system.

The primary goal of this research was to determine the effect of the 5E learning cycle model on students' academic progress in Physics at the bachelor's level. The following was the research question addressed in this study:

What effect does the 5E learning cycle model have on the academic achievement of bachelor's level physics education students?

Hypothesis

The study's null hypotheses were as follows:

$H0_1$: In a pretest of bachelor level physics in scientific education, there is no significant difference between the experimental and control groups of students.

$H0_2$: There is no significant difference in academic achievement between students who were taught physics using the learning cycle model and those who were taught physics using the conventional methods of bachelor level physics in science education in the post-test.

Methods and Procedures

A quasi-experimental research design with a pre-test and post-test control group in intact classroom setting was used in this study. Students in the second year of the physics course (Sc. Ed. 422) at the department of scientific education of the constitutional college of Kathmandu and Bhaktapur districts were studied during the 2022 academic year. All internal validity factors (testing, history, maturation, differential selection, instrumentation, experimental mortality, statistical regression, maturation interaction, and subject selection) were controlled in this study (Campbell & Stanley, 2015; Raninga, 2009).

The population included all students studying science education at the bachelor's level on Tribhuvan University's campuses. The study sample consisted of sixty (60) physics students from two constitutional education campuses in Kathmandu and Bhaktapur districts, who were in their second year of bachelor's degree. With 30 students in each group, the students were randomly divided into one campus as experimental and second one as a control group.

As a data collection technique, a set of achievement test items containing 40 objective type questions about electrostatic force, field, and potential were used. The test questions' topic validity was determined and accepted by university professors and lecturers. The test item's Kuder-Richardson 21 (KR-21) reliability was 0.78. Using SPSS software version 20, data were analyzed using descriptive and differential statistical techniques.

The experimental group was taught using the 5E learning model whereas the control group received instruction using conventional methods. Students in the experimental group were provided student directing instructional materials that were created using the 5E learning approach. These student guidance tools were created to encourage students to wonder, ponder, investigate, and search, as well as adapt and test their prior knowledge in new circumstances. Students in the experimental group were supervised by the teacher and used experiment reports; the control group did not employ any procedures other than those used in the experimental group. The validated tests were administered to students in the experimental and control groups both before and after the experiment. The SPSS tool, version 20, was used to analyze the acquired data using mean scores, standard deviations, and t-tests. At the 0.05 threshold of significance, all of the results were compared.

Results

The study's findings are presented in the following section. The pre - test scores of the experimental group of students who received the lesson by using 5E model and the control group of students who learnt the lesson using the conventional teaching method were examined by using t-test, with the findings displayed in Table1.

Table 1. *Pre-test Results for Academic Achievement in Physics (N =60) in the Control and Experimental Groups*

Test	Group	N	$\overline{X}$	SD	df	t	p
Achievement	Control	30	7.43	0.97			
	Experimental	30	7.40	1.00	58	-0.13	0.89

According to Table 1, there was no significant difference between the control and experimental groups' students' pre-test and post-test academic performance in physics at the 0.05 percent level of significance ($t_{(58)}$ =-0.13, p>0.05). The achievement test averages of the experimental and control groups are both 7.40 for the experimental group and 7.43 for the control group, respectively. As a result, H_{01} is accepted as the null hypothesis. It is safe to presume that both groups were close before the research of the subject.

Table 2. *Post-test Results for the Academic Success Test in Physics (N =60) between the Control and Experimental Groups*

Test	Group	N	$\overline{X}$	SD	df	t	p
Achievement	Control	30	9.70	1.08			
	Experimental	30	11.13	1.10	58	5.06	0.00

The contrast between two groups for the academic achievement test in physics is shown in Table 2. Table 2 shows that the average values of the experimental and control groups are substantially different. The experimental group's average score is higher than the control groups. Students in the experimental group outperform those in the control group in terms of academic achievement. A meaningful difference between the groups was seen at the conclusion of the t-test analysis for independent groups, as indicated by the estimated t value ($t_{(58)}$ =5.06; p<.05) at the 0.05 percent level of significance. As a result, the null hypothesis H_{02} is completely rejected.

Discussion

The study found a substantial difference in achievement between students taught electrostatic force, field, and potential in second-year bachelor's level science education in the academic year 2022 who were taught utilizing the 5E's learning cycle teaching approachfor fifteen teaching hours. The following were revealed as a result of the analysis:

i. Similar pre-test academic achievement levels were found for the pupils in the control and experimental groups.
ii. Academic achievement post-test results for the experimental group are significantly higher than post-test scores for the control group.

In light of the foregoing facts, it may be concluded that the 5E's learning model was more effective than conventional teaching methods. Previous research in the literature backed up 5E's learning model's favorable impact on students' learning. This finding contradicts those of Hagerman (2012), who found that using 5E's learning cycle model, science content comprehension did not improve significantly, and Appiah-Twumasi (2021), who found no significant differences between experimental and control groups for physics low ability students or gender. This result is supported with the results of the investigations carried out by Ozmen (2004), Amann (2005),Campbell (2006), Ozsevgec (2007), Aydogmus (2008), Ceylan and Geban (2009), Soomro et al. (2010),Cepni and Ipek (2010), Aydin and Hanuscin (2011), Madu and Amaechi (2012), Olaoluwa and Olufunke (2015), Shah et al. (2019), Nyirahagenimana et. al. (2022). Furthermore, students employing 5E's learning cycle model method reinterpret, rearrange, elaborate, and revise their initial notions through self-reflection and interaction with their peers and surroundings, according to (Bybee, 1997). Students also analyze things and experiences in terms of their present conceptual understanding and internalize those meanings. All of this led to the conclusion that the 5E learning cycle model was superior to conventional teaching methods for learning physics at the bachelor's level of scientific education.

Conclusion

Because there are few studies on science education in Nepal, this study could have a wide range of implications. The findings of this study may enliven the learning cycle model paradigm in compare to conventional teaching methods and may be useful for: creating new and more information about learning cycle models in physics subjects, as well as complementing philosophy and preparation in the classroom and at the institution level; and improving teacher training qualities by reviewing teacher education programs and training trainers in learning cycle models. In addition to other physics teaching methods, this model should be promoted at a higher level as well as at the school level; in assisting educational leaders and management in organizing workshops for professional development of in-service science/physics teachers; and for textbook authors, scientific experts, and curriculum developers to best utilize their efforts by incorporating this model into science/physics curricula that are currently offered.

Students were free to investigate and learn the course's main concepts on their own by asking questions, seeking, accessing primary sources, making connections to daily life, setting up testing equipment, and conducting experiments on their own. Therefore, it is strongly advised that this constructivist 5E learning model be applied to additional physics courses and that materials be created to evaluate the model's effectiveness. These models ought to be applied in pre-service teacher education courses as well to help students develop the superior critical thinking abilities that they will need in both their personal and professional life. The concept can be integrated or applied at multiple levels by science teachers and curriculum creators. The model could be the structure that arranges a number of daily lessons, specific units, or annual plans (Bybee, 1997). Similar study should be carried for diverse science courses in order to examine the 5E learning model's efficiency.

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