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The Effectiveness of the Predict-Explain-Enact-Observe-Reflect (PEEOR) Instructional Strategy on Conceptual Understanding and Motivation in Motion and Force Topic

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Abstract
The study aimed to assess the effectiveness of the Predict-Explain-Enact-Observe–Reflect (PEEOR) instructional strategy on general science students' conceptual understanding and motivation in the topic of motion and force. The research employed a pre-test post-test quasi-experimental design. The sample consisted of 107 general science summer, year II students from Woldia College of Teacher Education. Data collection involved a conceptual understanding test (comprising 15 questions) and a post-motivation questionnaire. The KR-20 reliability value for the conceptual understanding test was 0.75. The Cronbach Alpha (α) reliability coefficient for the scale was determined to be 0.84. Descriptive statistics and ANCOVA revealed the following: The PEEOR group (adjusted mean = 6.787) significantly outperformed the traditional group (adjusted mean = 5.134). The POE group (adjusted mean = 6.472) did not differ significantly from either PEEOR or the traditional group. Regarding student motivation: There was a statistically significant difference ($p < 0.05$) in post-test motivational questionnaire (PMQ) scores among the three groups. The F-statistic for this difference was 4.753. The study recommends that college physics teachers adopt the PEEOR instruction strategy. Additionally, the college and department heads of natural science should promote the potential benefits of this novel strategy among science educators.

Keywords: Conceptual Understanding, Motivation, Predict-Explain- Enact-Observe-Reflect Strategy, Predict-Observe-Explain Strategy

Introduction

Traditional education such as lecturing and reading may not be sufficient to improve students' understanding and motivation. Physics includes concepts such as energy and motion that are difficult and often confusing for students. Motion and force can be difficult to study in depth because of the need to grasp the force of a moving object and the force acting on it. Understanding these abstract concepts can cause bigger problems for students. In this study, we will take a closer look at problems related to the uncertainty of motion and force in order to help students understand these concepts. Therefore, teachers need to determine effective methods and strategies to provide good information in the learning environment. Currently, courses and training modules integrate the design process across disciplines, particularly physics. This approach emphasizes the idea that learning occurs when people create knowledge on their own, and puts the main role on teachers (Atasoy, 2004; Kubiatko & Prokop, 2017). Understanding is important in learning.

Extensive research clearly shows that a deep understanding of these concepts is the key to success. According to the American Association of Physics Teachers (AAPT), knowledge of the principles of motion and their interactions and their effects allows people to advance their knowledge. This rich understanding can be applied to different situations, allowing people to use their intellectual abilities in the problem solving process. The emphasis is not only on memorization of information but also on conceptual understanding of principles and ideas (AAPT, 2018).

Literature Review

Student participation and learning success in physics education depends on motivation. To develop this motivation, students should be given active and experiential learning opportunities. Research findings show a positive relationship between college students and their academic success in physics, especially when they are encouraged to investigate and solve problems independently (Llewellyn et al., 2010). Compared with traditional teaching methods, the predict-observe explain (POE) method has been found to be more effective in improving students' understanding of the content. The POE method (White & Gunstone, 1992) is a teaching method that emphasizes learning and encourages students to use their intellectual abilities.

Russell (2007) describes this as the effective way to learn as students are expected to gain the best knowledge through participation. It has three main functions: estimating the probability of an event, observing the actual occurrence, and interpreting the observed results. This approach is inquiry based and allows students to develop their knowledge of facts, theories, and principles by participating in activities designed by teachers. Therefore, it seems that this approach will support students to develop their ideas about physics. Bayraktar (2009) found that students using the POE method had better knowledge of concepts related to force and motion than students receiving traditional instruction. Similarly, Bada (2015) concluded that POEis more effective than traditional teaching methods in developing students' understanding of force and motion. Evidence shows that students who use the POE method are more motivated than students who are educated using traditional methods. As Syuhendri (2021) noted, the POE approach appears superior to traditional teaching methods in encouraging students to understand concepts related to motion and Force.

A recent study by Wossen and Tilahun (2020), showed a positive relationship between the use of POE strategies when teaching physics to tenth grade students and improving their understanding and retention of key concepts. This study is in the field of high school education and involves evaluating the quality of these ideas in the context of a teacher training school. In addition, the application of the POE method is limited when faced with complex problems that require more cognitive skills (such as metacognition, reasoning and problem solving). To solve these problems, researchers proposed a new teaching method called PEEOR teaching strategy. Rooted in POE pedagogy, this new approach includes additional levels of performance that require students to engage in work to strengthen their understanding of content, thereby encouraging engaging learning experiences and strengthening real-world connections.

Material and Method

The Study has been conducted with a predetermined objective which are mentioned as To investigate the effects of an intervention on perception scores and motivation to learn about movement and force in three groups (PEEOR, POE, and traditional teaching method) before and after the intervention. In connection to the set objectives, study tests the hypotheses

- Is there a significant difference between the perception scores of movement and conceptual strength between the PEEOR, POE and normal groups before and after the intervention?
- Are there significant differences in students' motivation to learn about movement and force after intervention?

Data Collection

Students engaged in a variety of predictions, analyses, and explanations of the subject through the utilization of prediction-observation explanation (POE). An illustration of this is demonstrated in the Predict-Explain-Enact-Observe-Reflect (PEEOR) approach, wherein students participate in the design and cognitive processes alongside the procedural steps of the POE strategy. Traditional teaching groups commonly employ teaching methods where instructors administer comparable activities throughout the entire lesson. Following the intervention phase, all three groups successfully completed the test and the subsequent post-motivation survey, which assessed the level of conceptual understanding. Researchers gained an understanding of the meaning of motion and force established in previous studies by Uyanik (2017) and Calli (2019). The concept comprehension test consists of 15 questions. The reliability of the KR20 is 0.78. The validity of the test content was verified by experts (1 physics teacher at Jimma University and 1 physics teacher at Addis Ababa University) and physics teachers at Woldiya Teachers College.

The Post Motivation Scale consists of 10 items that measure students' motivation toward instructional strategies (e.g., PEEOR, POE, and traditional instruction for movement and strength). According to the validity and reliability analysis of the 5-point Likert scale, the Kaiser-Meyer-Olkin (KMO) coefficient has a value of 0.685 and the Bartlett test of sphericity has a value of 0.00. The total variance explained by the factors determined in the threefactor analysis was calculated as 53.17%. The Cronbach Alpha (α) reliability coefficient value of this scale is 0.86.

Research Design

Quantitative Research Design

This research adopted a quantitative approach using a qualitative design, combining pretest and posttest. As shown in Table 1, the first group of students used the PEEOR method to study motion and force, and the second group of students used the POE method. The third group used traditional methods in teaching.

Table 1 Symbolic View of the intervention Pattern

Group	Pre-test	Treatment	Post-test
PEEOR	T_1	X_1	T_1, M_1
POE	T_1	X_2	T_1, M_1
Traditional	T_1		T_1, M_1

Note: T_1=motion and force unit conceptual understanding Test; M_1=post-motivation scale Towards motion and force topic; X_1=PEEOR Strategy-Based Teaching, X_2 = POE Strategy-Based Teaching.

Participants

The selection of the research topic was made using a convenience sample with a special focus on various segments of students enrolled in the physics 101 course. The selected sample was general science students in summer courses for the 2023 academic year, in all three classes and with a total of 107 students. The first group was taught using PEEOR (n = 34) teaching strategies, the second group was taught using POE (n = 38) teaching strategies, and the third group was taught using normal teaching/learning strategies (n = 35).

Interventions

Three pedagogical approaches were formulated and implemented for six weeks in the investigation.

- These methodologies encompassed:
- Guide on Predict-Explain- Enact- Observe-Reflection Instructional Strategy.
- Guide on traditional Instructional Strategy.
- Guide on Predict-Observe-Explain Instruction Strategy.

Guide on Predict - Explain- Enact- Observe-Reflection (PEEOR) Pedagogical Approach

A guide to specific teaching strategies. It has five steps: predict, explain, enact, observe and reflect. The idea is to have students make a prediction, explain why, try a task/task, observe the results, and reflect on their observations. The researchers gave instructions to professors and teachers at the physics to check and make sure everything was working properly.

Predict	Explain	Enact	Observe	Reflection
Student work individually to predict each of the scenario/ activities outcome.	Student explain their reason for their prediction.	Student in pair to perform the activities for each of the scenario/activities.	Student observe the outcome of the enact steps and record these observation.	Student reflect the difference between the observe result from their prediction.

PEEOR Strategy Activity Sheet

Instructions for the Prediction – Observation – Explanation (POE) Methodology

This instruction is for the second group. It has three stages: prediction,observe and explain. When making predictions, students predict what will happen during the experimentor observation. The observation method requires them to write down what they see in the experience or outcome, while the interpretation method requires them to explain why their predictions are right or wrong. This guide is designed for physics education professionals and experienced college physics teachers testing steps for content and performance.

Predict	Observe	Explain
Student work individually to predict each of the scenario/activities outcome.	Student observe the outcome of the enact steps and record these observation.	Student explain their prediction based on the record data.

POE Strategy Activity Sheet

Guide on the Traditional Pedagogical Approach

This instrument was used for group three and it is the teaching approach commonly used for physics teaching in most teacher training colleges. The following are the steps involved in the strategy:

- The teacher introduces the concept to learned and asks questions on Learners' prior knowledge. Learners sit down facing the chalkboard while the teacher writes on the chalkboard.
- The teacher explains the new concept, while learners listen to the teacher.
- The teacher demonstrates, solves numerical and non-numerical problems, and performs experiments using relevant procedural steps.

Treatment Implementation

Steps Involved in the Predict - Explain - Enact - Observe-Reflection (PEEOR) Instruction

Setting learning objectives is the first step in implementing the PEEOR teaching strategy. This goal may include the content, outcomes, or skills students need to understand. Once teachers identify learning objectives, they can create comprehensive lesson plans based on PEEOR guidelines. The plan should have several stages such as predicting, interpreting, implementing, evaluating and considering. The beginning of the course outlines the learning objectives and outlines the rationale behind using the PEEOR strategy. Students also need to be give lesson plans and details of the activities. The prediction phase requires students to make predictions about learning objectives specified by the teacher through questions or prompts. During the explanation phase, students are tasked with proving their predictions are correct through class discussion, written analysis, or presentations. After the explanatory period, students participate in an activity or activities related to the learning objectives, which may include experiments, exercises, or collaborations. The assessment phase then requires students to use written or video recordings to evaluate the consequences of their behavior or performance. During the reflection period, students are asked to reflect on their initial prediction and interpretation observations using discussion, reflective writing, or other appropriate methods. Once the hypothesis is completed, teachers should review and discuss predictions, interpretations, applications, observations, and thoughts with students. Answers should be provided to clarify misunderstandings and encourage students to increase their learning goals.

Steps Involved in the Predict - Observe- Explain (POE) Instruction

Determining learning objectives: The first step in using POE teaching methods is to define learning objectives. This may include content, outcomes, or skills that students need to learn. Use POE to create lesson plans: After identifying learning objectives, teachers can create lesson plans that include POE instruction. Lesson planning should include a prediction phase, an evaluation phase, and an interpretation phase. Introduce the lesson: At the beginning of the lesson, the teacher should introduce the learning objectives and introduce the principles of using POE techniques. There is also a plan for teaching and supervising the activities of the students who will participate. Phase Prediction: During the prediction phase, students should be encouraged to make predictions about the learning objectives. Teachers can provide students with questions or prompts to guide their predictions. Monitoring Phase: After this, students should carefully review the learning objectives. This may include taking tests, watching videos, or reading. Students should write down their observations individually or in groups. Explanation Level: At the explanation level, students must justify their predictions based on their observations. This can be done through class discussions, written evaluations, or presentations. Review and Improve: After explanation time, teachers should evaluate the prediction and explanation with the class. Feedback can be given, misunderstandings can be resolved, and students can be encouraged to understand the learning objectives.

Steps in the Traditional Strategy Instruction

In this group, the researcher presented the content and objectives of each lesson to the teachers in control groups. The following steps were followed.

Step I - The teacher introduced the concept.

Step II - The teacher explained the new concept.

Step III - The teacher solved problems.

Step IV - The teacher performed some experiments / demonstrations or activities.

Data Analysis

Due to the test sample being more than 30, the Kolmogorov Smirnov test is used to determine normality.

Table 2 Homogeneity Test

Groups of Participant	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PEEOR	.182	35	.005	.940	35	.055
POE	.191	38	.001	.897	38	.002
traditional	.171	34	.013	.924	34	.021

According to the table above, it is seen that the significance in the Shapiro Wilk line is $p<0.05$, therefore it can be concluded that the data does not comply with the normal distribution. For this reason, descriptive statistics, analysis of variance (ANCOVA) and pairwise comparisons were used to analyze the data collected in the pretest and posttest, and group differences statistical analysis was used to analyze the post motivation questionnaire.

Finding

The Effect of the Intervention on Conceptual Understanding

Table 3 shows the descriptive data of the student's conceptual understanding of motion and force topics. For the PEEOR and POE Groups, the posttest scores of the PEEOR and POE groups were better than the traditional groups.

Table 3 Descriptive Data of the Conceptual Understanding of the Three Groups

Group	N	Pre- test		Post- test	
		Mean	S.D	Mean	S.D
PEEOR Group	35	5.60	1,311	6.89	2.026
POE Group	38	5.34	1.169	6.47	1.782
Traditional Group	34	5.03	1.455	5.03	1.642

Table 4 The ANCOVA Results of the Posttest for the Three Group

Group	Adjusted mean	St. Error	F	p	η2
PEEOR group	6.787[a]	.300	8.105	.005	.073
POE group	6.472[a]	.286			
Traditional group	5.134[a]	.305			

a. Covariates appearing in the model are evaluated at the following values: pre test = 5.90

Table 5 The Multiple Comparison Results of the Posttest for the Three Groups

Group (I)	Group (J)	Difference of Mean (I-J)	Std. Error	p
PEEOR	POE	.41	.427	.601
	traditional	1.86	.439	.000
POE	traditional	1.44	.431	.003

Dependent Variable: post test; Tukey HSD

We used ANCOVA in our study. The interaction between independent variables and Statistical Analysis was not significant (F(2, 104) = 2.688, p = 0.073 > 0.05), so ANCOVA was the right choice. When we did not calculate the effect of pretest scores, we found differences in posttest scores between groups (F(2, 104) = 8.105, p = 0.005, see Table 3). From table 4, we also calculated a partial δ^2 value to show the effect size (F(2, 104) = 9.862, p = 0.000, δ2 = 0.073, which is considered a small effect according to Pallant (2007).

Table 5 shows. According to Pallant (2007), this is considered a small effect, the average increase of students in the PEEOR PEEOR group is higher (0.41) and is still higher compared to the traditional group (1.86). The difference in the average student increase in the PEEOR group (1.44) between the PEEOR group and the traditional group was also higher than the normal group, and a significant difference was observed between the two.

According to the figure 1, the average increase (p=.000) for students in the PEEOR teaching group is significant for students who were always present in teaching. Similarly, POE instruction (p= 0.003) was significant for students who received little traditional instruction. On the other hand, although there is a moderate difference (0.41) between the PEEOR and POE groups, it is not significant. Results of motivation intervention in general science summer II students and the issue of strength Students' motivation and strength in physics were evaluated using a motivation survey after the intervention.

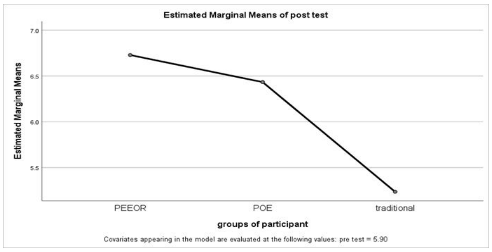

Figure 1 Estimated Mean of Posttest of the Three Groups

Table 6 ANOVA Results of the Post-Motivation Scores of the Groups

Group	N	Mean	S.D	F	p
PEEOR	35	42.5143	5.71567	4.753	.011
POE	38	40.4474	3.74669		
Traditional	34	39.3824	2.98496		

Table 7 The Multiple Comparison Results of the Posttest for the Three Groups

Group (I)	Group (J)	Difference of Mean (I-J)	Std. Error	p
PEEOR	POE	2.067	1.008	.105
	traditional	3.132*	1.036	.009
POE	traditional	1.065	1.015	.548

Dependent Variable: post test; Tukey HSD

As shown in Table 7, analysis of variance between packages was conducted to investigate students' withdrawal from our teaching method based on the Quality Assurance Questionnaire (PMQ). The PMQ scores of the three parties differed at the level of p < 0.05, F(2, 104) = 4.753, p = 0.011. Although it reaches significance, the difference between the average scores of the parties is small. The effect size determined using the square of the arrival time was 0.08. According to Table 6, in the post hoc comparison made with the Tukey HSD test, it was seen that the average score of the PEEOR group was higher than the normal group, with an increase of 3.132 points. Additionally, the POE group (mean increase = 2.067) was not significantly different from the PEEOR group or the badge group (mean increase = 1.065).

Discussion

In this investigation, an examination was conducted to assess the impact of implementing the PEEOR teaching approach within a summer science program on students' comprehension and motivation. Before the implementation of the PEEOR method, the levels of understanding among the students were relatively consistent across all three groups. The efficacy of the PEEOR technique proved to be significant in facilitating students' grasp of the subject matter. The outcomes of the research indicated a noticeable enhancement in students' comprehension through the utilization of the PEEOR strategy from table 4 (the average increase (p=.000) for students in the PEEOR teaching group is significant for students who were always present in teaching.). The reason behind the enhanced performance of students in the PEEOR group can be attributed to their comprehensive responses to all queries and utilization of prior knowledge when necessary. Moreover, the POE instructional approach demonstrated a more substantial influence on students' understanding compared to traditional methodologies (from table 4; p=0.003). Consequently, the findings suggest that POE instruction positively impacts students' conceptual comprehension in summer educational programs. A comprehensive analysis of existing literature indicates a correlation between the findings of this study and those of various scholars (Balaydin & Altınok, 2018; Erdem Özcan, 2019; Göktürk, 2015; Sreerekha, 2016; Tereci et al., 2018; Teerasong et al., 2010; Yaşar & Baran, 2020; Yildrim, 2016; Zakiyah et al., 2019).

The higher motivation displayed by the PEEOR guidance group towards movement and Power Point compared to the traditional group is attributed to its provision of individualized learning and enhancement of students' interest in the subject matter, a statistically significant difference (0.009 > 0.005). In contrast, the POE teaching approach does not show any statistically significant difference in motivation compared to either the PEEOR or traditional educational group. The results of this study align with those of Baladın-Duman (2019) upon analyzing the literature. The analysis revealed that POE had a positive impact on increasing students' motivation towards science illustrations compared to the traditional teaching method, as indicated by various studies (Akarsu, 2018; Bilen et al., 2016; Erdem Özcan, 2019; Göktürk, 2015; Köseoğlu et al., 2014; Özsoy, 2020; Venida & Sigua, 2020).

From this perspective, it is considered crucial for classroom teachers who want their students to have a motivation toward the science/physics lecture, to present the subject with this understanding. The PEEOR strategy was found to make the students very active during the lesson in this research. Although observation data were not reported in this study, the majority of the students engaged fully in the lessons throughout the course. It has been noticed that they actively participate while engaging voluntarily. It was also apparent that they enjoyed themselves while learning during the POE. In this sense, the use of PEEOR strategy in general science summer physics courses both entertains, arouses students' curiosity, and contributes to a more permanent learning process. Based on the results obtained from table 4 and figure 1, the average increase (p=.000) for students in the PEEOR teaching group is significant for students who were always present in teaching. Similarly, POE instruction (p= 0.003) was significant for students who received little traditional instruction. it is recommended that the PEEOR strategy be used in the general science summer II physics lesson for motion and force. In terms of a constructivist learning approach, it is believed that the PEEOR strategy is able to provide more effective activities for teachers.

Conclusion

According to this perspective, it is deemed crucial for college educators to hold the belief that their students ought to possess a positive inclination towards the discourse of physical sciences, thus opting to present the subject matter through the utilization of the PEEOR instructional approach. The application of the PEEOR method was identified as significantly enhancing student engagement during this particular study. Despite the absence of documented observational data within this research, a notable proportion of students remained actively involved in the instructional sessions facilitated by the PEEOR methodology. Their voluntary participation was observed to be consistent. Furthermore, there was a clear indication that students derived enjoyment from the learning process during these lectures. Consequently, the incorporation of the PEEOR strategy in general physics courses has the potential to captivate students, stimulate their curiosity, and facilitate their academic development.

Recommendation

The recommendations provided below can help educators effectively implement PEEOR and maximize its benefit for student learning .

- Establishing clear guidelines and expectations is crucial to facilitate effective student collaboration and promote active listening, appreciation for diverse perspectives, and active participation in collaborative learning processes.
- Providing various access points and alternative methods for students to interact with the curriculum is highly recommended.
- Utilize assessment data to pinpoint strengths and weaknesses, adapt instructional approaches accordingly, and offer prompt feedback to students to enhance positive thinking, meta-cognition, and collaboration.

Implications and Benefits for Educators

PEEOR's research-based methodology promotes student engagement within the educational process. Through activities such as prediction, concept clarification, provision of examples, observation, and reflection on learning, students actively participate in knowledge construction, leading to a more profound comprehension. The PEEOR concept advocates for meta-cognition, which involves the critical analysis of one's own knowledge and learning process. By reflecting on their predictions, explanations, enact, and observations, students enhance their understanding and can pinpoint areas for improvement. The utilization of the PEEOR framework fosters adaptability and adjustment in the teaching approach. Educators possess the capacity to adjust the content, provide diverse examples, and design activities tailored to meet the unique needs and varied learning preferences of students. By assessing students' predictions, explanations, examples, and viewpoints, teachers can acquire valuable insights to inform their teaching strategies and deliver precise feedback.

Future Study

It is imperative to assess the enduring repercussions of engaging in PEEOR's summer initiatives on students' comprehension of force and motion, as well as their ability to apply this knowledge across various contexts. The examination of the effectiveness of a professional growth scheme concentrating on PEEOR and evidence-based instructional approaches for summer educators in the field of science. Qualitative investigative techniques like interviews were employed to explore students' grasp of PEEOR-centered investigative practices. Pinpointing the variables impacting their conduct and involvement, while also collecting suggestions for refining and augmenting the integration of PEEOR in forthcoming summer schemes.

Limitation of the Study

This investigation encountered the following limitations. The initial constraint of the study pertained to Summer undergraduate students majoring in general science, who often operate within constrained time frames and limitations. These circumstances have the potential to impact both the efficacy and capacity for integration. The second limitation arises during the summer, where students' foundational knowledge varies, particularly among those studying general science, thereby influencing their aptitude for research-oriented learning and adaptability

Conflict of interest: The authors declare that there is no conflict of interest regarding the computing resources used in this research. The computations were performed using standard hardware and software tools that are commonly available in academic and research environments.

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