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RESEARCH ARTICLE

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

This study examined the effectiveness of Predict-Explain-Enact-Observe–Reflect (PEEOR) instructional strategy on Woldia College of Teachers' Education general science students' conceptual understanding and motivation in motion and force topic. The pre-test posttest quasi-experimental design was used for the study. The sample constituted purposefully selected 107 general science summer, year II students of Woldia College of Teacher Education. Data was collected through conceptual understanding test and post motivation questionnaire. The conceptual understanding test is made up of 15 questions. Its KR-20 reliability value was 0.75. The Cronbach Alpha (α) reliability coefficient value of the scale was determined to be .84. Results obtained through the use of descriptive statistics and ANCOVA showed that PEEOR group (adjusted mean =6.787) was significantly different from traditional group (adjusted mean =5.134). POE group (adjusted mean =6.472) did not differ significantly from either PEEOR or traditional group. On other hand with regard to the motivation of the student, there was a statistically significant difference at the $p < .05$ level in post test motivational questionnaire (PMQ) scores for the three groups $F(2, 104) = 4.753$, $p=.011$. Consequently, it was recommended that college physics teachers should adopt the Predict-Explain-Enact-Observe-Reflection instruction strategy while the college and department head of natural science should propagate the potentials inherent in the novel strategy among science teachers.

Keyword: Conceptual Understanding; Motivation; Predict-Explain- Enact-Observe-Reflect Strategy; Predict-Observe-Explain Strategy

Introduction

Traditional teaching techniques, like lectures and reading, may not be enough to inspire understanding and enthusiasm among students. Physics includes the topic such as force and motion, which are complex and often confusing for students. Studying motion and force can be complicated because it involves understanding how things move and what forces act on them. Students can actually grasp these abstractions even harder (Bao et al., 2019; Gire et al., 2020; Liao et al., 2021). This study looked at difficulties related to the abstract nature of motion and force and how to help students better understand them. Therefore, teachers need to find the right methods and strategies and deliver them successfully in the classroom. Today, in education and training programs, constructivist approaches are used in science courses/especially in physics. This means that learning occurs when someone uses their own efforts to organize their knowledge and teachers have a lot of homework (Atasoy, 2004; Kubiatko et al., 2017).

In-depth understanding of motion and force is important when teaching physics. Research has proven that a good grasp of these is the key to success. The American Association of Physics Teachers (AAPT) says that if you have a good understanding of the principles and relationships that govern the behavior of moving objects and the forces acting on them, you will be able to expand your knowledge and apply them to different contexts and use your brain to solve problems. It's not just about memorizing facts and figures, but actually understanding concepts (AAPT, 2018).

Motivation is what keeps us going, keeps us on track, and helps us achieve our goals. In the context of physics education, it is extremely important that students participate and do well when learning about physics course. To ensure this, you should give your students the opportunity to be active and learn through hands-on experiences. Studies have shown that when students have the opportunity to ask questions and figure things out for themselves, their motivation and physics scores increase (Llewellyn et al., 2010).

Inquiry-based teaching, such as Predict-Observation-Explain (POE) has been shown to be more helpful than traditional teaching methods in helping students better understand concepts. POE approach (White & Gunstone, 1992), is a teaching strategy that emphasizes active learning and encourages learners to use their own skills. Russell (2007) calls it the power of experience because learners are said to learn the most by doing. It includes three parts: predict the outcome of an event, observe an actual event, and interpret what was seen. This strategy is truly exploratory, allowing students to self-understand facts, theories, and principles by participating in teacher-designed activities. So it seems like this approach can be really helpful in helping students develop their understanding of concepts in physics.

Research has been conducted to see how useful POE learning strategies are in teaching physics and how they can help understand physics concepts. For example, Sarfo and Anamuah-Mensah (2012) found that POE students have a better understanding of force and motion than students taught in a

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traditional way. Similarly, Bozkurt and Ayas (2014) found that POE was more successful in helping students understand force and motion than traditional instruction. Studies have shown that students who learn in the POE method are more motivated than students who learn in the traditional way. According to Sutarto, Suparmi and Setiawan (2019), it seems that the POE method is much better than traditional teaching methods in motivating students to learn motion and force topic.

There is not much research on POE teaching strategies in Ethiopia. Wossen and Tilahun (2020) conducted a study and found that using POE strategies to teach physics to 10th graders improved their ability to understand and remember concepts. This is in the high school context, so one needs to consider the effectiveness of these strategies in the context of teacher training colleges. In addition to these POE has limitations when it comes to dealing with complex problems that require higher-order thinking and problem-solving skills, such as metacognition and logical tasks or rational affairs. To fill these gaps, the researcher applies a new strategy called PEEOR teaching strategy. This is based on POE learning strategies, but has an additional stage enactment where students must practice or demonstrate their understanding of a concept, which emphasizes hands-on learning and helps students establish a connection with the real world. It also helps them reflect on their learning and identify areas where they need improvement. Therefore, it is a great way to develop meta cognitive skills and autonomous learning. It is believed that this study will help fill a gap in research. It therefore aims to examine the effectiveness of PEEOR-based teaching on students' conceptual understanding of motion and force as well as their motivation in this regard. The following sub-problems were addressed to achieve this goal:

1. Is there a significant difference in the conceptual understanding scores of the PEEOR, POE and traditional groups for the motion and force topic before and after the intervention?
2. Is there a significant difference on students' motivation towards learning motion and force topic after the intervention?.

Method

Research Design

This study used a quantitative study with quasi-experimental design consisting of a pre-test and a post-test. As it is indicated in table 1, in the first group, the students studied motion and force using the PEEOR method, while the second group used the POE method. The third group was taught using traditional methods.

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. T1 = motion and force Unit conceptual understanding Test; M1= post- motivation Scale Towards motion and force topic ; X1=PEEOR Strategy-Based Teaching, X2 = POE Strategy-Based Teaching

Through POE, students made various predictions, observations, and explanations about the subject by attending the lesson personally while in PEEOR, student made enactment and reflection process in addition to the steps followed in POE strategy. In contrast, the method applied in the traditional group was described as the same activities used by the teacher during the course of teaching the subjects. As a post-test and post-motivation questionnaire , the three groups were administered the conceptual understanding test at the end of the intervention process.

Participants

The research subject was determined by using purposive sampling techniques based on the phy 101 course that was delivered to those sections. The selected samples were general science students of summer program in the academic year 2023 consisting of three classes of 107 students. The first group was taught by PEEOR (n = 34) instruction strategy, the second group was taught by POE (n = 38) instructional strategy while the third group was taught by conventional/traditional instructional strategy(n = 35).

Intervention

Three teaching methods were developed and used for the study which lasted six weeks of treatment implementation. These are:

1. Guide on Predict-Explain- Enact- Observe- Reflection Instructional Strategy.
2. Guide on Predict-Observe-Explain Instruction Strategy.
3. Guide on traditional Instructional Strategy.

Guide on Predict - Explain- Enact- Observe- Reflection (PEEOR) Instructional Strategy

This guide was designed for group one. It has five steps: predict, explain, enact, observe and reflect. Basically, the idea is for students to make predictions, explain why, try out the task/activities, observe the results, and reflect on their observations. The researcher presented instructions to experts and university physics instructors to review and make sure everything was working.

Table 2. **PEEOR strategy activity sheet.**

Predict	Explain	Enact	Observe	Reflection
10 Minte	10 Minte	35 Minte	20 Minte	25 Minte
Student work individuallly 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 thier prediction.

Guide on Predict – Observe – Explain (POE) Instruction Strategy

This guide was used for the second group. It includes three phases: Predict, observe and interpret. During the prediction process, students guessed what would happen in an experiment/activities or observation. The observation process required them to record what they saw during the experience or phenomenon, and the explanation asked them to explain why their prediction was right or wrong. This guide was given to physics education professionals and experienced college physics teachers who have tested the content and performance of the steps.

Table 3. **POE strategy activity sheet**

Predict	Observe	Explain
15minte	50minte	35minte
Student work individuallly 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.

Guide on traditional Instructional Strategy

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 learnt 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 experiment using relevant procedural steps

Treatment Implementation

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

Implementing the Predict-Explain-Enact-Observe-Reflection (PEEOR) instructional strategy in the classroom can be done in several ways. Here are some steps that can be followed to implement the PEEOR strategy effectively:

Identify the learning objective: The first step in implementing the PEEOR instructional strategy is to identify the learning objective. This could be a concept, a phenomenon, or a skill that students need to learn.

Develop a PEEOR lesson plan: Once the learning objective has been identified, the teacher can develop a lesson plan that incorporates the PEEOR instructional strategy. The lesson plan should include a prediction phase, an explanation phase, an enactment phase, an observation phase, and a reflection phase.

Introduce the lesson: At the beginning of the lesson, the teacher should introduce the learning objective and explain the purpose of the PEEOR strategy. The teacher can also provide an overview of the lesson plan and the activities that students will be engaged in.

Prediction phase: During the prediction phase, students should be encouraged to make predictions about the learning objective. The teacher can provide students with a prompt or question to guide their predictions.

Explanation phase: In the explanation phase, students should explain the reasoning behind their predictions. This could be done through class discussions, written reports, or presentations.

Enactment phase: Next, students should enact the task or activity related to the learning objective. This could involve conducting an experiment, practicing a skill, or engaging in an activity.

Observation phase: During the observation phase, students should observe the results of their actions or the outcomes of the task. This could be done through data collection, video recording, or other means.

Reflection phase: In the reflection phase, students should reflect on their observations and compare them to their initial prediction and explanation. This could be done through discussion, writing, or other forms of reflection.

Review and refine: After the reflection phase, the teacher should review the predictions, explanations, enactments, observations, and reflections with the class. The teacher can provide feedback, clarify any misconceptions, and encourage students to refine their understanding of the learning objective.

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

Implementing the Predict-Observe-Explain (POE) instructional strategy in the classroom can be done in several ways. Here are some steps that can be followed to implement the POE strategy effectively:

Identify the learning objective: The first step in implementing the POE instructional strategy is to identify the learning objective. This could be a concept, a phenomenon, or a skill that students need to learn.

Develop a POE lesson plan: Once the learning objective has been identified, the teacher can develop a lesson plan that incorporates the POE instructional strategy. The lesson plan should include a prediction phase, an observation phase, and an explanation phase.

Introduce the lesson: At the beginning of the lesson, the teacher should introduce the learning objective and explain the purpose of the POE strategy. The teacher can also provide an overview of the lesson plan and the activities that students will be engaged in.

Prediction phase: During the prediction phase, students should be encouraged to make predictions about the learning objective. The teacher can provide students with a prompt or question to guide their predictions.

Observation phase: Next, students should observe the learning objective. This could involve conducting an experiment, watching a video, or reading a text. Students should record their observations, either individually or in groups.

Explanation phase: In the explanation phase, students should explain their predictions based on their observations. This could be done through class discussions, written reports, or presentations.

Review and refine: After the explanation phase, the teacher should review the predictions and explanations with the class. The teacher can provide feedback, clarify any misconceptions, and encourage students to refine their understanding of the learning objective.

3) 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 collection tools

The researher adopted the conceptual understanding test on motion and force topic from the previous research work developed by Uyanik, (2017), and Çalli, (2019). The conceptual understanding test is made up of 15 questions. KR-20 reliability value was 0.78. The content validity of the test was ensured through experts (1 physics instructors at Jima University and 1 physics instructors at Adiss Abeba University) and more experienced physics instrucors at Woldia College of Teacher Education.

The post- motivation scale consists of 10 items and is used to assess students' motivation towards the teaching strategy i.e PEEOR , POE and traditional instruction toward motion and force topic. According to the validity and reliability analyses of the 5-point Likert scale, the Kaiser-Meyer-Olkin (KMO) coefficient was .685 and the Bartlett Sphericity test significance level was 0.00. In the three-factor scale, the total variance explained in terms of the determined factors was calculated as 53.17%. The Cronbach Alpha (α) reliability coefficient value of the scale was determined to be .86.

Data Analysis

As the number of samples was greater than 30, the Kolmogorov Smirnov test was used to determine normality.

Table 4. 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	3	.00	.897	3	.00

		8	1		8	2
tradition	.171	3	.01	.924	3	.02
al		4	3		4	1

Based on the table above, it can be seen that the significance in the Shapiro-Wilk column is p < 0.05, so the conclusion can be drawn that the data is not normally distributed. Therefore the collected data from the pretest and posttest were examined using descriptive statistics, analysis of covariance (ANCOVA), and pairwise comparisons and One way ANOVA between group was used to analyse the post motivation questionnaire of the three groups.

Results and Discussion

The Effect of the Intervention on Conceptual understanding

Table 5. 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 2 shows the descriptive data of the students' conceptual understanding on motion and force topic. For the PEEOR and POE Groups, the posttest scores of the PEEOR and POE group were better than the traditional groups.

Table 6. The ANCOVA results of the posttest for the three group

Group	Adjusted mean	St. Erorr	F	p	η 2
PEEOR group	6.787ᵃ	.300	8.105	.005	.073
POE group	6.472ᵃ	.286			
Traditional group	5.134ᵃ	.305			

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

Table 7. The multiple comparison results of the posttest for the three groups

Dependent Variable: post test
Tukey HSD

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

ANCOVA was conducted in this study. From the non-significant interaction of the independent variable and the covariate of the conceptual understanding test F(2, 104) = 2.688, p = .073 > 0.05, the use of ANCOVA was appropriate. After excluding the impact of the pretest scores, the ANCOVA results showed that a significant difference F(2, 104) = 8.105, p = 0.005 was found between the posttest scores of these group (see Table 3). In addition, a partial η2 value was provided as a substitute for the effect size F(2, 104) = 9.862, p = 0.000, η2 = 0.073 (small effect < 0.138) (Pallant, 2007).

Table 4 shows that the mean gain of students in the PEEOR instructional group (0.41) is higher than from POE instructional group and (1.86) from the traditional group which means PEEOR instructional group exhibts statistically significance mean difference in relation to traditional group. The mean gain of the students in POE instructional group (1.44) from the traditional group, which means there is also statistically mean difference between POE and traditional instruction group. So it can be conclude that the mean gain of the PEEOR instructional group is higher than that of the POE instruction group.

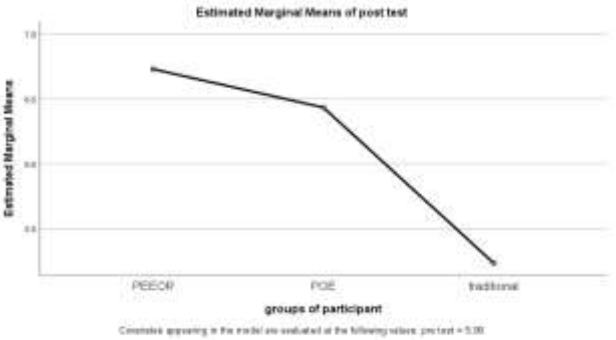

Fig 1. Estimated mean of posttest of the three groups

Based on the above figure, the implication of mean gain by students in the PEEOR instruction group (p = .000) which is stastical siginificant the students who where taught with with the traditional group. Similarly the POE instruction (p= 0.003) which is stastical siginificant the students who where taught with with the traditional group. On the other hand there is a mean difference between the PEEOR and POE group (.41) but it is not stastically significant.

The Effect of the Intervention on motivation towards motion and force topic

Students' motivation towards the motion and force topic were assessed using post motivation questionnaire after the intervention. Table 5 summarizes the results of the ANOVA tests of the students' motivation.

Table 8. ANOVA Results of the Post-motivation Scores of the groups

Groups	N	Mean	SD	F	p
PEEOR	35	42.5143	5.71567	4.753	.011
POE	38	40.4474	3.74669		
Traditional	34	39.3824	2.98496		

Table 9. The multiple comparison results of the posttest for the three groups

Dependent Variable: post test
Tukey HSD

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

As it is shown in the table above, a one-way analysis of variance between-groups was conducted to explore the motivation of the student on three teaching approach, as measured by the Post motivation questionnaire (PMQ). There was a statistically significant difference at the p < .05 level in PMQ scores for the three groups F(2, 104) = 4.753, p=.011. Despite reaching statistical significance, the actual difference in mean scores between the groups was quite small. The effect size, calculated using eta squared, was .08. From table 6, Post-hoc comparisons using the Tukey HSD test indicated that the mean score for PEEOR group (mean gain = 3.132) was significantly different from taditional group. On the other hand, POE group (mean gain = 2.067) did not differ significantly from either PEEOR or traditional group(mean gain = 1.065).

Discussion

In this study, the effect of PEEOR-based physics teaching on summer general science students' conceptual understanding and motivation towards motion and force topic was investigated. Before applying the PEEOR strategy, the fact that the conceptual understanding scores of the three groups was somewhat the same which showed equivalence(.544 > 0.05) among the three groups.The PEEOR strategy, which helped students better understand the concepts, events, or phenomena to be taught, an extremely advantageous technique used in teaching. This study concluded that the application of PEEOR strategy positively improved the conceptual understanding of the students, based on the findings obtained during the implemetation process. It is behaved that the reasons for the increase in the conceptual understanding of the PEEOR group students are the fact that the students answer all the questions asked in PEEOR applications/instruction and make use of their prior knowledge when necessary. Further, more, POE teaching instruction was more effective on the students' conceptual understanding than the traditional teaching method. Based on this result, POE instruction have a positive effect on the conceptual understanding of students in summer program teaching. Literature review reveal that, the POE findings of this study agree with the findings of the following researcher (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).

Among the reasons PEEOR instruction group showed higher motivation towards motion and force topic than traditional instruction group positively (statistically siginificant which is 0.009> 0.005), is that it provides students with individual learning, and increases their interest in the lesson. Where as POE teaching strategy has no statistiaclly signifiacnce difference on motivation with either the PEEOR or traditional instructional group. When the literature is examined, the findings of this study coincided with the findings of Baladın-Duman (2019). To find any contradictory results the literature was examined and it was concluded that POE had a positive effect in increasing the motivation of the students towards the science lesson than the traditional instruction stratergy (Akarsu, 2018; Bilen et al., 2016; Erdem Özcan, 2019; Göktürk, 2015; Köseoğlu et al., 2014; Özsoy, 2020; Venida & Sigua, 2020)

Conclusions and Recommendations

From this perspective, it is considered crucial for college teachers who want their students to have a positive motivation toward the physics lecture, they to present the subject using PEEOR instruction strategy. 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 implemetation of PEEOR instruction process. It was noticed that they actively participate while engaging voluntarily. It was also apparent that students enjoyed themselves while learning during the lecture. In this sense, the use of PEEOR strategy in college physics 101 courses can entertain, arouse students' curiosity, and contribute to the learning process.

The use of the PEEOR strategy is therefore recommended to college teachers for the teaching of Physics course at the college level to increase conceptual understanding and motivation in the subject. To this end, students should be encouraged by Physics teachers to construct their own ideas, identify their conceptions and misconceptions and be allowed to cone their own misconceptions with little assistance and direction from the teachers in science instruction general and Physics in particular. Students should be given the opportunity to perform all tasks/activities whether simple, complex, specific or general in physics instruction so as to evaluate their initial knowledge for necessary conceptual change. Finally, colleges should organise a form of sensitization programme to enhance effective use of the Predict- Expalin- Enact- Observe - Reflect (PEEOR) instructional Strategy and this can be done through workshops, seminars and conferences. These aforementioned activities can help them to effectively apply the PEEOR instructional Strategy in teaching Physics as well as other science subjects such as Biology, Chemistry.

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