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Exploring the Impact of Project-Based Learning on the Students' Attitudes towards Physics in Mbale District, Uganda

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Abstract: *This study explored the influence of project-based learning (PBL) on students' attitudes towards physics. The participants were fifty 10th-grade students from a purposively selected school in Mbale district, Eastern Uganda. Participants were randomly distributed to the experimental and control groups using cluster sampling. A mixed-method research approach was adopted. The pretest-posttest non-equivalent quasi-experimental design was used. The experimental group used the PBL approach, while the comparison group followed the conventional approach. An attitudes questionnaire with six items and focus group interview prompts were data collection tools. The survey test was validated by experts and piloted (α= 0.82). Data were analyzed using the independent samples t-tests, and effect size. Findings revealed a significant difference in the average scores of students' attitudes towards physics in favor of the experimental group. Therefore, the study recommends that science educators should adopt PBL to improve students' attitudes towards science and physics in particular.*

Keywords: *Project-based learning, Attitudes, Teaching, Egg drop project, 10th-grade students, Physics*

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1. Introduction

Physics is an important science subject in engineering, technology, and other related disciplines. Its significance among engineering students' academic and specialized fields makes it more than an instrumental substance for learning throughout the engineering program. It serves as the foundation for all engineering topics and has educational value for all engineering students. Nonetheless, physics is regarded as the least popular and most lackluster science subject among students (Guido, 2013; Veloo et al., 2015). In Uganda, students' achievement in physics is below average compared to other subjects. Students in Uganda struggle to thrive in physics since the vast majority of them are uninterested in the subject. Physics enthusiasm among students has been observed to be declining at all levels of study (Halim et al., 2018). Most students view physics to be difficult, since understanding physics requires students to deal with a variety of representations, including formulas, visual depictions, calculations, and abstract mental conceptions (Saleh, 2021). Students' inadequate mathematics abilities and lack of understanding of the problem are also key roadblocks in the circle of challenges that students face when tackling physics questions (Fadaei & César, 2015). Consequently, students struggle to grasp specific topics like kinematics, which are often perceived as missing tangible examples and requiring a lot of mathematical operations. Specifically, students struggle to understand the idea of force in Newtonian physics, and they frequently give incorrect responses to issues involving force and motion (Tomara et al., 2017). Furthermore, Newton's laws of motion play an important part in comprehending the world. When beheld in conjunction with other central physics notions, they are critical.

Students' attitudes toward school, lessons, and academic accomplishment are among the most important aspects that influence their academic progress (Ibrahim et al., 2019). The attitudes and interests of students may have a substantial impact on their science learning. Also, attitudes may serve as a bridge between all forms of reactions, which are divided into three categories namely sentiment, mental, and behavior. These three aspects explain how students feel about learning. Gardner (1975) defines attitude as a person's instincts and passions, prejudice, disquiets, threats, and beliefs on any given theme. In this study, an attitude refers to a student's favorable or negative views about physics instruction. Favorable learning attitudes are critical in the process of studying physics. A favorable attitude toward a subject motivates students to work hard and achieve higher grades, but an unfavorable attitude creates learning difficulties. Most students have a negative attitude toward physics, likely because they despise the topic, receive bad grades in exams despite their best efforts, and dislike physics teachers (Guido, 2013).

Studies show that students' lower accomplishment in physics is due to their negative attitude and lack of enthusiasm for the subject (Veloo et al., 2015). Students' internal motivation is influenced by their attitude, which has an impact on their academic achievement and participation in school. Low student enrolment in the science stream and physics-related courses at university can be attributed to students' negative attitudes regarding physics and a lack of enthusiasm for science. Students' attitudes towards physics are not inherited, rather, they are acquired through experience. Some attitudes are formed as a result of students' own experiences, knowledge, and talents, while others are formed as a result of outside influences. Nonetheless, attitudes do not remain constant, they evolve. Students' views toward physics are likely to alter when they are engaged in practical work, debates, questioning, and real-world challenges through authentic educational approaches (Fulmer et al., 2019). The PBL method is one of the popular approaches to teaching science, and physics in particular.

PBL is a student-centered, teacher-facilitated learning strategy (Bell, 2010). Students seek out information by posing questions that excite their innate curiosity. The starting point of a project is an investigation. Students create a question and are directed through the research process by the teacher. PBL method employs "projects" as a vehicle for boosting students' inspiration and displaying and explaining what they have learned. PBL activities customarily involve gathering data, interrogating specialists on the topic, performing experiments, evaluating data, and reporting outcomes. Such activities are possible in PBL because students are actively participating in the information-seeking process in authentic scenarios. PBL classrooms are substantially different from conventional learning milieus because they are independent of isolated, content-based, teacher-centered courses. During PBL, the teacher determines the topic that students will study, cultivates the students' desire to learn, and fosters the development of a driving question. Students are given the freedom to make decisions that are important to them (Larmer & Mergendoller, 2010). Students conduct in-depth research, review their findings, and receive feedback from the teacher and their peers. Students then give a presentation to a select audience on their results. Moreover, students have some autonomy in working cooperatively with their peers over a long period to generate realistic products or presentations under the supervision and facilitation of their teachers.

PBL is one of the most effective techniques for improving science education and enabling students to apply their scientific knowledge and skills to solve issues in their daily lives (Bell, 2010). Furthermore, PBL allows students to make connections between school and life, stimulates lifelong learning, and promotes self-control. Extensive research in different contexts and settings shows that PBL has improved students' academic achievements (Jarrar, 2020). PBL fosters favorable attitudes toward science (Yalçin, 2017). Another study by Çakici (2013) revealed that PBL had no effect on students' attitudes towards science. Notably, most studies focused on the influence of PBL on the attitudes of students in science in developed countries with different contexts. In Uganda, there have been no studies identified on how PBL improves students' views about physics, especially in kinematics. Thus, the present research aims to explore the influence of the PBL on the 10^{th}-grade students' attitudes toward physics.

2. Literature Review

2.1Attitude towards physics

Several experts have offered a comprehensive description of attitude. Attitude refers to a positive, negative, or neutral evaluative reaction to an item (Ibrahim et al., 2019). Put differently, attitude is a perspective on something. Attitude serves as a bridge between all forms of reactions, which are divided into three categories namely sentiment, mental, and behavior. These three aspects explain how students feel about learning. Gardner (1975) defines attitude as a person's instincts and passions, prejudice, disquiets, threats, and beliefs on any given theme. In this study, an attitude refers to a student's favorable or negative views about physics instruction. Favorable learning attitudes are critical in the process of studying physics. A favorable attitude toward a subject motivates students to work harder and achieve higher grades, but an unfavorable attitude creates learning difficulties. Most students have a negative attitude toward physics, likely because they despise the topic, receive bad grades in exams, and dislike physics teachers (Guido, 2013).

Teachers in schools have long noted that students' lower accomplishment in physics is due to their negative attitude and lack of enthusiasm for the subject (Veloo et al., 2015). Students' internal motivation is influenced by their attitude, which has an impact on their academic achievement and participation in school. Low student enrolment in the science stream and physics-related courses at university may be attributed to students' negative attitudes regarding physics and a lack of enthusiasm for science (Mollel et al., 2022). Students' attitudes towards physics are not inherited, rather, they are acquired through experience. Some attitudes are formed as a result of students' own experiences, knowledge, and talents, while others are formed as a result of outside influences. Nonetheless, attitudes do not remain constant, they evolve. Students' opinions toward physics are likely to alter when they are engaged in practical work, debates, questioning, and real-world challenges through authentic educational approaches (Fulmer et al., 2019).

2.2Project-based teaching approach

The PBL method is one of the popular approaches to teaching science. Experts have defined the PBL strategy in various ways throughout the literature, and there is no commonly acknowledged description of the PBL. For example, Bell (2010) defines PBL as a teaching strategy in which teachers assist students in gaining information. Gary (2015) describes PBL as a social action in which students apply what they have learned to investigate, analyze, and solve problems by shifting learning from the teachers to the students. Also, Liu (2016) expressed that PBL is a comprehensive learning technique that requires students to team up to complete a project. PBL is based on constructivist education, which emphasizes experiential learning and social engagement. This can be accomplished through field visits, laboratory investigations, and other multidisciplinary activities that go beyond the classroom (Lee, 2015). Furthermore, compared to conventional learning, PBL takes a more student-centered approach to learning. The projects themselves are centered on a specific question or problem that requires students to address fundamental concepts and principles in a certain field. Maida (2011) expounded that students gain relevant skills through a protracted learning process that focuses on multifaceted and realistic problems to create a design for a product or a specific assignment.

Moreover, projects are deemed noteworthy when they meet two key standards for learners. First, students must regard the project as a personally significant activity that they wish to complete successfully. Second, the project must achieve a learning goal by being well-planned, well-executed, and providing students with real-world skills. Karaman and Celik (2007) explain that PBL is a research tool that aids students in structuring projects by utilizing research questions to uncover new information and answers. The research question inspires a series of follow-up inquiries that students can use to construct a basis for their knowledge. Students are encouraged to explore, discover, and gain knowledge through experiential learning rather than memorizing facts from textbooks (Kaldi et al., 2011). Students may also share their knowledge, work together, and gain knowledge from one another's experiences.

2.3 Elements of project-based learning

There are several important elements to consider while planning and executing projects. For the PBL, Larmer and Mergendoller (2010) defined eight key elements of meaningful projects:

a. Significant content. Teachers should create a project that focuses on critical curriculum-based information and concepts. The content should also represent what the teacher believes is critical to comprehending the subject. Furthermore, students should find the material to be relevant to their own lives and interests.
b. The desire to know. Teachers should effectively stimulate students' desire to learn content by starting a project with an "entry episode" that captures their attention and prompts them to ask questions. This can be accomplished by employing engaging resources such as photographs, films, field trips, outdoor activities, a guest speaker, or a lively conversation to pique students' interest in the subject.
c. Driving question. This is a question that focuses on the project's core and establishes the project's goal or purpose. An effective question that encapsulates the project's heart is simple, and persuasive, giving students a sense of mission and dare. Too, the question must be open-ended, provocative, multifaceted, and related to what the teacher expects students to understand. A good driving question can help students become more involved in the project.
d. Student Voice and Choice. Projects that give students a voice and allow them to make some

decisions are more meaningful to them. For example, students can select their topics or themes under the driving questions.

e. 21st Century Competencies. Projects offer students the chance to learn skills like teamwork, communication, critical thinking, and technology use. Students are better equipped for the workplace and life when they are exposed to real-world skills.
f. In-Depth Investigation. Deep inquiry does not merely imply that students gather relevant material and offer it to others. It entails a lengthy process of gathering background information, identifying potential solutions to the problem, putting their theories to the test, and refining their investigation for more accurate results.
g. Critique (feedback) and adjustment. Students must get feedback on their initial draft or prototype of their work from peers, teachers, or even outside specialists. Students then revise their work. This helps students prepare for real-life employment, where review is common.
h. Public audience. When schoolwork is not performed solely for the benefit of the teacher or the exam, it becomes more meaningful. Students think more about the quality of their work as they bring it to a real audience outside of school, and they might also produce real products and ideas that people outside of school may use. The result could be a presentation, a product, or a marketing effort.

Furthermore, Pearlman and Thomas (2000) offered crucial PBL criteria to capture the uniqueness of this approach. The criteria are not intended to represent a definition of PBL, but rather to address the question, "What does a project need to be called a PBL instance?" Such criteria include:

1. Centrality. Projects are at the heart of the curriculum, not an afterthought. Students study the target contents through projects that are linked to the curriculum. Also, the centrality criterion means that projects in which students learn items outside of the curriculum, no matter how appealing or engaging, are not examples of PBL.
2. Driving question. Students must be "driven" or "led" to the target contents by questions, problems, or themes on which they must work.
3. Constructive investigations. Students must be able to study a topic or problem to develop new information or skills relevant to the target content through projects. This can be accomplished by conducting research, planning, investigating, making decisions, solving problems, and reporting the results.
4. Autonomy. PBL assignments should allow students to work independently for a significant length of time. Under the supervision of the teacher, students are responsible for finishing their projects.
5. Realism. Projects must include tasks, topics, performances, or products that students can face or employ in real-life settings.

2.4Benefits of project-based learning

Several types of educational studies have been used in arguments and disputes about the ideal educational strategy (Hwang & Wang, 2016). Some studies believe that the lecture approach is the most effective method of teaching science, while others believe that allowing students to develop their skills will help them learn more deeply (Ozverir et al., 2017). Unfathomable learning can be achieved through effective understanding and self-creation of knowledge, leading to improved learning outcomes and accomplishments for all students (Pegrum, Bartle, & Longnecker., 2015). Furthermore, students improve their awareness and retention of knowledge by connecting prior information to new information through critical examination of ideas. Thus, students should be actively involved in their learning to gain a deep grasp of science. This can be enhanced through the PBL approaches. The PBL technique can assist students in developing a comprehensive understanding of scientific concepts, which will improve information retention and acquisition (Lee et al., 2014). According to Slavin (2014), students who actively participate in cooperative learning obtain higher academic achievement than those who learn through conventional means.

Furthermore, when students are taught through the PBL approach, their 21st-century skills are improved (Bell, 2010; Musa et al., 2012). Astra et al. (2019) conducted a study to see how the PBL paradigm, which was aided by students' worksheets, affected students' critical thinking skills when learning physics. Results showed that the experimental group's critical thinking skills were shown to be significantly better than the control group. Furthermore, Mahamad and Fitriah (2021) indicate that the PBL approach improves students’ collaborative skills. Several studies have revealed favorable effects of PBL strategy on students' attitudes. For example, Baş (2011) conducted a study to see how the PBL technique affected 9th-grade students' academic achievement and attitudes about English lessons. The study found that students who were taught using the PBL technique were more successful and had a more positive attitude toward the lesson than students who were taught using the conventional approach. Moreover, Faris (2008) used a sample of twenty-five grade 9 students from Hamza school to perform research to see if the usage of the PBL strategy would change the students' attitudes toward learning science. According to the study's findings, students were inspired to design their experiments and carry them out, which enhanced their attitudes toward science.

3.Methodology

This study adopted mixed research methods. This study adopted a pretest-posttest non-equivalent quasi-experimental design having experimental and control groups. This design was employed to avoid disrupting the school's academic program by randomly assigning students to the two groups (Cohen & Morrison, 2007). In other words, intact classes of students at the chosen school were used for the study. Students in the experimental group were taught using the PBL technique whereas the control group experienced the conventional instructional method. The design of this study is shown in Figure 1.

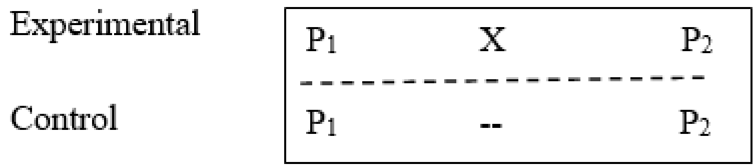

Figure 1: Research design.

P_1: Pretest in both experimental and control groups.
X: Treatment using Project-based learning method.
P2: Posttest in both experimental and control groups (Cohen et al., 2017).
The pretests P_1 were given to both the experimental and control groups before the intervention (Figure 1). The pretest was used to assess if the students in both groups had nearly the same attitudes towards physics. For four weeks (April 06 to April 29, 2022), the experimental group received the intervention (X), whereas the control group did not. After an intervention, both groups completed a post-test (P2). The items of P_1 and P_2 were the same. The goal of the post-test was to see if the PBL strategy had any effect on the students' attitudes towards physics.

Teaching in the experimental group

The teacher-researcher used PBL to teach the kinematics lesson to the students in the experimental group. The teacher-researcher began the project by showing students the Mars Exploration Rover Animation. Students were asked the driving question. The students were divided into four groups, each with six members. Students were given complete freedom to come up with whatever project they wanted to answer the driving question. Thus, the students chose the egg drop project. In this project, students agreed to design and build a container that would protect a raw egg from breaking when it fell from a height of 4 meters. Students brainstormed to get initial design ideas. Students were encouraged to conduct research into whatever they believed would assist them in completing their suggested project. The students were given a rubric to assist them to understand the project's criteria and how it would be graded. Furthermore, the teacher-researcher delivered inquiry-based lessons. The students applied the kinematics ideas they had learned to make egg protectors, which they then presented to their target audience. Table 1 shows the instructional plan for the PBL, which lasted four weeks.

Table 1: The plan for the project-based learning

School: Gold			
Class: Senior three (10^{th}-grade).			
Topic: Kinematics		Unit: One	No. of lessons: 10
Objective: Students should be able to apply concepts learned to solve a problem.			
Competences: Collaboration, Critical thinking, Communication.			
Driving question: How can you drop a raw egg on the ground without breaking it?			
	Day 1	Day 2	Day 3
Week 1	Pretest	Introduction of the project.	Determination of velocity of a tennis ball based on measurements of displacement and time.
Week 2	Determination of the acceleration of a tennis ball.	Freefall	Force and Newton's laws of motion.
Week 3	Momentum	Conservation of linear momentum	Change in momentum and impulse.
Week 4	Group project design and construction of the device.	Test of egg drop device and review.	Posttest

Teaching in the control group

The conventional teaching style of lecture and rote memorization was used to teach kinematics to students in the control group. Students were taught by another physics teacher with over fifteen years of expertise. Students received a posttest after four weeks.

Population and Sampling Techniques

The population of the study consisted of all the 10th-grade students in Mbale District, Uganda in the academic year 2022. The study sample consisted of 10th-grade students from school Gold. A purposive sampling strategy was used to choose School Gold. Purposive sampling was utilized because the school Gold's physics performance was among the worst in the district, with the school ranking last. The students were randomly assigned to the experimental and control groups using the cluster sampling technique. Therefore, there were 24 students in the experimental group and 26 in the control group.

Instruments

An attitudes questionnaire consisting of 06 items was adapted to explore students' attitudes towards physics (Mushinzimana et al., 2016). The instrument was validated by six experts with vast experience teaching physics. This helped to make the test items clear and understandable to the student's language levels. Furthermore, this was confirmed by five 10th-grade students who were outside the study sample. Each questionnaire item required students to express their level of agreement using a five-point Likert scale with 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree). The instrument was piloted on 36 grade-10 students who were not part of the study's sample. The reliability of the instruments was found using SPSS (version 20). The Cronbach alpha was found to be 0.82 Therefore, the attitude questionnaire was reliable.

Data Analysis

Levene's homogeneity test for equality of variances and Shapiro-Wilk normality test were conducted using SPSS (version 20). Because the sample size was small (n=50), the Shapiro-Wilk test was appropriate (Samuels et al., 2021). The independent samples t-test and effect size were conducted to test whether or not a substantial statistical disparity exists between the experimental and control groups' mean scores of students' attitudes towards physics. The focus group interview was premeditated to complement the quantitative data by exploring the students' verbal attitudes towards physics. The focus group interviews were videotaped and the conversations were transcribed verbatim in a text file. The transcriptions were analyzed using the procedures outlined (Lesh & Lehrer, 2000). After reading the transcriptions several times to understand their meaning, the analysis was polished for clarity.

4. Results and Discussion

This study aimed to explore the effect of the PBL strategy on the students' attitudes toward physics. The data were collected using an attitudes questionnaire.

Table *2* shows the results of Levene's homogeneity test.

Table 2: Test of Homogeneity

Instruments	Data	Significance value	Criteria
Attitudes questionnaire	Pretest	0.82	Homogeneous
	Posttest	0.83	Homogeneous

Table *2* reveals that p=0.82 (0.82>0.05) for the pretest and p=0.83 (0.83>0.05) for the posttest. This means that the pretest and posttest data have almost the same variance. Table 3 shows the results of the Shapiro-Wilk normality test.

Table 3: Test of Normality

Instruments	Groups		Significance	Results
Attitudes questionnaire	Experimental	Pretest	0.49	Normal
		Posttest	0.42	Normal
	Control	Pretest	0.21	Normal
		Posttest	0.32	Normal

The p-value for both pretest and posttest is greater than 0.05 in both the experimental and comparison groups (Table 3). This implies that the data were fairly normally distributed and a parametric approach was used for data analysis.

The overall pretest results are presented in table 4.

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Table 4: Percentage responses for the pretest attitude questionnaire

S.N	Items	Percentage of responses				
		SA	A	N	D	SD
1.	I like physics more than other subjects.	-	2.0	12.0	60.0	26.0
2.	I easily learn physics.	-	10.0	16.0	36.0	38.0
3.	I learn interesting things in physics.	-	-	22.0	50.0	28.0
4.	I am convinced that what I study in physics will be useful for me in life.	-	6.0	32.0	44.0	18.0
5.	The teacher's role is important for my success in physics.	-	30.0	54.0	8.0	8.0
6.	Physics experiments are useful because I talk with my classmates.	-	2.0	36.0	56.0	6.0

Table *4* shows that before treatment 2.0% of the students liked physics more than other subjects, 10.0% enjoyed learning physics, and most students found physics an uninteresting subject (Item 3). Only 60.0% of the students were convinced that physics is useful for their lives, 30.0% acknowledged the importance of a teacher for their success in physics, and 2.0% confirmed that physics experiments are important since they allow students to collaborate with others.

Results of the group statistics showed that students in both experimental (Mean= 47.61, S.D= 7.62) and comparison (mean= 47.69, S.D= 8.22) groups had nearly the same average score of attitudes toward physics (see table 5).

Table 5: Average pretest Scores of Students' Attitudes Towards physics

Pretest	N	Mean	Std. deviation
Experimental	24	47.61	7.62
Control	26	47.69	8.22

Table 6: The independent samples t-test of the pretest scores of students' attitudes towards physics

	T-test for equality of means		
	t	df	Sig. (2-tailed)
Equal variances assumed	-0.04	48	0.97

Table 6 showed no significant statistical change in the mean scores for pretest scores on students' attitudes towards physics (t(50)= -0.04, p=0.97). These results suggest that before treatment, students in both groups had almost the same level of attitudes towards physics.

To ascertain whether or not the PBL strategy had an impact on students' attitudes about physics, the posttest was administered to both groups after the intervention. The percentages of students' post-test results are presented in Table 7.

Table 7: Percentage response to the post-test attitude questionnaire

S.N	Questions	Percentage of responses				
		SA	A	N	D	SD
1.	I like physics more than other subjects.	-	-	20.0	56.0	24.0
2.	I easily learn physics.	-	4.0	14.0	60.0	22.0
3.	I learn interesting things in physics.	-	6.0	18.0	56.0	20.0
4.	I am convinced that what I study in physics will be useful for me in life.	-	14.0	42.0	40.0	4.0
5.	The teacher's role is important for my success in physics.	-	34.0	50.0	14.0	2.0
6.	Physics experiments are useful because I talk with my classmates.	-	20.0	42.0	36.0	2.0

Table 7 shows that most of the students preferred other subjects to physics, 4.0% enjoyed learning physics, and 6.0% learned interesting things in physics. Furthermore, 14.0% of the students were convinced that physics is useful for their lives, 34.0% acknowledged the importance of a teacher for their success in physics, and 20.0%

established that physics experiments are important since they allow students to collaborate with others.

Table 8 reveals that the experimental group's average score (Mean=56.89, S.D=6.74) for student attitudes toward physics was greater than the control group (Mean= 48.67, S.D= 6.99).

Table 8: The average posttest scores of students' attitudes towards physics

Posttest	N	Mean	Std. deviation
Experimental	24	56.89	6.74
Control	26	48.67	6.99

The results of the Independent samples *t*-test are presented in Table 9.

Table 9: The independent samples t-test of the posttest scores of students' attitudes towards physics

T-test for equality of means						
	Sig.	t	df	Sig. (2-tailed)	η	Effect size, η^2
Equal variances assumed	0.83	4.23	48	0.00	0.52	0.27

Table 9 reveals that the difference in average scores of students' attitudes towards physics in the two groups is statistically significant (t(50)= 4.23, p=0.00, η^2=0.27). The difference was in favor of students from the experimental group who were taught using the PBL approach. The variations in students' attitudes towards physics were also discovered during focus group interviews. In this study, students who took part in the focus group interview were identified using codes. The sampled experimental group's focus group participants were C1, C2, and C3, while the control group's focus group participants were D1, D2, and D3. Below are sample transcriptions of four students:

> Question: Would you like to study more physics? Why?
>
> C1 (Experimental group): "I like physics because it is applied everywhere in daily life. For example, physics concepts are used to understand the motion of all objects. I like Newton's laws of motion. For example, the first law states that a body continues in a state of rest or uniform motion in a straight line unless it is acted upon by a resultant force. This means that the resultant is responsible for the change of state of a body."
>
> C2 (Experimental group): "Yes. Physics is a very interesting subject. The practical exercises have arisen my interest in different topics, especially kinematics. Furthermore, I have the desire to pursue studies in physics-related careers such as mechanical engineering."
>
> C3 (Experimental group): "Yes. I am interested in physics. This is because physics allows us to explain everything in the world. Physics also aids in the development of new technologies such as the x-ray machine. Moreover, many interesting events occur on the planet. As one writes using a ball pen, the ball turns and gravity forces the ink down onto the top of the ball where it is transferred onto the paper."

The responses from the experimental group revealed that students had better attitudes towards physics. Students understood the value of physics in everyday life, as well as physics-related occupations and the importance of studying physics.

> D1 (Control group): "I like studying biology because it is simple compared to physics. Physics is full of formulas that are hard to remember. This makes me get low scores in physics."
>
> D2 (Control group): "Physics is good but required one to be bright to excel in it. We are always given notes which are challenging to understand. For example, I don't understand why Newton's laws of motion are applied."
>
> D3 (Control group): "Physics is not simple. Understanding physics problems are exceedingly challenging because it demands the use of complicated apparatus and lengthy experiments."

The responses from the control group show that students' attitudes towards learning physics are unfavorable. Students are aware that physics is complex, only understood by the mentally gifted, and full of computations. Furthermore, students in the control group appear to be oblivious of the importance of physics in everyday life and hence have little desire to learn about it.

Generally, both quantitative and qualitative results suggest that PBL improved students' attitudes towards physics. These results concur with earlier empirical study findings reported in the literature. For example, Baş (2011) revealed that the PBL strategy improves students' attitudes towards English. In a different study, Faris

(2008) found that students who are taught using the PBL approach have a more favorable attitude towards science.

5. Conclusion and Recommendations

This study aimed at investigating the influence of the PBL on the 10th-grade students' attitudes toward physics. Based on the results, the PBL approach improved 10th-grade students' critical thinking skills in kinematics. The impact was visible in both groups' posttest results, with the experimental class's attitudes towards physics outperforming the control group. The additional qualitative findings from focus group discussions support these quantitative results. Furthermore, the project-based learning is consistent with current Uganda's competency-based curriculum being implemented in the lower secondary school curriculum with inherent students' higher-order thinking skills. These results have far-reaching ramifications in physics education and for physics educators. Therefore, the researcher suggests that educators use the PBL approach to teach physics and other scientific disciplines. This will consequently benefit students in improving their attitudes towards science, particularly in physics. The study recommends replication of this research in other contexts to compare and contrast our findings. Lastly, further research may be undertaken on another specific discipline.

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