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Using Problem-Based Learning Model to Improve Physics Students' Performance in Gravity

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Abstract: The researchers' experience in teaching Gravity during Physics lessons at Senior High Schools in Ghana indicated that many Physics students, had difficulties in understanding concepts in gravitation that require problem-solving skills. This therefore leads students to perform poorly under this topic during examinations though little or no attention is given to the fact that the student's problem-solving skills can affect their performance in gravitation. This study was primarily aimed at enhancing the performance of Form Two students of St. James Seminary Senior High School, Sunyani, in solving problems related to gravity. Through direct observation in the school, the problem of poor problem-solving skills and low performance in gravitation was identified among the students. To curb the problem identified, action research design was embarked upon. Pre and post interventions activities were designed gather data to answer the research questions. The data collected were analysed using descriptive statistics. The study results clearly showed that teachers and learners would achieve their goals if the lesson includes a problem-based learning method. It was recommended that teachers should incorporate higher-order thinking problems into the curriculum to improve students' thinking skills, retain what they have learnt, provides stimulate their learning process and improve their higher-order thinking abilities for use in real-life situations.

Keywords: Gravitation, Problem-Based Learning Model, Motivation, Misconception, Perception, Transfer of Knowledge

1. Introduction

The development of teaching methods in physics lessons has changed in recent years. Students are expected to become more involved in the teaching and learning processes, improve their degrees, and thrive in today's global economy as they move away from memorization, and other traditional teaching approaches [1]. To, achieve this goal, students must learn the appropriate skills, such as problem solving and collaboration, within the framework of core knowledge such as physics [2]. Classes should not only aim to impart a knowledge base but, according to Hurst, Wallace and Nixon [3], aim to cultivate reasoned, analytical, creative and practical thinking using a knowledge base. Presently, many educational institutions are moving towards problem-based learning as a solution to produce graduates who can think creatively, critically, and analytically in solving problems unlike the use of the traditional lecture approach which according to most studies do not help students to acquire better conceptual understanding in topics in physics or science [1, 3].

The problem-based learning approach is a student-centered method based on a poorly structured (real or intricately simulated) realistic problem for which students work together to generate effective answers [4]. Problem-based learning involves more student responsibilities and activities than conventional learning [5]. Ansarian and Mohammadi [6] listed some of the characteristics of problem-based learning approaches that are put into practice in a course as follows: (a) Self-directed learning is paramount. Thus, the students take on a great responsibility for the acquisition of information and knowledge, (b) the development of research and problem-solving skills is just as important as the content-related knowledge acquisition for the solution of the problem, and (c) the learning is collaborative, communicative and cooperative.

Students work in small groups with a high level of interaction for peer learning. peer teaching, and group presentations.

Gravitation is widely considered a challenging concept for teaching, and it is difficult for students to understand, especially in situations involving acceleration as indicated by Yousif [7]. The difficulties are partly conceptual, partly descriptive, and sometimes a combination of the two.

Students consider gravitation to be a very difficult and abstract topic [8]. Numerous literature reveal that common misconceptions among students were that gravity only acts on falling objects, but not on stationary objects and again gravity does not affect objects buried beneath the Earth [7, 9, 10, 11]. There is also endless conceptual and terminological confusion, especially in "free-fall" and "weightlessness" cases [12, 13, 14].

The researchers' experience in teaching Gravity during Physics lessons especially at St. James Seminary Senior High School in the Sunyani Municipality in the Bono Region, indicated that many students, especially Physics students, had difficulties in understanding concepts in gravitation that require problem-solving skills and therefore avoided questions under this topic during examinations if they had the option. Similarly, students who attempt to answer questions under gravitation end up getting low marks and poor grades. Hence, they lose interest, and have negative attitudes towards gravitation.

Little or no attention is given to the fact that the student's problem-solving skills can affect their performance in gravitation. Based on this assertion, this study was to be geared towards the effect of the problem-based learning model on form two science students' performance in St. James Seminary Senior High School in the Sunyani Municipality.

The purpose of this study was to use the Problem-Based Learning Model to help improve form two science students of St. James Seminary Senior High School's problem-solving skills and performance in gravitation.

The following questions were formulated to guide the study: What are science students' perceptions on gravitation? What is the effect of the problem-based learning model on students' problem-solving skills.?

The study would train physics teachers to improve their methodology or strategies for teaching gravity in schools. It would also help students improve their performance and develop an interest in the field of gravity apart from being used as literature for researchers investigating problem-based learning in gravity.

2. Methodology

An action research design was chosen for this study. It is an approach in which the action researcher (s) and a client work together in diagnosing the problem and developing a diagnostic-based solution [15]. It needs people to bring their existing processes, ideas and assumptions to the test by collecting convincing proof that could persuade them that their previous processes, ideas and assumptions were either wrong or wrong-headed. It is a problem solving which requires thinking skills. The study was used to improve the performance of form two science students of St. James Seminary Senior High School through problem-based learning model. It is a school in the Sunyani Municipality at the Bono Region.

The target population of this study was all form two science students at St. James Seminary Senior High School age between 13 years to 17 years and totalling 148, four Physics teachers and seven Integrated Science teachers teaching in the school. One intact class consisted of 48 (all males) students was the sample size.

In this study, an observation checklist, interview and a questionnaire were used to gather data. On the questionnaire, the perception and the level of students' problem-solving skills in gravitation lessons were analysed to assess any shifts in attitude due to the new approach to teaching. The students' problem-solving skills questionnaire was divided into Pre and Post. Pre refers to students' problem-solving skills towards teaching and learning of gravitation before the teaching approach and Post was their problem-solving skills towards teaching and learning of gravitation after the teaching approach. An interview was arranged for the students, they were put into seven (7) students to answer questions in requesting information about their problem-solving skills and success in the study of gravitation. Observation checklists were designed for both the pre-intervention and post-intervention activities to help the researchers find out students' perception of gravitation, students' attitudes towards teaching and learning of gravitation and problem-solving skills exhibited by students.

To enhance content validity, the research instruments were appraised by two science education experts. To further establish content validity, a pilot study was carried out. The questionnaires and the classroom observation checklist were administered to both teachers and students for this purpose in a different school in the same region which has similar characteristics of the St. James Seminary Senior High School. This was done to determine the difficulty level of the questions and the items. On analysing the responses from the respondents, the items found inappropriate were either modified or discarded so as to improve the quality of the research instruments. Some items were found inappropriate and were replaced. In other cases, the wording of some items was reorganised so as to make them clear to the respondents. The reliability and internal consistency of the Likert-type scales questionnaire were checked after piloting it using Cronbach's alpha and was found to be 0.83, which is an acceptable level of reliability.

Pre-intervention activities were carried out to help identify the problems associated with the problem-solving skills of students in solving problems related to gravity. Data were gathered through class tests, questionnaires, observation checklist and interviews. These were done to get a clear picture about the students' problem-solving skills in performing gravitation task.

2.1. Intervention Activities

The results from the pre-intervention phase helped in the design of an intervention to solve the problem of students' problem-solving capacity and performance in learning about gravitation. The success of learning gravitation depends on the way students learn. The researchers engaged students in problem-based learning activities. This was a method in which a lot of problems were given to students for them to solve based on the topic being treated.

2.2. Conceptual Obstacles of Students with Respect to Gravitation

According Gonen [8], and Stein, Galili and Schur [16] students have naive views about gravity such as:

1) Gravity is a pressing force, “gravity is possessed exclusively by heavy body”, and “suspended substances are weightless”.
2) Students have idea that air is needed by gravity to exist.
3) Students have perception that gravity only act on object moving vertically downwards and not on object moving vertically upwards.

The researchers found that the students had the following misconceptions about gravity:

1) Things fall if they are not supported. When asked why things fall when dropped, most of the students said things fall because they are not held up.
2) Strength and effort prevent falling. When students were asked what keeps something from falling, they usually referred to some sort of effort or strength that prevents it from falling, and they even used this reasoning for the Sun, Moon, and clouds.
3) Gravity is not a force. For students who believe that things just naturally fall, no force is necessary. A few older students and even adults hold this misconception.
4) Heavier objects fall faster. This is a very deep-seated misconception held by most of the students.
5) Gravity attracts only heavy, slow, or inactive objects. This is a loose collection of misconceptions expressed by most of the students during the gravitation lessons.
6) Gravity acts upward. The students indicated a belief that gravity pushes upward rather than acting to pull things down to Earth’s surface.

2.3. Designing Problems for the Intervention

The researchers developed questions that were of interest to the intervention. The intervention occurred two times in a week. The entire teaching spanned seven sessions of 60 minutes each in accordance with the regular school timetable.

Table 1. *Schedule for Action Research Project; pre and post-tests data collection dates and intervention dates.*

Week	Date:	Pre-intervention:
	18th May-29th may	Introduction to gravitation and some gravitational laws Data Collection: Pre-intervention observation, administering pre-intervention questionnaire, pre-intervention observation, pre-intervention exercise
		Intervention:
1	1st June-5th June	Newton's law of gravitation and its application
2	8th June-12th June	Free fall and weightlessness
3	15th June-19th June	Gravitational field
4	22nd June-26th June	Gravitational field
5	29th June-3rd July	Celestial bodies and Satellite
6	6th July-10th July	Solve problems related to gravitations
		Post-intervention:
	13th July-24th July	Data Collection: Post-intervention observation, administering post-intervention questionnaire, post-intervention observation, post-intervention exercise

As a major feature of an action research, the intervention also adopted activity-oriented method which exposed the students to practical work in gravitation in order to improve their performance and problem-solving skills in that respect. Demonstration method and group work were incorporated in the activity-oriented method with practical problems related to gravitation. The intervention took place in the classroom, sometimes in the Physics laboratory and on the school premises during normal instructional periods. Series of activities were executed with participants in order to fix the problem under consideration. For example:

The researcher held a piece of stone and a feather and asked the students to predict what would happen if the two bodies were dropped from the same height simultaneously in a vacuum. The researcher asked the students, with the two bodies in the hands of the researcher in a vacuum, if they would be on the ground at the same time or at different times.

The students were shown a video of Galileo on the moon. Students were also asked whether they were expecting the piece of the stone and the feather to land on the surface of the moon at the same time when held at the same height. The students were also shown different videos of experiment on gravity in vacuum indicating falling of objects without opposing forces like air resistance.

Students were able to embrace or at least consider the concept that all objects, irrespective of their masses, dropped at the same rate in a vacuum after watching the various videos. Galileo conducted several experiments and concluded that, irrespective of the masses of certain objects, the effect of gravity on earthly objects is the same. He argued that all objects accelerate toward Earth at the same rate in the absence of other forces, such as air resistance.

The researchers found the approach to help students better differentiate weight from gravitational force and also helped to improve the conceptual understanding of the students on the gravitation. The results of this research showed a substantial increase in scientifically based responses between students. Based on the results of this study, the researchers emphasised in particular the importance of explanation to others in the context of a classroom as a tool to expand the advantages of self-explanation and to facilitate understanding and conceptual improvement.

The researchers based on this approach used problem solving and simulations to give better and clearer explanations to treat the other topics under intervention in Table 1.

2.4. Tutorial Support

The students received frequent tutorials or lectures on some of the theory or methods used for problem-solving. It was intended to reaffirm the knowledge that the students have learned and to give them confidence in themselves and the teaching technique. It also helped them to evaluate their learning and assess their learning needs. The researchers found the students had been very effective with problem-based learning in this method. Nevertheless, introduction of problem-based learning without having the required learning tools and encouragement for the students will cause the students to become disillusioned and fail to learn.

2.5. Post-Intervention Activities

Data were again collected through interviews and observations. At the end of the intervention activities, class test was also administered to gather data on the performance of the students on the topic, gravitation.

3. Results and Discussion

3.1. Pre Intervention Observation

The researchers found out from observation that students' participation in class especially during gravitation lessons was not encouraging. Students participated poorly in discussions during lessons and gave unscientific responses to questions posed. Most students had very low marks in class with few students showing interest in the lessons. Questionnaires and interviews were administered to students to find out their reasons for poor behaviour during gravitation lessons.

Students complained that most of the gravitation lessons were taught theoretically. Students admitted that they were imagining what they were being taught in the abstract and it made it difficult for them to relate concepts to the physical world. Students indicated that neither their teachers nor they themselves performed any activities during gravitation lessons. This meant that the students were not involved in the lessons taught which made each lesson complicated and boring for them.

Again, students were not given enough class exercises and assignments regularly. This made it difficult for them to get enough practice to be able to answer questions during their terminal examination leading to their poor failure in the subject.

A gravity lesson was observed and an observational checklist was used to obtain data on the attitude of students. It was revealed from the pre-intervention observation that students had a pessimistic attitude towards the learning of gravitation. Most of the students often left class during gravitation lessons.

Seven teachers were selected for this activity, three (3) of them were Physics teachers in the school and four (4) of them teaching integrated science in the school. They observed the lessons on different occasions.

The discussion of the results focuses on answering the research questions.

Research Question 1: What are science students' perceptions on gravitation?

This question was answered by using the observation checklist (question 1), students' pre-intervention questionnaire (questions 5 and 6), and students' pre-intervention interview (questions 1 and 2). These are represented in Tables 2, 3 and 4.

3.2. Observation Checklist Question 1

This was to find out from teachers whether students find learning gravitation difficult. Teachers' responses were shown in Table 2.

Table 2. *Teachers' perceptions on whether students find gravitation difficult or not.*

Response	Number	Percentage (%)
Yes	6	85.7
No	1	14.3
Total	7	100.0

Table 2 reveals that 6 teachers representing 85.7% indicated that they observed that gravitation lessons were difficult for students whilst 1 teacher representing 14.7% indicated gravitation was not a difficult topic for students. Majority of the teachers were of the view that students find gravitation difficult.

Students' perception on the difficulty of gravitation

Students' perceptions on the difficulty of gravitation were shown in Table 3:

Table 3. *Students' perception on the difficulty of gravitation.*

Response	Number	Percentage (%)
Strongly Agree	36	75.00
Agree	9	18.75
Uncertain	2	4.17
Disagree	0	0.00
Strongly disagree	1	2.08
Total	48	100.00

Table 3 indicates the responses given by students from question 5 of students' pre-intervention questionnaire. In their responses, 36 students representing 75% answered that they strongly agree that gravitation is a challenging topic, 9 students representing 18.75% also agreed that gravitation is a challenging topic, 2 students were not certain and 1 student representing 2.08% strongly disagreed that gravitation is a challenging topic. Majority of the students were of the view that they found gravitation to be difficult.

Students' perception on the difficulty of gravitation on pre intervention questionnaire

Students' responses were presented in Table 4:

Questionnaire item 5: I find gravitation challenging

Table 4. *Students' perception of the difficulty level of gravitation.*

Response	Number	Percentage (%)
Strongly Agree	33	68.75
Agree	14	29.17
Uncertain	0	0.00
Disagree	1	2.08
Strongly disagree	0	0.00
Total	48	100.00

Questionnaire item 6: I think gravitation is too hard/difficult

Table 4 indicates that 33 students representing 68.75%, strongly agreed that gravity is a difficult topic, and 14 students, representing 29.17%, also agreed that gravity is a difficult topic. Majority of the students considered gravitation was difficult to comprehend.

3.3. Questions 1 and 2 of Students' Pre-Intervention Interview

Do you enjoy studying gravitation? Why do you enjoy or not enjoy gravitation?

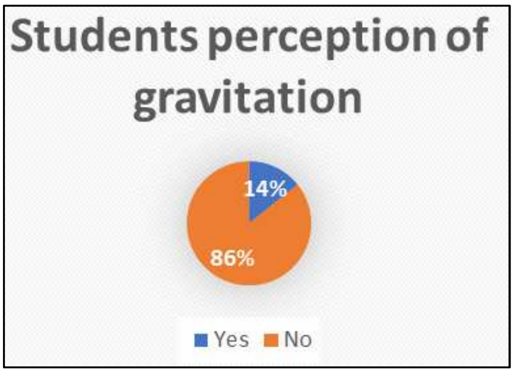

Figure 1. *Students' perception of gravitation.*

Figure 1 shows the responses provided by the students from question 1 of the structured interview with the students prior to the intervention. In their responses, 86% of the students replied that they did not enjoy studying gravity, while 14% replied that they enjoyed studying gravity. Majority of the students thought gravitation was abstract and that they did not enjoy learning it.

The students replied to Question 2 of the structured student interview that gravitation is difficult and not practical. Most of the students said gravitation was complicated since they had to deal with multiple representations at the same time, such as tests, mathematical formulas and equations, diagrams, and logical explanations.

Some of the students also complained they were always taught using the lecture method. In order to connect to the physical things around them the lecture approach resulted in making the subject complex. In this regard, in order to maximize the achievement of students by engaging them in learning activities, teachers must use a range of teaching strategies and if not, students tend to memorise what they are taught without conceptual understanding.

3.4. Intervention

After noting the issue and its underlying causes, the problem-based teaching and learning model was set up to help enhance the success of students in solving gravity-related problems. In the teaching of gravitation, the problem-based learning paradigm was introduced into theory. This was achieved to improve the students' deeper understanding of the concept. Relevant teaching and learning materials were used in order to do this. The students were grouped to address this problem of insufficient materials. During gravitation lessons, the groups conducted various exercises on various occasions.

3.5. Observation Made After the Implementation of the Intervention

The students were all involved in the teaching and learning activities, every student played a part. It was also observed that, students continued to learn gravitation even when it was time for break. Another noticed attitude was the seriousness of the students. They were paying attention and trying to follow directions given to them. The students were often on schedule for gravitation lessons with the use of the problem-based learning model. The involvement of students in class also improved, leading to an increase in their understanding of the principle of gravitation. It was also noted that students can now solve problems related to real life scenarios related to gravitation.

3.6. Post-Intervention Analysis

It analysed post-observation checklist, interviews and pre-intervention and post-intervention exercises provided to the students.

Research Question 2: What is the effect of the problem-based learning model on students' problem-solving skills in gravitation?

What is the level of students problem-solving skills in gravitation after implementing of learning modules based on problem-based learning as an intervention? Questions 1, 2, 3, 4 and also 6, 7, 8, 9, 10 of the post-observation checklist and questions 1, 2 and 5 of the post-intervention student interviews answered this question. Observation checklist question 1, 2, 3, and 4.

Table 5. *Teachers' perceptions on whether students find gravitation difficult or not.*

Variable	Response			
	Yes		No	
	Number	Percentage (%)	Number	Percentage (%)
Students find it difficult to study gravitation	2	28.57	5	71.43
The focus and direction of the lesson was often determined by ideas originating with students.	5	71.43	2	28.57
The lesson promoted strongly coherent conceptual understanding.	6	85.71	1	14.29
Students made predictions, estimations and/or hypotheses and devised means for testing them.	7	100.00	0	0.00

Table 5 indicates that 2 teachers representing 28.57% showed that it was difficult for students to study gravitation, whereas 5 teachers representing 71.43% have suggested that it was not difficult for students to study gravitation.

Five (5) out of 7 teachers, representing 71.43%, found that ideas from students frequently determined the emphasis and direction of the lesson. It was also revealed that the lessons supported strongly coherent conceptual understanding by 6 teachers representing 85.71%, while 1 teacher representing 14.29% suggested that the lesson did not encourage strongly coherent conceptual understanding. All 7 teachers, representing 100%, reported that during gravitation lessons, students made predictions, estimates and/or hypotheses. This was because the students were encouraged to produce conjectures, strategies for alternative solutions, and ways of interpreting evidence.

Finding: The majority of the teachers believe that students do not struggle with gravitation. This suggests that most of the students now understood problems of gravitation requiring problem-solving skills.

Observation checklist questions 6, 7, 8, 9 and 10.

Table 6. *Teachers' perceptions on students problem-solving skills.*

Variable	Response			
	Number	Percentage (%)	Number	Percentage (%)
Identifying problem correctly	6	85.71	1	14.29
Distinguish knowledge and opinion	5	71.43	2	28.57
Providing possible solution	7	100	0	0
Making decision	4	57.14	3	42.86
Identifying the impact of the implementation of their solution	4	57.14	3	42.86

The observation checklist data indicates that 6 teachers, representing 85.71%, reported that students were able to correctly identify problems. Therefore, in solving problems related to gravitation, there is a growing critical thinking capacity of learners. Five (5) (71.43%) of teachers also indicated that students gave highly suitable facts, excellent generalizations of facts, supporting their solutions, facts that were well used in making the case. Therefore, relative to their original style of learning, there is a growth in problem-solving skills.

All 7 teachers noticed that learners were excellent in thinking about the possible solution to the problem. Some of the teachers suggested that while students have done well in presenting solutions, they also need to improve the ability to fairly analyse such possible solutions. 4 out of 7 teachers, representing 57.41%, indicated that students gave excellent reasons for help, strong diversity, directly relevant. 57.41% of teachers noted that the provision of new information by students was excellent. Most of the teachers believe that students have a great ability to solve problems.

Questions 2 and 3 of students' post-intervention interview

Do you enjoy solving problem-based questions on gravitation? What makes you enjoy or not enjoy problem-based questions on gravitation?

Table 7. *Students' perceptions on their problem-solving ability in gravitation.*

Response	Number	Percentage (%)
Yes	5	71.43
No	2	28.57
Total	7	100.00

Table 7 answers question 2 of the post-intervention interview with the students. From the table, 71.43% of the students suggested that they enjoyed solving gravity problem-based questions, while 28.57% of the students said they still had issues with gravity problem-based questions. Most of the students answered question 3 by saying gravitation lessons are no more difficult and abstract, because they now understand the concept. Majority of the students considered that problem-based questions in gravitation were easy to understand.

Question 4 of students' post-intervention interview

What new things have you gained from some of the lessons?

Most of the students indicated that when problem-based learning models were incorporated into teaching and learning, their problem-solving skills and logical understanding of gravitation improved.

By introducing students to a range of problem-solving activities, incomplete or partial comprehension can be corrected so that students can develop solid logical thinking and reasoning skills and have a full mastery of key concepts.

Question 5 of the students' post-intervention interview and the results of the student's pre-intervention test and post-intervention test addressed this question. Question 5 of students' post-intervention interview. Are you happy with your performance in Physics especially gravitation so far?

Table 8. *Students' perception on their performance in gravitation.*

Response	Number	Percentage (%)
Yes	6	85.71
No	1	14.29
Total	7	100.00

Six (6) 6 of the students, representing 85.71%, said their performance had improved, so they were satisfied with their performance, while 1 student, representing 14.29%, said they were not happy with their performance. Majority of the students were of view that their performance in gravitation had improved.

Pre-intervention test and post-intervention test

Pre-intervention test and post-intervention exercises were organised for students before and after the researcher introduced problem-based learning model in teaching and learning of gravitation. The researcher taught the theoretical aspect of the topic "introduction to gravitation" before introducing the problem-based learning model and its activities. After the lesson, class test was given to students and marked and after the intervention another exercise was also given to students and marked. The scores obtained by the students in both pre-intervention class test and post-intervention class test were analysed using paired sample t-test to measure the impact of the problem-based learning model on teaching and learning of gravitation.

Paired sample t-Test

A paired sampled t-test was conducted to compare students' pre-test scores and post-test scores.

Table 9. *Paired sample t-test for pre-test and post-test means.*

	Post test	Pre-test
Mean	14.10416667	5.770833333
Variance	10.35062057	5.201684397
Observations	48	48
Pearson Correlation	0.354181282	
Df	47	
t Stat	17.94206811	
t Critical one-tail	1.677926722	
P (T<=t) one-tail	8.20839×10^{-24}	

The mean score of students on the post-test (14.10) was greater than their score on the pre-test (5.77). Since the p value is less than 0.05 ($p < 0.05$), it implies that there is a statistically significant difference between the score obtained by students on the pre intervention test, and that obtained on the post intervention test. Therefore, the null hypothesis of no significant difference is rejected.

The results show a significant difference in the achievement between the students' performance in the post-test after they were exposed to problem-based learning and its activities. In the problem-based learning classroom the students performed very well compared to the traditional teaching classroom process. It indicates that when the problem-based learning teaching approach was used in teaching gravitation, the problem-solving skills and thinking abilities of the student increased. A good teaching approach should allow students to understand and focus on the content they have been exposed to and help improve their problem-solving abilities [17].

It was noted that all students actively engaged in problem-based learning exercises, and this helped to develop their ability to think critically. The researcher sometimes questioned students about the progress of the problem-based learning activities they were employing, and almost every student was ready to respond positively.

After the intervention, the students themselves called for class exercises, class test and homework. They found assessment exercises as a mean to exhibit what they had learnt. Students of this class wanted more gravitation lessons even during their free period. Students' absence from gravitation lessons was a thing of the past. These were a clear indication of students change in attitude towards gravitation and its assessment exercises.

Students solve issues in a typical problem-based learning classroom as they move through the inquiry process in a real-life setting. Teachers encourage them to explore possibilities, invent possible options, interact with other students, try out ideas and theories, revise their thought, and present their best solutions while students are engaged in problem-based learning.

The findings of the study are similar to other research findings such as Agan and Sneider [18], Kavanagh and Sneider [19], and Asghar and Libarkin [20], which focused on student's understanding of gravity. They reviewed that most common misconceptions held by students stem from a strong Earth-centred reference frame, including the idea that things can fall "down" off of the Earth. In general, middle school and high school students have more sophisticated misconceptions, such as the idea that gravity needs a medium such as air to act through, that gravity is confused with magnetism and rotation, and a general confusion between physical concepts such as weight, mass, and force. There are several challenges when students have a poor critical skill in solving gravitation problems; one such difficulty is the misconception of students.

With respect to this study, Putri and Prodjosantoso [21] stated that teachers must include problem solving, critical thinking, presenting specific tasks, and challenging exercises to promote motivation and learning in order to satisfy the need for an intellectual challenge. The result from this study also showed that rational thought is used in learning gravitation when learners use problem-solving techniques using a combination of cognitive and practical abilities to produce ideas. This confirms what Indah [22] also found in his study. This will lead to learners finding a goal, generating and forming ideas, and refine skills. Generally, the result of this study shows that problem-based learning method could be more effective on problem solving skills than the conventional teaching method.

4. Conclusion

The study results clearly showed that teachers and learners would achieve their goals if the lesson includes a problem-based learning method. In this study, frequent use of the problem-based learning approach created remarkable outcomes that were rewarding. Positive reviews such as increased participation in lessons, good grades, and the desire to read ahead and be in class are signs of better gravitational teaching and learning. Problem-based learning used for science teaching and learning offers a way to address scientific questions, making students responsible for their own understanding. Problem-based learning helps to improve the process skills, thinking abilities of learners, and also a positive attitude towards science learning.

5. Recommendations

From the findings of this study the following recommendations are that:

1) Teachers should continue to incorporate higher-order thinking strategies into the curriculum (problem-based learning model). This does not only help students retain the information they are learning but also provides stimulation during the learning process and helps to further develop higher-order thinking abilities for use in other classes and real-life situations.
2) Secondly, although the use of problem-based learning was studied in gravitation and had a good student learning effect, it would be important to explore successful ways of applying this approach to different disciplines.

Appendix

Appendix 1. Lesson Observation Guide

(PRE-INTERVENTION ACTIVITIES)

School: Class: Date:

Topic/Subtopic:

Please make a tick [√] in the box beside your selected response. Where there are no options given, write your response in the space below the question.

Table 10. *Lesson observation guide.*

N/S	Variable	Yes	No
Perception of students before implementation of the intervention			
1	Students find learning gravitation difficult		
Propositional content knowledge			
2	Connections with other content disciplines and/or real-world phenomena were explored and valued.		
Procedural knowledge			
3	Students made predictions, estimations and/or hypotheses and devised means for testing them.		
4	Students were actively engaged in thought provoking activity that often involved the critical assessment of procedures.		
Classroom culture (communicative interactions)			
5	The teacher's questions triggered divergent modes of thinking.		
Students approach to problems			
6	Identifying problem correctly		
7	Distinguish knowledge and opinion		
8	Providing possible solution		
9	Making decision		
10	Identifying the impact of the implementation of their solution		

Appendix 2. Students' Survey Questionnaire

PRE-INTERVENTION ACTIVITY

This questionnaire seeks your opinions and concerns about teaching and learning of gravitation. Your responses will be treated confidentially and will be used for research purposes only. Thank you for completing the questionnaire. Your cooperation is greatly appreciated.

Please make a tick in the box beside your selected response. Where there are no options given, write your response in the space below the question.

Section A: BIO DATA

Gender: Male Female

Age: years.

School:

Class:

Section B

Read the following statements and kindly give your honest opinion by placing a tick in the appropriate box.

Key: Strongly Disagree SD (1), Disagree D (2), Uncertain NS (3), Agree A (4) and Strongly Agree SA (5).

Table 11. *Students' survey questionnaire on teaching and learning of gravitation.*

NO.	Variable	SD (1)	D (2)	NS (3)	A (4)	SA (5)
Students perception of gravitation						
5	I find gravitation challenging					
6	I think gravitation is too hard/difficult					
Students participation						
7	Asking question/answer question					

NO.	Variable	SD (1)	D (2)	NS (3)	A (4)	SA (5)
8	Volunteer to perform a task during a lesson					
Students learning approach						
9	Students work with gravitation problems individually					
10	students work with gravitation problems in groups					
Teacher guidance						
11	Shows us how new concepts in Physics relate to what we have already done					

Appendix 3. Interview Sample

PRE-INTERVENTION ACTIVITIES

Interview guidelines for students:

Do you enjoy studying gravitation?

Why do you enjoy or not enjoy gravitation?

Do you enjoy solving problem-based questions on gravitation?

Why do you enjoy or not solving problem-based questions on gravitation?

Would you like to consider studying gravitation again at the university?

Appendix 4. Lesson Observation Guide

(POST-INTERVENTION ACTIVITIES)

School: Class: Date:

Topic/Subtopic:

Please make a tick [√] in the box beside your selected response. Where there are no options given, write your response in the space below the question.

Table 12. *Lesson observation guide.*

N/S	Variable	Yes	No
Students understanding after implementation of the intervention			
1	Students find it difficult to study gravitation		
Propositional content knowledge			
2	The focus and direction of the lesson was often determined by ideas originating with students.		
3	The lesson promoted strongly coherent conceptual understanding.		
Procedural knowledge			
4	Students made predictions, estimations and/or hypotheses and devised means for testing them.		
Classroom culture (student/teacher relationships)			
5	Students were encouraged to generate conjectures, alternative solution strategies, and ways of interpreting evidence.		
Students approach to problems			
6	Identifying problem correctly		
7	Distinguish knowledge and opinion		
8	Providing possible solution		
9	Making decision		
10	Identifying the impact of the implementation of their solution		

Appendix 5. Interview Sample

Interview Sample

POST-INTERVENTION ACTIVITIES

Interview guidelines for students:

Do you enjoy studying gravitation?

Do you enjoy solving problem-based questions on gravitation?

What makes you enjoy or not enjoy problem-based questions on gravitation?

What new things have you gained from some of the lessons?

Are you happy with your performance in Physics especially gravitation so far?

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