OVERCOMING MISCONCEPTIONS ON 'GRAVITY AND FORCE' OF NINTH STANDARD STUDENTS

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ABSTRACT

Misconceptions hinder and challenge the learning of physics and science subjects in general. This study aimed to identify misconceptions in physics topics, namely gravity and force, and to overcome them through timely and appropriate interventions among ninth-grade students at Khuruthang Middle Secondary School in Punakha district, Bhutan. This study employed a quantitative method using two-tier diagnostic tests as a research tool, with a sample of 40 ninth-grade students. The key findings revealed the existence of common misconceptions among ninth-grade students in the school, which contribute to poor performance in these topics. Furthermore, this study showed that timely and appropriate interventions (such as a flipped classroom approach infused with cooperative learning) led to significant improvement. This approach helped students address misconceptions effectively and perform better in the topics. Therefore, this study recommends that physics or science teachers consider using flipped classroom techniques combined with cooperative learning or other alternative teaching strategies to overcome misconceptions and benefit students.

Keywords: Misconceptions, Gravity and Force, Flipped Classroom, Cooperative Learning, Intervention, Physics, Ninth Standard Students.

INTRODUCTION

Gravity and force are fundamental concepts in physics, but they can be difficult to understand for a few students. Many students develop misconceptions about these that can hinder their ability to learn and apply them in real-world scenarios. This study aims to identify and overcome these misconceptions among ninth standard students through a series of classroom interventions. Irrespective of age, whether they are children or adults, they develop misconceptions as they attempt to perceive the world they experience. Their general sense of understandings of physical phenomena is developed through life, influenced by various news, prominent journals, and misleading text, and this creates difficulty to challenge their misled understanding of concepts (Viennot, 1979).

1. Literature Review

Sneider and Ohadi (1998) carried out a study to find out misconceptions on earth's shape and gravity. The study included 539 students from 18 classrooms in 10 different states in the United States of America. On the pretest, all classes displayed a wide variety of conceptions, and they were differing from factual concepts of gravity. Griffith (2001) described several common misconceptions about gravity and motion. The study found students believe that objects are constantly losing energy and that the force of gravity only affects objects on the earth's surface.

There should be the introduction of new instructional strategies, such as those based on conceptual change that must be inculcated or instigated by physics teachers to promote deeper understanding of concepts in students. Traditional instruction strategies are found ineffective, and new strategies must be planned and introduced, or inappropriate ones could lead to further addition of misconceptions in students (Daud et al., 2015; Karadag & Yasar, 2010; Koeze, 2007). Further, it was found that false approaches to leading are one of the causes of the development of misconceptions in learners, and it was found that good questions on the problems are vital for students understanding of concepts as they draw attention to the essence of the problem (Kuczmann, 2017). Rowands et al. (2005) found that misconceptions of learners can be overcome by change in instruction in physics concepts, and in their studies, instruction strategies, namely concept and parallel questions, were found effective.

In the Bhutan education system, studies carried out on misconceptions and strategies to overcome them are scarce (Kinley et al., 2021). Even globally, there are few studies carried out on misconceptions on gravity and motion. Stein et al. (2008) confirmed that progress has been made toward helping learners understand specific concepts in ways that are aligned with views held by scientists. The written explanation of students revealed that they do not have a clear understanding of what gravity is and how objects behave as a result of gravitational forces.

2. Objectives

- To identify common misconceptions about gravity and force among ninth standard students (Maxwell, 2003).
- To develop and implement classroom interventions to overcome these misconceptions.
- To assess the effectiveness of these interventions in improving student understanding and performance in physics.

3. Situational Analysis

Khuruthang Middle Secondary School was established in 1996 as the only lower secondary school in the Dzongkhag with boarding facilities for classes VII and VIII.

It was upgraded to middle secondary school from the beginning of 2005. The need of this school was felt when Punakha HSS was earmarked for plus two courses phasing out classes VII and VII with the main objective of accommodating all class VII students of Punakha Dzongkhag who otherwise were placed in Punakha HSS. Built atop an impressive spur overlooking the new Khuru town.

According to Mrs. Lhamo Yangchen, a veteran science teacher who had been teaching physics for classes IX and X for more than 10 years in the same school, "I have always had to face numerous misconceptions on the discipline, especially in the field of gravity and force" (Jamtsho, 2019). It was further affirmed by other science teachers that misconceptions are one of the factors that hinder students understanding of physics concepts, and it ultimately affects their academic performances.

- Mass and weight are treated as the same.
- Force always causes motion.
- Force and energy are the same thing.
- Object with more mass always felt more gravity.
- Gravity only pulls things down.

Also, it's been observed that students draw small round shapes to denote particles, which is a mistake. When inquired, most of the teachers even agreed to have done the same, which is continued. The present science curriculum includes topics on atoms, structure of atoms, gravity, and force, but because of the limited information provided in the text book, the teachers need to confront a huge challenge in disseminating and imparting the exact information in clearing the misconceptions the students conjure in their minds.

These misconceptions, if not addressed or intervened, will continue their journey through the minds of their careers. Therefore, the science teachers in the school deemed it necessary to carry out comprehensive research on misconceptions of the students in physics so that a timely intervention could be made.

4. Research Questions

- How does the change in instructional strategies overcome misconceptions on gravity and force in ninth-grade students of Khuruthang middle secondary school?
- What are some of the prevailing common misconceptions of ninth-grade students in the topics 'Gravity and Force'?
- How effective is this intervention in improving student understanding and performance in physics?

5. Methodology

Using the purposive sampling method, the participants of this study are class IX students of Khuruthang Middle Secondary School, Bhutan. The school has only two sections of class IX with a total of 40 students, therefore, all of them are involved in this study.

Data collection followed by the conventional method of quantitative analysis was done in both the pretest and the posttest. Both the pretest and posttest were conducted using two-tier diagnostic tests: multiple choice questions followed by reasoning questions. The quantitative data collected using a two-tier diagnostic test was analyzed using Microsoft Excel and SPSS 22.0 (Statistical Package for Social Sciences).

6. Findings and Data Analysis

The data obtained from the two-tier diagnostic tests were interpreted by finding the number of students and percentage. A two-sample paired t-test was carried out to find out the statistical significance of the two tests (pretest and posttest) of students while taking variance or distribution into account. The quantitative data are represented using tables and bar graphs for easy interpretation and references.

6.1 Intervention Plan

Students were made to appear pretest using a two-tier diagnostic test, which includes multiple-choice questions and each question followed by reasoning questions.

After identification of misconceptions on gravity and force, a group of physics teachers planned and designed appropriate instructional strategies to overcome the misconceptions. According to planning and with designed instructional strategies, teachers planned and conducted classes for three weeks as an intervention. Physics teachers used a flipped classroom infused with cooperative teaching and learning strategies as an intervention to address the students' misconceptions on the topics (Abdulwaheed, 2023).

During the 1st week of intervention, students were divided into groups with five members each, and it was called 'Home Group'. Within each group, students were numbered from one to five, and for the same numbers, all groups were assigned a topic. Table 1 shows the assignment of topics carried out.

The teachers provided students with videos on the topic they were assigned for comprehensive understanding. For the 1st week, students were instructed to watch videos they are provided with individually and make notes on them.

In the 2nd week of intervention, students with the same topics are gathered as groups (expert groups), and they are instructed to share their notes with each other. Within the 2nd week, students in expert groups share notes, discuss, and come to a common consensus with constant guidance and monitoring by their respective teachers.

In the 3rd week of intervention, students are instructed to return to their home groups and share their understanding on the topic assigned to other members. All students in the group are given 20 minutes to present their work or notes on the given topics, followed by 5 minutes of a question-answer session.

After the intervention period, students were made to appear in the same two-tier diagnostic test, thereby assessing the effectiveness of the instruction strategies used as intervention.

Sl.No.	Number of the Members	Topic
1	One	Weight (Formula and Units)
2	Two	Factors Affecting Gravitational Force
3	Three	Newton's Law
4	Four	Acceleration
5	Five	Types of Force

Table 1. Assigning of Topics to Students

6.2 Common Misconceptions of Ninth Standard Students on Gravity and Force (Pre-Test)

The data obtained from two-tier diagnostic tests conducted on students revealed that a significant number of class IX students have misconceptions on the topic 'Gravity and Force'. The students having misconceptions on the topics are apparent from the total number of students, and the percentage of students is shown in Table 2.

The data revealed as many as 20 students (50%) are having misconceptions on Newton's law, 16 students (40%) had misconceptions on the topics: weight and factors affecting gravitational force, 12 students (30%) on types of force, and the topic 'acceleration' is the one with the least misconception (10 students or 25%).

6.3 Common Misconceptions of Students on Gravity and Force After Intervention Using Flipped Classroom Infused with Cooperative Learning Strategy (Post-Test)

The data obtained from two-tier diagnostic tests conducted on students after intervention for three weeks revealed that there was significant improvement in addressing misconceptions on the topic 'Gravity and Force'.

The significant improvement in understanding the concepts and overcoming misconceptions on the topics is apparent from the total number of students, and the percentage of students is shown in Table 3.

The data revealed there are 6 students (15%) having misconceptions on Newton's law, 4 students (10%) have misconceptions on the topics acceleration and factors affecting gravitational force, and 3 students (7.50%) on the topics weight and Newton's law, respectively.

The comparison of data from pre-test and post-test two-tier tests clearly revealed there is significant progress in addressing students' misconceptions on the topic 'Gravity and Force' with integration of the teaching strategy 'Flipped classroom infused with cooperative learning' in classroom teaching-learning as shown in Figure 1.

Further to confirm the efficiency of intervention (flipped classroom infused with cooperative learning) to address misconceptions on the topics. The two samples paired t-test was administered to check and validate its significance level. Table 4 shows the results of two samples paired t-tests.

The results of two samples paired t-tests with two tailed based on understanding of topics indicated the

Sl. No.	Topic or Concept	Total and Percentage (%) of Students Having Misconceptions					
		Misconception		Did Not Understand		Understood	
		No. of Students	Percentage	No. of Students	Percentage	No. of Students	Percentage
1	Gravity						
	Weight (Formula and Unit)	16	40%	13	32.50%	11	27.50%
	Factors Affecting Gravitational Force	16	40%	10	25%	14	35%
2	Force						
	Newton's Law	20	50%	17	42.50%	3	7.50%
	Acceleration	10	25%	26	65%	4	10%
	Types of Force	12	30%	20	50%	8	20%

Table 2. Total Number and Students having Misconceptions in Gravity and Force (PreTest)

Sl. No.	Topic or Concept	Total and Percentage (%) of Students Having Misconceptions					
		Misconception		Did not understand		Understood	
		No. of Students	Percentage	No. of Students	Percentage	No. of Students	Percentage
1	Gravity						
	Weight (Formula and Unit)	3	7.50%	7	17.50%	30	75%
	Factors Affecting Gravitational Force	4	10%	7	17.50%	29	72.50%
2	Force						
	Newton's Law	3	7.50%	5	12.50%	32	80%
	Acceleration	4	10%	14	35%	22	55%
	Types of Force	6	15%	10	25%	24	50%

Table 3. Total Number and Students having Misconceptions in Gravity and Force (Post-Test)

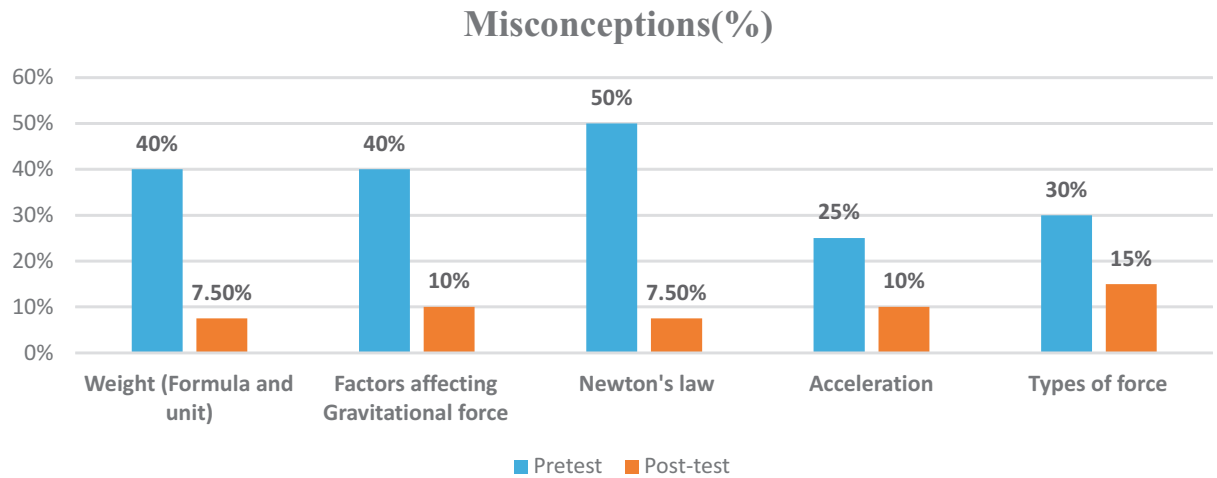

Figure 1. Students' Misconception before (Pre-Test) and After (Post-Test) Intervention

	Mean	N	Std. Deviation	Std. Error Mean
Pair 1 Pre-Test	18.4600	5	11.94313	5.34113
Post-Test	72.2840	5	11.06911	4.95026

Paired Samples Statistics

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-Tailed)
Pair 1 Pre-Test, Post-Test	-53.824	14.1472	6.32680	-71.390	-36.26	-8.507	4	.001

Paired Samples Test

Table 4. Two Samples Paired T-Test with Two Tailed

intervention used to address misconceptions is effective, with a post-test mean of 72.2840 and a standard deviation of 11.06911. Whereas the students' understanding of topics before intervention was with a mean of 18.4600 and a standard deviation of 11.94313. Further, the p-value of 0.001 (p-value < 0.005) confirmed the difference in performances of students is statistically significant with intervention.

7. Discussion

The main findings are discussed in relation to the research questions.

7.1 What are Some of the Prevailing Common Misconceptions of Ninth Standard Students in the Topics 'Gravity and Force'?

This study revealed ninth standard students do have misconceptions on the topics 'Gravity and Force' as apparent in data obtained from two-tier tests (pretest). There are as many as 20 students (50%) with misconceptions on the topic of Newton's law, as shown in Table 1.

This study reported 20 students (50%) have common misconceptions that 'a body moving with a constant speed along a straight-line path does not require force to increase its speed'.

The finding complements the study done by Kaniawati et al. (2019) on 30 students of senior high school in Bandung, Indonesia. They found 53% of students had the misconception that an object moving at constant velocity on a slippery floor will rest by itself or need to be forced to increase its speed. Furthermore, Liu and Fang

(2016) conducted a study based on 30 journals, and numerous conference proceedings revealed similar findings.

The study even revealed there are 16 students (40%) having misconceptions on the sub-topics, namely weight and factors affecting gravitational force, respectively. These two sub-topics, namely weight and factors affecting gravitational force, are under the topic 'Gravity'.

Further, the study revealed 16 (40%) students have common misconceptions that 'if a feather and coin are dropped from the same height in the air, both of them will reach the ground at the same time'. This finding is in line with a study carried out by Mushthofa et al. (2020) on the misconception profile of Newton's law concept using the Certainty of Response Index (CRI). They found 33.33% of students have the misconception that heavier objects will fall faster than lighter objects in the absence of air resistance. Similarly, Dognia and Dah (2023) found 37.2% of students believe that heavier objects fall faster than lighter objects in the absence of air resistance.

Hence, this study indicates the common misconceptions on gravity and force are that 'a body moving with a constant speed along a straight-line path does not require force to increase its speed' and 'if a feather and coin are dropped from the same height in the air, both of them will reach the ground at the same time in the presence of air resistance.'

7.2 How Effective is this Intervention in Improving Student Understanding and Performance in Physics?

The teaching-learning strategy used as an invention for addressing this is a flipped classroom infused with a cooperative learning strategy. The data findings confirm there is significant improvement in addressing ninth standard students' misconceptions on the topics 'Gravity and Force'.

This study revealed that after invention for three weeks, students' misconceptions on the topic 'Gravity' decreased significantly from 40% (average) of students to 8.75% (average) of students, and students' misconceptions on the topic 'Force' decreased 35% (average) to 10.83% (average). Further, the study reported students understanding of the concepts of the topic 'Gravity' increased significantly from 31.25% (average) to 73.75% (average), and students understanding of the concepts under the topic 'Force' significantly increased from 12.5% (average) to 61.67% (average).

The two samples paired t-test (two-tailed) with a p-value of 0.001 (p-value $<$ 0.05) asserts there are significant differences in pretest and post-test marks on ninth standard students' misconceptions on the topics. This supports the flipped classroom infused with cooperative learning strategy as intervention to address misconceptions on the topic 'Gravity and Force' is efficient, and consequently it will improve overall performance in physics among ninth-grade students.

The findings of this study complement the study carried out by Kibirige and Mamashela (2022) on high school students' misconceptions about force using a flipped classroom. The study reported there is significant improvement in students' understanding of the concepts in the topic 'Force'. The data from their study revealed that students taught with a flipped classroom scored with mean marks of 19.66 (standard deviation of 11.06), which is significantly higher than students taught with a traditional method scoring mean marks of 12.98 (standard deviation of 25.12). The findings suggest that a flipped classroom teaching-learning strategy does minimize misconceptions and improve the performance of students in physics at large.

Similarly, Widodo et al. (2022) using a flipped classroom during the COVID-19 pandemic revealed as many as 69.44% of students had understood the concept correctly, the remaining students did not understand or had misconceptions. The study confirmed the flipped classroom is an efficient strategy to address misconceptions in physics despite the physical absence of the tutor. Moreover, the study carried out by Kuczmann (2023) on the effect of cooperative learning strategies on secondary school physics students' achievement in Ilorin, Kwara State, Nigeria. The study revealed there is a mean gain of 40.61 in the performance of students (experimental group) taught using a cooperative learning

strategy and a mean again of 22.43 in the performance of students (control group) taught using the lecturer method. The results further correlate with the findings of Ho and Boo (2007), who studied cooperative learning: exploring its effectiveness in the physics classroom.

Therefore, in consideration of the effectiveness of a flipped classroom infused with cooperative learning strategies in addressing the common misconceptions and improving overall ninth standard students' performance in physics, the physics teachers need to use strategy to the maximum or also opt for better alternate strategies instead of the traditional or lecture method.

Conclusion

This study is aimed to identify and overcome common misconceptions on the topics 'Gravity and Force' of ninth standard students of Khuruthang middle secondary school in Punakha district, and this should not be generalized as findings from other schools in Bhutan. This study is the first of its kind carried out in a Bhutanese context to identify common misconceptions in the topics 'Gravity and Force' and overcome them using a flipped classroom infused with a cooperative learning strategy as an intervention. The identification of common misconceptions on the topics was done using two-tier diagnostic tests, and it was conducted twice, i.e., before and after intervention, namely, pretest and post-test.

The findings from this study revealed there are some common misconceptions in ninth grade students in the physics topics, and it was evident from the data collected using a two-tier t-test (pretest). The use of a flipped classroom infused with cooperative learning was found efficient to overcome the prevalent misconceptions among students, and it engaged each and every student in the learning process. As a result of overcoming misconceptions, the significant improvement in understanding concepts was evident in marks scored in the post-test.

The identification and overcoming of misconceptions in students of various grades and in every subject is of paramount importance. If identification and overcoming of misconceptions is not done timely, students will carry it throughout their lives, and there is possibility of passing it to younger ones. The use of two-tier tests is considered effective in identifying misconceptions, and the implementation of a flipped classroom infused with a cooperative learning strategy has significantly improved students' understanding of physics concepts, leading to enhanced performance in physics.

This study has limitations that affect the quality of the research. The research team could not include a qualitative study to support the findings, and the study was solely based on quantitative data collected. For future research, researchers could use the convergent parallel mixed method for in-depth study of the same topic. The findings of this study are expected to benefit both teachers and students in the teaching and learning of physics and other subjects.

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