Educational Innovation and Practice
Vol. 12 (1), February 2026, 66-88
DOI:10.17102/eip.12.2026.04

ISSN 2790-6310 (Print)
ISSN 2790-6329 (Online)

Misconceptions in Newtonian Mechanics: Diagnostic Findings and Contributing Factors

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Abstract

Newtonian Mechanics forms the foundational concepts of physics and serves as the basis for understanding force and motion. Yet, many students continue to struggle with the concepts of Newtonian Mechanics. This study aimed to identify prevalent misconceptions among grade IX students using a sequential explanatory mixed-methods design. A Four-Tier Diagnostic Test with a Certainty of Response Index (CRI) was administered to detect misconceptions, followed by a survey and focus group interviews to examine the contributing factors. A total of 461 students from seven Bhutanese secondary schools participated in the study. Findings revealed that misconceptions persist across specific aspects of Newtonian Mechanics due to limited conceptual understanding, difficulty in relating the concepts to real-world contexts and poor mathematical reasoning. Curriculum design and structure were found to be logical and supportive, but other factors, including pedagogical approaches, students' attitudes and engagement, competency, and resource utilisation and constraints, contributed to the persistence of misconceptions. The study recommends that teachers be provided with training on effective strategies integrating digital tools to address misconceptions in Newtonian Mechanics, and that schools invest in experimental kits and devices to support students' understanding of complex concepts.

Keywords: Conceptual understanding, misconception, Newtonian Mechanics, pedagogical approaches

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Introduction

Science education in Bhutan starts with general science in lower grades, which is bifurcated into three separate subjects: Biology, Chemistry, and Physics, in higher grades. Physics is a compulsory subject for school students opting for the biological or physical science stream. At the university level, this course is compulsory for students in the first and second years of biological science, while it remains a required component throughout engineering programmes. It is widely regarded as a critical subject that helps learners understand the physical world and the foundations of modern technological advancement (Wangchuk et al., 2023).

Given the important role physics plays in school and university science education and its relevance to students' future professional lives, a good performance is required. However, there are reports of schools across several countries performing poorly in physics (Huzaima & Living, 2025; Orowole, 2025; Wangchuk et al., 2023). Studies indicate that the poor performance is due to difficulty stemming from the abstract nature of the subject (Wangchuk et al., 2023), which contributes to students' poor performance (Dorji, 2022). Gönen (2008) has highlighted the challenge posed by the abstract nature of the concepts, which tends to result in misconceptions. Additionally, Chen et al. (2020) reported that misconceptions in subject matter significantly impact students' learning, ultimately leading to poor academic performance. Thus, this study investigated misconceptions in Newtonian Mechanics and their possible contributing factors, concentrating on Bhutanese secondary schools. Newtonian Mechanics was chosen because it comprises foundational physics concepts, such as force and motion.

The Bhutanese physics curriculum in schools starting from grade IX onwards consists of five broad themes: Newtonian Mechanics, Fluid Mechanics and Thermal Physics, Electricity and Magnetism, Waves and Optics, and Atomic, Nuclear and Space Physics. Newtonian Mechanics is accorded one of the highest total weightages of 23% in grade IX and is further subdivided into Force and Acceleration, and Newton's Laws of Motion. Further, Chetri (2022) reported that the complexities of Newtonian mechanics, combined with abstract concepts and limited time for classroom experiments, pose challenges for students in understanding the subject. Additionally, based on the researchers' many years of experience teaching physics in Bhutan, Newtonian mechanics is consistently associated with a wide range of difficulties, particularly in topics related to 'Force and Acceleration' and 'Newton's Laws of Motion.' These difficulties are associated with misconceptions on topics, such as kinematics, action-reaction pairs and the frame of reference. Newtonian mechanics is a key topic that students study not only in grade IX but also in higher grades. If the misconceptions they develop in grade IX are not addressed, their understanding of physics concepts may be affected, causing them to carry misunderstandings into later studies.

Thus, this research aimed to explore commonly held misconceptions in Newtonian Mechanics and the factors that lead to these misconceptions.

Literature Review

Newtonian Mechanics deals with forces and its effects, including concepts of Force and Acceleration, and Newton's Laws of Motion. Though it is considered the foundation of physics, it has been a subject of a myriad of misconceptions among learners that challenge acquisition and application into real situations (Ergin, 2016; Isra & Mufit, 2023; Kaniawati et al., 2019; Rusilowati et al., 2021). According to Resbiantoro et al. (2022), a misconception is defined as the difference between students' ideas and scientific conceptions. For instance, in physics, acceleration is explained as the rate of change of velocity with time. However, Liu and Fang (2016) reported that high school students tend to understand acceleration as increasing force and often ignore acceleration when velocity changes. Furthermore, students are confused between force and acceleration, force and mass, acceleration and velocity, force and energy, and gravitational force. A similar study by Daud et al. (2015) reported students' misconceptions related to force and motion, velocity and acceleration, gravity and free fall, and graphical representations in kinematics. Additionally, students find it difficult to connect the basic features of a graph to velocity, acceleration, and displacement (Erceg & Aviani, 2014).

The literature identifies several causes of misconceptions, with complexity of concept (Gafoor & Akhilesh, 2008) and abstract nature (Gönen, 2008; Graham et al., 2013) of physics often cited as the main factors leading to students' misconceptions. Besides, misconceptions arise from students' difficulty in comprehending an idea (Manunure et al., 2020), incomplete understanding (Liu & Fang, 2016), connecting a new concept with existing ideas (Suprapto, 2020), and poor analytical abilities (Syuhendri, 2018). Yin et al. (2008) indicated that students' misconceptions are also due to their preconceived notions about the natural world that have been influenced by textbooks, teachers' explanations, or everyday language. Likewise, Neidorf et al. (2020) asserted that misconceptions arise when students' beliefs are inconsistent with scientific facts and explanations. Once the beliefs are formed, they are hard to alter since they differ from the beliefs advanced by experts (Halim & Lestari, 2019). However, the use of student-centred pedagogy has been shown to improve conceptual understanding of complex physics concepts by promoting active engagement and knowledge construction (Assem et al., 2023; Gönen, 2008; Syuhendri, 2018). By using real-world applications and experiences, students may visualise abstract ideas (Shrestha et al., 2023). Therefore, in order to minimise misconceptions and improve comprehension, it is critical to employ strategies such as experimentation, discussion, and contextual learning (Puspitasari & Mufit, 2021). Discussion, feedback, and peer collaboration facilitate conceptual change (Alemu, 2020; Antwi et al., 2016; Bozzi et al., 2021), while the use of local resources improves conceptual comprehension (Abaniel, 2021).

If misconceptions are not corrected at an early stage, the students will carry these false points into their later lives (Korur, 2015). Assem et al. (2023) also stated that misconceptions are one of the factors leading to students' poor academic performance in physics. Consequently, it becomes important for teachers to diagnose students' prevalent misconceptions in topics, such as acceleration, kinematics, energy conservation, superposition force, action-reaction, and free fall, arising due to students' limited knowledge and understanding. These misconceptions primarily stem from the abstract nature of these concepts (Gönen, 2008; Syuhendri, 2018), hindering students from grasping more advanced physics concepts even at the university level (Daud et al., 2015).

Research Questions

Main Question
What are the prevailing misconceptions in Newtonian Mechanics held by grade IX students?
Sub-questions
This question will be addressed by synthesising findings from the following sub-questions:

(1) What specific aspects of Force and Acceleration are commonly misunderstood by students?
(2) What specific aspects of Newton's Laws of Motion are commonly misunderstood by students?
(3) What are the factors that contribute to the misconceptions in learning Newtonian Mechanics?

Methodology
Research Design

This study chose pragmatism as a research paradigm as it allows for the blending of paradigms, premises, techniques, and procedures for data collection and analysis as outlined by Creswell and Creswell (2018). A sequential explanatory mixed method was adopted for the study, with the collection and analysis of quantitative data followed by the collection and analysis of qualitative data (Creswell, 2022). A Four-Tier Diagnostic Test was implemented in the schools to identify prevailing misconceptions in Newtonian Mechanics. This was followed by a survey and then interviews to find the factors leading to the misconceptions.

Sample

The study included grade IX students from seven secondary schools in Bhutan. These students were chosen because the basic concepts of force, acceleration and motion are introduced to students in lower grades, while Newtonian Mechanics, focusing on Force and Acceleration, and Newton's Laws of Motion are introduced only in grade IX only. A total of 461 students participated in the Four-Tier Diagnostic Test and a survey. For the focus group interviews, 24 students with equal gender representation from six schools took part.

Ethical Consideration

Before conducting data collection (test, survey and interviews), consent was sought from all the seven schools' students of grade IX studying physics. They were verbally informed about the purpose of the study and their right to withdraw from the study at any point during the data collection period. They were also informed that pseudonyms will be used instead of their identity in this paper, and school names will not be used. Pseudonyms were assigned to maintain student-participant anonymity. For example, FG23 denotes the third student in the focus group of School 2, FG42 refers to the second student in the focus group of School 4, and FG14 represents the fourth student in the focus group of School 1.

Data Collection

The Four-Tier Diagnostic Test consisted of 14 questions from Newtonian Mechanics. The test questions were pilot tested in one school that was not part of the main study schools. A total of 26 students participated. Interpretation of the difficulty index and discrimination index for each test item was guided by Tox (2022). The results indicated that all items ranged from average to very difficult. However, the discrimination indices for four items were found to be poor. All items were revised accordingly for implementation.

To investigate participants' views on factors leading to misconceptions, a survey with a five-point Likert scale was implemented. The survey instrument was constructed based on understanding drawn from relevant literature (Abaniel, 2021; Assem et al., 2023; Baafi, 2020; Daud et al., 2015; Ergin, 2016; Gafoor & Akhilesh, 2008). Six key factors were identified: i) Pedagogical approaches consisting of eight items; ii) Students' attitudes towards the subject consisting of eight items; iii) Curriculum design and structure consisting of six items; iv) Students' perception and engagement consisting of six items; v) Students’ competency consisting of nine items; and vi) Resources utilisation and constraints consisting of seven items.

After the survey analysis, semi-structured focus group interviews were conducted. Focus groups were chosen so students involved in this study feel more at ease in expressing their opinions within a small group (McLeod, 2014). A total of 24 students with equal gender representation from six schools participated. One school did not take part due to a scheduling conflict with other school activities. Each focus group session lasted approximately one and a half hours.

Data Analysis Procedures

For the Four-Tier Diagnostic Test analysis, the data obtained from the second-tier level and fourth-tier level were categorised by mapping students’ confidence level as high or low using the CRI Confidence rating scale of Diani et al. (2019) as shown in Table 1. The data were then interpreted by mapping students’ conceptual understanding under the criteria: understand, not understand, and misconception, using the interpretation of Fariyani et al. (2017) as shown in Table 2.

Table 1

Certainty of Response Index Confidence Rate Scale

Category	Scale	Confidence level
Guessing	0	
Very Unconfident	1	Low
Unconfident	2	
Confident	3	
Very Confident	4	High
Highly Confident	5	

Table 2

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Interpretation of Four-Tier Diagnostic Test Results

Tier 1 Answer	Tier 2 Confidence	Tier 3- Reasons	Tier 4 -Level of Confidence	Criteria
Correct	high	correct	high	Understand
Correct	low	correct	low	Not Understand
Correct	high	correct	low	
Correct	low	correct	high	
Correct	low	wrong	low	
Wrong	low	correct	low	
Wrong	low	wrong	low	
Correct	high	wrong	low	
Wrong	low	correct	high	
Correct	low	wrong	high	Misconception
Correct	high	wrong	High	
Wrong	high	correct	low	
Wrong	high	correct	High	
Wrong	high	wrong	Low	
Wrong	low	wrong	High	
Wrong	high	wrong	High	

Descriptive statistical analysis was conducted on survey data to determine mean values and standard deviations. The mean interpretation was adapted from Bringula et al. (2012) as given in Table 3.

Table 3

Mean Interpretation

Means scores	Level of interpretation
1.00 — 1.50	Very low
1.51 — 2.50	Low
2.51 — 3.50	Moderate
3.51 — 4.50	High
4.51 — 5.00	Very high

The interviews were transcribed verbatim and analysed along the survey themes.

Results

The findings are presented in the following sequence: first, misconceptions held by students, followed by factors contributing to those misconceptions.

Misconceptions in Newtonian Mechanics

Since the school text covered two areas of Newtonian Mechanics: Force and Acceleration, and Newton's Laws of Motion, the misconceptions were studied around the specific aspects covered.

Force and Acceleration. The specific aspects covered on this topic include the graphical representation of distance–time and velocity–time graphs, and the equations of linear motion. The results of the Four-Tier Diagnostic Test with CRI on the misconceptions held by students are presented in Table 4.

Table 4

Percentage of Students Having Misconceptions in Force and Acceleration

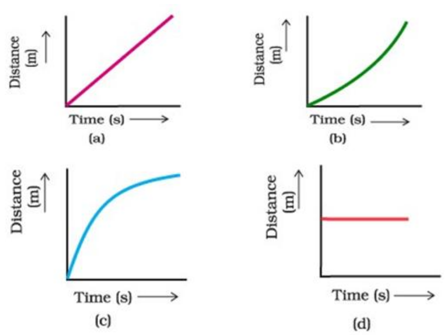
Item	Misconceptions	Not Understand	Understand
Which of the following options represents the distance-time graph of a stationary object? 	60.74%	13.88%	25.38%
If the velocity-time graph of an object is a straight line with a positive slope, what can you infer about the object's motion and acceleration?	59.22%	13.88 %	26.90%
If a car is initially at rest and accelerates uniformly at 2 m/s² to 22 m/s² for 5 seconds, what is the final velocity?	34.92%	26.90%	38.18%

Table 4 indicates that students had misconceptions in both graphical representation and linear motion concepts in Force and Acceleration. The highest misconceptions were observed on the graphical representation of distance–time and velocity–time graphs, indicating students' difficulty in interpreting visual graphs. On the Linear motion concept, students were required to solve a direct question (third question in Table 4) using a known formula with little analysis. While slightly over one-third of students were able to solve the problem, showing their understanding, an almost equal number demonstrated misconceptions reflecting incomplete understanding of the concept.

Overall, students displayed misconceptions in both graphical representation and linear motion concepts, which suggests incomplete conceptual comprehension.

Newton's Laws of Motion. The results of the Four-Tier Diagnostic Test with CRI on Newton's Laws of Motion are presented in Table 5.

Table 5

Percentage of Students Having Misconceptions in Newton's Laws of Motion

Newton's First Law of Motion

Item	Misconceptions	Not Understand	Understand
In the absence of external forces, an object at rest will…	60.09%	19.3%	20.61%
If an object is moving with a constant velocity, what can be said about its acceleration?	50.98%	16.48%	32.54%
According to Newton's First Law, what happens to the motion of an object when the net force acting on it is zero?	69.20%	15.62%	15.18%
According to Newton's First law, how does the concept of inertia relate to the motion of an object?	63.99%	23.86%	12.15%
A person sitting in a bus fall back when a bus suddenly moves forward. This is due to….	58.13%	18.66%	23.21%

Newton's Second Law of Motion

Item	Misconceptions	Not Understand	Understand

"*Momentum is the product of an object's mass and velocity.”* From the given statement, how does the relationship between an object's mass and velocity contribute to its momentum?	37.31%	16.27%	46.42%
Choose the statement that correctly describes the conservation of momentum in a collision. A. The total momentum of a system of objects is always conserved. B. Momentum is only conserved in elastic collisions. C. Momentum is conserved only if the objects are at rest. D. Momentum is conserved only if the objects have the same mass.	60.52%	18%	21.48%
If you push a box with a force of 20 *N* to the right and another person pushes it with a force of 15 *N* to the left, what is the net force on the box?	37.31%	23.21%	39.48%
If the force (F) acting on an object is doubled, and its mass (m) is constant, how does the acceleration (a) change according to Newton's Second Law?	52.28%	24.94%	22.78%
Dorji is driving a car of mass 1000 *kg* to Thimphu. Suddenly, he applies the brakes, and the car experiences a negative acceleration of –2 $\lvert -2\ ms^{-2}$ $\lvert ms^{-2}$ m/s^2. What is the resulting force experienced by the car?	45.77%	24.95%	29.28%
Newton’s Third Law of Motion			
Item	Misconceptions	Not Understand	Understand
When a person walks on the floor, which direction is the force applied by the person to move forward?	68.76%	21.48%	9.76%

Table 5 shows that students had misconceptions across all three Laws of Motion. In the First Law, the highest misconception was observed, in relating motion of the body with unbalanced force and understanding the concept of inertia of motion, which indicated students' difficulty in achieving clear conceptual clarity. The lowest misconception was in visualising how an object keeps moving in constant velocity when there was no external force, showing the challenges of visualising and interpreting data.

In the Second Law, the highest misconception was observed in applying the principle of conservation of momentum to a system of colliding objects, which showed weak conceptual understanding of momentum. This was followed by solving numerical problems when conditions were set for two variables (mass is kept constant and force is doubled) in the formula F = ma and rearranging the equation to find acceleration. Nearly half of the students failed to extract the key information from numerical questions, which were analytical in nature, and represent them mathematically. Misconceptions were also evident in solving problems involving negative acceleration. This highlighted students' poor mathematical computing knowledge and skills. The lowest percentages were observed in the third item, which required students to carry out direct calculation and the first item, which asked students to recall the definition of momentum. This indicated that students had fewer misconceptions when questions were direct and factual.

In the Third Law, nearly 70% of students demonstrated misconceptions in applying concepts of the law to daily life. This indicated that the students were not able to understand the concept of action- reaction in real-world contexts.

Overall, the students displayed misconceptions in applying the concepts of inertia, momentum, and force and motion in daily life and in solving numerical questions requiring analytical thinking. A lower percentage of students' misconceptions was seen in questions that were factual, such as definitions and direct substitution of numerical questions.

Factors Leading to Misconceptions

The findings on six factors contributing to misconceptions in learning Newtonian Mechanics are presented below.

Pedagogical approaches. The survey analysis on pedagogical approaches is shown in Table 6.

Table 6

Teachers' Use of Pedagogical Approaches

Item	Mean	SD	Interpretation
My teacher focuses on practical applications of concepts in understanding Newtonian Mechanics.	3.75	0.82	High

My teacher effectively uses different teaching approaches in teaching Newtonian Mechanics, which facilitates my learning.	3.78	0.77	High
My teacher creates a positive classroom atmosphere which enhances my learning of Newtonian Mechanics.	3.85	0.78	High
My teacher actively engages me to participate in Newtonian Mechanics class.	3.86	0.79	High
My teacher's instructions in Newtonian Mechanics are clear and easy to understand.	3.86	0.79	High
My teacher uses interactive methods to explain concepts in Newtonian Mechanics.	3.87	0.73	High
My teacher is approachable and open to questions in Newtonian Mechanics class.	3.88	0.76	High
My teacher provides constructive feedback and communicates well about my progress in Newtonian Mechanics.	3.78	0.79	High
Average	**3.83**	**0.78**	**High**

Table 6 shows that students had a high positive perception towards their teachers' use of teaching approaches. The moderate SD suggests some variability existed among students' responses. The high ratings indicate that effective pedagogical strategies are essential in enhancing student comprehension and minimising misunderstandings in Newtonian Mechanics. While the survey findings point to teachers using varied approaches, many students (FG24, FG43, FG44, FG64) suggested incorporating experiments, activities, practical life experiences, videos, group discussion and presentation as it helped make the concepts clearer and minimise misconceptions. Students also shared their preference for interactive lecture methods using digital tools. For instance, FG43 shared that the availability of a Smart TV in the classroom could be used to watch videos to enhance understanding of the teacher's lesson.

The results indicated that, though teachers use varied pedagogical approaches, students would like them to use more active learning approaches supported by digital tools to enhance students' understanding and engagement in learning Newtonian Mechanics.

Students' Attitude Towards Newtonian Mechanics. Students' attitudes towards learning Newtonian Mechanics were studied by assessing their confidence and understanding of key concepts related to the subject. Survey data analysis on this theme is presented in Table 7.

Table 7

Attitude Towards Newtonian Mechanics

Item	Mean	SD	Interpretation
I feel confident in applying Newton's Laws of Motion to solve physics problems.	3.78	0.81	High
Newtonian Mechanics is relevant to real-world phenomena.	3.92	0.81	High
I find the concepts of balanced and unbalanced forces in Newtonian Mechanics thought provoking and relevant to real-world scenarios.	3.87	0.74	High
I can interpret distance-time and velocity-time graphs, which are crucial for understanding Newtonian Mechanics concepts.	3.79	0.69	High
I can solve numerical problems related to linear equations from Newtonian Mechanics.	3.56	0.78	High
I can draw a relationship between the net force, mass, and acceleration by performing experiments.	3.61	0.73	High
I can explain the conservation of momentum.	3.78	0.77	High
I can explain how the momentum of a body depends on mass and velocity.	3.86	0.74	High
Average	**3.77**	**0.76**	**High**

Table 7 shows students' strong confidence and positive engagement in the subject, indicating their ability to apply key concepts of Newtonian Mechanics. In the interviews, students expressed a strong interest in Newton's Laws of Motion due to their real-life applications. For example, FG51 shared, 'I find Newton's Three Laws fascinating because we did practical activities and applied these laws to daily life.' However, nearly half of the students reported difficulties in solving numerical problems. A student, FG14 said, 'Solving equations of linear motion is very difficult because there are many variables to substitute, leaving us unsure about which formula to use.' This was echoed by FG41. Students also expressed other challenges, such as conceptual understanding of momentum and equations of linear motion (FG22; FG23) and interpreting velocity-time graphs (FG52). To overcome these challenges, many students expressed relying on peers, teachers, or textbooks. For instance, Student FG21 shared, 'There are many formulae and laws that confuse me, so I often ask my teacher and friends for help and refer to textbooks for better understanding.' They also made use of websites for additional support with FG53 commenting, 'When we can't solve these numerical problems, I seek help from teachers or sometimes refer to the internet, which is very helpful for learning.'

The results indicated that students are highly engaged and interested in Newtonian Mechanics, but face difficulties with numerical problem-solving, prompting them to actively seek support and resources to enhance their understanding.

Curriculum design and structure. This theme focused on evaluating how well the contents of Newtonian Mechanics are organised and its effectiveness in supporting student learning. The survey analysis is presented in Table 8.

Table 8

Curriculum Design and Structure

Item	Mean	SD	Interpretation
The contents of Newtonian Mechanics are logically sequenced and structured in a coherent manner.	3.55	0.71	High
The contents of Newtonian Mechanics are applicable and relevant to real-life situations.	3.89	0.72	High
The contents of Newtonian Mechanics provide opportunities for hands-on learning activities and experiments.	3.82	0.66	High
The contents of Newtonian Mechanics cater to my learning needs.	3.75	0.63	High
The contents of Newtonian Mechanics support fostering students' engagement and collaboration within students and between teachers and students.	3.83	0.68	High
The reading materials on Newtonian Mechanics provided by my teachers are easy to understand the concepts.	3.85	0.72	High
Average	**3.78**	**0.69**	**High**

Table 8 shows that students were appreciative of the design and structure of the curriculum. The SD reflects relatively consistent perceptions among students. Interview data aligned with survey findings, with students noting that the topics in Newtonian Mechanics are coherently arranged and easy to understand. For example, FG14 said, 'The topics in Newtonian Mechanics are arranged logically, which helps me understand them easily.'

The findings suggested that a well-structured, relevant, and logically sequenced curriculum enhances students' understanding, engagement, and ability to connect concepts to real-world contexts.

Students' Perception and Engagement. The theme examined how students viewed their understanding and interaction with Newtonian Mechanics concepts. The findings are shown in Table 9.

Table 9

Students' Perception and Engagement

Item	Mean	SD	Interpretation
I find Newtonian Mechanics concepts challenging to grasp due to their abstract nature.	3.42	0.72	Moderate

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I can connect theoretical concepts in Newtonian Mechanics to real-world applications, which enhances my understanding.	3.71	0.72	High
I feel motivated to explore Newtonian Mechanics beyond the classroom environment.	3.75	0.72	High
I find it difficult to understand abstract concepts of Newtonian Mechanics, which hinders my engagement in the subject.	3.32	0.81	Moderate
I believe incorporating real-world examples in Newtonian Mechanics lessons would improve my interest and understanding.	3.76	0.70	High
I seek help from my friends to clear some concepts from the Newtonian Mechanics.	4.03	0.79	High
Average	**3.67**	**0.74**	**High**

Table 9 shows that some abstract concepts are difficult to understand, leading to students' limited engagement. Peer support is a significant mechanism used by students to enhance understanding of concepts (*M* = 4.03). Interviews reinforced these findings, where the use of real-world examples was highlighted. For example, FG33 shared, 'I explain Newtonian Mechanics concepts to my friends with ease. The real-world examples make them simple to explain.' Other students further shared their preference for the use of real-world examples in learning. A student, FG21, stated, 'Incorporating more real-world examples in Newtonian Mechanics increases my understanding of Newton's laws.' This is supported by FG51, who remarked, 'Seeing is believing,' emphasising the importance of practical examples in enhancing comprehension.' But competency in language could hinder peer support. Student FG11 shared difficulties in using the right vocabulary, 'I've tried explaining concepts to friends but face difficulties finding the right words.'

Students' Competency. Students' competency is centred on their understanding and application of Newtonian Mechanics concepts, along with their approach to problem-solving and responding to feedback. The survey findings are presented in Table 10.

Table 10

Students' Competency

Item	Mean	SD	Interpretation
I have a clear understanding of Newtonian Mechanics.	3.58	0.78	High
I can effectively solve problems related to Newtonian Mechanics.	3.58	0.71	High
I can verbally explain concepts related to Newtonian Mechanics clearly.	3.53	0.66	High
I consistently use appropriate formulae and equations in problem-solving	3.64	0.69	High
I consistently follow instructions during scientific experiments or activities.	3.72	0.69	High

I display curiosity and interest in understanding Newtonian Mechanics	3.70	0.69	High
I am persistent in solving challenging problems related to Newtonian Mechanics.	3.53	0.66	High
I am receptive to feedback on my understanding and application of Newtonian Mechanics.	3.66	0.65	High
I am proficient in utilising ICT tools for the plotting and analysing graphs.	3.48	0.75	Moderate
Average	**3.60**	**0.70**	**High**

Students demonstrated a high level of competency in understanding and application of Newtonian Mechanics concepts, problem-solving abilities, and responsiveness to feedback. However, their proficiency in utilising ICT tools for plotting and analysing graphs was rated moderately, highlighting room for improvement (Table 10). The average SD indicates a slight variation in responses. In the interviews, students acknowledged the value of constructive feedback provided by teachers on their work in enhancing their understanding of Newtonian Mechanics. For instance, FG14 noted, 'Receiving feedback on my homework helps me learn. Negative feedback allows me to correct mistakes, leading to improvement, while positive feedback boosts my interest in learning new concepts beyond the textbook." On the use of technology, except for FG42, others reported that they do not use technology for plotting graphs in Newtonian Mechanics. The interview data on problem solving is already presented in the earlier theme on Students' Attitude towards Newtonian Mechanics.

The result suggested strong competency in core physics skills but highlighted the need for greater support in technology-based applications.

Resource Utilisation and Constraints. The theme focused on assessing the availability and effectiveness of resources in supporting students' learning and engagement with Newtonian Mechanics. The survey analysis is presented in Table 11.

Table 11

Resource Utilisation and Constraint

Item	Mean	SD	Interpretation
Adequate resources are available for conducting experiments in Newtonian Mechanics.	3.42	0.75	Moderate
Sufficient time is allocated for engaging in different activities within the Newtonian Mechanics.	3.53	0.68	High
Hands-on experiments and practical demonstrations of Newtonian Mechanics are conducted in the class or labs.	3.67	0.81	High
ICT facilities are accessible for carrying out activities in Newtonian Mechanics.	3.64	0.83	High
ICT tools are useful in plotting and analysis of graphs in Newtonian Mechanics.	3.69	0.80	High

Resources allocated for learning Newtonian Mechanics are effectively utilised.	3.64	0.61	High
Textbooks and other reading materials are available for learning Newtonian Mechanics.	3.89	0.74	High
Average	**3.64**	**0.75**	**High**

Table 11 indicates that most resources are accessible and utilised by students. However, the availability of adequate resources for conducting experiments was rated moderately, suggesting room for improvement in this area. Similarly, interviews showed that while students had easy access to prescribed textbooks and teachers' notes, they had minimal access to devices, relying mostly on teachers to present key content through projectors and smart TVs, which served as the primary means for accessing educational videos, websites, and other online resources. For instance, FG53 shared,

> In Newtonian Mechanics, we learn to plot graphs using various technologies, such as projectors and smart TVs. However, students are not allowed to use smartphones, so we rely on projectors, where teachers present lessons through YouTube videos, websites, and other online resources.

The classroom environment significantly influenced students' ability to focus and learn. Issues such as overcrowding, noise, weather conditions, and inattentive peers were noted as distractions. For example, FG41 remarked, "When my seat partner is sleeping, I also feel drowsy, which reduces my capacity to learn."

The findings reflected that while some basic resources are accessible and utilised effectively, there is still a need for further enhancement in some areas, particularly in experiment-related resources. The need for access to devices to support learning is highlighted.

Discussion

Prevailing Misconceptions in Newtonian Mechanics

On Force and Acceleration, misconceptions exist in graphical representation of motion and Linear motion. In the graphical representation of motion, the misconceptions were more prevalent in distance-time and velocity-time graphs, suggesting a gap in students' ability to interpret and understand motion through visual data. This aligns with Daud et al. (2015), who reported students' difficulty in distinguishing displacement-time, velocity-time, and acceleration-time graphs due to their similar shapes. Further, Erceg and Aviani (2014) explained that students' difficulties arose due to difficulty in connecting basic features of the graph, such as 'height, slope, area under the graph to the corresponding physical quantity like velocity, acceleration, displacement' (p.61). They also reported students' inability to visualise the actual motion on the basis of the graph representation. In linear motion, students were required to apply known equations to solve direct questions requiring minimal analysis. The study observed that students still had misconceptions, although fewer compared to graphical representation. This indicated their incomplete understanding of concepts. A similar finding was reported by Nuraeni (2025) in her study with the physics education students on Linear motion.

On Newton's Laws of Motion, misconceptions were evident across all three laws of motion. On the First Law, misconceptions existed in establishing the relationship between force and velocity, and applying the conceptual understanding of inertia of rest and motion to everyday experiences. These findings align with other literature (Ergin, 2016; Isra & Mufit, 2023; Kaniawati et al., 2019; Rusilowati et al., 2021), where students failed to connect conceptual understanding of law to real-world applications. Further, Sundaygara et al. (2021) highlighted that students find difficulty in relating how motion of an object keeps moving in constant velocity, mainly because of their everyday experiences. Fewer misconceptions were observed in solving numerical problems that were basic and direct. On the Second Law, misconceptions existed due to students' poor conceptual understanding. They were able to solve factual direct numerical problems but struggled with analytical questions, as found in the First Law. These findings are consistent with those of Turşucu et al. (2020), who reported that high-school students have difficulty in solving problems because of their inability to use algebraic equations, symbols, and mathematical reasoning. Huda et al. (2022) claimed that this is because students are not exposed to real examples while learning Newton's Second Law. For the Third Law, many students were unable to apply concepts of action and reaction to real-world examples. This echoes the findings of Isra and Mufit (2023) that misconceptions in the concepts of action and reaction arise from personal experiences.

Factors Leading to Misconceptions

Pedagogical approaches. The findings highlight the significant role of pedagogical approaches in promoting students' understanding of Newtonian Mechanics and minimising misconceptions. While there was general appreciation of teachers' use of varied teaching approaches, there were strong expressions of need to use student-centric active learning strategies supported by digital tools to enhance learning and engagement. These results mirror Assem et al.'s findings (2023). Further, studies have shown that when teaching strategies focus on clarity, engagement, and practical applications, students are better equipped to grasp complex concepts (Gönen, 2008; Syuhendri, 2018). Therefore, aligning pedagogical methods with students' learning needs and providing comprehensive and engaging learning experiences are essential for addressing misconceptions in Newtonian Mechanics.

Students' attitude towards Newtonian Mechanics. The study found that students have a strong interest in learning Newtonian Mechanics due to its real-life applications. However, students faced challenges in solving numerical problems due to the involvement of numerous variables, often leaving students uncertain about which formulae to use. Other challenges were in understanding concepts due to its complex nature, and in interpreting graphs, which aligns with the findings of Daud et al. (2015). To overcome these challenges, students sought support from peers, teachers, and other resources. Research has shown that peer support can effectively clarify concepts and improve learning outcomes, a practice commonly seen in schools and colleges (Alemu, 2020; Antwi et al., 2016; Bozzi et al., 2021). The findings also align with other literature on scaffolding and support for complex topics in physics (Ergin, 2016; Rusilowati et al., 2021).

Curriculum Design and Structure. Evidence from this study suggests that misconceptions did not arise due to curriculum design and structure. This could be because the National Science Curriculum Framework of Bhutan (Centre for School Curriculum Development [CSCD], 2025), adopts a spiral approach that promotes progressive learning and deeper understanding over time. In addition, the clarity of content and the relevance of the materials support Liu and Fang's (2016) claim that misconceptions can be minimised when students develop an accurate comprehension of the subject matter.

Students' Perception and Engagement. The findings revealed that the abstract nature of some concepts in Newtonian Mechanics made students less engaged, but they used peer support to help understand difficult concepts. The main practice used in peer support was explanation using real-world examples. These patterns aligned with Shrestha et al. (2023), who noted that active engagement and real-world connections can help students better visualise abstract ideas. Puspitasari and Mufit (2021) also suggested using approaches, such as discussion, experimentation, and contextual learning, to reduce misconceptions and enhance comprehension.

Students' Competency. The findings showed students' strong level of competency in understanding concepts, solving basic problems and being receptive to feedback, which are essential for improving performance and deepening their understanding in the subject. Constructive feedback helped students correct misconceptions and motivate them to extend their learning beyond classroom expectations. These findings aligned with previous studies (Rahayu et al., 2022; Worku et al., 2025). However, students' minimal use of ICT tools for graphing and analysing data may hinder their learning progress. This reflects a recurring challenge noted in earlier research, where students frequently encounter difficulties in technical areas, such as graphing and data analysis using digital platforms (Becker et al., 2023; Condon, 2025; Pols et al., 2021).

Resource Utilisation and Constraint. While students have access to key learning resources, such as textbooks and teacher notes, the minimal availability of devices and other resources highlights a gap that needs to be addressed to further enhance learning outcomes. Furthermore, the reliance on teachers for delivering content via projectors and smart TVs, due to limited access to devices, points to a need for more personalised learning opportunities. The study showed the use of local resources, although they were mostly basic. The use of local resources to support students' learning aligns with Abaniel's (2021) assertion that students benefit from open inquiry learning. However, distractions such as overcrowded classrooms, noise, and inattentive peers can be a significant barrier to effective learning, reinforcing Baafi's (2020) findings.

Conclusion

The study highlighted the presence of misconceptions in Newtonian Mechanics, attributed mostly to limited conceptual understanding, difficulty in relating the concepts to real-world contexts and poor mathematical reasoning, especially in analysis and use of formulae. Even in basic and direct problem solving, the percentage of students showing misconception though fewer, was noticeable. These misconceptions, if not attended to, may possibly impede learning more advanced physics concepts in higher grades.

Students' misconceptions in the subject were often intensified by multiple factors. In this study context, the six factors under consideration were pedagogical approaches, students' attitudes towards the subject, curriculum design and structure, students' perception and engagement, students' competency, and resource utilisation and constraints. Out of these six factors, students' misconceptions did not actually arise from curriculum design and structure, as it was generally well-received, with students finding it logical and supportive. Of the other factors, students in general were appreciative of the varied teaching approaches used by their teachers to teach Newtonian Mechanics concepts. However, to support students' learning, student-centred approaches supported by the use of digital tools should be employed to make abstract concepts easier to represent visually. Students' positive attitude towards the subject was due to its real-life applications and knowing that one can draw support from peers and teachers. While students may have required competencies to learn the subject, having access to only basic resources remains a key concern, with certain areas requiring enhanced support, such as incorporating more digital tools. Furthermore, the reliance on teachers for delivering content, due to limited access to devices, points to a need for more personalised learning opportunities. Addressing these challenges through improved pedagogical strategies, resource allocation, and classroom environments could significantly minimise students' misconceptions and enhance learning in Newtonian Mechanics.

This study recommends that the relevant stakeholders of the Ministry of Education and Skills Development (MoESD), to provide professional development for physics teachers focused on implementing effective strategies to address misconceptions in Newtonian Mechanics. Schools are encouraged to invest in experimental kits and devices to support students' understanding of complex concepts, which could be better learnt through hands-on activity, simulation, and videos. Teachers are also encouraged to integrate digital tools to strengthen conceptual learning. Finally, the study suggests future research to explore remedial interventions targeting prevalent misconceptions to enhance students' overall learning in the subject.

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