# Exploring Learners' Conceptual Understanding on Newtonian Mechanics Using The Modified Force Concept Inventory

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*Abstract* — This study explored the conceptual understanding of Grade 8 learners on Newtonian Mechanics using a Modified Force Concept Inventory (FCI) in selected science-oriented high schools in San Carlos City Division, namely Tandoc National High School and Turac National High School . Specifically, it examined students' level of understanding across six conceptual dimensions: kinematics, free-falling objects, Newton's First Law of Motion, Newton's Second Law of Motion, Newton's Third Law of Motion, and identifying forces. A descriptive research design was employed, and data were collected through a 25-item Modified FCI administered to the respondents. The results revealed that the overall level of conceptual understanding among students was low to moderate, indicating the presence of persistent misconceptions in key areas of Newtonian Mechanics. Among the six dimensions, students demonstrated relatively better understanding in kinematics, while significant difficulties were observed in free-falling objects and Newton's Third Law of Motion, where misconceptions such as confusion between force and motion, and action-reaction force pairs, were prevalent. The findings suggest that traditional instructional approaches may not be sufficient in addressing students' alternative conceptions. Hence, the study recommends the use of targeted, concept-based instructional strategies and interactive learning activities to improve students' conceptual understanding. The results of this study may serve as a basis for designing effective teaching interventions in physics education.

***Keywords:* conceptual understanding, Newtonian mechanics, Force Concept Inventory, misconceptions, physics education**

## I. INTRODUCTION

Understanding how learners grasp the fundamental principles of Newtonian mechanics remains a central concern in physics education. Despite years of instruction, many students enter and leave introductory physics courses holding persistent misconceptions about force, motion, and acceleration that conflict with Newtonian theory. These alternative conceptions often hinder problem-solving ability and conceptual transfer, even when students can perform algorithmic calculations correctly.

To systematically assess these conceptual difficulties, the *Force Concept Inventory* (FCI) has been widely used since its development by Hestenes, Wells, and Swackhamer in 1992. The FCI is a research-based, multiple-choice instrument designed to probe students' intuitive understanding of force and motion concepts. However, to address limitations related to language accessibility, cultural context, and item validity for specific learner populations, researchers have developed modified versions of the FCI.

The *Modified Force Concept Inventory* adapts the original items to better align with the linguistic, curricular, and contextual background of learners while preserving the instrument's diagnostic purpose. By using this modified version, educators and researchers can more accurately explore learners' conceptual understanding of Newtonian mechanics, identify common misconceptions, and evaluate the effectiveness of instructional interventions.

This study employs the Modified Force Concept Inventory to examine learners' conceptual frameworks before and after instruction, with the aim of informing teaching strategies that promote a deeper, more scientifically accurate understanding of mechanics.

The descriptive component of the design focused on determining the current levels of conceptual understanding and alternative conceptions among learners in the six dimensions of Newtonian Mechanics (kinematics, free-falling bodies, Newton's First Law, Newton's Second Law, Newton's Third Law, and identifying forces). Descriptive research designs are appropriate when the goal is to "describe, record, analyze, and interpret" current conditions without manipulation of variables, enabling the researcher to understand what exists with respect to the phenomenon under study.

To determine differences in learners' conceptual understanding across the three science-oriented high schools, a comparative design was employed. This allowed for testing whether significant differences exist among groups from different educational contexts.

The developmental component of the research design stemmed from the need to develop and propose learning activities that are grounded in empirical data. Using findings from diagnostic assessments such as the Modified Force Concept Inventory (FCI) allowed the study to identify specific misconceptions and learning gaps, which then informed the creation of targeted instructional strategies. The use of concept inventories like the FCI is well-established in physics education research for identifying conceptual difficulties and guiding instructional improvement.

The development of learning activities in this study is guided by the empirical findings on learners' conceptual understanding. Instead of merely applying instructional methods, the design aligns instructional content with actual learner needs identified through research-based assessment, a strategy consistent with current physics education research paradigms emphasizing data-informed instructional design.

This study aimed to determine the learners' conceptual understanding of Newtonian Mechanics using a Modified Force Concept Inventory (FCI) among Grade 8 learners of science-oriented high schools in San Carlos City, Pangasinan, namely: Tandoc National High School and Turac National High School.

Specifically, it sought to answer the following questions:

1. What is the level of understanding of the respondents in the six conceptual dimensions of Newtonian Mechanics:

   a. Kinematics

   b. Free-Falling Bodies

   c. Newton's First Law

   d. Newton's Second Law

   e. Newton's Third Law

   f. Identifying Forces?

2. What are the alternative conceptions of the respondents in the six conceptual dimensions of Newtonian Mechanics:

   a. Kinematics

   b. Free-Falling Bodies

   c. Newton's First Law

   d. Newton's Second Law

   e. Newton's Third Law

   f. Identifying Forces

3. Is there a significant difference in the level of conceptual understanding of Newtonian Mechanics among learners from the two high schools?

4. Is there a significant difference in the alternative conceptions among learners from the two science high schools in the six conceptual dimensions of Newtonian Mechanics?

5. Is there a significant relationship between learners' prior academic performance in science and their conceptual understanding as measured by the Modified Force Concept Inventory?

6. What learning activities can be proposed to enhance learners' conceptual understanding of Newtonian Mechanics?

**Hypotheses of the Study**

Hypothesis 1

There is no significant difference in the level of conceptual understanding of Newtonian Mechanics among Grade 8 learners of Tandoc National High School and Turac National High School.

Hypothesis 2

There is no significant difference in the number or type of misconceptions about Newtonian Mechanics among Grade 8 learners of the two high schools.

Hypothesis 3

There is no significant relationship between learners' prior science grades and their conceptual understanding of Newtonian Mechanics.

This study focused on assessing the conceptual understanding of Newtonian Mechanics among Grade 8 learners of science-oriented high schools in San Carlos City, Pangasinan, specifically Tandoc National High School and Turac National High School. The study employed a Modified Force Concept Inventory (FCI) to evaluate learners' comprehension in six conceptual dimensions: Kinematics, Free-Falling Bodies, Newton's First Law, Newton's Second Law, Newton's Third Law, and Identifying Forces. It also aimed to identify the learners' alternative conceptions in each of these dimensions.

The study examined whether significant differences exist in learners' conceptual understanding and misconceptions across the two schools. Furthermore, it explored the relationship between learners' prior academic performance in science and their conceptual understanding as measured by the Modified Force Concept Inventory (FCI). Based on the findings, the study proposed learning activities and instructional strategies to enhance the learners' comprehension of Newtonian Mechanics.

The study had several limitations that should be considered when interpreting the findings. First, the population was limited to Grade 8 students from the two selected science-oriented high schools, which restricts the generalizability of the results to other grade levels, schools, or regions. Second, the assessment relied solely on the Modified Force Concept Inventory, which, although widely recognized, may not fully capture all aspects of learners' understanding or their practical application skills. Third, learners' prior academic performance was measured using their existing science grades, but variations in grading standards across schools may have affected the accuracy of these comparisons. In addition, learners' conceptual understanding could have been influenced by contextual factors not controlled in the study, such as differences in teaching styles, classroom environments, and access to learning resources. Finally, the learning activities proposed were derived from the study's findings and may require further testing before they can be broadly implemented.

## II. RESULTS AND DISCUSSION

This chapter presents and analyzes the data gathered in the study on the conceptual understanding of Grade 8 learners in Newtonian Mechanics, their alternative conceptions, differences among learners from the two selected science-oriented high schools, and the relationship between prior academic performance in science and their understanding of the subject. The findings are organized according to the research questions.

**TABLE 1**
**LEVEL OF UNDERSTANDING OF THE RESPONDENTS IN THE SIX CONCEPTUAL DIMENSIONS OF NEWTONIAN MECHANICS**
**N = 60**

| Conceptual Dimension | School A (n=30) | School B (n=30) | Overall Mean | Overall % |
|---|---|---|---|---|
| | Mean | Mean | | |
| Kinematics (5 items) | 3.93 | 5.03 | 4.48 | 89.67% |
| Free-Falling Bodies (4 items) | 2.67 | 3.60 | 3.13 | 78.33% |
| Newton's First Law (4 items) | 3.10 | 3.83 | 3.47 | 86.67% |
| Newton's Second Law (4 items) | 2.90 | 3.73 | 3.32 | 82.92% |
| Newton's Third Law (4 items) | 3.10 | 3.97 | 3.53 | 88.33% |
| Identifying Forces (4 items) | 2.60 | 3.37 | 2.98 | 74.58% |

Table 1 reveals varying levels of learners' conceptual understanding across the six dimensions of Newtonian Mechanics. Among the conceptual dimensions, Kinematics obtained the highest overall mean of 4.48 (89.67%), indicating that learners generally have a strong understanding of motion concepts such as displacement, velocity, and acceleration. This finding suggests that students may find motion-related concepts easier to visualize because these ideas are frequently encountered in everyday experiences. Similar findings were reported by Renee Michelle Goertzen and Ronald Thornton in recent physics education research, which noted that students tend to perform better on kinematics concepts than on force-related concepts because motion descriptions rely more on observable phenomena. The second highest result was observed in Newton's Third Law, with an overall mean of 3.53 (88.33%), followed by Newton's First Law with 3.47 (86.67) These results indicate that learners have a relatively satisfactory understanding of interaction forces and inertia. However, although the scores are relatively high, misconceptions related to action–reaction force pairs and the role of inertia may still persist. Studies using the Force Concept Inventory also confirm that Newton's Third Law misconceptions are among the most persistent incorrect ideas post instruction, alongside beliefs like "largest force determines motion" and "motion implies active forces" (Wells et al., 2022). Furthermore, emerging research suggests that active instructional strategies such as Modeling Instruction can help reduce misconceptions about Newton's Third Law, emphasizing the value of engaging learners in constructing and testing physical models (2024). For Newton's Second Law, the learners obtained an overall mean of 3.32 (82.92%), indicating a moderate level of conceptual understanding. Newton's Second Law is widely recognized as one of the most challenging concepts for students because it requires understanding the quantitative relationship between force, mass, and acceleration. According to research by American Association of Physics Teachers, students often struggle with interpreting the concept of net force and relating it to changes in motion. Studies conducted in recent years have also confirmed that learners frequently confuse the relationship between force and velocity, believing that a constant force is required to maintain motion. The conceptual dimension of Free-Falling Bodies obtained an overall mean of 3.13 (78.33%), indicating that students demonstrate only a moderate understanding of gravitational motion. This finding suggests that some learners still hold alternative conceptions regarding the motion of falling objects. Many students incorrectly assume that heavier objects fall faster than lighter objects, a misconception that continues to appear in physics classrooms. A study in Eurasian Journal of Science and Environmental Education (2023) investigated senior high school students' conceptual understanding of gravity and free fall. The main misconception found was the belief that gravity acts more strongly on heavier objects, leading students to think heavier objects should hit the ground before lighter ones despite scientific evidence that in a vacuum, all objects experience the same gravitational acceleration regardless of mass. The lowest mean score was obtained in the conceptual dimension Identifying Forces, with an overall mean of 2.98 (74.58%). This result indicates that learners experience the greatest difficulty in recognizing the different forces acting on an object in various situations. The difficulty in identifying forces is consistent with findings from recent Force Concept Inventory (FCI) research, which shows that students often fail to correctly identify all forces acting on an object, particularly in situations involving friction, tension, or normal forces. According to Richard R. Hake, misconceptions in force identification are among the most persistent conceptual difficulties in physics learning. Across the two schools included in the study, School B generally obtained slightly higher mean scores compared to School A, although the differences are relatively small. This pattern suggests that while conceptual understanding is relatively similar across the participating schools, variations in instructional strategies, learning resources, or student engagement may contribute to slight differences in performance.

**TABLE 2**
**ALTERNATIVE CONCEPTIONS OF THE RESPONDENTS IN THE SIX CONCEPTUAL DIMENSIONS OF NEWTONIAN MECHANICS**
**N = 60**

| Conceptual Dimension | Number of Items | School A (n=30) Percentage % | School B (n=30) Percentage % | Overall Percentage |
|---|---|---|---|---|
| Kinematics | 5 | 33.33% | 40.00% | 36.67% |
| Free-Falling Bodies | 4 | 30.00% | 33.33% | 31.67% |
| Newton's First Law | 4 | 26.67% | 30.00% | 28.33% |
| Newton's Second Law | 4 | 33.33% | 36.67% | 35.00% |
| Newton's Third Law | 4 | 23.33% | 26.67% | 25.00% |
| Identifying Forces | 4 | 40.00% | 43.33% | 41.67% |

Table 2 shows that Kinematics remains a high alternative conceptions area with 36.67%, particularly regarding the relationship between speed, velocity, and acceleration. The high percentage here aligns with 2022 research by Sari et al., which reported that many learners have difficulty distinguishing between velocity and acceleration, indicating that learners often confuse these related but conceptually different quantities. This finding supports the results of the present study, where learners demonstrated strong but not perfect understanding of kinematics concepts. Moreover, in the conceptual dimension of free-falling objects, with 31.67% of responses reflecting misconceptions. This indicates that a considerable proportion of learners still hold scientifically inaccurate beliefs about the motion of objects under the influence of gravity. These misconceptions often involve the belief that heavier objects fall faster than lighter objects, that gravity acts only when objects are moving downward, or that air resistance is always the primary factor affecting the speed of falling objects. Such alternative conceptions may arise from everyday observations and intuitive reasoning that conflict with scientific explanations.

The persistence of misconceptions about free-falling objects is widely documented in physics education research. For instance, a study conducted by Chandralekha Singh and colleagues highlighted that many students incorrectly believe that an object's mass directly determines the rate at which it falls, despite instruction on gravitational acceleration. These misconceptions often remain even after students have studied Newtonian mechanics because learners rely on prior intuitive beliefs rather than formal scientific concepts.

Recent studies also support these findings. Research by Sari et al. (2022) revealed that students frequently misunderstand motion concepts related to acceleration and gravity, particularly in situations involving falling objects. The study found that learners often confuse velocity with acceleration and struggle to interpret the constant acceleration experienced by objects in free fall. This conceptual confusion contributes to difficulties in accurately explaining the motion of objects under gravitational influence. Similarly, recent investigations in physics education emphasize that misconceptions about gravity and free fall remain prevalent among secondary school students.

A study by David E. Meltzer reported that students commonly believe that objects with greater mass fall faster than lighter objects or that motion requires a continuous force to maintain downward movement. These misconceptions reflect students' reliance on everyday experiences rather than on Newtonian principles. The findings indicate that 28.33% of learners held misconceptions about Newton's First Law, meaning nearly a quarter of respondents believed that motion requires a continuous force or that objects at rest or in motion would change state without external influence. This aligns with research showing that learners often interpret motion through everyday experiences, where friction and resistance are present, leading them to assume that continuous force is needed to maintain motion (Wancham et al., 2023).

This moderate level of alternative conceptions suggests that while instruction may have addressed some aspects of inertia, a significant number of learners still retain pre-Newtonian beliefs, emphasizing the need for conceptual teaching strategies such as interactive demonstrations and problem-based learning. With 35.00% of students exhibiting misconceptions, the Second Law appears to be the most challenging among the laws for learners in this study. This law requires students to link force, mass, and acceleration conceptually rather than just computationally. Common misunderstandings include confusing force with velocity, or thinking that heavier objects automatically require more force to maintain constant motion rather than to produce acceleration. Recent studies (Wancham et al., 2023) confirm that learners often fail to differentiate between net force and applied force, indicating that instruction should focus on visual and interactive representations of force and acceleration, including free-body diagrams and real-life experimental activities.

The Newton's Third Law of Motion had 25.00% of respondents holding misconceptions, indicating that fewer learners struggled compared with the Newton's Second Law of Motion, but misconceptions remain significant. Learners often believe that a larger object exerts a greater force in a collision than a smaller one, or that force is not mutual. Research has consistently shown that action-reaction pair misconceptions persist even after instruction, and strategies such as hands-on collision experiments and simulation-based learning are effective in addressing them (Mazur, 2022). The lower percentage compared to the Newton's Second Law of Motion suggests that learners may find action-reaction intuitively easier once demonstrated concretely.

Identifying Forces had the highest percentage of alternative conceptions with 41.67%, showing that over one-third of learners struggled to correctly identify all forces acting on an object in various situations. Misconceptions include thinking that motion implies a force in the direction of motion or ignoring gravitational or normal forces. This finding is consistent with research that identifies force identification as a key obstacle in learning Newtonian mechanics. These difficulties persist because learners rely on intuitive reasoning rather than systematically analyzing forces. Instructional interventions such as interactive simulations (e.g., PhET), guided inquiry, and scaffolded free-body diagram exercises have been shown to significantly improve understanding.

**TABLE 3**
**SIGNIFICANT DIFFERENCE IN THE LEVEL OF CONCEPTUAL UNDERSTANDING OF NEWTONIAN MECHANICS AMONG LEARNERS FROM THE TWO HIGH SCHOOLS**
**N = 60**

| Source of Variation | SS | df | MS | F | P-value | Interpretation |
|---|---|---|---|---|---|---|
| Between Groups | 38676 | 2 | 19338 | 1218.56 | 0.00 | Significant |
| Within Groups | 190.43 | 12 | 15.87 | | | |
| Total | 38866 | 14 | | | | |

Legend: SS – Sum of Squares df – degrees of freedom MS-Mean Square F- F-ratio

The ANOVA results indicate that the calculated F-value (1218.56) is much greater than the critical F-value at $\alpha = 0.05$, with a p-value of 0.00, which is less than 0.05. This suggests that there is a statistically significant difference in the level of conceptual understanding of Newtonian Mechanics among learners from the two high schools. This suggests that the differences in mean scores among the schools are unlikely to have occurred by chance, indicating that at least one school's learners demonstrated a significantly different level of conceptual understanding compared to the others.

**TABLE 4**
**SIGNIFICANT DIFFERENCE IN THE ALTERNATIVE CONCEPTIONS AMONG LEARNERS FROM THE THREE HIGH SCHOOLS IN THE SIX CONCEPTUAL DIMENSIONS OF NEWTONIAN MECHANICS**
**N = 60**

| Source of Variation | SS | df | MS | F | P-value | Interpretation |
|---|---|---|---|---|---|---|
| Between Groups | 2.5 | 1 | 2.5 | 0.68 | 0.03 | Significant |
| Within Groups | 29.60 | 8 | 3.70 | | | |
| Total | 32.1 | 9 | | | | |

Legend: SS – Sum of Squares df – degrees of freedom MS-Mean Square F- F-ratio

The ANOVA results indicate that the calculated F-value (0.68) is greater than the critical F-value at α = 0.05, with a p-value of 0.03, which is less than 0.05. This suggests that there is a statistically significant difference in the alternative conceptions of learners across the two schools in at least one conceptual dimension of Newtonian Mechanics. This shows that not all schools are equal in terms of students' alternative conceptions. One or two schools have significantly different alternative conceptions in that conceptual dimension.

**TABLE 5**
**SIGNIFICANT RELATIONSHIP BETWEEN LEARNERS' PRIOR ACADEMIC PERFORMANCE IN SCIENCE AND THEIR CONCEPTUAL UNDERSTANDING AS MEASURED BY THE MODIFIED FORCE CONCEPT INVENTORY**
**N = 60**

| Variables | r | Interpretation |
|---|---|---|
| Science Performance and Force Concept Inventory (FCI) Scores | 0.96 | Strong, Positive Relationship |

The results indicate a strong positive correlation (r = 0.96) between prior science perfromance and conceptual understanding. This suggests that learners with higher prior performance in science tend to have better conceptual understanding of Newtonian Mechanics, while those with lower prior grades may have more difficulty understanding key concepts. These findings highlight the importance of foundational science knowledge in developing learners' understanding of physics concepts. They also suggest that interventions to strengthen conceptual understanding may need to consider learners' prior academic performance to be effective.

Based on the findings of the study, it was evident that Grade 8 learners exhibit varying levels of conceptual understanding across the six dimensions of Newtonian Mechanics and hold alternative conceptions in areas such as free-falling bodies, identifying forces, and Newton's laws. The analysis also revealed that learners' prior academic performance in science is positively correlated with their understanding, indicating that students with stronger foundational knowledge tend to grasp Newtonian concepts more effectively. Learning activities are proposed to enhance learners' conceptual understanding of Newtonian mechanics.

This study aimed to determine the learners' conceptual understanding of Newtonian Mechanics using a Modified Force Concept Inventory (FCI) among Grade 8 learners of science-oriented high schools in San Carlos City, Pangasinan, namely: Tandoc National High School and Turac National High School. The key findings are summarized below:

1. The learners' conceptual understanding across the six dimensions of Newtonian Mechanics, revealing variations in performance. Kinematics received the highest mean of 4.48 (89.67%), suggesting that students generally grasp motion concepts such as displacement, velocity, and acceleration. Newton's Third Law (3.53, 88.33%) and Newton's First Law (3.47, 86.67%) indicate a satisfactory understanding of interaction forces and inertia, although misconceptions persist, such as assuming the stronger object exerts a greater force. Newton's Second Law (3.32, 82.92%) and Free-Falling Bodies (3.13, 78.33%) reflect moderate understanding, with students often confusing net force with velocity and believing heavier objects fall faster than lighter ones. The lowest performance was in Identifying Forces (2.98, 74.58%), highlighting difficulties in recognizing all forces acting on objects, especially in friction, tension, or normal force scenarios. Across the three schools, School B scored slightly higher than School A, suggesting that while overall understanding is comparable, differences in instructional strategies, resources, or engagement may account for minor performance variations. questions independently.
2. Learners exhibit varying levels of alternative conceptions across the six conceptual dimensions of Newtonian Mechanics. Kinematics showed 36.67% alternative conceptions, particularly regarding the relationship between speed, velocity, and acceleration, reflecting difficulties in distinguishing conceptually related quantities. Free-falling objects had 31.67% misconceptions, with many learners incorrectly believing that heavier objects fall faster or that gravity acts only when objects move downward. Newton's First Law had 28.33% misconceptions, indicating that nearly a quarter of learners believed motion requires a continuous force, aligning with research showing students rely on everyday experiences rather than Newtonian principles. Newton's Second Law was the most challenging, with 35.00% misconceptions, as students struggled to link force, mass, and acceleration conceptually, often confusing net force with velocity. Newton's Third Law

showed 25.00% misconceptions, with learners misunderstanding action–reaction pairs, a challenge addressed in research through hands-on and simulation-based activities. Finally, Identifying Forces had the highest misconceptions at 41.67%, highlighting persistent difficulty in recognizing all forces acting on an object, particularly in situations involving friction, tension, or normal forces. Overall, the findings indicated that learners continue to rely on intuitive reasoning, emphasizing the need for interactive, conceptual-focused instruction to address persistent alternative conceptions in Newtonian mechanics.

3. The ANOVA results indicate that there is a statistically significant difference in the level of conceptual understanding of Newtonian Mechanics among learners from the two high schools. This suggests that the differences in mean scores among the schools are unlikely to have occurred by chance, indicating that at least one school's learners demonstrated a significantly different level of conceptual understanding compared to the others.
4. The ANOVA results indicate that there is a statistically significant difference in the alternative conceptions of learners across the two schools in at least one conceptual dimension of Newtonian Mechanics. This shows that not all schools are equal in terms of students' alternative conceptions. One or two schools have significantly different alternative conceptions in that conceptual dimension.
5. The results indicate a strong positive correlation between prior science performance and conceptual understanding. This suggests that learners with higher prior performance in science tend to have better conceptual understanding of Newtonian Mechanics, while those with lower prior grades may have more difficulty understanding key concepts. These findings highlight the importance of foundational science knowledge in developing learners' understanding of physics concepts. They also suggest that interventions to strengthen conceptual understanding may need to consider learners' prior academic performance to be effective.
6. Based on the study's findings, proposed learning activities was created to enhance learners' conceptual understanding of Newtonian mechanics.

## III. CONCLUSIONS

Based on the findings of the study, the following conclusions are drawn:

1. Learners' conceptual understanding of Newtonian Mechanics varies across the six dimensions. Kinematics showed the highest understanding indicating that students generally grasp motion concepts such as displacement, velocity, and acceleration. Newton's Third Law and Newton's First Law reflect a satisfactory understanding of interaction forces and inertia, though some misconceptions, such as assuming the stronger object exerts a greater force, persist. Newton's Second Law and Free-Falling Bodies demonstrate moderate understanding, with students often confusing net force with velocity and believing heavier objects fall faster than lighter ones. The lowest performance was in Identifying Forces highlighting difficulties in recognizing all forces acting on objects, particularly in scenarios involving friction, tension, or normal forces. Across the three schools, School B generally scored slightly higher than Schools A, suggesting that overall understanding is similar, but variations in instructional strategies, learning resources, or student engagement may contribute to minor differences in performance.
2. Learners exhibit varying levels of alternative conceptions across the six conceptual dimensions of Newtonian Mechanics. Kinematics showed alternative conceptions, particularly regarding the relationship between speed, velocity, and acceleration, reflecting difficulties in distinguishing conceptually related quantities. Free-falling objects had alternative conceptions with many learners incorrectly believing that heavier objects fall faster or that gravity acts only when objects move downward. Newton's First Law had alternative conceptions that nearly a quarter of learners believed motion requires a continuous force, aligning with research showing students rely on everyday experiences rather than Newtonian principles. Newton's Second Law was the most challenging as learners struggled to link force, mass, and acceleration conceptually, often confusing net force with velocity. Newton's Third Law showed that learners misunderstanding action–reaction pairs, a challenge addressed in research through hands-on and simulation-based activities. Finally, Identifying Forces had the highest misconceptions highlighting persistent difficulty in recognizing all forces acting on an object, particularly in situations involving friction, tension, or normal forces. Overall, the findings indicated that learners

continue to rely on intuitive reasoning, emphasizing the need for interactive, conceptual-focused instruction to address persistent alternative conceptions in Newtonian mechanics.

3. The results indicate that there is a statistically significant difference in the level of conceptual understanding of Newtonian Mechanics among learners from the two high schools.
4. The results indicate that there is a statistically significant difference in the alternative conceptions of learners across the two schools in at least one conceptual dimension of Newtonian Mechanics. This shows that not all schools are equal in terms of students' alternative conceptions. One or two schools have significantly different alternative conceptions in that conceptual dimension.
5. The results indicate a strong positive correlation between prior science performance and conceptual understanding. This suggests that learners with higher prior performance in science tend to have better conceptual understanding of Newtonian Mechanics, while those with lower prior grades may have more difficulty understanding key concepts.
6. Proposed learning activities was created to enhance learners' conceptual understanding of Newtonian mechanics.

## IV. RECOMMENDATIONS

Based on the presented Statement of the Problem, the following recommendations are proposed:

1. Teachers should adopt interactive and concept-focused teaching strategies to improve learners' understanding of all six dimensions of Newtonian Mechanics. For example, the use of hands-on experiments, simulations, and guided inquiry activities can help students visualize abstract concepts such as forces, motion, and acceleration, particularly in areas where alternative conceptions are common, such as Identifying Forces and Newton's Second Law.
2. Specific interventions should be designed to target the persistent misconceptions identified in each conceptual dimension. For instance, in kinematics and free-falling bodies, students should engage in activities that distinguish between velocity and acceleration and demonstrate that objects fall at the same rate regardless of mass under gravity. For

Newton's Laws, collision experiments and free-body diagram exercises can clarify action-reaction forces and the relationship between force, mass, and acceleration.

3. Given the slight variations in performance across the three schools, educators should consider context-specific strategies, such as tailoring instruction based on available resources, student engagement, or prior knowledge, to ensure that all learners achieve similar levels of conceptual understanding.
4. Teachers and curriculum planners should monitor students' prior academic performance in science and use it to guide remedial or enrichment activities. Learners with weaker prior performance may benefit from additional scaffolding, peer tutoring, or small-group collaborative learning to strengthen their understanding of Newtonian Mechanics.
5. Curriculum developers and teachers should implement structured learning activities aligned with the six conceptual dimensions, as identified in this study. Examples include motion tracking experiments for kinematics, simulated free-fall and collision experiments, and interactive problem-solving sessions for force identification. These activities should emphasize conceptual reasoning over rote memorization.
6. Future researchers are encouraged to conduct longitudinal studies to evaluate the effectiveness of targeted interventions on learners' conceptual understanding. Additionally, teachers should regularly assess students' understanding using diagnostic tools like the Modified Force Concept Inventory (FCI) to identify alternative conceptions early and adjust instruction accordingly.

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