Students' Misconceptions and Learning Experiences in Linear Motion: Basis for an Evidence-Based Intervention Framework

Hannah B. Arceño[1], Rezy V. Mendaño, PhD[2]*

[1]**Wright National High School, Paranas Samar, Philippines, 6703**

[1,2]**Graduate School, Samar State University, Catbalogan City, Philippines, 6700**

***Corresponding Author**

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ABSTRACT

This study examined Grade 7 students' conceptual understanding of linear motion and developed an evidence-based intervention framework to address identified learning gaps in physics education. Using a sequential explanatory mixed-methods design, quantitative data were collected from 110 Grade 7 students using a researcher-developed, validated two-tier concept test, followed by qualitative data gathered through semi-structured interviews with 15 selected students to explore their learning experiences and conceptual difficulties. Descriptive statistical analysis revealed that students demonstrated a Fairly Satisfactory level of conceptual understanding, with a mean score of 77.67, indicating moderate mastery of concepts related to displacement, distance, speed, and velocity. However, persistent misconceptions in fundamental motion concepts were identified. Qualitative findings revealed five major themes related to students' learning experiences: exhibiting conceptual misunderstanding in linear motion, relying on procedural and formula-based problem-solving, expressing uncertainty and low confidence in learning, utilizing everyday experiences to understand motion concepts, and identifying instructional and language-related learning needs. These findings indicate that students' understanding of linear motion is influenced by cognitive, affective, instructional, and contextual factors. Based on the findings, the M.O.T.I.O.N.-S.T.E.P Framework was developed to improve conceptual understanding through diagnostic assessment, conceptual clarification, collaborative learning, contextualized instruction, multilingual support, and continuous assessment. The study concludes that improving students' conceptual understanding of linear motion requires learner-centered instructional strategies that address misconceptions, strengthen conceptual reasoning, and support students' confidence and comprehension. The findings provide practical implications for improving instructional practices in physics education.

Keywords: Conceptual Understanding; Linear Motion; Misconception; Two-Tier Diagnostic Test;, Mixed-Method Design; Physics Education

INTRODUCTION

Science education plays a vital role in shaping students' understanding of the natural world and preparing them for future academic and professional engagement in science, technology, engineering, and mathematics (STEM) fields. Within this domain, physics serves as a foundational discipline that develops critical thinking, analytical reasoning, and problem-solving skills necessary for interpreting natural phenomena. As emphasized by Mitrevski (2019), physics education contributes significantly to the development of logical reasoning and cognitive abilities required in the 21st century.

Despite its importance, physics is frequently perceived by students as difficult and intimidating due to the abstract nature of its concepts and the complexity of its problem-solving processes. Among the topics commonly identified as challenging are displacement and velocity, which are fundamental concepts in kinematics and serve as prerequisites for more advanced topics in mechanics and motion (Dalal, 2025). Failure to develop a clear understanding of these concepts early on may hinder students' progress in physics and lead to persistent misconceptions.

Research has consistently shown that misconceptions in motion concepts are widespread among junior high school learners. Jufriadi et al. (2021) reported that students commonly confuse displacement with distance, while Jufriadi and Andinisari (2020) identified difficulties related to velocity, acceleration, and directional concepts. These misconceptions often persist despite formal instruction (Zaid & Zainuddin, 2017) and are resistant to conceptual change, emphasizing the need for effective diagnostic and instructional interventions.

In the Philippine context, Grade 7 learners continue to demonstrate low conceptual understanding of fundamental physics concepts such as motion (Boller & Mendaño, 2024; Madca et al., 2025). Motlhabane (2016) further observed that students frequently interpret concepts such as time, position, velocity, and acceleration using qualitative or everyday reasoning rather than scientific explanations. To address these misconceptions, researchers have validated the use of two-tier diagnostic tests, which assess both students' answers and the reasoning behind their responses. Previous studies have demonstrated the effectiveness of these instruments across various physics domains, including thermodynamics, optics, and Newtonian mechanics (Aini & Bunawan, 2020; Kamcharean & Wattanakasiwich, 2014). Rohmantika et al. (2022) further reported that two-tier tests effectively identified moderate-level misconceptions among learners, highlighting their usefulness for both diagnostic assessment and instructional planning.

Despite the growing body of literature on misconceptions in physics, few studies specifically focus on Grade 7 learners in the Philippine educational setting, particularly regarding displacement and velocity. Existing research predominantly involves senior high school or college students, overlooking the developmental and instructional needs of learners in early secondary education. For instance, Solikin et al. (2026) focused on Grade 11 students, suggesting that studies on physics misconceptions remain concentrated on older learners. Consequently, instructional approaches tailored to the conceptual difficulties of Grade 7 students remain insufficiently explored.

Moreover, many existing studies rely heavily on quantitative methodologies, such as multiple-choice assessments and pretest–posttest designs, with limited integration of qualitative approaches that examine students' reasoning processes and learning experiences. While quantitative data provide useful measures of conceptual understanding, qualitative exploration can offer deeper insights into how students interpret motion concepts, the sources of their misconceptions, and the contextual factors influencing their learning. Understanding students' reasoning patterns and classroom experiences is particularly important in designing interventions that are both contextually relevant and instructionally effective.

Given these gaps, the present study aimed to examine Grade 7 students' conceptual understanding of linear motion using a sequential, explanatory, mixed-methods approach. Specifically, the study investigated students' misconceptions about displacement and velocity using a two-tier diagnostic test and explored their learning experiences through qualitative inquiry. Based on the findings, the study developed an evidence-based intervention framework intended to support improved conceptual understanding and more effective instructional practices in physics education.

METHODS

Research Design

This study employed a sequential explanatory mixed-method design to examine Grade 7 students' conceptual understanding of linear motion and develop an evidence-based intervention framework. The design involved collecting and analyzing quantitative data, followed by a qualitative inquiry to further explain and elaborate on the quantitative findings (Creswell & Plano Clark, 2018).

During the quantitative phase, a researcher-developed and validated two-tier diagnostic test was administered to Grade 7 students to assess their conceptual understanding of key linear motion concepts, including distance, displacement, speed, and velocity. The quantitative results served as baseline data for identifying students' conceptual strengths and misconceptions. Descriptive statistical techniques, including percentages, means, and standard deviations, were used to analyze the quantitative data.

The qualitative phase was conducted to provide deeper insight into students' learning experiences and conceptual difficulties in linear motion. Specifically, the study explored how students understood motion concepts, the misconceptions they held, and the factors that influenced their conceptual understanding. A qualitative descriptive approach was employed to obtain direct and detailed descriptions of students' experiences without imposing complex theoretical interpretations.

Participants for the qualitative phase were selected through purposive sampling based on their performance in the two-tier concept test. Students representing varying levels of conceptual understanding, including sound, partial, inconsistent, and misconceptions, were included to ensure comprehensive representation of learning experiences.

Semi-structured interviews were conducted to gather qualitative data. The interviews allowed flexibility in probing students’ responses while maintaining consistency in guiding questions. These interviews provided deeper insight into students’ reasoning processes and clarified the conceptual difficulties reflected in the quantitative findings.

Qualitative data were analyzed using thematic analysis following Braun and Clarke’s (2006) six-phase framework: familiarization with the data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report. To support data organization and clustering, AI-assisted tools were used during the coding process; however, all analytical decisions, interpretations, and validations remained under the researcher's supervision to ensure rigor and credibility.

The integration of quantitative and qualitative findings provided a comprehensive understanding of students’ conceptual understanding of linear motion and served as the basis for developing the M.O.T.I.O.N.-S.T.E.P intervention framework.

Research Locale and Participants

The study was conducted in a public secondary school under the Department of Education (DepEd) Samar Division, Philippines. The selected school serves learners from predominantly rural and semi-urban communities and implements the K to 12 Basic Education Curriculum prescribed by the Department of Education.

The study participants were 110 Grade 7 students enrolled in three intact classes. The classes included 35 students in Class A, 35 students in Class B, and 40 students in Class C. The participants were selected based on their exposure to Grade 7 science competencies involving linear motion concepts.

For the qualitative phase, 15 students were purposively selected based on their performance in the two-tier diagnostic test. The selection ensured representation across varying performance levels, including low, average, and high scorers. Participant selection continued until data saturation was achieved, at which point no new significant themes or insights emerged from the interview data.

Research Instruments

Two-Tier Concept Test. The primary quantitative instrument used in the study was a researcher-developed, two-tier diagnostic test consisting of 35 items. Each item contained two components: Tier 1 assessed students' conceptual understanding through a multiple-choice question, while Tier 2 required students to select the reasoning that best justified their answers. This structure enabled the identification of both students' answers and the reasoning underlying their responses. The instrument covered major Grade 7 linear motion concepts, including distance, displacement, speed, and velocity. The distribution of items followed the Table of Specifications and considered levels of difficulty and cognitive domains based on Bloom’s taxonomy. The test consisted of 60% easy items, 30% average items, and 10% difficult items.

Each correct response in Tier 1 and Tier 2 was assigned 1.5 points, resulting in a total of 3 points per item and a maximum possible score of 105 points. Raw scores were converted into Mean Percentage Scores (MPS) and interpreted according to Department of Education standards under DepEd Order No. 8, s. 2015.

Interview Guide. To complement the quantitative findings, a semi-structured interview guide was utilized to explore students' learning experiences and conceptual understanding of linear motion. The interview guide focused on students' prior knowledge, reasoning processes, misconceptions, problem-solving strategies, and learning experiences related to distance, displacement, speed, and velocity.

The interview guide consisted of open-ended questions organized into five sections: (1) prior knowledge and learning experiences, (2) reflection on two-tier test items, (3) conceptual understanding of linear motion, (4) reasoning and problem-solving strategies, and (5) learning experiences and suggestions. The structure allowed flexibility for probing while ensuring consistency in data collection.

Validation and Reliability of Instruments

The two-tier concept test underwent pilot testing and item analysis to determine the appropriateness of the items in assessing varying levels of conceptual understanding. Item difficulty and discrimination indices were analyzed, and necessary revisions were made to improve poorly performing items.

The instrument's internal consistency reliability was established using the Kuder–Richardson Formula 20 (KR-20), yielding a coefficient of 0.809, indicating acceptable reliability for diagnostic assessment.

The qualitative instruments, including the interview guide, underwent content and construct validation by three experts in science and physics education. The validators assessed the instruments using a four-point content–construct alignment scale. Results showed an Item-Level Content Validity Index (I-CVI) of 1.00 for all sections, indicating unanimous agreement regarding relevance.

At the scale level, the Scale-Level Content Validity Index using both the average method (S-CVI/Ave) and universal agreement method (S-CVI/UA) yielded values of 1.00, indicating excellent content validity. Minor revisions were incorporated based on validators' recommendations to improve clarity and probing structure.

Data Gathering Procedure

Prior to data collection, ethical clearance was secured from the Samar State University Ethics Review Committee. Permission to conduct the study was subsequently obtained from the Schools Division Superintendent of DepEd Samar and the District Supervisor of Wright I District.

For the quantitative phase, the validated two-tier diagnostic test was administered to 110 Grade 7 students during regular science class sessions. Standardized instructions were provided to ensure consistency in administration, and students were given approximately 40 to 45 minutes to complete the test.

Following the quantitative analysis, 15 students were selected for the qualitative phase based on their performance in the concept test. Semi-structured interviews were conducted individually in a quiet environment within the school premises. Each interview lasted approximately 10 to 15 minutes and was audio-recorded with participants' consent. The interviews were subsequently transcribed verbatim for analysis.

All collected data were treated with strict confidentiality. Participants' identities were anonymized using codes, and all records were securely stored and accessed only by the researcher.

Data Analysis

Quantitative data were analyzed using descriptive statistical techniques. Frequency and percentage distributions were used to describe students' performance levels based on Department of Education standards. The mean and standard deviation were computed to determine students' overall conceptual understanding and score variability.

Qualitative data obtained from the semi-structured interviews were analyzed using thematic analysis following Braun and Clarke’s (2006) six-phase framework. Interview transcripts were transcribed, coded, categorized, and organized into themes reflecting students’ conceptual understanding, reasoning processes, misconceptions, and learning experiences. To support data organization and pattern recognition, the coding and theme development process was AI-aided using ChatGPT-5.2, which assisted in clustering recurring ideas and synthesizing patterns across transcripts. Prior studies have demonstrated the potential of AI tools in supporting qualitative analysis (Mazeikienė & Kasperiunienė, 2024). Nevertheless, all coding decisions, theme development, interpretation, and validation were conducted by the researcher to ensure analytical rigor and contextual accuracy. Credibility was strengthened through triangulation and member checking procedures.

Ethical Considerations

Ethical standards were observed throughout the study. Ethical clearance was secured from the Samar State University Ethics Review Committee (IHREC Code: 2025-0070-G) prior to data collection. Informed consent and student assent were obtained from all participants, including parental consent for minors. Participants were informed of the study's purpose, the voluntary nature of participation, and their right to withdraw at any time without penalty.

Confidentiality and anonymity were maintained through the use of coded identifiers and secure storage of data. All information collected was used solely for research purposes. The study posed minimal risk to participants, and transparency was maintained throughout the research process.

RESULTS AND DISCUSSION

Level of Students’ Conceptual Understanding of Linear Motion

Table 1 presents the level of Grade 7 students’ conceptual understanding of linear motion as measured through the two-tier concept test.

Table 1 Level of Conceptual Understanding of Linear Motion Using a Two-tier Concept Test

Percentage Score	Adjectival Description	No. of Students	Percent
90 - 100	Outstanding	-	-
85 - 89	Very Satisfactory	1	0.91
80 - 84	Satisfactory	38	34.55
75-79	Fairly Satisfactory	50	45.45
≤ 75	Did Not Meet Expectations	21	19.09
Total		110	100
Mean		77.67	-
SD		3.86	-

Legend: 90-100: Highly Proficient, 85-89: Very Satisfactory, 80-84: Satisfactory,75-79: Fairly Satisfactory, ≤ 75 : Did Not Meet Expectations(DepEd Order No. 8, s. 2015,.

The findings revealed that most students demonstrated a Fairly Satisfactory level of conceptual understanding, with 50 of 110 students (45.45%) falling into this category. Meanwhile, 38 students (34.55%) received a Satisfactory rating, indicating that many learners have a basic yet developing understanding of linear motion concepts. However, 21 students (19.09%) were classified under Did Not Meet Expectations, suggesting that a considerable number of learners still struggle with the concepts. Only one student (0.91%) achieved a Very Satisfactory rating, while none reached the Outstanding level.

The overall mean score of 77.67 indicates a Fairly Satisfactory level of understanding, suggesting that students’ conceptual understanding of linear motion remains moderate. The low standard deviation (SD = 3.86) shows that students generally shared similar levels of understanding and conceptual difficulties.

These findings suggest that while students can answer some test items correctly, many still rely on memorization and formulas rather than deep conceptual understanding. Renkl (2021) explained that learners may solve problems procedurally without fully understanding the underlying concepts. Similarly, Eichenlaub and Redish (2019) noted that students often treat mathematics only as a computational tool rather than connecting it to physical concepts.

The findings also indicate that students tend to use surface-level learning approaches, such as memorization, rather than deeper understanding (Mestre & Docktor, 2020). This limits their ability to understand relationships among displacement, velocity, and time. The presence of students under the Did Not Meet Expectations category further shows persistent misconceptions and conceptual difficulties in learning motion concepts (Stefanel, 2019).

Moreover, the absence of students in the Outstanding category supports the idea that misconceptions in science are deeply rooted and difficult to change (Vosniadou, 2020). Since linear motion is a foundational topic in physics, weak conceptual understanding may create difficulties in more advanced topics such as dynamics (Waldron & Schmiedeler, 2016).

The findings also highlight the value of two-tier diagnostic tests in identifying not only students' answers but also their reasoning and misconceptions. Overall, the results show that students possess a basic understanding of linear motion, but their conceptual knowledge still needs further improvement.

Learning Experiences of Students in Linear Motion

Theme 1: Conceptual Misunderstanding in Linear Motion

One of the major themes that emerged from the interviews was the presence of conceptual misunderstandings related to linear motion. Students demonstrated confusion in distinguishing between distance and displacement, speed and velocity, and scalar and vector quantities.

Vignettes:

“Because speed has a time and velocity… velocity, yes, distance… ahh… nalilito pa ako.” (Because speed involves time while velocity involves distance, although I am still confused and do not fully understand the concept.), “Because scalar means direction and vector means no direction… pero diri ako sure.” (Scalar means it has direction, while vector means it has no direction, but I am not sure about it.) – **Student01**

“Because distance can also have direction… siguro.” (Because I think distance can also have direction.) – **Student03**

“Distance includes direction while displacement does not.” – **Student07**

"Standing still counts as distance… I do not care about direction… because what we talk about here is distance." – **Student09**

“Distance is a whole velocity… and displacement is a shortcut way…” (Distance is the total motion while displacement is just a shortcut.) – **Student10**

“Negative velocity means lower than a positive or normal velocity…” – **Student13**

Some learners believed that distance involves direction, whereas displacement does not, whereas others interpreted velocity merely as speed, without considering its directional components. These responses indicate fragmented conceptual understanding and suggest that learners rely heavily on intuitive reasoning and prior experiences rather than scientifically accurate explanations.

The persistence of these misconceptions supports previous studies reporting that students commonly confuse displacement with distance and interpret velocity as simply speed (Jufriadi et al., 2021). These misconceptions are deeply rooted in learners’ prior knowledge and may persist unless directly addressed through conceptual clarification and guided instruction.

The findings imply that students have not yet developed a strong conceptual foundation in linear motion. Without a clear understanding of basic concepts, learners are more likely to depend on memorization rather than meaningful reasoning, which may hinder learning in more advanced physics topics.

The results highlight the importance of instructional strategies that directly address misconceptions through guided discussions, conceptual questioning, visual representations, and contextualized examples.

Theme 2: Reliance on Procedural and Formula-Based Problem Solving

Another major theme identified in the interviews was students' reliance on procedural and formula-based problem-solving strategies. Learners frequently emphasized memorizing formulas, following structured procedures, and focusing on obtaining correct answers rather than understanding concepts.

Vignettes:

"I listed the solutions and formulas… amo la gihapon akon ginbubuhat." (I listed the solutions and formulas, and that is what I usually do when solving problems.), "I focus on the answer… diri ko gud gin-iintindi an concept usahay." (I focus on getting the correct answer, and sometimes I do not really try to understand the concept.) **– Student01**

"I always use formulas… amo gud la…" (I always use formulas, that is what I do.) **– Student02**

"To find a formula… amo la gihapon." (To find a formula, that is what I usually do.) **– Student03**

"I start with formulas… then use formulas… and do given, find, and solutions… amo la akon paagi." (I start with formulas, follow the given-find-solution steps, and that is my method.) **– Student04**

"Problem-solving… because if there is no formula, you cannot solve…" **– Student09**

"I usually try formulas until I find the right answer… amo la." (I try different formulas until I get the correct answer.) **– Student13**

Students commonly described their problem-solving approach using the "given-find-solution" format and admitted that they relied heavily on formulas in solving motion-related problems. Some learners also expressed that they could not solve problems without formulas, reflecting a computational rather than conceptual orientation toward physics learning.

These findings suggest that students approach physics problem-solving procedurally rather than conceptually. While procedural fluency is important, excessive reliance on memorized formulas may limit students' ability to interpret concepts and apply knowledge in unfamiliar contexts.

The findings support studies indicating that procedural knowledge alone does not equate to conceptual understanding (Rittle-Johnson et al., 2016). Learners who rely heavily on memorization often struggle to explain why formulas work or when they should be applied.

The results imply the need for instructional approaches that balance procedural skills with conceptual reasoning. Teachers should encourage learners to explain their thinking, interpret relationships among variables, and connect formulas to real-world situations through inquiry- and problem-based learning.

Theme 3: Expressing Uncertainty and Low Confidence in Learning

The interviews also revealed that students expressed uncertainty and low confidence in explaining linear motion concepts. Many learners hesitated in answering questions and frequently stated that they were unsure of their responses.

Vignettes:

"My confidence is six out of ten… medyo diri pa gud ako sigurado." (My confidence is six out of ten, and I am still not fully confident in my understanding.) – **Student01**

"I don't know ma'am… waray ako idea… diri ko gud nasasabtan." (I do not know, I have no idea, and I really do not understand it.) – **Student05**

"I don't know ma'am… waray ako sure." (I do not know, I am not sure.) – **Student03**

"Because… what was that again?... um… ma'am I don't have." – **Student06**

"I really don't know ma'am." – **Student07**

"I'm not sure if my answer is correct… since I didn't actually understand that part of the lesson." – **Student11**

Students' responses reflected self-doubt, difficulty recalling concepts, and uncertainty in articulating explanations. These findings indicate that learners experience not only conceptual difficulties but also affective challenges in learning physics.

Low confidence may discourage students from actively engaging in conceptual discussions and attempting challenging problems. The findings align with studies emphasizing the importance of self-efficacy and confidence in students' engagement and achievement in physics learning (Uçar & Sungur, 2017).

The results further suggest that students perceive physics as a difficult and abstract subject, which may contribute to anxiety and hesitation during learning tasks. Consequently, cognitive and affective factors appear interconnected, as conceptual gaps may reduce confidence while low confidence may limit participation and meaningful engagement.

The findings highlight the importance of creating supportive learning environments that foster confidence through guided practice, collaborative learning, positive feedback, and student-centered instructional approaches.

Theme 4: Utilizing Everyday Experiences to Understand Motion Concepts

Another significant theme that emerged was students' use of everyday experiences in understanding linear motion concepts. Learners frequently used familiar situations such as walking to school, returning home, or moving objects back and forth to explain displacement and distance.

Vignettes:

"Yes… pwede po Mam… when you go to the West, then you return to the East… pero mayda ka gihapon nalakatan nga distance." (Yes, it is possible because when you go to the west and then return to the east, you still travel a certain distance even if you go back to your starting point.) – **Student01**

"Because distance gin-a-add la bisan ano nga direction… while displacement gin-a-minus if opposite…" (Distance is added regardless of direction, while displacement is subtracted when the direction is opposite.) – **Student02**

"When I go to school and I forgot my lunch… I go back to my house… so displacement is zero… amo ito." (When I go to school and return to my house, the displacement becomes zero because I ended at my starting point.) – **Student08**

"For example… you are in your house, you go to the market, then you go back home… so displacement is zero because you return… amo ito." (If you go from your house to the market and then return home, displacement becomes zero because you return to your starting point.) – **Student09**

"For example, I go from the room to the canteen 10 meters and then return…" – **Student10**

The use of real-life examples suggests that students attempt to construct meaning by connecting abstract concepts to everyday experiences. While this approach may support initial understanding, some students also demonstrated oversimplified or partially accurate reasoning.

For example, some learners explained that distance is always "added" while displacement is "subtracted," indicating an intuitive but incomplete understanding of the concepts. These findings suggest that students rely heavily on prior experiences and informal reasoning in interpreting motion concepts.

The results support constructivist perspectives, emphasizing that learners build understanding from prior knowledge and experiences (Vosniadou, 2019). However, intuitive interpretations may also reinforce misconceptions if not properly guided by instruction.

The findings imply that teachers should use contextualized instruction and real-life examples while ensuring that students' intuitive explanations align with scientific principles. Guided inquiry, demonstrations, and reflective discussions may help students refine their understanding and achieve conceptual change.

Theme 5: Identifying Instructional and Language-Related Learning Needs

The final theme that emerged from the interviews involved students' instructional and language-related learning needs. Learners emphasized the importance of clearer explanations, more examples, demonstrations, videos, and group activities, as well as the use of familiar languages such as Waray and Filipino, in learning physics concepts.

Vignettes:

“To explain it well… maghatag hin damo nga examples… and if possible, butangan hin actions.” (Teachers should explain the lesson clearly, provide many examples, and include demonstrations or actions to help understanding.), “Pagpakita hin videos… mas masabtan gud.” (Showing videos helps students understand the lesson better.) – Student01

“Mas maupay kun i-translate ha Waray or Tagalog…” (It is better if the lesson is translated into Waray or Tagalog so we can understand it more easily.) – **Student02**

“To give examples… and activities… maghatag pa gud hin examples…” (Teachers should give more examples and activities to improve understanding.) – **Student03**

“Teachers can use examples… demonstration… role play… or video lessons…” – **Student04**

“Teachers can help us… teaching in Waray-waray or Filipino…” – **Student06**

“Teachers can translate… Waray or Tagalog… give more examples… para masabtan…” (Teachers should translate into Waray or Tagalog and provide more examples so students can understand better.) – **Student09**

“Group activity… because I cannot do it on my own…” – **Student14**

“Games… because it is more fun… and helps us bond…” – **Student11**

Students reported understanding lessons more effectively when teachers used demonstrations, visual aids, and contextual examples. Many learners also expressed a preference for multilingual explanations to improve comprehension of complex concepts.

These findings indicate that language and instructional delivery significantly influence students’ conceptual understanding. Difficulties in understanding the language of instruction may contribute to misconceptions and learning barriers.

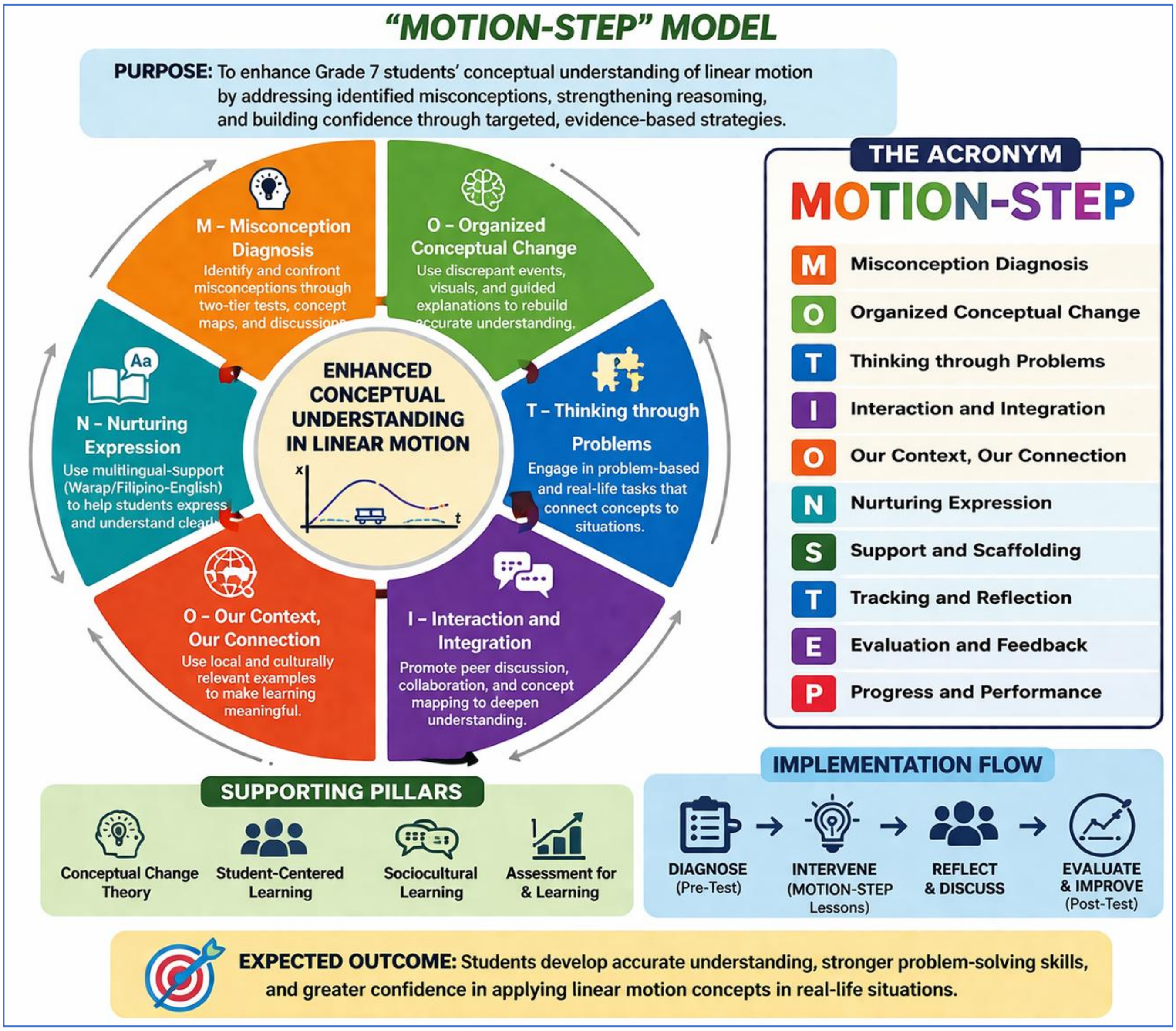
These findings indicate that language and instructional delivery significantly influence students’ conceptual understanding. Difficulties in understanding the language of instruction may contribute to misconceptions and learning barriers. The findings support studies emphasizing that language proficiency and instructional strategies affect students' understanding of scientific concepts (Shubani & Mavuru, 2022). Similarly, Bolanio and Mendaño (2025) emphasized that contextualized instruction and the use of improvised instructional materials enhance students' engagement and conceptual understanding by connecting scientific concepts to learners' real-life experiences and local contexts. Such strategies make abstract physics concepts more meaningful, accessible, and easier to comprehend, particularly for learners in resource-limited, multilingual learning environments.

The results imply that instructional approaches should be responsive to students' contextual and linguistic needs. Teachers should incorporate interactive activities, collaborative learning, visual representations, and strategic multilingual support to enhance students' understanding and participation.

Proposed Intervention Framework

Based on the study's quantitative and qualitative findings, a proposed intervention plan was developed to address gaps in students' conceptual understanding of linear motion. The results of the two-tier concept test showed that students demonstrated a Fairly Satisfactory level of understanding, indicating moderate conceptual mastery. The qualitative findings further revealed misconceptions in key concepts, reliance on formula-based problem-solving, low confidence in explaining concepts, and difficulties with language and comprehension.

In response to these findings, the researcher developed the M.O.T.I.O.N.-S.T.E.P Framework, which serves as the foundation of the proposed intervention plan. The framework is presented in Figure 1.



"MOTION-STEP" MODEL

PURPOSE: To enhance Grade 7 students' conceptual understanding of linear motion by addressing identified misconceptions, strengthening reasoning, and building confidence through targeted, evidence-based strategies.

M – Misconception Diagnosis
Identify and confront misconceptions through two-tier tests, concept maps, and discussion

O – Organized Conceptual Change
Use discrepant events, visuals, and guided explanations to rebuild accurate understanding.

T – Thinking through Problems
Engage in problem-based and real-life tasks that connect concepts to situations.

I – Interaction and Integration
Promote peer discussion, collaboration, and concept mapping to deepen understanding.

O – Our Context, Our Connection
Use local and culturally relevant examples to make learning meaningful.

N – Nurturing Expression
Use multilingual-support (Warap/Filipino-English) to help students express and understand clear

ENHANCED CONCEPTUAL UNDERSTANDING IN LINEAR MOTION

THE ACRONYM
MOTION-STEP

M	Misconception Diagnosis
O	Organized Conceptual Change
T	Thinking through Problems
I	Interaction and Integration
O	Our Context, Our Connection
N	Nurturing Expression
S	Support and Scaffolding
T	Tracking and Reflection
E	Evaluation and Feedback
P	Progress and Performance

SUPPORTING PILLARS
- Conceptual Change Theory
- Student-Centered Learning
- Sociocultural Learning
- Assessment for & Learning

IMPLEMENTATION FLOW
DIAGNOSE (Pre-Test) → INTERVENE (MOTION-STEP Lessons) → REFLECT & DISCUSS → EVALUATE & IMPROVE (Post-Test)

EXPECTED OUTCOME: Students develop accurate understanding, stronger problem-solving skills, and greater confidence in applying linear motion concepts in real-life situations.

Figure 1. **The M.O.T.I.O.N.-S.T.E.P Intervention Framework**

The framework is designed to address students' learning difficulties through a structured and learner-centered approach. It integrates diagnostic assessment, conceptual clarification, problem-based learning, collaborative activities, contextualized instruction, and continuous evaluation to improve conceptual understanding.

The intervention specifically targets misconceptions about displacement, velocity, and other motion concepts through conceptual reasoning and real-world applications. It also incorporates collaborative and multilingual instructional strategies to improve students' engagement, confidence, and comprehension.

Overall, the M.O.T.I.O.N.-S.T.E.P Framework provides an evidence-based and practical instructional guide for improving students' conceptual understanding of linear motion. By addressing misconceptions, reducing reliance on memorization, and promoting active learning, the intervention is expected to enhance students' understanding and overall performance in physics.

CONCLUSION AND RECOMMENDATIONS

The study found that Grade 7 students demonstrated a Fairly Satisfactory level of conceptual understanding of linear motion, indicating moderate mastery of concepts such as displacement, distance, speed, and velocity. Although students demonstrated a basic understanding of these concepts, many still showed misconceptions and conceptual difficulties, particularly in differentiating related motion concepts.

The qualitative findings further showed that students relied heavily on formulas and procedural problem-solving rather than on conceptual reasoning. Many learners also expressed uncertainty and low confidence in explaining physics concepts, suggesting that both cognitive and affective factors influence learning. In addition, students commonly used everyday experiences to understand motion concepts, though these interpretations sometimes led to misconceptions. The findings also highlighted the importance of instructional and language-related factors, as students emphasized the need for clearer explanations, interactive activities, contextualized examples, and multilingual support to improve comprehension.

Based on these findings, the study concludes that traditional instruction alone may not be sufficient to address students' conceptual difficulties in linear motion. There is a need for instructional approaches that emphasize conceptual understanding, active learning, and conceptual clarification rather than memorization and formula-based problem solving alone. In response to the identified learning gaps, the M.O.T.I.O.N.-S.T.E.P Framework was developed as an evidence-based intervention designed to improve students' conceptual understanding through diagnostic assessment, collaborative learning, contextualized instruction, multilingual support, and continuous assessment.

The findings suggest that science teachers should integrate inquiry-based, collaborative, and contextualized learning activities to promote deeper conceptual understanding in physics. Teachers are also encouraged to use diagnostic tools such as two-tier concept tests to identify misconceptions and provide appropriate instructional interventions. The use of visual aids, demonstrations, multimedia resources, and familiar language may further improve students' comprehension and engagement. Moreover, the implementation of the M.O.T.I.O.N.-S.T.E.P Framework is recommended to determine its effectiveness in improving students' understanding of linear motion. Future studies may also be conducted with larger samples, across different grade levels, and on other physics topics to validate the study's findings further.

Overall, the study highlights the importance of learner-centered, conceptually focused instruction for improving students' understanding of physics concepts and addressing misconceptions in linear motion.

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REFERENCES

1. Aini, N., & Bunawan, W. (2020). The development of two-tier multiple choice tests to assess student’s conceptual understanding in physics learning assisted by ALGODOO. Jurnal Inovasi Pembelajaran Fisika (INPAFI), 8(4), 33–41.
2. Bolanio, J. C. R., & Mendaño, R. V. Simplified Wave Energy Converter: An Apparatus for Teaching Energy Transformation.
3. Boller-Aying, S., & Villegas-Mendano, R. (2024). STUDENTS’PERFORMANCE ON THE HORIZONTAL AND VERTICAL COMPONENTS OF PROJECTILE MOTION USING PROJECT-BASED LEARNING. Ignatian International Journal for Multidisciplinary Research, 2(4), 1689-1704.
4. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa
5. Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research (3rd ed.). SAGE Publications.
6. Dalal, R. (2025). Core concepts of mechanics and thermodynamics. Educohack Press.
7. Eichenlaub, M., & Redish, E. F. (2019). Blending physical knowledge with mathematical form in physics problem solving. In Mathematics in Physics Education (pp. 127-151). Cham: Springer International Publishing.
8. Jufriadi, A., & Andinisari, R. (2020). JITT with assessment for learning: Investigation and improvement of students understanding of kinematics concept. Momentum: Physics Education Journal, 94–101.
9. Jufriadi, A., Kusairi, S., & Sutopo, S. (2021, April). Exploration of student’s understanding of distance and displacement concept. In Journal of Physics: Conference Series (Vol. 1869, No. 1, p. 012195). IOP Publishing.
10. Kamcharean, C., & Wattanakasiwich, P. (2014, March 26). A two-tier multiple choice questions to diagnose thermodynamic misconception of Thai and Laos students. Journal of the Physical Society of Japan Conference Proceedings, 1, 017008. https://doi.org/10.7566/JPSCP.1.017008
11. Madca, H., Balinton, C., Agustin, C., & Nabua, E. B. (2025). Learners’ conceptual understanding on force, motion, and energy: Its relationship with motivation. International Journal of Research and Innovation in Social Science. https://doi.org/10.47772/IJRISS.2025.90300039
12. Mazeikiene, N., & Kasperiuniene, J. (2024). AI-enhanced qualitative research: Insights from Adele Clarke's situational analysis of TED Talks. The Qualitative Report, 29(9), 2502–2526.
13. Mestre, J., & Docktor, J. (2020). Science Of Learning Physics, The: Cognitive Strategies For Improving Instruction. World Scientific.
14. Mitrevski, B. (2019, February). Teaching critical thinking and problem solving in physics. In AIP Conference Proceedings (Vol. 2075, No. 1, p. 180001). AIP Publishing LLC.
15. Motlhabane, A. (2016). Learner’s alternative and misconceptions in physics: A phenomenographic study. Journal of Baltic Science Education, 15(4), 424–440.
16. Renkl, A. (2017). Learning from worked-examples in mathematics: Students relate procedures to principles. Zdm, 49(4), 571-584.
17. Rittle-Johnson, B., Fyfe, E. R., & Loehr, A. M. (2016). Improving conceptual and procedural knowledge: The impact of instructional content within a mathematics lesson. British Journal of Educational Psychology, 86(4), 576–591.
18. Rohmantika, N., Kurniawan, E. S., & Sriyono, S. (2022). Effectiveness of two-tier multiple choice diagnostic test for analyzing students' misconceptions in high school physics learning. Radiasi: Jurnal Berkala Pendidikan Fisika, 15(2), 79–90.
19. Shubani, M., & Mavuru, L. (2022). ENGLISH SECOND LANGUAGE LEARNERS'CHALLENGES IN COMPREHENDING PHYSICAL SCIENCES CONCEPTS.

20. Solikin, Bukit, T. F., Eltera, G. A., Advent, E. B., Pardede, N., Fatimah, F., Hutagalung, R. B. S. D., Munthe, R. T. B., & Cahyani, W. A. (2026). Identifying and analyzing misconception of XI grade students about basic kinematics material by using two-tier test method in SMA Negeri 1 Percut Sei Tuan. Sultan Adam: Jurnal Hukum dan Sosial. https://doi.org/10.7.1456/sultan.v4i1.1567
21. Stefanel, A. (2019). Graph in physics education: From representation to conceptual understanding. In Mathematics in Physics Education (pp. 195–231). Cham: Springer International Publishing.
22. Uçar, F. M., & Sungur, S. (2017). The role of perceived classroom goal structures, self-efficacy, and engagement in student science achievement. Research in Science & Technological Education, 35(2), 149-168.
23. Vosniadou, S. (2019). Conceptual change research: An introduction. In S. Vosniadou (Ed.), International handbook of research on conceptual change (2nd ed., pp. 1–28). Routledge.
24. Vosniadou, S. (2020). Students' misconceptions and science education. In Oxford Research Encyclopedia of Education.
25. Waldron, K. J., & Schmiedeler, J. (2016). Kinematics. In Springer handbook of robotics (pp. 11–36). Cham: Springer International Publishing.
26. Zaid, H. M., & Zainuddin, A. (2017, November). A study on foundation students' misconceptions in projectile motion and free fall. In 2017, the 7th World Engineering Education Forum (WEEF) (pp. 693–696). IEEE.