Science Teachers' Insights on Students' Misconceptions in Acceleration: Need for Scaffold Inquiry-Based Learning Instruction

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ABSTRACT

This study examined Grade 8 learners' conceptual understanding of acceleration by identifying their misconceptions and exploring the effectiveness of scaffolded inquiry-based learning in addressing these misconceptions. An explanatory mixed-methods research design was employed, integrating quantitative data from a 50-item pretest–posttest assessment with qualitative data obtained through student interviews, reflective journals, and teacher-researcher field notes. The participants consisted of Grade 8 learners selected through purposive sampling from intact class sections in a natural classroom setting. Quantitative data were analyzed using mean scores, standard deviation, and paired-samples t-test, while qualitative data were used to explain and enrich the quantitative findings. The results revealed that learners initially held misconceptions about acceleration, commonly associating it only with increasing speed and experiencing difficulty distinguishing it from related concepts such as speed and velocity. Following the implementation of scaffolded inquiry-based learning, learners demonstrated a statistically significant improvement in conceptual understanding, with mean scores increasing from 25.69 in the pretest to 36.12 in the posttest, $t(41) = 7.854$, $p < .001$. Qualitative findings further indicated that teacher scaffolding, guided inquiry, contextualized examples, and structured learning activities supported learners in reconstructing prior knowledge, addressing misconceptions, and developing a deeper understanding of acceleration. Although the study did not include a comparison group, the findings suggest that scaffolded inquiry-based learning is a promising instructional approach for enhancing learners' conceptual understanding of abstract physics concepts.

Keywords: scaffolding, inquiry-based learning, conceptual understanding

INTRODUCTION

Acceleration is a fundamental yet challenging concept in physics, and fostering true conceptual understanding has long been a concern in science education. Many students interpret acceleration based on everyday experiences, often equating it solely with "speeding up," rather than recognizing it as a change in velocity that also includes slowing down and changes in direction. These persistent misconceptions hinder students' ability to develop accurate scientific understanding and apply concepts effectively.

Traditional teaching methods, which rely heavily on lectures and rote memorization, often fail to bridge the gap between abstract theoretical knowledge and real-life applications. This disconnect leads to superficial learning, where students may recall definitions but struggle to apply them meaningfully. Recognizing these limitations, active learning strategies have emerged as viable alternatives, emphasizing student engagement, collaboration, and critical thinking (Beaumont, 2025). Mediana et al., (2025) mentioned that inquiry-based learning consistently gained prominence as a response to the shortcomings of conventional teacher-centered instruction, promoting active exploration and deeper conceptual understanding.

Additionally, OECD (2023) results indicate that Filipino learners continue to demonstrate low achievement in science. The Philippines ranked among the lowest-performing countries in the PISA 2022 science assessment,

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suggesting that many students experience difficulties in understanding and applying fundamental scientific concepts. These findings suggest that many Filipino students have difficulty developing the conceptual understanding, scientific reasoning, and problem-solving skills required in physics, highlighting the need for effective instructional approaches that strengthen students' understanding of fundamental physics concepts.

Although, IBL encourages student participation, its effectiveness depends on appropriate guidance (Chu et al., 2023). Without structured guidance, inquiry may become unproductive and lead to confusion (Alanazi et al., 2024). This highlights the importance of scaffolding, which provides structured support through guided questioning, contextualized examples, and step-by-step learning Petersen (2022). Scaffolding helps students connect prior knowledge with new concepts, facilitating scientific understanding and conceptual development.

Despite the recognized benefits of inquiry-based and scaffolded approaches, there remains limited research on their combined use in teaching abstract concepts such as acceleration. This study addresses this gap by developing and implementing scaffolded inquiry-based learning activities designed to improve Grade 8 learners' conceptual understanding of acceleration. By integrating structured guidance, inquiry-driven tasks, and contextualized learning experiences, the activities aim to reduce misconceptions, facilitate conceptual understanding, and enhance learners' application of complex physics concepts.

METHODOLOGY

Research Design and Participants

This study employed an explanatory mixed-methods research design involving two intact sections of Grade 8 learners, both of which were taught using scaffolded inquiry-based learning (Creswell & Guetterman, 2021). A comparison or control group was not included because the study aimed to evaluate the implementation of the intervention within authentic classroom settings, allowing all participants to experience the scaffolded inquiry-based learning activities. According to Johnson et al. (2007), mixed-methods research integrates both quantitative and qualitative approaches to provide a more comprehensive understanding of a research problem.

The explanatory mixed-methods design was selected because it first examines the effectiveness of the intervention through quantitative data, followed by qualitative data to explain, interpret, and provide deeper insights into the quantitative findings. Quantitative data were collected through a pretest–posttest assessment, a perception questionnaire, and activity performance scores. The pretest and posttest measured learners' conceptual understanding before and after the intervention, serving as the primary quantitative measure of the effectiveness of the scaffolded inquiry-based learning activities. The perception questionnaire assessed learners' perceptions, while activity performance scores measured their learning achievement during the intervention.

After the quantitative phase, qualitative data were gathered through student interviews, reflective journal entries, and teacher-researcher field notes to explain learners' improvement, identify persistent misconceptions, and explore their experiences with the scaffolded inquiry-based learning activities. The study involved two intact Grade 8 sections during the Academic Year 2025–2026. The participants were purposively selected from existing standardized class sections because they possessed the necessary foundational knowledge of physics concepts and represented the typical classroom learning environment. Using intact sections preserved the natural classroom setting, enhanced the internal validity of the study, and ensured that the data collected were relevant and meaningful in addressing the research objectives.

Instruments

- The needs assessment questions were developed by the researcher to identify gaps in students' understanding, teachers' familiarity with scaffolding strategies, and the challenges encountered in teaching acceleration. These questions were used to determine the specific misconceptions students possess, particularly in understanding acceleration as an abstract concept, as well as the instructional practices currently used by teachers. The result served as a foundation for the design of instructional intervention. Specifically, the identified misconceptions guided the development of learning activities that target conceptual understanding, while the reported challenges informed the integration of scaffolding strategies and real-life contextualization. As a result, the intervention was tailored to address both learners' conceptual difficulties and teachers' instructional needs, ensuring its relevance and effectiveness.

- Physics Conceptual Understanding Test. A 50-item multiple-choice achievement test, adapted from K–12 curriculum assessments, was administered before and after the intervention to measure students' conceptual understanding of physics. The assessment was aligned with the Grade 8 Science MATATAG Curriculum, specifically the Fourth Quarter content standards on acceleration. To establish content validity, the instrument underwent face validation by a panel of educators and subject matter experts. The pretest and posttest scores were used to examine changes in students' conceptual understanding following the intervention; however, given the one-group pretest-posttest design, the observed improvements indicate an association with the intervention rather than definitive causality.

- Learners' Perception Questionnaire. The perception questionnaire gathers learners' views, attitudes, and experiences related to the topic of acceleration and the developed scaffold learning activities. The data gathered helps explain factors affecting learning and measures the effectiveness of the intervention by offering a holistic view of the learners' performance and providing a comprehensive progress of the learners.

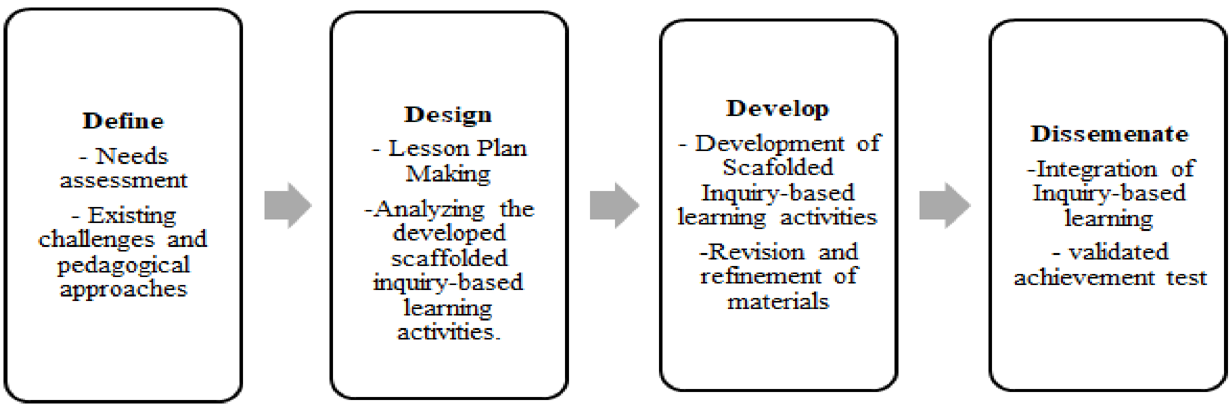
- Usability Perception Questionnaire. This test evaluates the usability of inquiry-based learning activity, 10-item questionnaire with 4-point Likert scale with three open-ended questions was administered for science teachers. This set of items evaluates how easy, convenient, and practical it is for teachers to utilize the intervention or the developed learning worksheet. It gathers their feedback on its simplicity of use, clarity of instructions, and suitability for actual classroom procedures. It is important and relevant as it measures the tool's functionality and workability, identifies any difficulties or limitations in application, and ensures that it can be smoothly integrated into regular teaching instruction without unnecessary complications.

- Acceptability Perception Questionnaire. This test evaluates the acceptability of the inquiry-based learning (IBL) activity, 10-item questionnaire with 4-point Likert scale with three open-ended questions was administered for science teachers. This set of items gathers teachers' feedback on the acceptability of the intervention or the developed learning worksheet. It assesses their views on its content clarity, alignment with the learning goals, and the quality of the overall intervention. It is relevant and important as it determines whether the tool is feasible and acceptable for classroom instruction, provides insights for further improvement, and confirms that it enhances conceptual understanding of physics concepts while ensuring alignment with educational standards.

Data Gathering Procedures

The development of the activity worksheet followed the 4D model (Define, Design, Develop, and Disseminate) developed by Thiagrajan (1974).

Figure 1. 4D Model developed by Thiagrajan (1974).



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In the Define phase, the study focuses on analyzing the needs assessment questionnaire for the teachers to identify students' misconception. The needs assessment survey is essential for diagnosing gaps in physics education, focusing on teachers' strategies for tackling student misconceptions and their experience with scaffold inquiry-based learning.

The Design phase focused on planning and structuring of the activity worksheet based on the successful inquiry-based learning and scaffolding techniques. This phase involves creating the instructional material that integrated scaffolding elements such as teacher modeling, guided practice, collaborative learning, and independent learning to support learners as they explore, investigate, and construct their own understanding of the topic.

During the Develop phase, the first draft of the instructional materials was subjected to face validation by the research adviser and panel members. Revisions were made based on their comments and suggestions. The revised draft was then evaluated by expert science teachers using an adopted assessment tool for developed activity worksheets. In addition, the developed activity worksheets, lesson plans, interview guide, perception questionnaire, and journal prompts underwent expert validation by specialists in science and physics education to ensure their content validity and appropriateness. The achievement test was adapted from DepEd learning materials ensuring its content validity. Based on the comments and recommendations of the experts, the instructional materials underwent final revisions before they were administered during the intervention.

Finally, the Disseminate phase involved the implementation of the activity worksheet with the selected participants. A 50-item pre-test was administered to assess baseline conceptual understanding. The learners then participated with developed scaffold inquiry-based learning activities for a week-long period. After the intervention, a posttest containing the same questions- rearranged in a random order was administered to measure changes in conceptual understanding. This phase included the collection of learners perceptions and the usability and acceptability from the science teachers to evaluate the effectiveness of the intervention.

RESULTS

Summary Results of the Needs Assessment of the Key Participants

The nine (9) in service grade 8 science teachers were among the participant of this study to answer the needs assessment questionnaire. To ensure the confidentiality and privacy of the participants, each science teacher was assigned a unique identifier (NAST1–NAST9), which was used consistently throughout the data collection, analysis, and reporting phases.

From the results of the needs assessment, most of the respondents showed students' experiences difficulty in understanding acceleration and common misconception of concept acceleration, suggesting a significant instructional challenge in the classroom. The following table shows the summary responses of science teachers on the challenges encountered on teaching acceleration.

Table 1. Summary of Responses of The Science Teachers on Students' Misconception

Themes	Utterances	Implications to the Study
Common misconceptions about acceleration and force-motion concepts	Students commonly confuse acceleration with speed and velocity, believing that acceleration only means moving faster.	The findings indicate that students possess deeply rooted alternative conceptions about acceleration and related force-motion concepts prior to instruction. These misconceptions may hinder the development of accurate scientific understanding and negatively affect performance in physics.

	Many fail to recognize that acceleration also occurs when an object slows down, changes direction, or momentarily has zero velocity. Other misconceptions include believing that motion requires a continuous force, heavier objects fall faster, and balanced and unbalanced forces are the same	Therefore, there is a need for instructional approaches that explicitly address misconceptions through conceptual development, hands-on investigations, real-life contextualization, graph interpretation, and guided inquiry activities.
	Teachers attributed these misconceptions to everyday language, limited opportunities for experimentation, weak foundational knowledge, semantic confusion, and insufficient real-life applications.	The results support the development of a Scaffolded Inquiry-Based Learning intervention designed to help students reconstruct their existing conceptions, strengthen conceptual understanding, and connect abstract physics concepts to observable phenomena.

Table 1 presents the science teachers' perceptions regarding students' common misconceptions about acceleration. The findings revealed that students frequently confuse acceleration with speed and velocity, often believing that acceleration only refers to an increase in speed. Teachers also noted that learners struggle to understand that acceleration can occur when an object slows down, changes direction, or momentarily has zero velocity. Additional misconceptions related to inertia, force interactions, and the distinction between balanced and unbalanced forces were likewise identified.

These findings suggest that students enter physics classes with pre-existing conceptions derived from everyday experiences and language, which often conflict with scientific explanations. Such misconceptions may hinder the development of accurate conceptual understanding and problem-solving skills in physics. Therefore, the results highlight the need for instructional approaches that explicitly address misconceptions through guided inquiry, hands-on activities, real-life contexts, and scaffolded learning experiences. These findings provide a strong basis for the development of a Scaffolded Inquiry-Based Learning intervention aimed at improving students' understanding of acceleration.

Ouch and Widiyatmoko (2023) mentioned in their study how students' misconceptions persist and constitute a major barrier to effective science learning, as they often conflict with scientifically accepted concepts and hinder development of accurate scientific understanding. These misconceptions can continue to influence students' thinking even after instruction, limiting their ability to fully understand new information. While research has identified various strategies for addressing misconceptions, their study also points out that teachers frequently encounter challenges in integrating students' prior ideas into their instructional practices due to fragmented knowledge and lack of structured approaches.

Table 2. Summary of Teaching Strategies Used to Address Students' Misconceptions

Theme	Utterances	Implications to the study
Strategies used to address students' misconceptions about acceleration	Teachers reported using a variety of instructional strategies to correct misconceptions, including real-life examples, hands-on experiments, motion graphs, visual representations, simulations, Think-Pair-Share (TPS), guided questioning, Socratic dialogue, Predict-Observe-Explain (POE), inquiry-based learning, and contextualized demonstrations.	The findings suggest that teachers recognize the importance of active, student-centered, and inquiry-oriented approaches in addressing misconceptions about acceleration.

	They emphasized the importance of allowing students to confront their misconceptions through observation, experimentation, discussion, and reflection rather than relying solely on direct instruction.	The consistent use of guided questioning, collaborative learning, experimentation, and contextualized instruction indicates a need for structured learning experiences that actively engage students in knowledge construction.
	Teachers also highlighted the value of repetition, practice activities, and connecting scientific concepts to learners' everyday experiences.	These findings provide empirical support for the development of the Scaffolded Inquiry-Based Learning intervention, which integrates inquiry activities, collaborative discussions, teacher guidance, and real-life applications to promote and improve students' understanding of acceleration.

Table 2 presents the instructional strategies employed by science teachers to address students' misconceptions about acceleration. These include the use of real-life examples, hands-on activities, collaborative learning, visual representations, guided questioning, and Predict-Observe-Explain (POE) activities. Such strategies allow students to actively examine their prior conceptions, compare them with scientific explanations, and construct a more accurate understanding of acceleration. These approaches emphasize the concept of acceleration as a change in velocity and support students by being actively involved in the lessons and having well-structured learning experiences. The teachers' responses further suggest that conceptual understanding is enhanced when learners are provided with opportunities to investigate, discuss, and relate scientific concepts to real-world experiences.

The results of this study are consistent with the study of Yeoh et al. (2024), which found that game-based scaffolding significantly improved learning outcomes and reduced student anxiety compared to traditional approaches. Similarly, the improvement in students' conceptual understanding may be attributed to the scaffolding mechanisms embedded within the inquiry-based activities. Guided questioning, contextualized examples, collaborative discussions, and progressively challenging learning tasks provided structured support that enabled learners to develop their understanding step by step. As students gained confidence and competence, the level of teacher support was gradually reduced, encouraging them to apply concepts independently. Furthermore, studies on inquiry-based learning have shown that guided investigations, collaborative discussions, and teacher scaffolding promote deeper conceptual understanding and help students replace alternative conceptions with scientifically accepted ideas. These findings support the use of Scaffolded Inquiry-Based Learning as an effective approach for improving students' understanding of acceleration.

Table 3. Summary of Teachers' Familiarity with Scaffolding Strategies in Teaching Acceleration

Theme	Utterances	Implications for the study
Teachers' familiarity with scaffolding strategies and their role in developing conceptual understanding	Teachers exhibited varying levels of familiarity with scaffolding strategies. While some were unfamiliar with the formal term, most described practices consistent with scaffolding, such as activating prior knowledge, breaking complex concepts into manageable parts, using visuals and real-life examples, employing guided questioning, promoting inquiry, and gradually increasing task difficulty.	The findings suggest that although teachers may differ in their familiarity with the terminology of scaffolding, they recognize and implement practices aligned with scaffolded instruction. These responses highlight the importance of providing structured support that enables learners to move from prior knowledge toward a more sophisticated understanding of acceleration.

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	Teachers emphasized that scaffolding supports learners through structured guidance, hands-on exploration, and collaborative learning while gradually fostering independence, confidence, and deeper conceptual understanding.	The results support the development of a Scaffolded Inquiry-Based Learning intervention that systematically guides students through inquiry activities while promoting conceptual understanding, critical thinking, learner independence, and conceptual understanding.

Table 3 outlines teachers generally view scaffolding as an effective strategy for helping students understand complex concepts such as acceleration. Participants emphasized the importance of building on prior knowledge, using guided questioning, simplifying difficult concepts, and gradually transferring responsibility to learners. These practices enable students to actively construct understanding while reducing cognitive overload and preventing frustration during inquiry activities.

DISCUSSIONS

The needs assessment revealed that Grade 8 learners possessed persistent misconceptions about acceleration, particularly by associating it only with increasing speed and confusing it with related concepts such as speed and velocity. These misconceptions, influenced by everyday experiences and limited opportunities for meaningful scientific inquiry, hindered learners' conceptual understanding. Consistent with previous research, the findings underscore the importance of instructional approaches that explicitly address alternative conceptions through guided inquiry-based learning. Science teachers emphasized the use of learner-centered strategies, including guided inquiry, contextualized examples, hands-on investigations, collaborative discussions, and guided questioning, to help learners reconstruct their prior knowledge. Although teachers differed in their familiarity with the formal concept of scaffolding, they consistently employed scaffolded practices such as activating prior knowledge, providing structured guidance, and gradually transferring responsibility to learners. These findings have significant implications for the study, as they provided the empirical basis for developing the Scaffolded Inquiry-Based Learning activities. The identified misconceptions and instructional needs informed the design of the intervention, ensuring that the learning activities incorporated appropriate scaffolding, contextualized inquiry tasks, and progressive instructional support to facilitate and improve learners' understanding of acceleration.

The finding of this study is consistent with the theoretical perspectives of Lev Vygotsky, who proposed that learners achieve higher levels of understanding when provided with appropriate support within their Zone of Proximal Development (ZPD). Likewise, Jerome Bruner emphasized that temporary instructional support, or scaffolding, enables learners to accomplish tasks beyond their current capabilities until they can perform them independently. Similarly, Van de Pol et al. (2018) demonstrated that scaffolding enhances student learning by providing structured guidance that is gradually withdrawn as learners develop competence and independence. Collectively, these theoretical and empirical perspectives support the use of Scaffolded Inquiry-Based Learning as an effective instructional approach for fostering conceptual understanding, learner autonomy, and meaningful engagement in science learning.

Consequently, these results are aligns with the study of Gillies and Nichols (2014), which highlights that inquiry-based science teaching enhances student engagement and learning autonomy while shifting teachers' roles from direct instruction to facilitation. Their findings further reinforce that the use of scaffolding is essential in guiding inquiry-based learning, ensuring that it remains structured, purposeful, and conducive to meaningful learning rather than becoming unstructured or disorganized.

Table 4. Pretest and Posttest Scores of the Learners

	Mean	SD	df	t	p
Pre-Test	25.69	6.845	41	-7.854	< .001
Post-Test	36.12	6.663			

Table 4 shows the result of the paired samples t-test revealing a statistically significant difference in scores between pre-test and post-test of the students with $t(41) = 7.854$ and $p < .001$. There is an overall increase in the mean score of students from 25.69 in the pre-test to 36.12 in the post-test. This indicates that there was substantial improvement in the performance of students after the implementation of the scaffold inquiry-based learning instruction. The increase of scores implies that breaking down complex ideas and providing guided support can significantly impact students' performance by providing deeper and conceptual development. This result implies that the developed activity worksheet is effective and can significantly improve students understanding.

The improvement in learners' conceptual understanding may be attributed to the scaffolded inquiry-based learning activities, which incorporated teacher modeling, guided questioning, collaborative investigations, contextualized examples, structured worksheets, and the gradual release of responsibility. These scaffolding strategies provided appropriate instructional support, reduced cognitive load, and enabled learners to progressively develop a more accurate understanding of the concept of acceleration.

This finding is consistent with Yeoh et al. (2024), who reported that scaffolded learning significantly improved learners' achievement while reducing learning anxiety. The present findings also support Perwaiz (2024), who emphasized that allowing learners to engage in productive struggle before receiving structured guidance promotes deeper conceptual understanding and motivation. Although Hendrayana and Mutaqin (2025) found that the effectiveness of scaffolding varies according to learners' prior knowledge, the lower activity scores observed in this study should not be interpreted as instructional failure. Rather, they highlight the need for continuous scaffolding, explicit feedback, and differentiated support to help learners successfully navigate complex concepts.

Furthermore, the findings align with MacLeod and Van Der Veen (2019), who demonstrated that structured guidance, gradual support, and well-designed learning tasks enhance students' understanding while promoting active collaboration. Their study further suggests that effective scaffolding fosters learners' confidence, autonomy, and engagement in collaborative learning. Taken together, these findings reinforce the value of scaffolded inquiry-based learning as an instructional approach that promotes conceptual understanding through appropriate guidance, productive struggle, and gradual learner independence.

CONCLUSION

The findings indicate that scaffolded inquiry-based learning using contextualized examples was associated with improved learners' conceptual understanding of physics concepts. The needs assessment revealed that learners initially held misconceptions, particularly by equating acceleration with speed or viewing it only as an increase in motion. Following the intervention, the significant improvement in pretest and posttest scores suggests that the instructional approach effectively supported conceptual understanding. The integration of scaffolding strategies, guided inquiry, and real-life contexts enabled learners to reconstruct prior knowledge, address misconceptions, and actively engage in the learning process.

Additionally, the findings support the use of scaffolded inquiry-based learning as an effective instructional approach for enhancing conceptual understanding of abstract physics concepts while acknowledging that the observed improvements should be interpreted with consideration of the study's methodological limitations.

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