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THE ROLES OF CONTEXTUAL INSTRUCTIONAL MODELS IN ADDRESSING MISCONCEPTIONS HELD BY SECONDARY SCHOOL PHYSICS STUDENTS

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Abstract

Secondary school physics students' misconception has caused more harm than good in education industry. Therefore, this study examines the pivotal role of contextual models in addressing and demystifying common misconceptions in secondary school physics. Physics concepts, often abstract stems from misconceptions. These misconceptions conflict with students' intuitive understandings rooted in everyday experiences, leading to persistent low achievement in the subject. Contextual models, by embedding scientific principles within relatable real-world scenarios, facilitate a deeper and more accurate conceptual understanding of physics. They help students bridge the gap between their pre-existing notions and scientific explanations by demonstrating the practical application and relevance of physics. This approach fosters cognitive conflict, prompting students to critically evaluate their existing ideas and reconstruct their knowledge based on scientific principles. Ultimately, integrating contextual instructional models in physics education enhances conceptual clarity, promotes critical thinking, and improves students' ability to apply physics effectively, thereby reducing the prevalence and impact of misconceptions.

Keywords: Physics, Misconception, Contextual instructional models

Introduction

Physics is a natural science that involves the study of matter and its motion through space and time, along with related concepts such as energy and force. More broadly, Physics is the study of nature in an attempt to understand how the universe behaves (Young, 2014). Physics uses the scientific method to help uncover the basic principles governing light and matter, and to discover the implications of those laws. It assumes that there are rules by which the universe functions, and that those laws can be at least partially understood by humans (Holzner, 2016). It is also commonly believed that those laws could be used to predict everything about the universe's future if complete information was available about the present state of all light and matter (Holzner, 2016). Physics is the most fundamental and the root of every field of science (Erilmaz 2016). According to Anyakoha (2016), physics is defined as the natural science that involves the study of matter and energy and their interactions in a given environment. Physics is the study of natural phenomenon at its most fundamental levels and manner (Onah, 2022). Physics deals with the study of laws that determine the structure of the universe with reference to the matter and energy in the universe (Ike, 2014). Physics as the core subject taught in secondary school contributes to the cognitive development of the students. Physics is the most utilized basic science subjects in most technology and technology-based profession. This is because physics, exposes the students to the true nature of the universe around them, and as well forms the basis for the nation's technological advancement and human resource development (Abubakar 2012 and Onah, Anamezie and Nnadi, 2022). Physics is an exciting intellectual adventure that inspires young people and expands the frontiers of our knowledge about Nature. Physics generates fundamental knowledge needed for the future technological advances that will continue to drive the economic engines of the world. Physics contributes to the technological infrastructure and provides training for personnel needed to take advantage of scientific advances and discoveries (Onah & Anamezie, 2022, and Onah, Anamezie & Nnadi, 2022). Physics as a physical science presents pre-knowledge to the students before classroom interaction. These prior knowledge present alternative conceptions in most cases. Physics education at the secondary school level is pivotal in shaping students' understanding of fundamental scientific principles. However, students often enter classrooms with deeply rooted misconceptions—alternative or naive conceptions that deviate from scientifically accepted ideas.

Misconceptions in physics are persistent, incorrect beliefs or alternative conceptions that students hold, often stemming from literary understanding, intuitive reasoning, everyday experiences, or misinterpretations of scientific concepts. Misconceptions refer to students' incorrect or incomplete understandings of physical phenomena that deviate from scientifically accepted concepts. These are not mere errors or random mistakes but rather stable, deeply rooted cognitive frameworks that students develop based on their prior experiences, intuitive reasoning, or interactions with the world. According to Majidy (2025), misconceptions in physics are particularly prevalent at the secondary school level, where students are still forming their understanding of abstract concepts like force, motion, energy, power, and gravity. These misconceptions hinder deep understanding and effective application of physics in real world. Researchers are worried about this horrific situation as its bad omen in education system cannot be overemphasized. Misconceptions are the major bottlenecks that impede students' understanding of physics concepts (Onah, 2022). According to Onah and Achufusi (2022), metacognitive models like contextual models are required to help students dissociate with the alternative conceptions they come to classroom with.

Contextual instructional models are schemas, graphical representations, pictorial representation, c-maps and mind mapping framework that relates to real-life situation and environment. Contextual instructional models, which embed physics concepts within real-world or relatable scenarios, have emerged as a powerful approach to address these misconceptions (Majidy, 2025). By situating abstract principles in meaningful contexts, these models facilitate conceptual change and deeper understanding (Trianto, 2010). The purpose of contextual instructional model is to provide students with more practical knowledge and skills that is essence for the learning of theoretical things into practice. Method of implementation of contextual model is developed in such a manner that, it is learned and applied in real situations. In this context, students understand what is meant by learning, the benefits of what status they are in, and how to achieve it. They realize that what they learn is helpful for their later life. Thus, they position themselves as people who need provisions for their future lives. They learn what is helpful to them and strive to achieve it. In that effort, they need teachers as directors and mentors (Lotulung, 2018). This report explores the role of contextual models in demystifying misconceptions in physics, drawing on educational research and cognitive science, with a focus on their theoretical foundations, empirical evidence, and practical applications. These misconceptions, such as believing a continuous force is needed for continuous motion or that gravity does not act in water, can hinder effective learning. Contextual models, which integrate real-world contexts into physics instruction, have emerged as a promising approach to address these misconceptions by making abstract concepts more relatable and fostering deeper conceptual understanding. This seminar research explores the roles of contextual models in demystifying misconceptions in secondary school physics to enable the students have conceptual understanding of the subject matter.

Understanding Misconceptions in Physics

Misconceptions in physics are often context-dependent, arising from students' everyday experiences, literary interpretations or intuitive reasoning. For instance, students may believe that power in physics is the same as the one used by government officials, peers and pious society (church). Like saying that President Tinubu is in power or students may believe that heavier objects fall faster due to gravity, a misconception rooted in intuitive observations of objects in real-world settings. Intuition from Everyday Experience reforms our brains to naturally form models based on what we observe daily, which often don't align with the underlying physics precepts (e.g., friction's omnipresence on Earth masks the concept of inertia). These alternative conceptions are stable and resistant to change, often persisting even after traditional instruction. Research indicates that misconceptions are not merely errors but reflect fragmented or context-specific knowledge structures that lack integration with expert-like understanding (Rebello 2024). Identifying and addressing these misconceptions is critical for effective physics education.

Types of Misconceptions in Physics

Misconceptions in physics can be categorized based on their nature or the domains they affect. Below are key types, with examples drawn from secondary school physics:

1. **Factual Misconceptions**: Incorrect beliefs about specific facts, such as thinking that the Earth is the only body exerting gravitational force in the solar system (Schwarz et al., 2024). The reality is that gravitational force in the solar system forms a complex web of interactions among all objects with

mass. Each body exerts its own gravitational pull, proportional to its mass and diminishing with distance. Far from being the sole source of gravity, Earth is just one participant in this cosmic dance. Recognizing gravity as a universal phenomenon dispels the misconception and underscores the interconnected nature of our solar system.

2. **Conceptual Misconceptions:** Misunderstandings of fundamental principles, such as believing that an object at rest has no forces acting on it, ignoring balanced forces like gravity and normal force. The belief that an object at rest has no forces acting on it ignores the reality of balanced forces, like gravity and the normal force, which work together to maintain stillness. Examples like a book on a table or a person on the ground illustrate this, while Newton's first law reinforces it. Far from being force-free, stationary objects are often held in place by this delicate balance—an essential truth in physics that dispels the misconception and deepens our understanding of the world.
3. **Procedural Misconceptions:** Errors in applying physics concepts to problem-solving, such as misinterpreting vector addition in force diagrams due to a lack of understanding of vector components. Procedural misconceptions happen when students apply physics concepts incorrectly during problem-solving, often because they don't fully understand the underlying principles. Here, the focus is on vector addition in force diagrams. Vectors are quantities with both magnitude and direction—like forces—unlike scalars, which only

have magnitude. When multiple forces act on an object, we need to calculate the net force by adding these vectors correctly. Misinterpreting this process, especially due to confusion about vector components, is a frequent and impactful error. Ohm's law and its mathematical representation.

4. **Ontological Misconceptions:** Ontological misconceptions occur when individuals assign incorrect categories to physical entities or processes, leading to flawed conceptual frameworks. Unlike simple factual errors, these misclassifications affect how students' reason about physics, making them a critical focus for educators. Misclassifying physical entities, such as classification of moon as a luminous body and treating heat as a substance rather than a transfer of energy, a common issue in thermodynamics education (Wei et al., 2025).
5. **Context-Specific Misconceptions:** Beliefs that hold true in one context but not another, such as assuming that gravity does not act in fluids because objects appear to "float" in water. Like power means strength literarily but rate of doing work in physics. Again, motion is a factor of mass. These illustrate how everyday observations or language can clash with scientific frameworks. In everyday language, "power" often refers to strength, influence, or authority (e.g., "She has the power to make decisions"). In physics, however, power is a precise quantity defined as the rate at which work is done or energy is transferred. Confusing these meanings can lead to errors when applying physics

concepts. Again, in everyday life, people notice that heavier objects require more effort to move, leading to the assumption that mass directly controls motion. In physics, however, motion is a result of forces acting on a mass, and the relationship is governed by precise laws. This discrepancy between intuitive observation and scientific principles creates the misconception.

Examples of Misconceptions in Physics

Misconception: A continuous force is required to keep an object moving at a constant speed.

Correction: This idea aligns with Aristotelian physics but is incorrect according to Newton's First Law of Motion (Inertia). An object in motion will stay in motion with constant velocity unless acted upon by a net external force. On Earth, friction is the external force that typically brings moving objects to a stop, making it seem like a continuous force is needed to maintain motion. Bringing it to the context of human training, when a child has received adequate training from the parent; he ought to be independent pending to when he is faced with challenges that requires parental attention.

Misconception: If an object is at rest, no forces are acting on it.

Correction: An object at rest can still have multiple forces acting on it, as long as these forces are balanced (sum to zero), resulting in a net force of zero. For example, a book on a table has gravity pulling it down and the normal force from the table pushing it up.

Misconception: Mass and weight are the same thing, or an object is hard to push because it's heavy.

Correction: Mass is a measure of an object's matter contents or inertia (resistance to changes in motion). It is an intrinsic property and remains constant regardless of location. **Weight** is the force of gravity acting on an object's mass (W=mg). While a heavier object is harder to push, this is due to its greater mass (inertia), not its weight. An object's weight can change depending on the gravitational field (e.g., on the Moon, you weigh less, but your mass is the same).

Misconception: Energy and force are interchangeable terms.

Correction: Force is a push or pull that can cause a change in motion. Energy is the ability to do work. They are related (Energy is force times distance), but fundamentally different concepts with different units.

Misconception: Energy is "used up" or "lost."

Correction: The Law of Conservation of Energy states that energy cannot be created or destroyed, only transformed from one form to another. While energy transformations might result in forms less useful (like heat dissipated to the environment), the total amount of energy in a closed system remains constant.

Contextual Instructional Models in Physics Teaching

Contextual instructional models are frameworks or representations that incorporate the environment or context in which a system, phenomenon, or behaviour operates. Contextual instructional models are schemas and mind mapping framework that relates the subject matter to real-life situation and environment. Contextual instructional models take into account the surrounding conditions, constraints, and influences that affect the system. Contextual models in physics education involve embedding physics concepts within real-world scenarios or problems that are relevant to students' lives or interests. Unlike de-contextualized problems that focus purely on abstract principles (e.g., solving for velocity using equations), contextual models tie concepts to practical situations, such as calculating the motion of a car or the forces in a sports activity. These models align with context-based instruction, defined as “using concepts and process skills in real-world contexts that are relevant to students from diverse backgrounds” (Nurhidayah 2016). By grounding abstract ideas in familiar contexts, these models aim to enhance engagement, motivation, and conceptual understanding. According to Nurhidayah (2016), there are eight characteristics of contextual models, namely 1) Making meaningful connections (making meaningful relationships), 2) Doing significant work (doing important work), 3) Self-regulated learning (learning to self-regulate), 4) Collaborating (cooperation) students can work together, 5) Critical and creative thinking (think critically and creatively), 6) Nurturing the individual (nurturing individuals), 7) Reaching high standards (achieving high standards) students recognize and achieve high standards high and 8) Using authentic assessment (holding an authentic assessment). Students use academic knowledge in real-world contexts for a meaningful purpose.

Roles of Contextual Instructional Models in Addressing Misconceptions

1. Enhancing Conceptual Understanding

Contextual instructional models promote conceptual understanding by connecting abstract physics principles to tangible scenarios, helping students integrate fragmented knowledge into coherent cognitive structures. For example, Length is a measure of how long something is from one end to another. This means that distance, displacement, radius, height, width, breadth and circumference are lengths. But holds conception that length is not the same as other parameters mentioned. Again, addressing the misconception that “gravity does not affect objects in water” can be tackled by using a contextual model involving a sinking and floating experiment in a swimming pool scenario. Research by Wei et al. (2025) found that contextualized physics problems (CPPs) can enhance interest and motivation among 8th graders, who are often newly introduced to physics, by making concepts more relatable, though older students (9th to 11th graders) showed a preference for de-contextualized problems due to familiarity with abstract problem-solving. This suggests that contextual models are particularly effective for younger students or those with limited prior exposure to physics.

2. Facilitating Cognitive Conflict

Contextual instructional models can create cognitive conflict, a key mechanism for challenging misconceptions. By presenting scenarios that contradict students' naive beliefs, these models encourage students to confront and revise their existing ideas. For instance, a contextual model involving a roller coaster can challenge the misconception that "a continuous force is needed for continuous motion" by demonstrating how inertia governs motion in the absence of external forces. Curricula like Physics by Inquiry (Gasana et al. (2023) use inquiry-based contextual approaches to engage students in resolving such conflicts, leading to improved conceptual learning. Although these approaches are effective, they require careful design to ensure the context is relevant and appropriately challenging.

3. Promoting Engagement and Motivation

Engagement is critical for overcoming misconceptions, as students are more likely to confront and revise their beliefs when motivated. Contextual models leverage real-world relevance to increase student interest and motivation in physics. For instance, Al-Kamzari and Alias (2024) explored contextual and project-based hybrid learning, it was found that contextual project-based learning increased student motivation in learning physics concepts like linear motion. Similarly, Gasana et al. (2023) reported that students taught through contextual project-based learning (PjBL), a form of contextual modelling, showed better conceptualization of linear motion and higher motivation compared to traditional methods. These findings highlight how contextual models can make physics more appealing, encouraging students to engage deeply with content and address misconceptions.

4. Supporting Model-Based Learning

Model-based learning, a subset of contextual approaches, emphasizes the use of scientific models to represent and explain phenomena. These models help students visualize and manipulate abstract concepts, such as using a spring model to understand harmonic motion. Schwarz et al (2024), found that model-based teaching, when contextualized, supports multidimensional learning by allowing students to apply models to diverse scenarios, thus addressing misconceptions like those related to Newton's laws of gravitation. For example, a model of planetary orbits can clarify that gravitational attraction is not solely caused by planets, countering a common misconception identified in a study.

5. Addressing Equity and Inclusivity

Contextual instructional models can be tailored to diverse cultural and socio-economic contexts, making physics accessible to students from varied backgrounds like ethnoscience: ethno-physics, ethno-chemistry and ethno-biology. This deals with incorporation of cultural and materials available from the environment in the teaching and learning of science. By incorporating culturally relevant examples, such as traditional practices or local phenomena, these models help demystify physics for students who might otherwise feel disconnected. A study by Lotulung, Ibrahim and Tumurang (2018) noted that project-based contextual models enhanced higher-order thinking skills in physics, particularly when designed with inclusive contexts that resonate with students lived experiences. This approach ensures that misconceptions are addressed in ways that are meaningful and equitable across diverse student populations.

Theoretical Framework

Jean Piaget's Constructivist Learning Theory (Piaget, 1970) posits that learning is an active, constructive process where individuals build new knowledge based on their existing cognitive structures. The key tenets of the theory, as proposed by Piaget, include: Learners actively construct their understanding by interacting with their environment, rather than passively receiving information from the instructors or teachers. Knowledge is built through experiences that challenge or extend existing mental frameworks (schemas). Learning occurs through two complementary processes: assimilation, where new information is integrated into existing schemas, and accommodation, where existing schemas are modified to incorporate new, conflicting information. Misconceptions arise when students assimilate incorrect information into their schemas, and learning requires accommodation to correct these inaccuracies. Piaget proposed that learners progress through distinct developmental stages (sensorimotor, preoperational, concrete operational, and formal operational), each influencing their ability to process abstract concepts. Secondary school students, typically in the formal operational stage, can engage with abstract physics concepts but may still hold misconceptions due to prior experiences or intuitive thinking. Learning involves a process of achieving cognitive equilibrium, where learners resolve discrepancies between their existing knowledge and new information. Misconceptions represent a state of disequilibrium, which can be addressed by confronting students with evidence or experiences that challenge their incorrect beliefs.

Application Constructivist theory to the Study

In the context of secondary school physics, contextual instructional models serve as powerful tools to address misconceptions by providing tangible, relatable, and interactive experiences that align with constructivist principles. For instance, in optics, students may hold misconceptions about the nature of light or image formation in mirrors. By using contextual models like ray-tracing kits or virtual simulations, researchers can facilitate active engagement, challenge incorrect schemas, and promote accommodation of scientific concepts. These models also foster a collaborative learning environment, as emphasized by Piaget, where peer discussions and teacher guidance enhance understanding. The roles of contextual model tools in addressing misconceptions, aligning with Piaget's emphasis on active learning and equilibration. By grounding this study in Constructivist Learning Theory, the research can explore how contextual models facilitate the correction of misconceptions, enhance conceptual understanding, and promote engagement in secondary school physics.

Challenges and Limitations of contextual Instructional models

Despite their benefits, contextual instructional models face challenges. Wei et al. (2025) highlighted a perception gap between teachers and students, where teachers often overestimate the motivational impact of contextualized problems, particularly for older students who prefer abstract problems. Additionally, the design of contextual models requires careful consideration to avoid overwhelming students with overly complex scenarios, which could reinforce rather than resolve misconceptions. For instance, a poorly designed contextual problems can confuse students if the real-world context obscures the underlying physics principle. Contextual models often struggle to generalize effectively across the wide range of misconceptions students may have. For example, a student might incorrectly believe that heavier objects fall faster than lighter ones in a vacuum, a misconception rooted in intuitive experiences rather than physics principles. Models trained on specific datasets may fail to identify or correct less common or highly individualized misconceptions, especially if they deviate from the training data's scope. This limitation stems from the models' reliance on predefined patterns, which may not encompass the full spectrum of erroneous beliefs students develop from real-world observations. Furthermore, teachers limited pedagogical content knowledge can hinder effective implementation. Contextual models typically lack the ability to engage in such dynamic, interactive dialogues, as they are often designed to provide direct answers rather than iterative questioning. For instance, addressing a misconception about the conservation of energy might require asking a student to explain their reasoning step-by-step, but most models deliver static responses, limiting their ability to adapt to the student's evolving understanding.

Conclusion

Contextual instructional models play a multifaceted role in demystifying misconceptions in secondary school physics by enhancing conceptual understanding, facilitating cognitive conflict, promoting engagement, supporting model-based learning, and addressing equity. While challenges such as teacher training and design complexity persist, strategic implementation through curriculum design, teacher training, and technology integration can maximize their effectiveness.

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