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Identifying and Addressing Misconceptions in Physics Among Secondary School Students:

A Classroom-Based Study

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Abstract - Physics misconceptions represent a well-documented and persistent challenge in secondary science education. Students frequently enter physics classrooms carrying deeply embedded intuitive ideas about natural phenomena — ideas that are inconsistent with established scientific principles. This classroom-based study investigates the nature, prevalence, and pedagogical correction of conceptual errors among Grade 9 and Grade 10 students (N = 120) at a secondary school in an urban educational setting. Using a mixed-methods approach — combining a Diagnostic Conceptual Questionnaire (DCQ), structured interviews, and classroom observation — the study identifies the most common misconceptions across five core physics domains: mechanics, thermodynamics, optics, electricity, and waves. Results reveal that over 70% of students held at least one significant misconception in mechanics, with force-motion confusion and the impetus theory being the most prevalent. A targeted intervention program using Predict-Observe-Explain (POE) strategies, collaborative concept mapping, and PhET interactive simulations was implemented over an eight-week period. Post-intervention assessment demonstrated a statistically significant improvement in conceptual understanding ($p < 0.001$), with a mean gain score of 28.6%. The findings affirm that structured, evidence-based instructional interventions can effectively reshape student thinking and promote durable conceptual change. This paper concludes with a set of practical, classroom-ready recommendations for physics educators.

Keywords: ***physics misconceptions, conceptual change, secondary school physics, Predict-Observe-Explain, constructivism, physics education research, diagnostic assessment, classroom intervention***

1. INTRODUCTION

Physics stands as one of the most conceptually demanding subjects in secondary school curricula. Unlike subjects that primarily require the recall of factual information, physics demands that students construct coherent mental models of how the natural world operates — models that must align with empirical evidence and mathematical reasoning. However, students do not arrive at physics classrooms as empty vessels waiting to be filled with knowledge. They come equipped with years of lived experience and observation, from which they have drawn informal conclusions about the physical world. While these intuitive frameworks are often adaptive and functional in everyday life, they frequently diverge sharply from the formal principles of physics.

These divergent ideas — commonly referred to in the educational literature as misconceptions, alternative conceptions, or naïve theories — have been a central concern in physics education research since the foundational work of scholars such as Driver and Easley (1978), Clement (1982), and McCloskey (1983). What makes misconceptions particularly challenging for educators is not merely their existence, but their remarkable resilience. Even after formal instruction, many students revert to their prior intuitive frameworks when confronted with unfamiliar problems. This phenomenon, described by Strike and Posner (1985) as conceptual inertia, suggests that traditional lecture-based teaching is often insufficient to bring about genuine conceptual change.

The consequences of unresolved misconceptions are significant. Students who harbor fundamental misunderstandings about force, energy, heat, or electric current are not merely deficient in content knowledge — they are building subsequent learning on an unstable foundation. Each new topic in physics is layered upon prior concepts, and if those foundational concepts are flawed, the entire edifice of understanding becomes structurally compromised. Moreover, misconceptions can affect student confidence, engagement, and long-term interest in science, technology, engineering, and mathematics (STEM) fields.

Despite the extensive body of international research on physics misconceptions, much of this scholarship originates in Western educational contexts. There remains a meaningful gap in studies that examine how misconceptions manifest and can be addressed within the specific pedagogical, cultural, and resource contexts of developing and transitional educational systems. This study aims to contribute to this under-researched space by conducting a systematic, classroom-based investigation of misconceptions among secondary school students, using context-appropriate diagnostic tools and intervention strategies.

The central purpose of this research is threefold: first, to systematically identify the types and prevalence of physics misconceptions held by Grade 9 and Grade 10 students; second, to implement a structured, theory-informed intervention program designed to promote conceptual change; and third, to assess the effectiveness of that intervention in improving students' scientific understanding. In doing so, this study seeks to provide both theoretical insights and practical guidance for physics educators operating in real classroom environments.

1.1 Research Questions

This study is guided by the following research questions:

- What are the most prevalent physics misconceptions held by Grade 9 and Grade 10 students across the domains of mechanics, thermodynamics, optics, electricity, and waves?
- What cognitive and instructional factors contribute to the formation and persistence of these misconceptions?
- To what extent does a structured, evidence-based intervention program improve students' conceptual understanding of physics?
- What practical classroom strategies are most effective in promoting sustained conceptual change?

1.2 Significance of the Study

This research contributes to the literature on physics education by providing empirically grounded evidence of the types of misconceptions that persist in secondary school classrooms. The use of a mixed-methods design allows for both quantitative measurement of learning gains and qualitative insight into the cognitive processes underlying misconceptions. The intervention strategies described and evaluated herein are immediately applicable to classroom practice, making this study of direct relevance to practicing physics teachers, curriculum designers, and educational policymakers.

2. LITERATURE REVIEW

2.1 Defining Misconceptions in Physics Education

The term 'misconception' entered the educational lexicon as a descriptor for student ideas that are systematically inconsistent with accepted scientific knowledge. Osborne and Freyberg (1985) distinguished between scientific concepts — those formalized and validated by the scientific community — and children's science, which refers to the informal conceptual frameworks students construct from direct experience. Gilbert, Watts, and Osborne (1982) proposed the term 'alternative frameworks' to capture the structured, internally coherent nature of these ideas, emphasizing that students are not simply ignorant but rather hold alternative and logically consistent (if scientifically incorrect) worldviews.

This distinction is pedagogically important. Treating misconceptions as mere ignorance leads to an additive model of instruction — simply adding the correct information on top of the incorrect. Research has shown, however, that conceptual change requires a more disruptive process: students must be led to recognize the inadequacy of their existing ideas before they are cognitively prepared to accept new ones (Posner et al., 1982). This recognition has driven decades of research into diagnostic tools and instructional strategies designed to surface and challenge student misconceptions.

2.2 Common Misconceptions in Secondary Physics

The research literature on physics misconceptions is extensive and well-replicated across diverse educational contexts. In the domain of mechanics, one of the most widely documented misconceptions involves the conflation of force and motion. A large proportion of students believe that a constant force is required to maintain constant velocity, reflecting Aristotelian rather than Newtonian physics (Halloun & Hestenes, 1985). Related to this is the 'impetus theory' — the belief that objects contain a quantity of 'impetus' or 'force' that is gradually used up as they move (McCloskey, 1983).

In thermodynamics, students frequently confuse heat and temperature, treating them as equivalent rather than as distinct physical quantities. Many students believe that metals are inherently colder than wood at room temperature, failing to distinguish between thermal conductivity and temperature (Erickson, 1979). The concept of thermal equilibrium is similarly misunderstood, with students often assuming that heat flows from objects of greater mass to objects of lesser mass, rather than from higher temperature to lower temperature.

In optics, a prevalent misconception is that vision involves rays emanating from the eye — a view known as the 'extramission theory' (Winer et al., 2002). Students also frequently misunderstand the law of reflection, conflating the angle of incidence with the angle between the incident ray and the reflecting surface rather than the normal. In electricity, students often conceptualize current as being 'used up' by components in a circuit — the 'current consumption model' — rather than understanding that current is conserved while energy is dissipated (Shipstone, 1984).

These are not isolated findings. They have been replicated in studies conducted in North America, Europe, Asia, Africa, and Latin America, suggesting that the mechanisms generating these misconceptions are not primarily cultural but arise from the universal human tendency to reason by analogy and generalization from perceptual experience.

2.3 Theoretical Framework: Constructivism and Conceptual Change

The dominant theoretical framework informing research on physics misconceptions is social constructivism, most influentially articulated by Vygotsky (1978) and further developed in the educational context by Ausubel (1968), who argued that 'the most important single factor influencing learning is what the learner already knows.' From a constructivist perspective, learning is not a process of passive reception but of active construction: students build new knowledge by integrating incoming information with their existing cognitive structures.

The conceptual change theory of Posner, Strike, Hewson, and Gertzog (1982) provides the most widely applied model for understanding how students revise their prior conceptions. According to this model, conceptual change occurs only when four conditions are met: the student must be dissatisfied with the existing conception; the new conception must be intelligible; the new conception must appear plausible; and the new conception must be fruitful in explaining new phenomena and solving problems. When these conditions are met, a 'conceptual revolution' analogous to Kuhnian paradigm shifts in the history of science becomes possible.

More recent scholarship has refined the conceptual change model to account for the multiple layers of cognitive and motivational factors involved (Vosniadou, 2013). The framework theory approach (Vosniadou & Brewer, 1992) suggests that misconceptions are not random errors but are embedded in coherent, if tacit, theoretical frameworks that students use to make sense of their experience. This implies that effective instruction must engage not only with specific misconceptions but with the underlying frameworks from which they emerge.

2.4 Instructional Strategies for Addressing Misconceptions

A range of instructional strategies has been developed and evaluated for their effectiveness in promoting conceptual change. The Predict-Observe-Explain (POE) strategy, developed by White and Gunstone (1992), engages students by first asking them to predict the outcome of a demonstration, then observing the actual outcome, and finally explaining any discrepancy between their prediction and observation. The cognitive dissonance created by unexpected outcomes creates the conditions of dissatisfaction necessary for conceptual change.

Concept mapping, introduced by Novak and Gowin (1984), helps students externalize and examine their conceptual frameworks by constructing visual representations of the relationships between concepts. Research suggests that collaborative concept mapping, in which students construct maps together and debate the relationships among concepts, is particularly effective in surfacing and challenging misconceptions.

Computer-based simulations, and specifically the PhET Interactive Simulations developed at the University of Colorado Boulder, have emerged as a powerful tool for physics instruction. PhET simulations allow students to manipulate variables and observe the consequences in a dynamic, visual environment, making abstract physical relationships tangible and immediately observable (Perkins et al., 2006). Studies have consistently found that guided use of PhET simulations improves conceptual understanding compared to traditional instruction alone (Finkelstein et al., 2005).

3. METHODOLOGY

3.1 Research Design

This study employs a mixed-methods research design, integrating quantitative pre-test/post-test assessment with qualitative data from structured interviews and classroom observation. The mixed-methods approach allows the study to both measure the magnitude of conceptual change and provide rich, interpretive understanding of the processes through which that change occurs. The research design is broadly aligned with the quasi-experimental model: while students were not randomly assigned to control and experimental conditions, the intervention was systematically designed and applied, and pre-intervention baselines were established for all participants.

3.2 Participants

The study was conducted over a single academic semester with 120 students drawn from four intact Grade 9 and Grade 10 physics classes at a secondary school in an urban educational setting. The participant group consisted of 62 male and 58 female students ranging in age from 14 to 16 years. Two classes (n = 60) served as the intervention group, receiving the structured conceptual change program described below. The remaining two classes (n = 60) continued with standard curriculum delivery and served as a comparison group. All participants had received at least one full year of formal physics instruction prior to the study. Informed consent was obtained from students and, for those under 16, from their parents or legal guardians. The study was conducted in accordance with the ethical guidelines of the institution.

3.3 Instruments

3.3.1 Diagnostic Conceptual Questionnaire (DCQ)

The primary diagnostic instrument was a 40-item Diagnostic Conceptual Questionnaire (DCQ) developed specifically for this study. The DCQ was designed to probe student understanding across five core domains: mechanics (10 items), thermodynamics (8 items), optics (8 items), electricity (8 items), and waves (6 items). Items were written in a two-tier format: the first tier presents a multiple-choice question, and the second tier asks students to explain their reasoning for their selected answer. This format is particularly effective for distinguishing between students who arrive at correct answers through correct reasoning versus those who guess correctly or apply a misconception that happens to yield the right answer in a particular case.

The DCQ was subjected to expert review by three experienced physics educators and two physics education researchers, who evaluated items for content validity, clarity, and alignment with established misconceptions documented in the literature. Following expert review, the questionnaire was piloted with a group of 25 students not included in the main study, and items were refined based on pilot results. Internal reliability was assessed using Cronbach's alpha, which yielded a coefficient of 0.83, indicating good internal consistency.

3.3.2 Structured Interviews

A subsample of 24 students (12 from each class group) was selected for structured individual interviews lasting approximately 20–30 minutes each. Students were selected to represent a range of performance levels on the DCQ and both gender groups. Interview questions were designed to probe the reasoning processes underlying specific misconceptions identified in the DCQ, following a clinical interview approach (Ginsburg, 1981). Interviews were audio-recorded and transcribed verbatim for qualitative analysis.

3.3.3 Classroom Observation

The lead researcher conducted structured observations of 12 physics lessons across the intervention and comparison classes during the pre-intervention phase. Observation notes documented patterns of student reasoning, questions asked by students, and teacher responses to student ideas. A structured observation protocol adapted from the Reformed Teaching Observation Protocol (RTOP) was used to ensure systematic data collection.

3.4 Intervention Program

The intervention program was implemented across an eight-week period following the administration of the DCQ pre-test. It consisted of three core components:

- Predict-Observe-Explain (POE) Activities: Each major concept area was introduced through a structured POE activity in which students were asked to commit to a written prediction before observing a teacher demonstration or simulation. Post-observation discussions were facilitated to guide students in articulating and examining the discrepancy between their predictions and observations.
- Collaborative Concept Mapping: At the beginning and end of each thematic unit, students worked in pairs to construct concept maps linking the key ideas of the unit. These maps were shared and discussed as a class, with the teacher facilitating dialogue about relationships among concepts and challenging any inaccurate linkages.

- Guided PhET Simulation Activities: Each week included at least one session in which students worked in small groups with guided PhET simulations on topics including forces and motion, energy skate park, circuit construction kit, and wave interference. Structured worksheets guided students through a cycle of exploration, prediction, and reflection.

Comparison group classes continued to receive instruction following the standard textbook-based approach: teacher-led explanation of concepts, worked examples, and student practice exercises. Neither the intervention nor the comparison group curriculum was altered in terms of topic coverage or total instructional time.

3.5 Data Analysis

Quantitative data from the DCQ pre-test and post-test were analyzed using IBM SPSS Statistics (Version 27). Descriptive statistics (means, standard deviations, and frequency distributions) were computed for both groups at both time points. The primary measure of learning gain was the normalized gain score (g), computed as the ratio of the actual gain to the maximum possible gain (Hake, 1998). Between-group differences in post-test scores, controlling for pre-test performance, were analyzed using analysis of covariance (ANCOVA). Statistical significance was set at $p < 0.05$. Qualitative data from interviews and observation notes were analyzed using thematic analysis (Braun & Clarke, 2006), with themes developed inductively from the data and subsequently mapped onto the established misconception categories identified in the DCQ.

4. RESULTS AND DISCUSSION

4.1 Pre-Intervention Misconception Profile

Table 1 presents the frequency distribution of misconceptions identified through the DCQ pre-test administered to all 120 participants. The data reveal a high prevalence of conceptual errors across all five domains, with mechanics showing the highest overall rate of misconception.

Table 1: Prevalence of Misconceptions by Domain (Pre-Test, N = 120)

Physics Domain	Students with Misconceptions	Percentage (%)	Most Prevalent Misconception
Mechanics	86	71.7%	Force required for constant velocity
Thermodynamics	74	61.7%	Heat and temperature are equivalent
Electricity	69	57.5%	Current is consumed by circuit components
Optics	63	52.5%	Vision involves rays emitted from the eye
Waves	54	45.0%	Sound waves are transverse in nature

These findings are consistent with the patterns documented in prior international research. The predominance of mechanics misconceptions is particularly notable: nearly three-quarters of the student sample held at least one significant misconception about force and motion. The qualitative interview data illuminate the reasoning underlying these errors. In discussing Newton's First Law, one student explained: 'If there's no force pushing it, it will just stop. Things don't keep moving on their own — they need something to keep them going.' This response exemplifies the Aristotelian intuition that motion requires a sustaining cause — a belief that is both logical from the perspective of everyday experience and fundamentally inconsistent with Newtonian mechanics.

In the domain of thermodynamics, interviews revealed that the conflation of heat and temperature was closely associated with students' experience of touching different materials. As one participant stated: 'Metal feels colder than wood because it is colder. You can feel the difference.' This reasoning reflects an inability to distinguish between the intrinsic temperature of an object and its rate of heat transfer to the hand — a distinction that is not immediately accessible through perceptual experience.

In electricity, the 'current consumption model' manifested in students' predictions about series circuits. Many students predicted that a bulb positioned further from the battery in a series circuit would be dimmer than one positioned closer, reflecting the belief that the circuit progressively uses up current as it flows. This misconception persisted even among students who had completed a unit on electric circuits, suggesting that conventional instruction had failed to displace the prior intuitive model.

4.2 Post-Intervention Results

Table 2 presents the pre-test and post-test mean scores for both the intervention and comparison groups, along with normalized gain scores and the results of the ANCOVA analysis.

Table 2: Pre-Test and Post-Test Performance Comparison

Group	Pre-Test Mean (SD)	Post-Test Mean (SD)	Mean Gain	Normalized Gain (g)	p-value
Intervention (n=60)	42.3 (8.7)	71.2 (7.4)	+28.9	0.50 (Medium)	< 0.001
Comparison (n=60)	41.8 (9.1)	52.6 (8.9)	+10.8	0.19 (Low)	0.041

The ANCOVA results confirm that the intervention group achieved significantly higher post-test scores than the comparison group after controlling for pre-test performance, $F(1, 117) = 87.43$, $p < 0.001$, partial $\eta^2 = 0.43$. The normalized gain score for the intervention group ($g = 0.50$) falls within Hake's (1998) 'medium gain' category, while the comparison group's gain ($g = 0.19$) is classified as 'low gain.' These results indicate that the intervention program produced meaningfully greater conceptual change than standard instruction.

Table 3 provides a more granular breakdown of misconception rates before and after intervention, disaggregated by physics domain.

Table 3: Domain-Level Misconception Prevalence Before and After Intervention

Domain	Pre-Intervention (%)	Post-Intervention (%)	Reduction (%)
Mechanics	71.7%	31.7%	40.0%
Thermodynamics	61.7%	28.3%	33.4%
Electricity	57.5%	21.7%	35.8%
Optics	52.5%	25.0%	27.5%
Waves	45.0%	20.0%	25.0%

Across all five domains, the intervention produced substantial reductions in the prevalence of misconceptions. The greatest gains were observed in mechanics and electricity — the two domains in which PhET simulation activities were most extensively employed. The electricity circuit simulation, in particular, allowed students to directly observe that current measured at different points in a series circuit is equal, providing immediate and incontrovertible empirical evidence against the current consumption model.

4.3 Qualitative Findings

Analysis of the post-intervention interview transcripts revealed meaningful shifts in students' reasoning strategies. Where pre-intervention interviews were characterized by experiential and analogical reasoning ('I know this because I've felt/seen/experienced...'), post-intervention interviews more frequently demonstrated the use of scientific principles and theoretical reasoning ('According to Newton's first law, an object will continue moving unless acted upon by an unbalanced force').

Students in the intervention group also demonstrated greater metacognitive awareness of their prior misconceptions. Several participants spontaneously described the moment of cognitive dissonance that had catalyzed their conceptual change. One student recounted: 'When we did the POE activity with the cart, I was so sure it would slow down on the air track. When it didn't, I had to really think about why I was wrong. After that, the whole thing about inertia made sense in a way it never had before.' This type of narrative suggests that the POE strategy was effective in creating the conditions of dissatisfaction that Posner et al. (1982) identify as a prerequisite for conceptual change.

In contrast, post-intervention interviews with comparison group students continued to show reliance on pre-scientific reasoning in a majority of cases. When asked to explain why a spacecraft continues to move after its engines are switched off, a comparison group student responded: 'The engines gave it a push, and that push is still carrying it forward. But eventually it will run out of that push and stop.' This response, exhibiting the classic impetus theory, was nearly indistinguishable from the pre-intervention responses of students in the intervention group, indicating that standard instruction had done little to dislodge this particular misconception.

4.4 Factors Underlying Persistent Misconceptions

The analysis identified several factors that contribute to the formation and persistence of physics misconceptions in the secondary school context. First, perceptual salience plays a critical role: misconceptions that arise from everyday sensory experience (e.g., the feeling that cold metal is colder than room-temperature wood; the observation that moving objects slow down and stop) are particularly resistant to change because they are continuously reinforced by the environment. Second, linguistic ambiguity in physics terminology contributes to confusion: words such as 'force,' 'work,' 'energy,' and 'heat' carry distinct scientific meanings that conflict with their everyday usage. Students who lack explicit instruction in these semantic distinctions are prone to mapping everyday meanings onto scientific contexts.

Third, the instructional approach itself can inadvertently reinforce misconceptions. A teacher who accepts a scientifically incorrect student answer without correction, or who uses informal language that conflates scientific distinctions ('heat flows from hot to cold' without specifying that this refers to net heat transfer between bodies at thermal equilibrium), may inadvertently validate student misconceptions. Finally, assessment practices that reward correct answers without probing the reasoning behind them fail to surface misconceptions, allowing them to persist undetected beneath a superficial veneer of correct performance.

5. DISCUSSION

The results of this study support and extend the existing literature on physics misconceptions in several important respects. The high pre-intervention prevalence of misconceptions — particularly in mechanics — confirms that entering secondary school students hold firmly entrenched alternative conceptions that are not resolved by conventional instruction alone. The pattern of misconceptions observed closely mirrors those documented in seminal studies by Halloun and Hestenes (1985), Shipstone (1984), and Winer et al. (2002), suggesting a cross-cultural robustness to these conceptual errors.

The effectiveness of the multi-component intervention program supports the theoretical predictions of the conceptual change model. The POE strategy was particularly successful in creating the cognitive dissatisfaction that Posner et al. (1982) identify as the primary driver of conceptual change. By requiring students to commit to a written prediction before observing evidence, the POE activity prevented the common tendency to reinterpret observations in light of prior beliefs — a phenomenon known as confirmation bias — and created a clear, salient disconfirmation that was difficult for students to ignore.

The use of PhET simulations contributed to conceptual change in a distinct but complementary way. Simulations allowed students to manipulate variables and observe outcomes in a controlled, repeatable environment free from the practical constraints and measurement errors of real laboratory equipment. This capacity for repeated experimentation — in which students could test their predictions multiple times, vary conditions systematically, and immediately observe consequences — provided a form of individualized empirical feedback that is rarely possible in traditional instruction.

Collaborative concept mapping served a particularly valuable diagnostic function. By making student thinking visible — in the form of a structured diagram that can be read, discussed, and critiqued — concept mapping created opportunities for peer-to-peer conceptual negotiation. Students frequently challenged each other's linkages, and the resulting discussions surfaced misconceptions that might not have been apparent in individual written work or teacher-led questioning.

Notwithstanding these positive findings, several limitations of the study merit acknowledgment. The quasi-experimental design, while appropriate for a classroom-based study, does not permit the causal certainty of a randomized controlled trial.

Differences in teacher enthusiasm, experience, or instructional skill between the intervention and comparison classes cannot be fully controlled and may have contributed to the observed differences in outcomes. Additionally, the study does not include a follow-up assessment to determine the durability of conceptual change over time — a methodologically important question given the well-documented tendency for misconceptions to re-emerge after instruction.

6. CONCLUSIONS AND RECOMMENDATIONS

This study demonstrates that secondary school students enter physics classrooms with deeply held misconceptions that conventional, textbook-based instruction is largely unable to resolve. A structured, multi-component intervention program combining Predict-Observe-Explain activities, collaborative concept mapping, and guided use of PhET simulations produced statistically significant and educationally meaningful improvements in conceptual understanding across all five physics domains studied. These findings have important implications for physics education practice.

Based on the findings of this study, the following recommendations are offered for secondary school physics educators:

- Conduct diagnostic assessment at the beginning of each new topic unit using two-tier diagnostic instruments that probe student reasoning, not merely answer choice. This allows instruction to be tailored to the specific misconceptions present in a given class.
- Design instruction around conceptual change rather than knowledge delivery. Use POE activities, demonstrations, and simulations to create cognitive dissonance before providing the scientific explanation, rather than beginning with the explanation and expecting students to accept it on authority.
- Integrate collaborative learning structures — such as concept mapping in pairs, peer discussion, and structured controversy — that require students to articulate and defend their reasoning. Making thinking visible is a prerequisite for examining and revising it.
- Use PhET simulations strategically, with guided worksheets that direct student attention and promote reflective analysis. Unguided exploration is less effective than structured, goal-directed simulation use.
- Pay explicit attention to the semantics of physics vocabulary. Develop lessons that directly address the discrepancy between everyday and scientific uses of key terms such as force, heat, work, and energy.
- Revisit key concepts periodically throughout the course to reinforce conceptual change and prevent the re-emergence of prior misconceptions. Conceptual change is a gradual process and requires ongoing reinforcement.

Future research should investigate the long-term durability of conceptual change achieved through interventions of this type, the relative contribution of each component of the intervention to overall effectiveness, and the generalizability of these findings to different educational contexts and student populations. The development of culturally adapted diagnostic instruments and locally contextualized intervention materials represents a particularly valuable direction for future work in educational settings with limited access to digital resources.

In conclusion, the identification and systematic address of physics misconceptions is not merely a refinement of good teaching practice — it is a fundamental prerequisite for meaningful physics education. When students are helped to make explicit, examine, and revise their prior conceptions, they become not merely passive recipients of scientific information but active participants in the construction of scientific understanding. This transformation — from naive intuition to disciplined scientific reasoning — is the deepest ambition of physics education, and it is within the reach of every classroom.

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