

Misconceptions in Science Learning Among Secondary School Learners in Odisha

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ABSTRACT

This study investigated misconceptions in science learning among secondary school learners, focusing on physics topics such as motion, force, and gravitation. The objectives were to identify common misconceptions, examine their causes, and suggest remedial strategies. A convergent parallel research design was adopted, and data were collected from 328 ninth-grade learners in two secondary schools in Bhubaneswar, Odisha, using a diagnostic test and structured questionnaire. Findings revealed widespread misconceptions in areas including acceleration and speed, distance and displacement, Newton's laws, gravitational force, and free fall. Many learners were unable to correctly differentiate related concepts or apply them accurately. The causes were multifactorial, including reliance on rote teaching methods, learners' prior experiences, and informal sources such as the internet, peers, and mass media, which often reinforced incorrect ideas. To address these issues, the study recommended experiential and inquiry-based approaches, including simulations, concept mapping, peer discussions, and regular formative assessments. It emphasized the need for teacher training, structured implementation by school leadership, and parental involvement. The study highlights the importance of systematic efforts to improve conceptual understanding and reduce persistent misconceptions in science learning.

Keywords: Misconceptions, Science Learning, Secondary school learners

1. Backdrop

“Education is natural harmonious and progressive development of man's innate powers” - Heinrich Pestalozzi

Science is all about facts. It basically focuses on the pursuit of a profound comprehension of facts, events, and natural phenomena, cannot be completed without a proper understanding of it. Science education scholars, Psychologists, and science teachers have recently shown a great deal of interest in comprehending scientific phenomena. Most people today believe that Learners bring to science classes certain preconceived conceptions and ideas that are deeply ingrained in their thought processes. The terms "misconceptions" (Helm 1980), "preconceptions" (Novak 1977), and "alternative frameworks" (Driven 1981) have been used to describe Learners' ideas that differ from those typically acknowledged by the scientific community. There is ample evidence in the literature that in the secondary level, Learners frequently have misconceptions about concepts like “gravity” (Dogina and Dah 2023), “season”, “Big bang” (Cardinot and Fairfield 2021), “force”, motion, chemical bonding and cell biology. Different types of factors that cause misconceptions among the individuals related to internet, learners' prior knowledge, textbooks, teacher, parents, Prerequisite knowledge, a negligence on the conditions and assumptions behind a rule, an Interference of learnt materials, an uncritical acceptance of incorrect information and a wrong deduction due to False reasoning. Despite of that Diagnostic Tests, Interview and Tests consisting of Open-ended Questions, Concept map and Multiple-choice Tests used for Identify the Misconceptions. Addressing these misconceptions is crucial for effective science learning. Understanding their origins and prevalence allows educators to design targeted interventions that promote conceptual change, ensuring Learners develop accurate and coherent scientific knowledge. This paper explores common misconceptions among secondary school Learners, their impact on learning, and strategies for overcoming them.

2. Review of Related Literature

In order to gain deeper understanding over the topic the investigator reviewed available literature pertaining to the topic and categorised them into following dimensions:

- **Origin of Misconceptions**

Research indicates that misconceptions arise from multiple sources including internet misinformation, prior knowledge, parental influence, teachers, media, and instructional materials. Incorrect online content contributes significantly to misconceptions (Burcin et al., 2010). Learners' prior experiences and prerequisite knowledge shape alternative ideas (Alagumalai, 2005; Bilgin & Uzuntiryaki, 2003). Misunderstanding of assumptions, faulty reasoning, and uncritical acceptance of information also contribute to misconception formation (Driver et al., 1994; Wandersee, Mintzes, & Novak, 1994).

- **Concept of Misconception**

Misconceptions are described as incorrect or alternative understandings constructed from personal experiences (Martin, Sexton, & Gerlovich, 2002). They are also termed preconceived notions, naïve theories, or conceptual misunderstandings (Hanuscin, n.d). Several researchers refer to them as alternative conceptions or frameworks differing from scientific views (Driver & Easley, 1978; Gilbert & Watts, 1983; Van den Berg & Grosheide, 1993; Muthukrishna et al., 1993). These reflect learners' conceptual difficulties in science learning (McDermott, 1993).

- **Identification of Misconceptions**

Various diagnostic tools are used to identify misconceptions. Diagnostic tests, interviews, and open-ended questions help uncover learners' informal reasoning (Wu & Tsai, 2007; Eshach & Schwartz, 2006). Multiple-choice diagnostic instruments and structured assessments have been effectively used to detect misconceptions in chemistry and physics concepts (Peterson, Treagust, & Garnett, 1989; Taber, 1999a; Tan & Treagust, 1999).

- **Classification of Misconceptions**

Misconceptions are classified into learner, external, and teacher variables. Learner variables include cognitive development mismatch, IQ status, vocabulary misunderstanding, and prior knowledge (Baser, 2006; Marek et al., 1991; Pintrich, Marx, & Boyle, 1993). External variables involve informal learning and textbook representations (Gerber, Marek, & Cavello, 2001b; Mayer, 2001). Teacher variables include instructional language, interaction patterns, and insufficient awareness of learners' prior knowledge (Gilbert & Zylberstajn, 1985; Valanides, 2000).

- **Studies on Misconceptions in Physics**

Empirical studies reveal widespread misconceptions in physics topics such as gravity, heat, temperature, relativity, waves, hydrostatic pressure, and astronomy. A significant proportion of learners exhibit misconceptions in gravity and free fall (Dogina & Dah, 2023), heat and temperature (Alwan, 2011; Fenditasari & Istiyono, 2020), and waves (Caleon & Subramanian, 2020). Diagnostic assessments consistently indicate persistent alternative conceptions across grade levels (Cardinot & Fairfield, 2021; Wijaya & Muhardjito, 2016).

- **Remediation Strategies**

Research highlights conceptual change approaches as effective in reducing misconceptions. Learning cycle texts and conceptual change texts significantly improve conceptual understanding (Musheno & Lawson, 1999; Chambers & Andre, 1997). Additional strategies include hands-on activities, analogies, computer-supported instruction, exposing events, and structured text designs to promote conceptual restructuring (Brown, 1992). These approaches facilitate deeper cognitive engagement and correction of alternative conceptions.

3. Rationale of the Study

The present study is anchored in the pragmatism paradigm, which integrates both positivist and interpretivist approaches within a single framework. This paradigm emphasizes practical solutions and utility, combining quantitative and qualitative methods to address real educational concerns. By focusing on actionable outcomes, the study seeks to generate contextually relevant insights into misconceptions in science learning among secondary school learners.

The significance of the study is reinforced by constitutional and policy directives that prioritize scientific temper and inquiry. Article 51A of the Constitution of India mandates the development of scientific temper, humanism, and a spirit of inquiry among citizens. Major policy initiatives such as the National Education Policy 2020, National Knowledge Commission, and Secondary Education Commission emphasize strengthening science education at all levels. The Scientific Policy Resolution and the Science and Technology Policy further highlight the central role of science and technology in national development, modernization, and societal advancement.

In this context, addressing misconceptions is essential for building accurate conceptual foundations in science. Misconceptions hinder meaningful understanding and impede the transition from elementary to secondary education. Reducing them enhances critical thinking, knowledge retention, confidence, and informed decision-making. Furthermore, limited research on science misconceptions in Odisha underscores the necessity of this study, making it both academically relevant and regionally significant.

4. Research Questions

The research questions of the present study are as follows:

1. What are the common misconceptions held by secondary school learners in science learning?
2. What are the possible causes behind the misconceptions in science learning among the learners at secondary level?
3. What are the remedial strategies for correcting misconceptions among secondary school learners?

5. Research Objectives

The objectives of the present study are as follows:

1. To identify the common misconception of learners in science learning at secondary level.
2. To assess the possible causes behind the misconceptions in science learning among the learners at secondary level.
3. To suggest the remedial strategies that science teachers employ in correcting misconceptions among secondary school learners.

6. Methodology

• Design

Keeping in mind the objectives of the research, the researcher was adopting convergent parallel design of mixed method research.

• Population

In present study, the Population for the study was all Secondary School Learners (9th Class) in Odisha. The Accessible Population for this study was Secondary School Learners (9th class) of South-East Zone, Bhubaneswar (Capital High School Unit –III, Bhubaneswar, and Govt. High School, Unit-II, Bhubaneswar), Odisha.

• Sample

In the present study, the researcher was using purposive sampling technique on the ground that these schools have high student enrolment possessing excellent academic track record which in turn helps to develop deeper understanding pertaining to science learning among learners. The sample is all the ninth-class learners (secondary school learners) of both the schools, and the sample size is N= 298 comprising the total number of learners.

• **Tools**

Keeping in mind the objective of this research, the researcher in consultation with the experts in the field of science education and research, decided to collect the data with following tools:

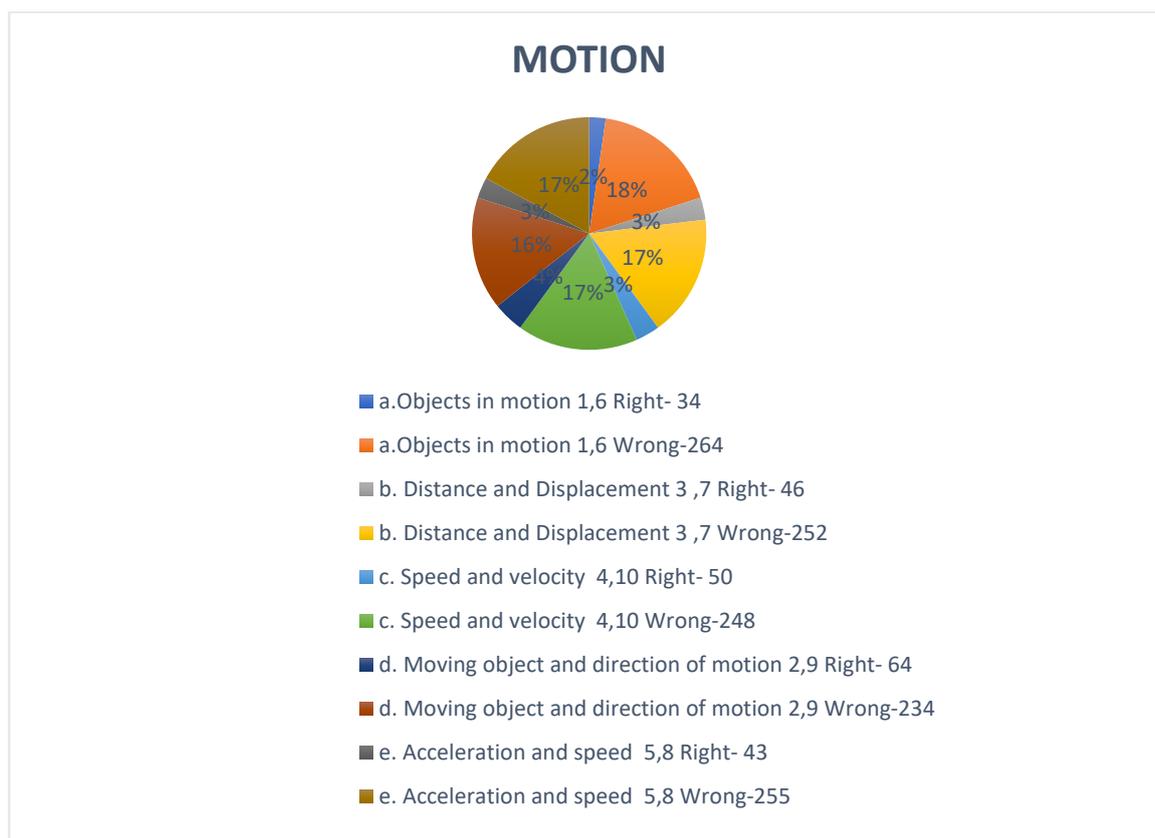
- For the first objective, a self-developed diagnostic test meant for the secondary level learners which was based on standardized tools, such as, ‘Simple Electric Circuit Diagnostic Test’ by Haki Pesman and Ali Eryilmaz in 2010.
- For the second objective, a self-developed questionnaire for the secondary level learners was using which would be based on standardized tools, such as, ‘Questionnaire for Teachers about Science Curriculum’ by R. Sivakumar in 2018.

• **Data Analysis and Interpretation**

For the present study, the researcher is analyzing the data using frequency, percentage, and content analysis (for open ended items) techniques for the respective quantitative and qualitative data. The frequency of each response for a particular item as given by the respondents are calculated. The responses are analysed on the basis of scoring key available and thereafter the results, findings and interpretations are derived.

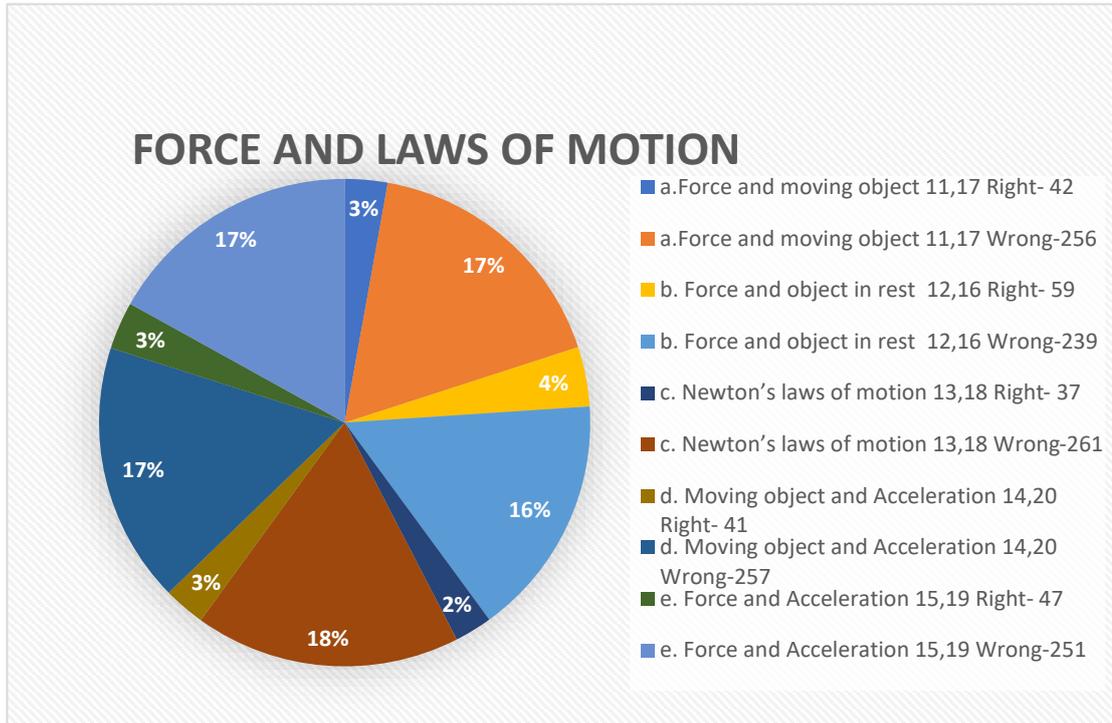
7. Major Findings

Objective 1: To identify the common misconception of learners in science learning at secondary level



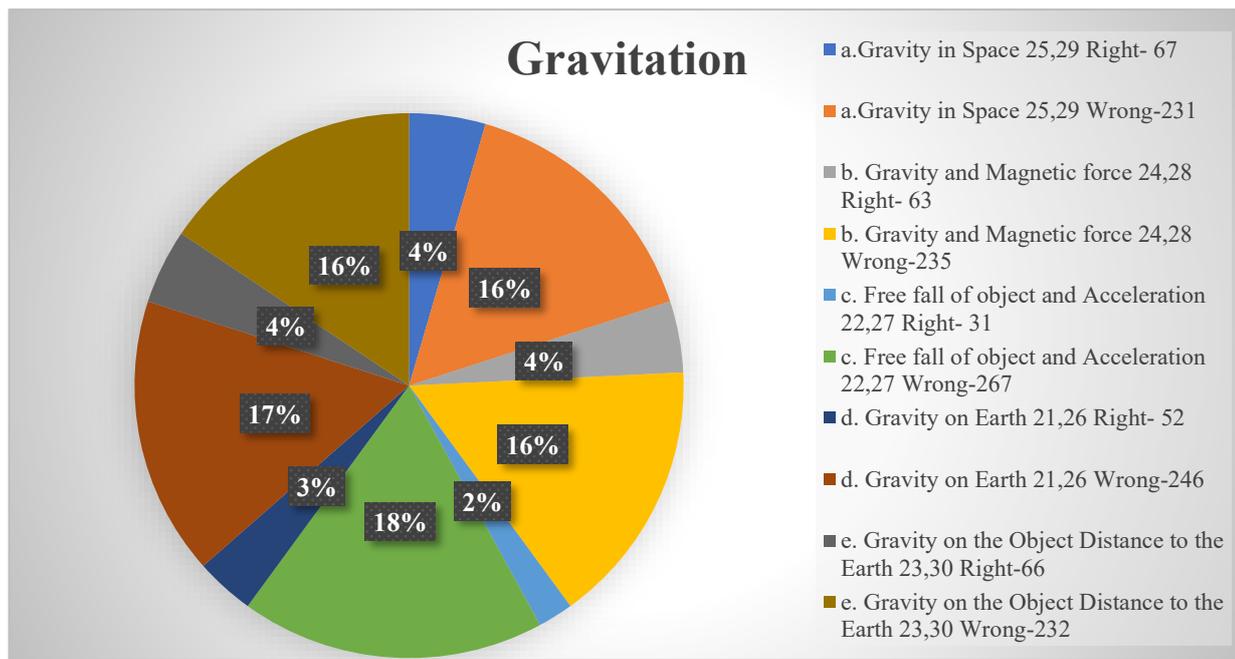
(Figure 7.1)

The item-wise analysis of the chapter Motion shows very low performance across all subtopics, with over 80% incorrect responses on average. Learners displayed major difficulties in understanding motion, distance and displacement, speed and velocity, direction, and acceleration. The findings indicate weak foundational understanding of kinematics, likely resulting from abstract instructional methods without adequate experiential or concept-based learning approaches.



(Figure 7.2)

In this analysis indicates significant misconceptions in Force and Laws of Motion, with over 80% incorrect responses across subtopics. Learners show weak understanding of force, balanced and unbalanced forces, Newton’s laws, and the $F = ma$ relationship. Major difficulties exist in applying concepts to real-life situations, suggesting inadequate conceptual clarity, limited hands-on experiences, and insufficient contextual teaching approaches.

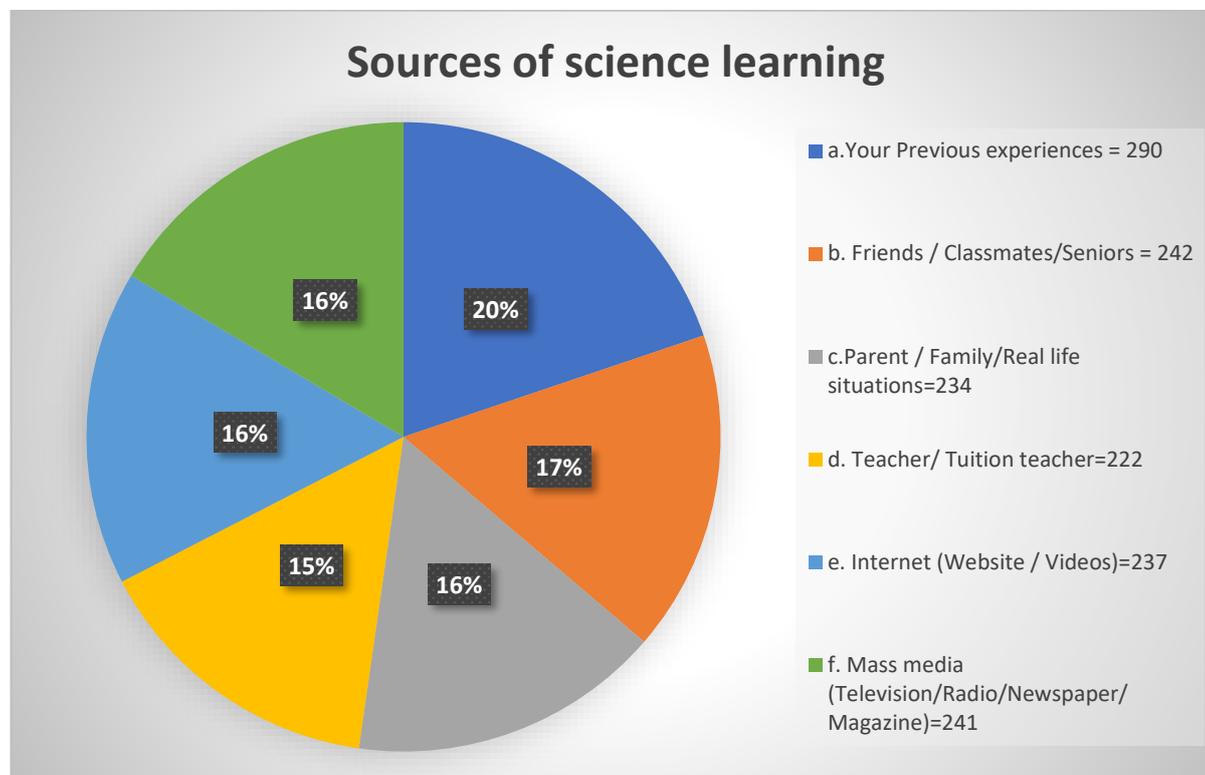


(Figure 7.3)

The analysis of gravitation reveals widespread misconceptions, with 77–90% incorrect responses across subtopics. Learners show major confusion about gravity in space, differences between gravity and magnetic force, free fall principles, gravity

on Earth, and variation of gravity with distance. Extremely low understanding of free fall indicates deep conceptual gaps. Overall, results reflect fundamental misunderstandings rather than minor factual errors.

Objective 2: To assess the possible causes behind the misconceptions in science learning among the learners at secondary level.



(Figure 7.4)

The data shows learners rely heavily on prior experiences (97.31%) for understanding science, making it the most influential source. Peers (81.20%), media (80.87%), internet (79.53%), and parents (78.52%) also significantly shape learning, often more than teachers (74.49%). This indicates growing dependence on informal sources, highlighting the need to connect classroom teaching with real-life and accurate scientific information.

Misconceptions hinder physics learning and stem mainly from learners’ prior knowledge (Pintrich, Marx & Boyle, 1993; Dole, 2000), teachers, parents (Driver & Erickson, 1983), internet (Burcin et al., 2010), mass media (Driver et al., 1994), and peers (Erman, 2017). Limited conceptual change practices (Gaigher, 2014) and inadequate prior knowledge (Bilgin & Uzuntiryaki, 2003) further reinforce memorization over scientific understanding.

Objective 3: To suggest the remedial strategies that science teachers employ in correcting misconceptions among secondary school learners.

- Suggestions for Teachers:**

Use diagnostic and formative assessments to identify misconceptions, followed by simplified explanations. Incorporate real-life examples, demonstrations, simulations, concept mapping, hands-on activities, peer discussions, and visual tools like graphs and charts to strengthen conceptual understanding and ensure continuous correction of errors.

- Suggestions for Headmasters:**

Promote scientific inquiry, organize workshops, provide teacher training, digital resources, and infrastructure. Encourage professional development, strengthen monitoring systems, involve parents, and reward effective teaching. Ensure proactive implementation of strategies to eliminate misconceptions.

- **Suggestions for Learners:**

Use reliable sources, connect new concepts with prior experiences, practice critical thinking, question facts logically, reflect regularly, and maintain learning journals to strengthen scientific understanding.

- **Suggestions for Parents:**

Create a supportive and curious home environment, communicate with teachers, encourage scientific thinking, and promote reliance on evidence rather than assumptions.

8. Educational Implications

- The study aids in identifying and reducing misconceptions, improving science learning outcomes.
- Teachers should anticipate misconceptions and apply appropriate remedial strategies.
- Clear explanation of scientific terms is essential to prevent confusion.
- It promotes effective teaching strategies for better classroom practice.
- It strengthens conceptual understanding and fosters scientific temper.

9. Suggestions for Further Research

These are listed below as suggestions for the further research-

1. The present study was delimited to 3 chapters of physics. However, science as a subject comprises of three broad core areas - physics, chemistry and biology. Therefore, further researches can be conducted comprehensively in a particular core subject area, as well.
2. Present study is limited to secondary school learners. Further researches can be conducted for primary as well as senior secondary levels.
3. A comparative study can be undertaken consisting of any two or more subject areas.
4. There are a number of demographic variables associated with misconceptions such as – learner and teacher ratio, home tuitions and professional coaching, parent 's occupation and qualification, family environment, etc. Each of them separately can be considered for further in-depth studies.

10. Conclusion

The study reveals that misconceptions in science among secondary learners are deeply rooted and resistant to change, particularly in topics such as motion, force, laws of motion, and gravitation. Learners' prior experiences are the primary source, along with peers, media, internet, and sometimes teachers. Traditional teaching methods often fail to correct these entrenched beliefs. The findings highlight the need for diagnostic, inquiry-based, and experiential teaching approaches. Coordinated efforts among teachers, parents, and policymakers are essential to promote reflective, interactive science learning and ensure accurate conceptual understanding for academic and real-world competence.

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