Research Article

What Factors Hinder Elementary Students' Understanding of Friction Concepts? Insights From Quantitative Descriptive Data

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Abstract.
This study explores the factors affecting elementary school students' understanding of force concepts, particularly friction. Using a quantitative descriptive approach, 61 randomly-selected fifth-grade students participated in a concept understanding test, which covered seven indicators: explaining, comparing, inferring, summarizing, classifying, providing examples, and interpreting. Results showed that students performed well in explaining (70.49%) and inferring (77.05%), while comparing (26.23%), classifying (37.7%), providing examples (22.95%), and interpreting (26.23%) had lower success rates. The main challenges identified were limited hands-on activities, insufficient teaching tools, and a lack of contextual learning. The study suggests that incorporating more interactive and experiment-based teaching methods, tied to real-life contexts, could enhance students' understanding. Additionally, the study highlights the importance of considering factors such as teaching methods, prior knowledge, real-world experiences, and individual differences in learning styles and motivation to improve conceptual understanding.

Keywords: conceptual understanding, force concepts, elementary student

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1. INTRODUCTION

Understanding the concept of force is a fundamental element in science education, especially for elementary school students. The concept of force encompasses various phenomena such as pulling, pushing, gravity, friction, and magnetic forces (1,2). A strong understanding of these concepts is crucial as it forms the foundation for students to learn more complex physical phenomena. However, many studies report that elementary students often face difficulties in understanding the concept of force, which impacts their ability to apply this knowledge in everyday contexts (3). One major obstacle in understanding force concepts is the level of abstraction in the material (4). Many students struggle to connect theoretical concepts with their real-life experiences (5).

For instance, the concept of gravity is often challenging for students to grasp because it is typically explained verbally without showing how it works in concrete terms. A similar issue arises with the concept of friction, which plays a critical role in daily life, such as preventing objects from sliding too quickly or helping vehicles stop (6). A lack of understanding of friction can result in students failing to comprehend its significance in activities like walking, riding a bike, or even writing with a pencil (7). This limitation can lead students to perceive force concepts, including friction, as distant and unrelated to their lives (8,9).

In the context of elementary education, friction is often taught theoretically without relevant hands-on experiences for students (6). Students often struggle to understand friction because they are only given its definition as a force that opposes motion. Without real-life examples or experiments, like sliding objects on rough and smooth surfaces, they find it hard to see how friction works or why it matters. This makes it difficult for them to connect the concept to their everyday lives and leads to a shallow understanding (10). Therefore, more interactive and experience-based teaching approaches, such as conducting simple experiments or observing everyday activities involving friction, are needed to help students develop deeper and more practical understanding of this concept (11).

Understanding friction can be hard without hands-on experiments. Practical activities help students see how things work, but many schools don't have the tools or resources for interactive learning (12). Students are usually taught friction through definitions and theories without exploring its real-world applications. Simple experiments, like comparing how objects move on smooth and rough surfaces, could help explain friction, but limited time and resources make these activities rare. As a result, students memorize the concept without understanding its everyday uses, such as walking safely or controlling a bike downhill, making learning less effective and disconnected from real life (13).

In addition to the lack of hands-on experimentation, other factors also hinder elementary students' understanding of force concepts, including friction (14). One such factor is deeply rooted misconceptions, such as the belief that objects move only when continuously acted upon by a force, which often remains uncorrected during lessons (15). Overly theoretical and teacher-centered teaching methods also pose challenges by reducing student engagement in the learning process. This is exacerbated by the lack of simple yet effective teaching aids for explaining force concepts, such as rough and smooth surfaces for understanding friction (16). Lessons that don't connect friction to students' daily activities make the concept feel abstract. Limited time for science lessons

means experiments and exploration are often skipped. Additionally, many teachers lack training to teach force concepts in creative and engaging ways, and the use of technology like simulations or interactive apps is often insufficient, making learning even more challenging (17). Variations in students' learning styles are also not well accommodated, particularly for kinesthetic learners who require direct experiences to understand concepts (18,19). A lack of problem-based learning approaches and low student motivation in science further reduce learning effectiveness (20). These factors interact and require special attention to optimize students' understanding of force concepts (21).

While many studies have discussed the challenges elementary students face in understanding force concepts, several gaps remain. First, most research identifies misconceptions but lacks practical solutions for classrooms with limited resources (22). Second, studies often focus on laboratory-based learning, which is difficult to apply in schools with minimal teaching aids. Few have explored simple, everyday activities to teach concepts like friction (23). Third, while experiment-based learning is shown to help, variations in methods, such as problem-based learning or digital simulations, are rarely studied (24). Lastly, there is limited research on how different learning styles—visual, auditory, or kinesthetic—affect students' understanding of force concepts, with most studies using uniform approaches (18,25)..

This study aims to explore the challenges elementary students face in understanding the concept of force, with a focus on friction. Friction is chosen because it relates to everyday activities like walking, biking, or sliding, which are often ignored in teaching. The research seeks to suggest simple and effective teaching strategies that connect theory to real-life experiences. By addressing gaps in previous studies, this study aims to make science learning more practical and meaningful for elementary students.

2. METHODOLOGY/MATERIALS

This study employed a quantitative approach with a descriptive design to identify factors hindering elementary school students' understanding of force concepts. The research followed these systematic stages.

1. Population and Sampling

The study targeted three fifth-grade classes as the population. Using proportional random sampling techniques, 61 students were selected as the sample to ensure representativeness across the population.

2. Instrument Development and Validation

A multiple-choice test was designed to assess students' conceptual understanding, with items tailored to specific indicators of force concepts. Before implementation, the instrument was reviewed and validated by experts to ensure its reliability and validity for measuring the intended outcomes.

3. Data Collection

The validated test instrument was administered to the sample. Students completed the test under standardized conditions to ensure consistent data collection.

4. Data Analysis

The test results were analyzed using percentage and frequency distribution methods. This analysis aimed to identify the most significant factors impeding students' understanding of force concepts, providing a clear and systematic overview of the challenges they face.

By following these steps, the study provides an objective and comprehensive analysis of the barriers to learning force concepts among elementary school students.

3. RESULTS AND DISCUSSIONS

Based on the research findings, there are significant differences in students' understanding of the concept of force, particularly friction, as reflected in seven identified indicators of conceptual understanding. These indicators include explaining, comparing, inferring, summarizing, classifying, exemplifying, and interpreting. The results are illustrated in figures 1below:

Figure 1 highlights students' abilities to understand and apply the concept of force in daily life. The first indicator, explaining, measures how well students can describe force concepts, especially friction. With a score of 70.49%, most students demonstrate clear and systematic explanations. However, the compare indicator scores only 26.23%, showing that students struggle to identify similarities and differences between concepts, indicating a need for more practice. In contrast, the draw inferences indicator scores 77.05%, reflecting strong critical thinking and the ability to make accurate conclusions based on information.

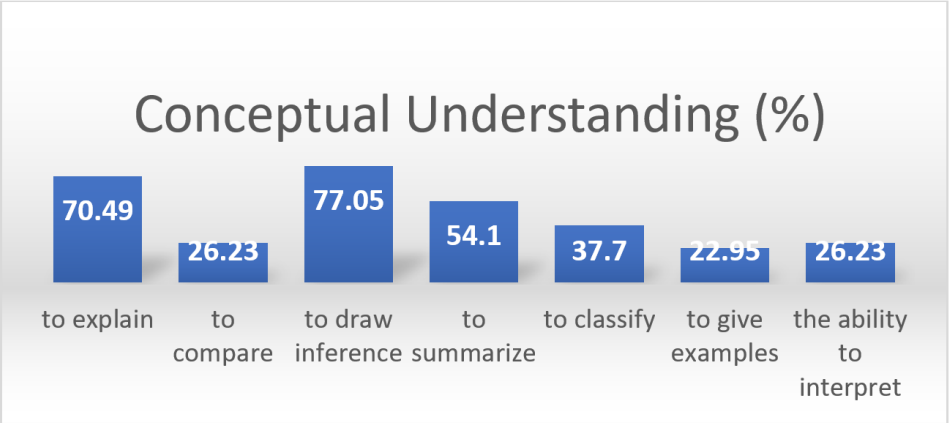

Figure 1: Conceptual Understanding Research Results.

Students' summarizing skills score moderately at 54.1%, showing they can extract main points but need more practice. The abilities to classify 37.7% and provide examples 22.95% are low, indicating challenges in organizing information and linking theory to real-life applications. Interpretation skills also score low at 26.23%, revealing difficulties in understanding and analyzing information from text or visuals. While students show potential in some areas, significant improvement is needed in comparing, providing examples, and interpreting, which can be supported by more contextual and structured teaching methods.

Students' conceptual understanding varies significantly across different aspects. The ability to explain concepts scores well, indicating that most students can articulate ideas clearly and systematically. This aligns with Berger et. Al (26) who emphasized the importance of explanatory skills in enhancing students' understanding and communication abilities. However, the low score in comparing skills reveals that many students struggle to analyze similarities and differences between concepts. Greeno (27) similarly found that this skill requires extensive practice to develop students' analytical abilities. On the other hand, students' ability to draw inferences scores very well. Research by Plummer et.al (28) supports this finding, showing that students with strong inferencing abilities tend to exhibit better critical thinking skills. This ability can be further strengthened through learning strategies that require decision-making based on data or evidence. Summarizing skills, while moderate, demonstrate that students can grasp the main points of a subject, though further reinforcement is recommended (29).

The ability to classify, shows that students need more practice to understand relationships between concepts and categorize information accurately. González-Salamanca et.al (30) stated that classification skills require repetitive practice to enable systematic

grouping of information. The ability to provide relevant examples remains low, indicating that students struggle to link theoretical concepts to practical applications. Frequent and contextual examples can significantly improve this skill. Lastly, the ability to interpret information scores low, reflecting students' difficulties in understanding and interpreting both textual and visual data. Aditomo & Klieme (31) emphasized that this skill can be enhanced through instruction focused on interpreting complex data and texts. Overall, these findings suggest that while there is progress in some areas of conceptual understanding, there are still gaps to be addressed, particularly in comparing, providing examples, and interpreting information. Implementing contextual and structured teaching strategies can help students further develop these skills.

Several factors may contribute to the variation in students' conceptual understanding of force concepts. One key factor is the instructional methods used in the classroom. Studies have shown that active and hands-on learning, such as experiments and interactive activities, can significantly improve students' comprehension (32). In contrast, traditional lecture-based teaching, which lacks real-world connections, may hinder deeper understanding. Another factor is prior knowledge and cognitive development. Students with stronger foundational knowledge or better-developed cognitive skills are more likely to grasp complex concepts, such as force, more easily. The students' exposure to real-world experiences, such as daily encounters with friction or the use of related technology, also plays a significant role in enhancing their understanding and application of theoretical concepts. Additionally, the use of visual aids, diagrams, and multimedia resources has been shown to support students' learning by making abstract concepts more concrete and accessible (33). Finally, individual differences, such as learning styles and motivation, can influence how students engage with and retain new information. Encouraging a growth mindset and fostering a supportive learning environment can help address some of these individual differences and improve overall conceptual understanding.

4. CONCLUSION

In conclusion, this study shows that elementary students have varying levels of understanding of force concepts, especially friction. While students are good at explaining and drawing inferences, they struggle with comparing, classifying, providing examples, and interpreting concepts. These challenges suggest difficulties in connecting theory with practice and understanding the relationships between concepts. Factors such as less

contextualized teaching, limited hands-on activities, and a lack of real-life examples are key obstacles to their understanding. To improve, teaching strategies should be more interactive and hands-on, like simple experiments and activities tied to real-life situations. This will help students better understand and apply force concepts. The study also emphasizes the importance of engaging students actively in learning, helping them link theory to real-world applications. Several factors affect students' understanding. Active learning strategies improve comprehension, while traditional teaching methods may not be as effective. Students' prior knowledge, cognitive skills, and real-life experiences also play a role. Using visual aids and multimedia can make abstract concepts clearer. Finally, differences in learning styles and motivation influence how well students grasp and retain information, and providing a supportive learning environment can help address these differences.

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