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Misconceptions of science learning on force and motion material for elementary school

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Abstract

One of the factors contributing to the low learning outcomes of physics students in school is the lack of concept mastery. The aim of carrying out this research is to provide insight to educators regarding identifying misconceptions about force and movement and to assist teachers in resolving these misconceptions. The research method uses a narrative literature review. The data obtained were 20 national and international journal articles randomly indexed by Sinta and Scopus regarding the concept of science learning on force and motion material in elementary education in 2012 - 2024. Data collection techniques were carried out through literature studies. Data analysis techniques from this research consist of research questions, conducting searches, identifying keywords, reviewing abstracts and articles, and resulting documents. The findings of this research show that there are still misconceptions in science learning regarding friction force, gravitational force, and free-fall motion. This misconception occurs among pupils and students (prospective teachers). The causes of these misconceptions are the students themselves, teaching materials, context, teachers, and teaching methods. The implication of this research provides an illustration that teachers must use interactive, innovative, and creative media with innovative learning models to minimize students' misconceptions in elementary schools so that learning is appropriate to students' cognitive development stages, namely concrete operations.

INTRODUCTION

Background of the Study

Science education is a concept of learning about nature and has a very wide relationship with human life. Physics in science education is a subject in the field of science that has a very close relationship with daily life. Physics explains physical phenomena in the natural world with a high level of comprehensive understanding (Sasmita, 2017). Understanding concepts in a lesson needs to be learned correctly. One of the factors contributing to the low learning outcomes of physics students in school is the lack of concept mastery. Students are expected to be able to understand abstract concepts of science, including those that have been learned well and correctly. The common problem faced by teachers is misconceptions. Apart from that, inadequate facilities are also a factor in teachers' lack of ability to convey learning information.

Problem of The Study

Misconceptions are a person's understanding that does not align with the scientific concepts recognized by experts (Mariyadi & WA, 2023a). One of the physics concepts in daily life that often experiences misconceptions is the force and motion of objects. In general, misconceptions are caused by five groups, namely students, teachers, textbooks, context, and teaching methods (Suparno in Nasution, et al., 2021). Misconceptions can hinder the subsequent learning process because of the mismatched ideas. Teachers must be able to provide concrete and real knowledge according to physics studies.

Research's State of the Art

Based on previous research regarding misconceptions of force and motion conducted by Aziza et al. (2023), misconceptions occur when students are confused while studying the material due to the numerous forces being learned. Supported by research by Respasari et al. (2022) that the cause of misconceptions is due to incorrect information from friends, teachers, or other learning references, and the students' incomplete understanding of the concept of friction (force of friction) that they are learning. On the other hand, research by Topalsan & Bayram (2019) that the cause of misconceptions about force and motion, for the most part, originates from the students themselves (prospective teachers) - namely, an understanding that is not in line with the concepts of physicists.

Novelty, Research Gap, & Objective

It is hoped that science education can run smoothly without misconceptions. Teachers provide concrete and real knowledge in line with the study of physicists. In reality, misconceptions can occur in students from elementary school to university

students, influenced by several factors. The novelty of this research lies in its research method, which is a literature review of 20 national and international journal articles indexed on Google Scholar about research that has been conducted. Researchers collect data sources and analyze them. Based on the explanation above, it is important to carry out this research to provide insight to educators regarding identifying misconceptions about force and movement and assisting teachers in resolving these misconceptions.

METHOD

Type and Design

The research method used is qualitative research with a literature review or literature study. A literature study seeks relevant theoretical references related to a case or problem found to conclude (Pilendia, 2020). The topic of the lesson to be analyzed for misconceptions is the force and motion of objects for basic physics education materials

Data and Data Sources

The data obtained were 20 national and international journal articles randomly indexed by Sinta and Scopus regarding the concept of Science Learning on Force and Motion Material in Elementary Education from 2012 to 2024.

Data Collection Technique

Data collection techniques were carried out through literature studies. Data taken from source referrals are recorded and managed so that they can the right conclusion is drawn.

Data Analysis

Data analysis techniques from this research are to use internal stages the use of literature reviews consisting of research questions, conduct a search, identify keywords, review abstracts and articles, and document results. The data obtained was analyzed through several stages to produce conclusions so that they could provide an idea or description of the topics discussed (Ahmad & Muslimah in Aziza et al., 2023).

RESULTS

Misconceptions are a person's understanding that does not align with the scientific concepts recognized by experts (Suparno in Nasution, et al., 2021). Misconceptions frequently occur in subjects, particularly in physics. Based on the

literature review sources obtained, misconceptions of force and movement in basic education vary greatly, especially in the subject of study. The first literature, by Nasution et al. (2021) analyzed spring force misconceptions. His study explains that according to class V students, spring force is a force that arises when an elastic object is pulled or pressed, and then can return to its original shape after the force is stopped. Students experience errors in understanding the relationship between spring force and acceleration. This is caused by factors within the student, the context of the teaching materials, and the teaching methods used by the teacher. The second study, by Danil et al. (2023) shows the results of the misconception of gravitational force in class IV students, namely the force of attraction of an object towards the center of the Earth. Gravitational force is the force that can pull objects falling to the Earth's surface. The causes of misconceptions are factors within the student, teaching materials, teaching media, and teaching methods. The third research, by Mariyadi & WA (2023), analyzing misconceptions about the gravitational force of class VI students, found that students had misconceptions about the meaning of force and gravitational forces. Misconceptions that force can change the shape, size, and direction of objects. The misconception that the direction of gravitational force is towards the earth causes objects on the earth to have weight. The context of the teaching materials, the teacher's teaching methods, and the students' factors are the causes of misconceptions. Fourth, research by Aziza et al. (2023) there are various types of misconceptions about force, one of which is gravity and friction. However, in both styles of material, there are often mispronunciations and wrong meanings. The friction force is only related to motion and can only be seen if there is motion present. In addition, students assume that the friction force is related to the surface area of other objects. Finally, students believe that friction is a result of surface roughness only and that friction does not occur on smooth surfaces. Meanwhile, the weight of an object is the magnitude of the gravitational force acting on the object. The fifth research, by Respasari et al. (2022) stated the results of an analysis of students' misconceptions about friction. Misconceptions that occur include errors in determining the value of the friction force and the direction of the friction force acting on the object. Students' incomplete understanding of the concept of friction and the material studied is the cause of misconceptions. The sixth research, by Ariyastuti & Yuliawati (2017a), showed similar results that the misconception of friction force occurs because when braking, the wheels and road rub against each other which creates a friction force, whereas

the misconception of gravity force occurs because the sky board can slide. The seventh research, by Khoiriyah (2018) identified misconceptions using the CRI (Certainty of Response Index) method showing results that objects that have a greater mass will fall to the ground first. Friction occurs between the friction of two surfaces, namely smooth and rough. Objects will be thrown far away if given a pull on the rubber slingshot. The faster you pedal the bicycle, the speed will increase, while the slower you pedal the bicycle, the slower it will be. Plasticine can change shape because the structure of plasticine is flexible and elastic. Strengthened by the eighth research, by Rochman & Winanto (2012) that the force that can change the motion of an object comes from muscle force. Clay is molded and plasticine is not strong. There is power so that it exerts muscle force. The ninth research, by Rahmi (2013) states the misconception that greater force is needed to lift objects with a smaller mass. Denser objects will reach the ground first. The tenth research, by Wibowo (2016) explains the physics misconception that the stopping of the rotation of a rolling wheel is influenced by the force of gravity. Objects falling downwards are not part of the gravitational force. The way to reduce the friction force between the axle and the car wheels is to install spokes. Supported by the eleventh research, that errors in the concept of the definition of force and motion are caused by the majority of students analyzing according to experiences in daily life without paying attention to the correct science concepts, students' understanding abilities related to ongoing learning, difficulties in reading, in terms of context, namely lack of confidence in interaction. students and teachers, as well as the teaching methods used by teachers (Fabilla et al., 2023). The twelfth research, by Dewanty (2020) stated the misconception that force will only accelerate the motion of an object, force cannot bend the direction of an object's motion. Mass is related to the time an object takes in a problem regarding free fall motion. The thirteenth, similar study by Saputri (2021) states that the absence of air in the tube does not mean there is no gravity, because gravitational force is an attractive force between objects, there is no force on stationary objects and the frictional force moves in the same direction. The fourteenth research misconception, which is in line with Astiti et al. (2020) states that heavier objects will fall first than lighter objects if dropped from the same height from the earth's surface. A marble will fall earlier than a chicken feather if dropped from the same height and time in a vacuum.

The fifteenth research, was conducted by Arif et al. (2024) who analyzed misconceptions about frictional forces in the BSE class IV books in the independent

curriculum. In the book, an error was found in explaining that surface area affects the magnitude of the friction force. In addition, inaccuracies were found in comparing the motion of blocks and balls traversing an inclined plane in practice. This strengthens the cause of material misconceptions from the textbook content factors used. Furthermore, the sixteenth research by Budiwati et al. (2023) also conducted an analysis of misconceptions in the IPAS book for class IV in the independent curriculum. The results of the analysis show that according to the reasoning in the book, only humans have muscle strength that can be used to move objects. Supposedly, the muscles of animals and humans produce power when moving body parts, carrying objects from one place to another, and performing other tasks. In addition, a misconception was found that the Earth's gravitational force is the force that attracts objects on Earth to the Earth's core. The book's discussion of gravitational forces is specifically based on our planet. The context of gravitational force is that it is not only the earth that has it. A similar analysis of science books carried out by Purwaningrum (2021) explained that the textbook content was the cause. The gravitational force will cause all objects on the surface of the earth to always be attracted towards the earth. Meanwhile, according to scientists, "gravitational force causes objects on the surface of the earth to remain in their place.

Eighteenth research, by Laksana (2016) conducted an analysis of misconceptions about style material among prospective teachers. The concept of friction is based on an illustration, objects at rest do not experience force because objects at rest do not experience displacement/movement. The concept of gravitational force on the moon is based on an illustration, if an object is dropped on the surface of the moon it will not fall because there is no gravitational force on the moon. The concept of free fall, if two balls made from different materials are dropped from the same height, the heavier ball will touch the floor first. The concept of spring force is based on the picture, the amount of pulling force possessed by object (a) is greater than object (b). This is because the friction force that occurs on the object (c) is greater. Misconceptions about these four materials are caused by students' internal knowledge based on learning experiences. Furthermore, in the nineteenth research, student misconceptions on force material are that no forces are acting on stationary objects. Only gravitational force acts on stationary objects. If a force is lost on a moving object, its movement will slow down and stop. A constant force is needed to keep an object moving at a constant speed. If the resultant force

acting on an object is constant, then the object moves at a constant speed. A moving object always has the same direction of motion as the direction of the resultant force acting on it. This is caused by students' experiences of everyday phenomena and the results of their thoughts (Resbiantoro et al., 2017). Recent misconception research by Topalsan & Bayram (2019) states that energy is only related to movement. Objects that don't move have no energy. Objects have gravitational potential energy based on their position and gravitational potential energy only depends on the height of the object. The box gains energy due to the force applied by the worker so there is no energy in its final state. There is a lot of friction in the box, so the energy is much less than the worker's energy. Some of the research above was caused by students not understanding the concept.

Based on the results of research that has been conducted regarding misconceptions of force and motion, it turns out that subjects still experience misconceptions. Misconceptions are experienced by elementary school students to university students (future teachers). Physics materials that often experience misconceptions are friction, gravitational force, and free fall. The research results show that the causes of misconceptions are influenced by several factors, namely students, teachers, textbooks, context, and teaching methods. The following is a summary of misconceptions and their causes.

Table 1. Summary of Misconceptions of Force and Motion

No.	Scientific Concept	Misconceptions	Study Level
1.	Friction Force	Friction is a result of surface roughness only and no friction occurs on smooth surfaces. When braking, the wheels, and road rub together which creates friction The way to reduce the friction force between the axle and the car wheels is to install spokes. Friction moves in the same direction. There is a lot of friction in the box, so the energy is much less than the worker's energy.	Elementary School and University
2.	Gravity Force	The absence of air in the tube does not mean there is no gravity because gravitational force is an attractive force between objects. The gravitational force causes objects on Earth to have weight. Only gravitational force acts on stationary objects. Objects falling downwards are not part of the gravitational force.	Elementary School and University
3.	Free Fall Motion	Denser objects will reach the ground first	Elementary School

Based on Table 1, the misconception of friction force above, according to Hardiansyah (2021), the friction force is a force caused by a force that moves in the opposite direction to the movement of an object due to contact between two objects. Wheels have a serrated or grooved surface. The goal is to increase the friction force between the wheels and the ground. The greater the friction, the less likely the wheels will slip, especially on slippery ground or surfaces. This proves that the friction force is influenced by the direction of motion of the object and the surface of the object. The Earth's gravitational force is a force that attracts living and nonliving objects on the Earth's surface toward the Earth's core (Lestari et al., 2024). The mass of the earth causes a strong gravitational field around it. The greater the mass of an object, the stronger the Earth's gravitational pull. Distance also affects the gravitational force between two objects which is greater when they are closer to each other.

Free fall is the movement of an object falling in a vertical direction from a certain height without initial speed (Giancolli in Nurhayati et al., 2021). The constant acceleration for free fall is the acceleration due to the effects of the earth's gravity so that the acceleration value of an object when experiencing a free fall is close to the acceleration value of the earth's gravity (Nurhayati et al., 2021). If an object is released around the earth, the object will be attracted by the earth, meaning that the area is in the earth's gravity area.

The results of this research are in line with previous research that misconceptions about concepts in elementary school science material are very diverse (Laksana, 2016b). Misconceptions regarding the material of force and motion are still at a high level, among students in elementary education (Topalsan & Bayram, 2019).

DISCUSSIONS

Based on research, the causes of misconceptions regarding friction material are students' understanding, textbook content, and teaching methods. Students analyze according to experiences in daily life without paying attention to correct science concepts, students' understanding abilities related to ongoing learning, and difficulties in reading. The causes in terms of context are a lack of confidence in student interactions with teachers, as well as the teaching methods used by teachers. Students' incomplete understanding of the concept of friction and the

material studied (Arif et al., 2024; Ariyastuti & Yuliawati, 2017b; Aziza et al., 2023; Fabilla et al., 2023; Khoiriyah, 2018; Respasari et al., 2022; Topalsan & Bayram, 2019). Another cause is students' feelings and direct experiences that are different from scientific beliefs. The lack of understanding that arises from students regarding concepts (Budiwati et al., 2023b; Danil et al., 2023; Laksana, 2016b; Mariyadi & WA, 2023a; Purwaningrum, 2021b; Rochman & Winanto, 2012; Saputri, 2021; Wibowo, 2016b). Causes of misconceptions about teaching methods. Students' experiences with everyday phenomena and the results of their thinking. The condition of students when receiving concepts, teachers who teach already have concepts that are not following the truth of the concept, learning methods, books, and context (Astiti, 2020; Laksana, 2016b; Resbiantoro et al., 2017). The teaching materials used are per the learning objectives that the learning process is designed to involve student activity (Yunianto, 2021).

The solution that can be offered is that teachers can use interactive, innovative, and creative learning media in the learning process. The use of media in the learning process is an innovative solution by manipulating learning conditions to become more realistic and adapted to everyday life (Sari & Jupriyanto, 2023). Research by Sari & Jupriyanto (2023) which carried out the development of interactive media integrated with problem-solving models for science learning has been verified as feasible and practical to use. Apart from that, learning models also affect increasing student learning achievement, one of which is the Flipped Learning learning model (Sukma et al., 2022). Research by Jupriyanto et al. (2024) which uses the Realistic Mathematics Education learning model in mathematics learning can influence and increase student motivation. In science learning, the advanced organizer model has been proven to improve students' concept-understanding skills (Badarudin, 2017).

The research results are still limited to research sources so it is hoped that further research can examine a wider range of sources. The results of this research can be used as a guide for teachers to correct misconceptions that occur in learning friction force, gravitational force, and the motion of falling objects. Apart from that, it can be used as a reference source for further research on misconceptions in more depth.

CONCLUSION

Based on the discussion above, it can be concluded that there are still misconceptions in science learning about force and motion at the basic education level, namely misconceptions about frictional forces, gravitational forces, and free fall motion. This misconception occurs among students and university students (prospective teachers). The causes of these misconceptions are the students themselves, teaching materials, context, teachers, and teaching methods.

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