CHAPTER I
INTRODUCTION

1.1 Research Background

Widiyatmoko & Shimizu (2018) stated that one primary concern of science education has been on conceptual understanding of science, at all levels of formal education. For students, conception becomes one of the crucial aspects. According to Gurel et al. (2015), students develop their concepts through their experiences in both formal education at school and their everyday activities. Furthermore, due to ongoing scientific and technological progress, knowledge has been continuously expanding, leading to changes in the interpretations and implications of various concepts (Aktan et al., 2015).

During the learning process, students often generate numerous conceptions that differ from established scientific knowledge (Zhao et al., 2021). A concept that is not in line with the scientific understanding or the accepted knowledge within the field of expertise is referred to as a misconception (Maryanti et al., 2022). As a result, the newly acquired knowledge of a student may involve a concept that varies from or is a misinterpretation of the content presented by the teacher (Yeo et al., 2022). It is well-known that misconception is a barrier to students in learning science. Misconceptions possess a nature that is resistant and persistent to change and problematic in the advancement of future scientific knowledge (Soeharto et al., 2019).

It is crucial for teachers to have a comprehensive understanding of the misconceptions that students bring to the science classroom (Slater et al., 2018). To address the negative consequences from misconceptions, efforts have been invested in conducting research aimed at rectifying these inaccuracies. Multiple factors underscore the significance of confirming students' conceptions, thereby highlighting the necessity of identifying their misconceptions. Research has revealed that understanding lower-secondary school students' alternative conceptions not only help science education stakeholders grasp their cognitive structures before learning but also serves as a foundation for enhancing the effectiveness of science teaching and addressing these alternative conceptions (Yeo et al., 2022).

Researchers and teachers should be aware of the typical types of misconceptions that often arise in students' perceptions (Anjarsari, 2018). Teachers who are aware of their students' most prevalent misconceptions are more likely to enhance their students' scientific knowledge compared to teachers who are unaware of these misconceptions (Sadler & Sonnert, 2016). Conversely, certain factors are more inherent to the student, such as motivation, prior knowledge, and the challenges they face while learning specific subjects. This is particularly relevant when dealing with complex scientific content, such as certain physical, chemical, and/or biological processes (Tapia et al., 2019). However, preventive measures against misconceptions must still be implemented to achieve students' scientific understanding.

Those factors mentioned above make it crucial for researchers and teachers to understand the types of misconceptions that commonly occur in students' perceptions. The field of misconception research remains expansive, particularly concerning diagnostic tests, misconception remediation strategies, and certain unexplored topics in physics (Resbiantoro et al., 2020). Therefore, it is crucial to recognize the science concepts that pose challenges for students in order to assess what modifications might be necessary in the school curricula. This approach aims to enhance the teaching and learning of these fundamental subjects across elementary, middle, and secondary school levels (Neidorf et al., 2020).

Misconceptions are a common occurrence in the field of science, encompassing various physics concepts. Out of 700 investigations on misconceptions, approximately 300 focused on mechanics, around 159 on electricity, roughly 70 on heat, optics, and materials properties, about 35 on earth and space, and others covered modern physics (Suprapto, 2020; Suparno, 2005; Wandersee, Mintzes, & Novak, 1994). The characteristics of the concepts themselves, such as their abstractness and complexity, are the main cause of the students' misconceptions (Soeharto et al., 2019). The complexity can be seen from the relationship between the concepts because studying physics essentially is not apart from facts, concepts, laws, and theories. The essence of physics as a process is related to phenomena, hypotheses, observations, measurements, investigations, and publications, and the essence of physics as an attitude encompasses attitudes that stem from thinking. (Herliandry et al., 2018). Students' misconceptions regarding principles in physics frequently stem from their encounters or observations of everyday physical phenomena (Neidorf et al., 2020).

In the field of physics, all subfields, including mechanics, thermodynamics, sound and waves, optics, electricity and magnetism, and modern physics, experience misconceptions. Some of these misconceptions are easily corrected, while others can be quite challenging, especially when the concept has practical applications in real life (Putra et al., 2019). The field of mechanics ranks at the top among the physics subfields that encounter misconceptions. Work and energy are among the complex topics found in the field of mechanics (Maison et al., 2020). This aligns with prior studies that indicated the most notable misconceptions arise within the field of mechanics, encompassing concepts such as work and energy. This is because the subject of work and energy involves numerous formulas, so when students encounter problems related to concepts and involve some calculations, some of them experience misconceptions (Zafitri, 2018; Suparno, 2013).

In recent years, many researchers have carried out related research on the diagnosis of misconceptions of students about different physics contents including the work topic. For instance, Anggrayni & Ermawati (2019); Maison et al. (2020); and Mustari et al. (2020). In the 2013 curriculum in Indonesia, the topic of work is integrated in one chapter with the discussion of simple machines. Researchers also have carried out related research on the diagnosis of misconception on simple machines topic, but mostly focus on the remediation and instrument development. Studies that solely focus on surveys in diagnosing misconceptions related to the topic of simple machines are Ponidi (2011), Yuberti et al. (2020), and Annisa (2023).

The aforementioned previous research identified various misconceptions held by students. 21.59% of high school students experience misconceptions about the topic of work and energy (Maison et al., 2020; Saheb, et al., 2018). Furthermore, Zafitri, et al. (2018) stated that misconceptions were identified in each concept of the subject of work and energy, with an average of 41.07%. Nugraha (2014) demonstrated that students tend to have misconceptions regarding positive and negative work, total work by conservative and non-conservative forces, as well as the law of conservation of mechanical energy.

Based on the other research finding it stated that more than half of the students (60.98%) still had misconceptions about simple machine concepts. Around 86.87% of students were unable to determine the types of forces, pivot points, and arms in a lever. Over half of the students (53.75%) did not know the formula for mechanical advantage. Approximately 41.66% of students could not identify the point of application of effort force, determine and differentiate the magnitudes of effort forces. All students (100%) did not understand the meaning of force amplification. About 47.5% did not comprehend the concept of displacement amplification in a lever. Around 36.11% were unable to provide examples of tools and situations that utilize the principles of simple machines, such as levers, pulleys, and inclined planes (Christina et al., 2022; Ponidi 2011).

According to Satriana and Hamdani (2019), previous research results also uncover some forms of misconception among students on simple machine topic, which are: 1) students assume that all types of levers are same; 2) students assume that at inclined plane mechanical advantage gets bigger when the height of the plane extend; 3) students assume that the longer arm of effort arm then the force that needed is increase; 4) students assume that mechanical advantage of the lever is the result of dividing the force by the load; 5) students assume that the mechanical advantage of all pulleys are the same. The latest findings from Annisa (2023) found that the percentage of students who possess misconceptions is 34.6%.

Due to the consistent occurrence of misconceptions among novice students in science learning topics (Soeharto et al., 2019), researchers have utilized diverse diagnostic tests to uncover student misconceptions in science. Since the 1980s, science education research has been primarily dedicated to diagnosing students' comprehension of scientific concepts (Zhao et al., 2021). Researchers have conducted numerous studies aimed at identifying, evaluating, and diagnosing students' conceptions. Diagnostic tests for misconceptions prove valuable in recognizing and promoting a deeper understanding among prospective teacher students (Kaniawati et al., 2019).

Researchers have developed and employed various diagnostic tools to assess misconceptions, including interviews (Chen, 2009), multiple-choice tests (MCTs) (Liu et al., 2011), word association (Malek et al., 2012), Certainty of Response Index

(CRI) (Mustari et al., 2020), two-tiers (Kılıç & Sağlam, 2009), three-tier diagnostic test (Caleon & Subramaniam, 2010), and four-tier diagnostic test (Maharani et al., 2019). While the three-tier tests are considered valid and reliable for measuring student misconceptions, they do have certain drawbacks related to the conversion of confidence ratings on the first and second tiers. This can lead to overestimating students' level of knowledge and inaccurately assessing the number of misconceptions and correct responses. As for the use of a four-tier multiple-choice test to assess misconceptions, the research is still in its early stages and requires improvement (Soeharto et al., 2019). Tests structured into four-tier tests prove to be more efficient when dealing with a substantial number of participants (Resbiantoro et al., 2022).

Based on the reasons explained above, several things need to be noted. The importance of students' conceptions and the prevalence of misconceptions found in physics topics drive the need for preventive measures. Based on prior research on multiple-tier concept tests, it has been recognized that four-tier tests serve as diagnostic tools and are widely favored by researchers (Gurel et al., 2017; Sreenivasulu & Subramaniam, 2014; Caleon & Subramaniam, 2010). These four-tier tests have shown to be more effective compared to other diagnostic tests.

For the topics, previous research discovered that many students have misconceptions about the topic of work. This study aims to build upon these findings by exploring a more comprehensive approach since the 2013 curriculum in Indonesia integrates the topic of work with the discussion of simple machines in one chapter. This aligns with the fact that research on student misconceptions about work combined with simple machines is relatively limited. Supported by the suggestion from previous research about misconception in simple machines by Nazura (2021), the researcher proposes including the topic of force and work in further research to enhance the instrument's quality. Therefore, this research will focus on several subtopics aligned with the indicators in the 2013 curriculum concerning the chapters on work and simple machines. These subtopics include work, types of simple machines, and the principles of simple machines in human movement system. The study of simple machine topics is essential in daily life and relates to various tools commonly used by students and human movement systems that operate based on the same principles.

In conclusion, the objective of this study was to employ the four-tier diagnostic test to diagnose students' misconceptions regarding work and simple machines topics. The analysis of these misconceptions proves valuable for educators as it enables them to develop and implement innovative teaching approaches, particularly targeting students' misconceptions.

1.2 Research Problem

Based on the previous explanation, the research problem can be formulated as follows: “What is the diagnosis result of students’ misconception on work and simple machine topics using a four-tier test?”. Two research questions are formulated based on the research problem.

1. What is the level of students' conceptions about work and simple machine topics?
2. What are some of the misconceptions students have about work and simple machine topics?

1.3 Operational Definition

To prevent any misconceptions regarding this research, certain operational definitions are provided. The meanings of these terms are elucidated as follows:1.

1. Students’ Conception

Conception is the ability to understand the concept. Students’ conception is defined as the ways students understand phenomena in their surroundings. The measurement of students' conception is conducted using a diagnostic test with four tiers, classifying their conceptions into five distinct levels. These levels have been adopted from earlier studies and consisted of scientific knowledge, false positive, false negative, misconception, and knowledge and lack of knowledge. The focus of this research lies specifically on identifying students' conceptions related to the subjects of work and simple machines.

3. Misconception

Misconception is a conception that is incompatible with the scientific idea or conception accepted by the expert in the field. This is also assessed through a four-tier diagnostic test. A diagnosis where students offer incorrect responses to the main and reasoning questions yet display confidence in their answers. This phenomenon is validated when students answer incorrectly in the first and third tiers but they remain convinced in the second and fourth tiers.

3. Four-Tier Test

A diagnostic test comprising four tiers serves as an instrument to measure students' conception. These tiers encompass the main question, the confidence level for the main question, the reasoning question, and the confidence level for the reasoning question. In the first and third tiers, there exist four response options, while the second and fourth tiers each offer two choices: "sure" and "not sure". The combination of students' responses for each question generates a sequence, subsequently subjected to analysis employing a rubric derived from previous research. This sequence is categorized as either scientific knowledge, false positive, false negative, misconception, or lack of knowledge. Frequencies and percentages are statistically examined to analyze students' conceptions regarding work and simple machine concepts.

1.4 Limitation of Problem

Several limitations are applied so that the research can run under the objectives as follow:

1. Research Subject

The results and conclusions obtained in this study refer specifically to the sample group involved in the study.

2. Four-Tier Test

Four-tier test is an instrument used to measure students' conception that consists of the main question, the confidence level for the main question, the reasoning question, and the level of confidence of the reasoning question. In this research, the confidence level question within the four-tier test is restricted to two options: "sure" and "not sure." Furthermore, this research does not determine the cause of students' misconceptions.

3. Work and Simple Machines

The concept in this study refers to the concept in the work and simple machines topic for 8th-grade, as constrained by core competency number 3 and basic competency number 3.3 according to Indonesia's curriculum of 2013.

1.5 Research Objective

The objectives of this study are outlined as follows:

1. To analyze the level of students' conceptions about work and simple machine topics.
2. To analyze some of the misconceptions students have about work and simple machine topics.

1.6 Research Benefit

1. Teacher

This research provides teachers with insights into the current level of students' conception regarding work and simple machine concepts. The information is beneficial for teachers by providing them common students' conception on the topics. This becomes particularly valuable when teachers don't have sufficient time to do a diagnostic test on their students before conducting the lesson. Furthermore, even if teachers manage to allocate time for the diagnostic test, they can employ this instrument to diagnose students' conceptions of the topics before conducting the lesson or to assess those conceptions after conducting the lesson.

2. Student

This research proves advantageous to students by providing them with insights into concepts related to work and simple machine concepts. This understanding empowers students to introspect about their conception and formulate strategies for their forthcoming studies. It will help students correct the misconceptions that they might experience. This allows students to proactively avoid the misconceptions highlighted in this research, while concurrently enhancing their knowledge.

3. Other Researchers

This research holds value for fellow researchers by providing additional insights and data on methodologies for diagnosing students' conceptions concerning work and simple machine subjects. Subsequent studies dealing with diagnosing students' conceptions across different subjects could draw upon this research as a point of reference. Furthermore, this research introduces new instruments that hold potential for future research endeavors aimed at diagnosing students' conception of work and simple machine topics. Moreover, the findings of this research urges more research that is objective to increase students' scientific knowledge and eliminate students' misconception on science topics.

1.7 Organizational Structure of Research Paper

Chapter I: Introduction

The research background, research problem, research question, operational definition, research objective, research benefit, limitation of research, and the organization of the research paper are all included in this chapter.

Chapter II: Literature Review

The chapter contains a literature review of the variables that are considered important. Those variables are students' understanding of science, students' misconception in science, four-tier test as diagnostic instrument, and content analysis of work and simple machines in national middle school.

Chapter III: Research Methodology

The chapter explains how the research is carried out. It explains the research design, research method, population and sample, research instruments, data analysis, and research procedure.

Chapter IV: Result and Discussion

The chapter contains the result of the data analysis. It also contains a discussion that is constructed based on the result. The result and the discussion in this chapter are meant to answer the research questions.

Chapter V: Conclusion, Implication and Recommendation

The chapter consist of the conclusion drawn from the result and discussion. It also contains implications and recommendations for future research.