# CHAPTER I

# INTRODUCTION

## 1.1 Background

In the last few decades, researchers have turned their attention to students' understanding of scientific concepts at different school levels (Taslidere, 2016). Students do not come to the class with absolutely no knowledge of a topic. Students build the concepts in their mind from their experiences in school education or daily activities in the natural world that have imbued them with certain ideas about science, knowingly or unknowingly, that they bring to the classroom. (Gurel et al., 2015; Yan & Subramaniam, 2018). Since students have different experiences, they might have the right or wrong concept from scientific conceptions (Kaniawati et al., 2019). Moreover, during scientific learning, ideas that are based on students' preconceptions and seem logical to them may sometimes be incompatible with the scientific information adopted by the scientific community. Several scientists state that this incomplete conceptual understanding must be considered because students build new knowledge on existing knowledge (Gurcay & Gulbas, 2015; Peşman & Eryilmaz, 2010).

Students' conceptions that are different from those of the scientific community (Gurcay & Gulbas, 2015) or that are incompatible with scientific understanding accepted by experts in the field (Maryanti et al., 2022) are called misconceptions. In science education literature, misconceptions are widely referred to as alternative conceptions, preconceptions, alternative frameworks, erroneous ideas, naive beliefs, and spontaneous reasoning (Arslan et al., 2012; Ergin & Atasoy, 2013; Gurcay & Gulbas, 2015; Habiddin & Page, 2021; Peşman & Eryilmaz, 2010). They are in agreement that many of these ideas are different from those generally accepted by the scientific community. For this research, the term misconception is used when referring to students' incompatible ideas with scientific views. Research-based evidence indicates that misconceptions create a barrier to knowledge restructuring, are often held strongly resistant to change (Onsekiz, 2019; Peşman & Eryilmaz, 2010), may become

a hindrance for learners to learn advanced science concepts and form new cognitive structures (Arslan et al., 2012; Gurcay & Gulbas, 2015).

The problem of misconceptions is a major obstacle to learning and is frequently encountered in Physics because of its abstract nature (Gurcay & Gulbas, 2015). Several studies on students' misconceptions about Physics have been conducted over the past three decades or more. It is claimed that students' misconceptions are one of the most important factors that affect students' achievement in Physics (Eryilmaz, 2010). One of the concepts in Physics that is essential but students still difficult to understand and have a lot of misconceptions in it is Heat (Gurcay & Gulbas, 2015). Heat is one of the basic concepts of Thermodynamics that is included in the curricula of lower and upper secondary school in Indonesia, as well as in several other countries around the world. Ekawati's research found that almost 55% of seventh grader junior high school pupils had misunderstandings regarding heat material and changes in substance form (Ekawati et al., 2021). In Physics education research, misconceptions in heat were studied, in addition to those in Mechanics (Caleon & Subramaniam, 2010; I. Caleon & Subramaniam, 2010; Kaltakci-Gurel et al., 2017; Kaniawati et al., 2019, 2021; Kiray & Simsek, 2021; Samsudin et al., 2021; Taslidere, 2016; Taşlıdere, 2021), Electricity (Ergin & Atasoy, 2013; Peşman & Eryilmaz, 2010), Optics (Kaniawati et al., 2020), and Astronomy (Kanli, 2014; Korur, 2015; Onsekiz, 2019; Romine et al., 2015; Ürey et al., 2020).

Various studies are available on students' misconceptions about Heat (Ekawati et al., 2021; Suhandi et al., 2020), Heat Transfer (Anam et al., 2019; Suhendi & Ardiansyah, 2021), and Heat and Temperature (Eryilmaz, 2010; Fenditasari et al., 2020; Gurcay & Gulbas, 2015; Suhandi et al., 2020). According to these studies, students regarded heat as a type of matter that is inside objects and that can be transported within objects and moved from one object to another. Temperature, however, is perceived as a property of the material of which the object is composed. Students failed to distinguish between the concepts of 'heat and temperature'. Some students consider temperature to be a measure of heat. Besides, students have not been able to distinguish the concept of heat transfer.

Several factors play a part in why students have difficulty learning the concepts. Differences between the scientific language and everyday language, and the terminological language used in school textbooks are among the factors that make learning difficult. For example, some textbooks include statements arguing that heat 'is a form of energy' or 'is internal energy'. These different statements made about the concept of heat make it more difficult for students to understand these concepts (Gurcay & Gulbas, 2015). In addition, misconceptions in students can arise from various sources-for example, textbooks, teaching, native culture, and the media (Zhao et al., 2021) and from everyday experiences (Taber & Akpan, 2017).

To overcome all the bad effects of misconceptions, researches had been carried out to eliminate it. Researchers have been done various research to identify, assess, and diagnose students' conceptions. There are several reasons which support the statement that diagnosing students' conception is essential. The identification and investigation of misconceptions is one of the most important tasks in educational research (Caleon & Subramaniam, 2010). In addition, identification of misconceptions in different topics is important as it provides instructors research-based evidence of students' learning difficulties in these topics so that these could be used to inform the development of strategies for teaching (Sreenivasulu & Subramaniam, 2014) and lessons that ultimately result in the reconceptualization of learning (Arslan et al., 2012). Furthermore, diagnosing students' conceptual understanding and misconception as early as possible is necessary in order to help reduce the buildup of mistaken concepts that may lead to negative consequences in the future (Yeo et al., 2022).

Researchers tried and are still trying to develop techniques, methods, and strategies to eliminate students' misconceptions. To prove that a particular way is effective to eliminate students' misconceptions, a diagnostic test needs to be done before and after the intervention was done. One of the challenges of assessing students' conceptual understanding is the scarcity of reliable assessment tools and methods. Historically, educators have attempted to measure students' conceptual understanding in science through multiple-choice questions (MCQs), with a single correct answer choice and two or more incorrect options (Aydeniz et al., 2017; Caleon &

Subramaniam, 2010). However, MCQs have one fundamental weakness: they cannot differentiate correct answers due to correct reasoning from those which are due to incorrect reasoning (Caleon & Subramaniam, 2010). That means not all errors made by students in tests can be categorized as ACs. Instances of students getting an answer to a test item incorrect through guesswork or their having difficulties in explaining their answers are not regarded as true ACs (Sreenivasulu & Subramaniam, 2014).

Researchers who have voiced their concerns about the limitations of MCQs then developed, used and promoted the use of such assessment tools as open-ended questionnaires and interviews to assess students' conceptual understanding. Although these methods do expose details about the misconceptions held by students in scientific areas, these methods take a lot of time and are not suitable for a large sample (John et al., 2017; Zhao et al., 2021). Therefore, more recent research studies have been concentrating on how to assess students' misconceptions with a more reliable, valid, and feasible method (Eryilmaz, 2010). Although most teachers and researchers are familiar with the development of achievement test, they may not be familiar with that of misconception test or diagnostic test (Caleon & Subramaniam, 2010).

A two-tier diagnostic test is then developed. It has been used to help teachers gauge whether or not students have misconceptions (Yeo et al., 2022). The first tier is a typical multiple-choice question in which students choose the right answer from a set of choices, whereas the second tier directs students to select a reason for the answer that they chose in the first-tier (Korur, 2015). Relative to typical MCQs, two-tier test can be used to better probe students' misconceptions, as they measure not only the students' ability to select correct responses, but also the reasoning behind their choices. Unfortunately, two-tier tests have limitations. It cannot identify whether the student's wrong choice is due to lack of knowledge or the misconceptions (Arslan et al., 2012). It also cannot tell whether the student's correct answer is based on guessing or really grasping the knowledge (Caleon & Subramaniam, 2010). This limitation can be addressed significantly by introducing confidence ratings as additional tiers to two-tier tests.

In three-tier test, the confidence level question is added as the third level or the third tier of misconception questions, where students state whether they are "certain" or "uncertain" about their answer to the previous questions (Korur, 2015). Some of the advantages of three-tier tests is the possibility to estimate the percentages of false positives and false negatives which can be utilized to determine the validity of the test and distinguish a lack of knowledge from a misconception (Arslan et al., 2012; Peşman & Eryilmaz, 2010). Nevertheless, three-tier test requiring students to express only one confidence rating for the subjects' responses in the answer and reason tiers, it is not clear if students have different levels of confidence for the two tiers, noting that each tier measures different levels of knowledge. Therefore, the three-tier test still need development by the researchers.

In order to find efficient assessment tools that bring out students' conceptual background, the researchers develop three-tier test with additional tiers requiring students to specify confidence ratings separately for their choice of answers in the answer and reason tiers (Caleon & Subramaniam, 2010). So, there are four tiers which are the main question, the confidence level for the main question, reason, and confidence level for the reason. Since each question consists of four tiers, this type of instrument enables researchers to have a better view of students' understanding. The four-tier test instrument is more sensitive and powerful (Caleon & Subramaniam, 2010).There are various types of student's confidence levels. The first is that the confidence level rated from 1 to 6 consists of just guessing, very unconfident, unconfident, confident, very confident, and absolutely confident (Sreenivasulu & Subramaniam, 2013). There is also a confidence level rated from 1-100 as a score. Another is rated by two options which are sure and not sure (Fratiwi et al., 2020). In this research, a four-tier diagnostic instrument with two options confidence level is used.

A large number of studies on using four-tier test in diagnosing students' conception in Physics has been done in different topics such as Optic (John et al., 2017; Kaltakci-Gurel et al., 2017; Kaniawati et al., 2020), Wave (I. Caleon & Subramaniam, 2010; Taslidere, 2016), Density (Kiray & Simsek, 2021), Newton's Laws (Kaniawati

et al., 2019), Force and Vibration (Kaniawati et al., 2021), Work and Energy (Samsudin et al., 2021). For Heat Topic, most of the studies was carried out using three-tier test (Ekawati et al., 2021; Gurcay & Gulbas, 2015; Peşman & Eryilmaz, 2010) for diagnosing students' conception. However, there have been relatively fewer studies that have focused on this topic using four-tier test. In addition, not only in Physics, four-tier test also used in diagnosing students conception in Biology (Zhao et al., 2021), and Chemistry (Chinaka, 2021; Habiddin & Page, 2019; Jusniar et al., 2020b; Laliyo et al., 2021; Maryanti et al., 2022; Sreenivasulu & Subramaniam, 2013, 2014; Sujana et al., 2021; Yan & Subramaniam, 2018)

Diagnosing students' conception in science education has been done in different school levels. Sometimes, students' conceptions are being compared in various ways. For instance, it is compared between control groups and experimental groups (Erlina, 2018; Jusniar et al., 2020a), between prospective science and social studies teachers (Ürey et al., 2020), between students and pre-service science teachers (Korur, 2015), and among bachelor, master, and PhD students (Eryilmaz, 2010). The comparison had also been done related to Heat. Research in 2010 was done to analyze and compare students' conception on Heat. It includes 1,619 bachelor students, 219 master students, and 60 PhD students. Using three-tier test, students' conception of higher education level in Turkey are analyzed. The result shows that there is significant difference among levels (Eryilmaz, 2010). Nevertheless, there is still lack of research that compare student's misconception between male and female.

From the reasons elaborated above, several things are different in this research. The first is that the topic chosen is more specific in Heat. In the previous research, the topics chosen were heat and temperature or heat transfer only. In this research, the three kind of heat transfer: radiation, convection, and conduction will be included as well as nature heat. The second is that the instrument used is different with previous studies. In this research, four tier-test is used rather than three-tier test. The last is that in this research, students' misconception are compared based on gender instead of school level. Therefore, the researcher decided to use the four-tier test for diagnosing students' conception on Heat topic and compare students' misconceptions based on gender.

## 1.2 Research Problem

The research problem of this study can be defined as "How does students' conception that is diagnosed by using four-tier test on heat topic?" Based on the research problem, the research attempt to define the following questions:

1. How is the level of students' conceptions on heat topic?
2. What are the most common students' misconceptions on heat topic?
3. Is there a significant difference between male and female students' misconceptions on heat topic?

## 1.3 Research Objective

The objectives of this research are described as follows:

1. To analyze the level of students' conceptions on heat topic.
2. To analyze the most common students' misconceptions on heat topic.
3. To analyze the difference between male and female students' misconceptions on heat topic.

## 1.4 Research Benefit

1. Teacher

   This research is useful for junior high school teacher by providing information about students' conception on heat topic especially when they don't have sufficient time to do the diagnostic test in the beginning of the lesson. Besides that, if teachers have time to do the diagnostic test, they can also use the instrument before conducting the lesson to diagnose students' conception about heat topic or after conducting the lesson to see the improvement of students' conception. Other than that, teacher can prepare a better learning methods strategies that can help to reduce students' misconception on heat topic.

2. Student

   This research is useful for junior high school students by providing information about their conceptions on heat topic. It will help students correct their misconceptions that they might experience. Hence, they can try to avoid the

common misconceptions that are found in this research and try to avoid them while trying to strengthen their knowledge.

3. Researcher

This research is useful for researcher by providing materials on how to diagnose students' conceptions on heat topic that can also be used as a reference for another research in different topics. Other than that, this research offer a new instrument that can be used for future research in diagnosing students' conception on heat topic. Moreover, the result of this research urges more researches that aim to increase students' scientific knowledge and eliminate students' misconception.

## 1.5 Organizational Structure of Research Paper

Chapter I: Introduction

This chapter contains the research background, research problem, research objective, research benefit, the organizational structure of research paper, and limitation of problem.

Chapter II: Literature Review

This chapter contains a literature review of the variables that are considered important. Those variables are students' conception, misconception, four-tier test, and heat topic.

Chapter III: Research Methodology

This chapter explains how the research will be carried out. It explains the research design, research method, participant, research instruments, instruments analysis, data collection, and research procedure.

Chapter IV: Result and Discussion

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

Chapter V: Conclusion and Recommendation

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

## 1.6 Limitation of Problem

To focus the research, there are some limitation as follows:

1. Heat Topic

   Heat topic that used in this study cover the topic in $7^{th}$ grade that is limited by Core Competence number 3 and Basic Competence number 3.4 in Indonesia's Curriculum of 2013.

2. Four-Tier Test

   Four-tier test is an instrument used to measure students' conception that consists of four tiers which are the main question, the confidence level for the main question, the reason, and the confidence level for the reason. The confidence level questions of four-tier test that used in this study only consist of two options which are sure and not sure (Kiray & Simsek, 2021).