CHAPTER I
INTRODUCTION

This section serves as the introduction to the research, providing an explanation of the research background, research problem formulation, research objectives, significance of the study, operational definitions, and the organizational structure of the thesis.

1.1 Background of the Research

Physics education at various levels of formal education aims to help students understand the concepts, principles, and laws governing physical phenomena in everyday life. However, alternative conceptions often occur among students regarding several concepts, such as fluids (Irwansyah et al., 2018), momentum and impulse (Adimayuda et al., 2021; Kaniawati et al., 2021), simple harmonic motion (Nurhasanah et al., 2022), the concept of light (Aminudin, et al., 2019; Haryadi & Pujiastuti, 2020; Samsudin, 2023), and the concept of heat (Febrianti et al., 2019; Haryono et al., 2021; Nurul et al., 2016; Suhandi et al., 2020; Wulandari & Prihandono, 2018). In the concept of heat, students often have significant alternative conceptions that require a more effective instructional approach.

This knowledge gap is attributed to the abstract nature of heat as a concept, making it challenging for students to grasp through traditional teaching methods (Julaila et al., 2021; Lebdiana et al., 2013; Suhandi et al., 2020). Many students struggle to connect theoretical knowledge with real-world applications, which hinders their ability to fully appreciate the importance of heat in everyday life and scientific phenomena.

This challenge is even more pronounced for students with special needs, who often face additional barriers to learning due to limitations in conventional teaching materials, classroom environments, and instructional approaches that are not fully inclusive (Bañados et al., 2024; Jander et al., 2024; Li & Singh, 2022; Muksalmina et al., 2024; Wood & Robertson, 2018). According to Sunanto & Hidayat (2016), inclusive education plays a crucial role in ensuring that all students, including those with disabilities, have access to quality education tailored to their unique learning needs. However, the inclusive approach to teaching in many schools still lacks the flexibility to accommodate diverse learners (Pusat Analisis Keparlemenan Badan Keahlian DPR RI., 2024). For students with special needs, these limitations can further exacerbate difficulties in understanding abstract physics concepts, such as heat, potentially leaving them behind their peers.

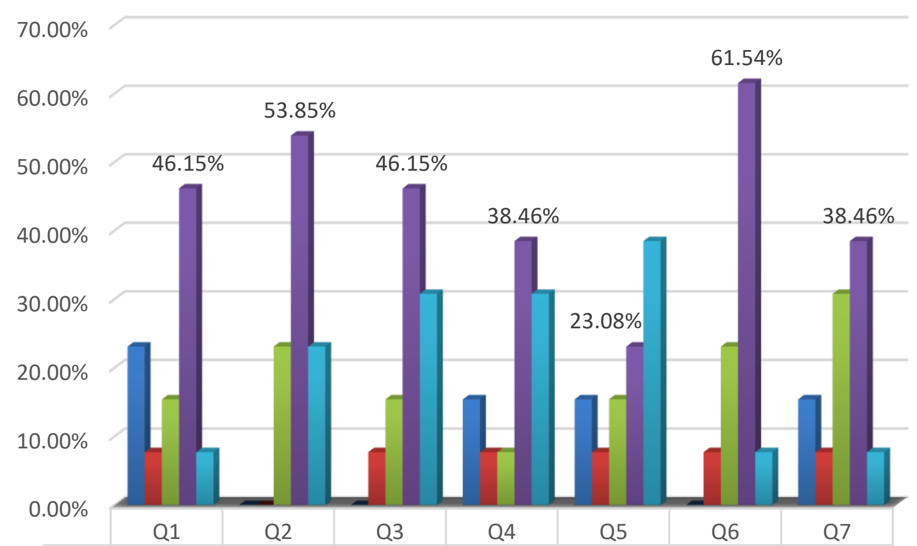
As advocated by UNESCO, inclusive education promotes a system that respects the diversity of all students and provides equal learning opportunities. UNESCO highlights that inclusive education is both a fundamental right and essential for ensuring equitable educational outcomes and fostering social inclusion. According to UNESCO's 2017 report on inclusive education, effective inclusion requires transforming educational systems to accommodate all students, including those with special needs, to participate fully in the learning process. This aligns with global initiatives toward Sustainable Development Goal 4 (SDG 4), which focuses on ensuring inclusive and equitable quality education for all by 2030.

In Indonesia, the Ministry of Education and Culture (*Kemendikbud*) has acknowledged the importance of inclusive education and implemented policies to improve access for students with disabilities. Permendikbud No. 70 of 2009 provides a legal framework for inclusive education, requiring schools to accommodate students with special needs. The concept of inclusion in this regulation aligns with the definition provided by Staub and Peck (1995), which describes inclusion as the full-time placement of children with mild, moderate, or severe disabilities in regular classrooms.

In recent years (2022), the *Merdeka Belajar* initiative, introduced by Kemendikbud, has further emphasized the importance of personalized, student-centered learning that allows for greater flexibility and innovation in the classroom. This initiative recognizes the necessity of modifying learning processes, particularly for students with special needs, to ensure they receive an inclusive and effective education. Among the six recommended modifications for teachers, one focuses on content adaptation. For example, while general education students may learn to calculate the the changing volume of a substance after thermal expansion, involving arithmetic skills such as multiplication and division, students with intellectual disabilities might focus solely on identifying and understanding the phenomenon without complex mathematical operations. This approach allows them to grasp the fundamental concepts without becoming overwhelmed by calculations.

Despite efforts to promote inclusive education in Indonesia, significant gaps remain, particularly in the teaching of physics concepts like heat (Bilad et al., 2024; Komarudin & Kaeni, 2023; Liem, 2024; Rosyidah & Rindaningsih, 2024; Syahnas Nabiela & Ulfatin, 2023). These concepts are inherently challenging for students, especially those with special needs, due to the reliance on conventional teaching methods that predominantly focus on text and lecture-based learning.

To explore this issue, a field study was conducted involving 13 students at an inclusive school in Bandung, West Java. The study employed a three-tier diagnostic test focused on the topic of heat. Students' conception profiles were mapped using the categorization developed by (Aminudin, 2019), as illustrated in Figure 1.1.



	Q1	Q2	Q3	Q4	Q5	Q6	Q7
SU	23.08%	0.00%	0.00%	15.38%	15.38%	0.00%	15.38%
PP	7.69%	0.00%	7.69%	7.69%	7.69%	7.69%	7.69%
PN	15.38%	23.08%	15.38%	7.69%	15.38%	23.08%	30.77%
MC	46.15%	53.85%	46.15%	38.46%	23.08%	61.54%	38.46%
NU	7.69%	23.08%	30.77%	30.77%	38.46%	7.69%	7.69%

SU PP PN MC NU

Figure 1. 1. Conception Profile of Inclusive Students on the Topic of Heat

Seven questions were used to assess students' conceptions of heat-related topics. Each question represented a key concept in the subject matter: heat and temperature (Q1, Q2), heat transfer (Q3), thermal expansion (Q4), specific heat capacity (Q5), conduction (Q6), and radiation (Q7). Based on the results presented in Figure 1.1, misconceptions were found across all questions. This indicates the persistence of inaccurate scientific conceptions among the students.

These findings point to the limitations of current teaching practices, especially for students with disabilities who require more engaging and multimodal approaches to understand complex scientific concepts. The need for such approaches is well-established. An interview with a physics teacher at an inclusive school revealed that the current instructional methods are still heavily reliant on text and lectures. This mode of delivery hinders students' comprehension of abstract concepts, particularly for those with special needs who benefit from inclusive, differentiated interventions. Additionally, the lack of interactive learning media further compounds the issue, underscoring a critical educational gap that requires urgent attention.

A promising solution to addressing these gaps is the integration of Augmented Reality (AR) technology. AR enhances learning by overlaying digital elements onto the real world, providing an engaging and hands-on experience (Bakri et al., 2023; Bang et al., 2023; Septian & Burhendi, 2022; Widiasih et al., 2023; Yoon et al., 2017). This approach makes abstract concepts, like heat, more accessible and easier to comprehend. By utilizing AR, educators can create a more inclusive classroom where all students are provided equal chances to fully immerse themselves in complex scientific subjects.

Jdaitawi and Kan'an (2022) conducted a comprehensive literature review spanning from 2011 to 2020, revealing that most studies support the positive impact of augmented reality (AR) in special education. Their findings highlight AR's ability to address the diverse needs of students with disabilities, including those with learning challenges. AR has been shown to benefit individuals with visual impairments, enhance social interaction among disabled individuals, and motivate their participation in social and daily activities. Furthermore, AR offers students with special needs real-life experiences, improving their social interactions and fostering collaboration with peers and teachers. As a result, AR is widely recognized as a promising tool for enhancing both the academic and social skill development of students with special needs.

Despite its advantages, the literature also identifies certain challenges. Designing AR-based activities can be complex, and the multitasking nature of AR technology may pose difficulties for some students. An alternative approach to addressing these challenges has been demonstrated by Samsudin et al. (2021), who combined virtual simulations with rebuttal text using the Predict, Observe, and Explain (POE) strategy. This method has proven effective in overcoming difficulties when designing student activities aimed at enhancing student's conceptions. While the multitasking nature of AR may present challenges for some students, there remains a strong demand for AR-based learning media. Islim et al. (2024) conducted a needs analysis that highlighted science teachers' enthusiasm for using AR in inclusive classrooms, particularly as a learning media to facilitate student understanding of complex subjects.

Adding to this body of research, Wong et al. (2024) explored the impact of AR on students with special needs by developing an Augmentative and Alternative Communication (AAC) system. This system has proven effective in facilitating communication among students and enhancing the teaching and learning process. It also helps children with special education needs develop essential life skills. To address challenges such as improving students' mastery of basic living skills and academic achievement, educators are encouraged to adopt research-based pedagogical practices that bridge the gap between theory and classroom application.

Both Jdaitawi & Kan'an (2022) and Wong et al. (2024) demonstrate the effectiveness of AR technology in improving the basic living skills and academic achievement of students with special needs. However, neither study specifically examines its application in teaching abstract physics concepts, such as heat.

Building on this foundation, the present research focuses on developing and implementing **ARSEN (Augmented Reality for Special Education Needs)**, a learning media designed to **enhance students' scientific conceptions of heat in an inclusive classroom**. ARSEN leverages the immersive nature of AR to create interactive simulations of heat-related phenomena, allowing students with special needs to visualize and manipulate these concepts in real-time. By incorporating Rebuttal Text for designing student activities, this approach makes learning more engaging and accessible, helping students overcome the challenges associated with abstract physics topics.

Moreover, ARSEN aligns with UNESCO's vision for inclusive education and Indonesia's national educational policies, ensuring that all students, regardless of their abilities, can fully engage in the learning process. By providing a more interactive and accessible way of learning, ARSEN aims to bridge the educational gap that students with special needs encounter in traditional learning environments, particularly when dealing with complex scientific content.

1.2 Formulation of the Problem

Based on the background presented, the research question is: "How can the development and implementation of ARSEN (Augmented Reality for Special Education Needs) enhance students' scientific conceptions of heat in an inclusive classroom?" The research question is further elaborated into the following:

1. How are the characteristics of ARSEN utilized as a physics learning media on the topic of heat for students with special needs in an inclusive classroom?
2. How does the ARSEN intervention contribute to enhancing the scientific conceptions of heat among students with special needs?
3. What are the students' responses to using ARSEN in physics learning?

1.3 Objectives of the Research

The objective of this research is to gather information regarding the influence of ARSEN on physics learning in an inclusive classroom to enhance the scientific conception of heat among students with special needs.

1.4 Significance of the Research

This research has several significant theoretical and practical advantages. It is described as follows.

1. Theoretically, this research is expected to contribute to the scientific literature regarding the application of Augmented Reality technology to enhance the scientific conception for students with special needs.
2. Practically, this research is expected to provide benefits to teachers, as it can serve as an alternative reference for teachers in finding solutions to problems in teaching physics in inclusive classrooms. This research is also a form of technology application in the field of education, thus increasing the availability of digital learning media specifically designed for inclusive classrooms in physics education. On the other hand, this research is also expected to benefit students by providing new experiences for students with special needs in using interactive learning media in physics education.

1.5 Operational Definitions

Some terms in this research need to be clarified. The definitions are as follows.

1.5.1 The ARSEN Learning Media

ARSEN (Augmented Reality for Special Education Needs) Learning Media is a specialized digital educational media that utilizes Augmented Reality (AR) to help students with special needs comprehend abstract scientific concepts more effectively. Specifically designed for inclusive classrooms, ARSEN enhances the learning experience by offering interactive, immersive visualizations that bring complex subjects, such as the concept of heat, to life in ways traditional methods cannot. When applied to the concept of heat, ARSEN allows students to visualize phenomena such as thermal expansion, specific heat capacity, and heat transfer (conduction, convection, and radiation). For example, students can interact with AR models that demonstrate how heat moves from one object to another, observe how molecules behave when heated, or explore the effects of heat on different materials.

Through these AR simulations, abstract concepts like thermal expansion, specific heat capacity, or insulation properties can be made more tangible. ARSEN enables students to manipulate these models, observe the changes that occur, and receive instant feedback, thereby fostering a deeper understanding of how heat behaves in real-world contexts. This interactive and visual approach helps bridge the gap between theoretical learning and practical understanding, making abstract physics topics more accessible, especially for students with special needs who benefit from multimodal learning experiences.

Characteristics of ARSEN refers to the evaluation of whether ARSEN Learning Media is suitable for practical use in educational settings. This includes assessing its technical functionality, ease of use, effectiveness in supporting diverse learning needs (especially for students with special needs), and ability to engage students and teachers in the learning process. Feasibility is determined through validity tests (how well the media meets educational objectives), practicality (how easily it can be integrated into real classroom scenarios) and effectiveness (students' achievement of desired learning outcomes).

1.5.2 The Enhancement of Scientific Conception for Students with Special Needs

Conceptions refer to students' pre-existing ideas or beliefs, shaped by everyday experiences, which must be addressed or restructured through education to align with accurate scientific knowledge. The Enhancement of Conceptions for Students with Special Needs focuses on improving the conceptions held by students with special needs. This term emphasizes how effectively the ARSEN intervention aids these students in developing more scientifically accurate conceptions, particularly concerning the concept of heat. The extent of improved conceptions will be assessed by comparing students' understanding before and after the ARSEN intervention, providing a visual representation of the enhancement process. Data on conception enhancement will be collected using a four-tier test instrument and analyzed with Ministep software to offer a clearer understanding of ARSEN's impact through Guttman scale. Students with the potential for conception enhancement will be categorized using the Quantity of Enhanced Conceptions (QEC) equations. Based on the QEC results, students' conceptions will be classified into three levels: low, medium, and high.

1.5.3 The Inclusive classroom

The term inclusive classroom refers to a regular classroom setting that integrates students with special needs, including those with mild, moderate, or severe disabilities, as defined by Staub and Peck (1995). This environment is designed to promote equitable learning opportunities, fostering the participation of all students regardless of their abilities. The development and implementation of ARSEN (Augmented Reality for Special Education Needs) will be guided by this definition. ARSEN is envisioned as a versatile educational tool capable of addressing the diverse needs of students with various types of disabilities. Its design will prioritize accessibility, ensuring it accommodates physical, cognitive, and sensory impairments.

In the context of an inclusive classroom, ARSEN must function effectively to support learning by providing interactive, adaptive interventions that cater to the unique needs of each student. This includes facilitating engagement, enhancing conceptual understanding, and bridging gaps in traditional educational approaches. By aligning with the principles of inclusivity, ARSEN will aim to create a more equitable and supportive learning environment for all students.