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Analysis of Students' Misconceptions about Thermodynamics Material and Their Perceptions of Augmented Reality as A Cognitive Conflict-Based Teaching Material

Dwi Agustina[1], Fatni Mufit[2]
[1,2] Departement of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia

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ABSTRACT

The goal of 21st century learning in the independent curriculum is that students are able to deepen concepts and strengthen competencies. Efforts that can be made to achieve this goal are the use of teaching materials that are able to increase students' understanding of concepts. This research was conducted to develop teaching materials based on cognitive conflict integrated with augmented reality technology, so it is necessary to carry out a needs analysis as an initial stage of developing teaching materials. This type of research is quantitative descriptive research, the data collection instruments used are journal analysis and teacher and student analysis questionnaire sheets. Research was conducted to determine the need for developing open materials in schools. The results of the analysis of student needs show that physics learning is still teacher-centered, technology-integrated teaching materials, especially *Augmented Reality*, are not yet available, and learning models that overcome students' misconceptions are not yet used. The results of this preliminary research indicate the need to develop open physics materials that are able to increase student understanding of concepts and interest in learning. The solution to this is to develop cognitive conflict-based teaching materials that are integrated with technology by utilizing augmented reality technology.

***Correspondence:**
Fatni Mufit, Departement of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia.
email : fatni_mufit@fmipa.unp.ac.id , Phone: 085365218418

INTRODUCTION

The development of technology and science in the 21st century has developed so rapidly that it has influenced various aspects of life, one of which is the field of education. The skills needed to improve human resources to keep pace with technological advances are to improve critical thinking, communication, creative thinking and collaboration (Wijaya et al., 2016). Education has an important role in improving 21st century skills. One of the characteristics of 21st century learning is technology integrated learning. The impact of technological developments in the education sector can be seen by the emergence of many new innovations

to support education (Megahantara, 2017).

Not only technology, but human quality is also very important to improve. To prepare quality human resources that are competitive, this can be done by increasing the ability, independence and competitiveness of the nation through quality education(Ririnsia & Hau, 2019). 21st century skills can be trained through education so that educators and students can further develop their abilities with technology to improve the quality of human resources and social life (Farisi, 2016). The government's initiatives to raise educational standards by announcing a novel idea—the introduction of a separate curriculum. Students should be able to acquire or explore the knowledge they will learn with the aid of the autonomous curriculum. The goal of studying physics in the autonomous curriculum is for students to gain knowledge and confidence in their ability to comprehend concepts and principles, which will enable them to continue their education at a higher level and advance science and technology.

Understanding concepts is the most important thing that students must have. Understanding concepts is the main thing in scientific literacy competence (Dirman dan Mufit, 2022). Due to their poor conceptual comprehension, students still frequently have misconceptions about the physics subject they are learning. It is not uncommon for students of physics to struggle with conceptual comprehension mistakes or a lack of conceptual knowledge. Misconceptions can be defined as discrepancies between the way concepts are used in science and the way specialists or scientists communicate such notions. Misconceptions can be an obstacle to the progress of the learning process (Mufit, 2018)

Using instructional resources, such as teaching materials, is one method of enhancing students' conceptual comprehension. In the field of education, teaching materials serve as both learning resources and communication tools (National, 2010). Students' attention, perceptions, sentiments, thinking ability, imagination, and encouragement towards learning materials and activities may all be generated by the usage of engaging instructional materials (Widada & Rosyidi, 2018).The teaching materials developed can be technology-based, the advantages of learning using technology can make students more interested and can make student work more efficient, because students can interact with images, sounds, even videos, and something instant (Utami, Ade Dwi, 2003). The attractiveness of teaching materials can also raise students' attention, perceptions, feelings, thinking power, imagination and encouragement from within students towards learning materials (Widada & Rosyidi, 2018). This promotes reform initiatives aimed at enhancing the learning process's usage of technology. Creating technology-based instructional resources is one way to achieve student-centered learning objectives.

Physics is a field of science that discusses nature and its phenomena, from those that are real (visible in reality) to those that are abstract or even only in the form of theories whose discussion involves the ability to imagine or involve strong mental images (Sutarto, 2008). Thermodynamics content is high-level theory. Students of physics should familiarise themselves with the principle of thermodynamics. This is due to the fact that the principles of thermodynamics may be found everywhere. That thermodynamics is a science connected to energy and is one of the materials needed to comprehend natural processes. (Mulop et al., 2012) Human life is profoundly affected by thermodynamics. Thermodynamics has been a staple of the academic canon since its introduction (Hassan & Mat, 2005). According to Kulkarni and Tambade (2013), the study of thermodynamics is crucial in physics due to the breadth of its relevance across scientific and technological disciplines. Despite their widespread use, thermodynamic materials are typically invisible to the human eye. This material's utilization of technologically-based teaching aids significantly improves the quality of instruction.

The expectations of the autonomous curriculum are not entirely met by the actual conditions that exist in the field. Based on the findings of the initial preliminary study carried out at SMA A, it was determined that there was no student involvement in the implementation of learning on thermodynamics material because the teacher used a direct learning model or lecture to explain the material. This is not in line with the requirements of an autonomous curriculum and may give the impression that learning is boring, which deters students from actively engaging in the process. Teachers more often give calculation questions than concept questions. Teachers have not used special models to overcome students' misconceptions about thermodynamics material. Learning places more emphasis on memorizing physics formulas/equations and less on conducting trials/experiments to discover concepts. When learning objectives are focused on teachers, pupils don't get the material and are just motivated to commit formulae to memory (Mufit et al., 2020). This can cause students' conceptual understanding of thermodynamics material to be low.

Using a cognitive conflict-based learning paradigm to build technology-integrated teaching materials is one way to address the low comprehension of concepts in thermodynamics content. Whereas the four syntaxes of a cognitive conflict-based learning model are used to build the syntax of instructional materials, the first one is (1) activation of preconceptions and misunderstandings. (2) the demonstration of cognitive conflicts; (3) the identification of ideas and commonalities; and (4) introspection. The benefit of PbKK is that it may identify misunderstandings that arise, instill confidence in the identification of ideas linked to conceptual similarities, and assess the degree of comprehension of concepts being learned (Mufit, 2018). Utilizing cognitive conflict-based instructional resources can aid students in learning concepts and foster critical, creative, communicative, and cooperative thinking.

Cognitive conflict-based teaching materials have previously been developed by several researchers. Whereas prior studies have shown (Mufit, 2018) that cognitive conflict based instructional materials allow students to engage in deeper thought, create ideas, reconstruct information, and generate novel notions that are consistent with scientific theories. As we know, thermodynamics is a physical notion of heat and work. Consistent with this, studies have discovered that the cognitive conflict-based teaching materials created by the same team (Mufit et al. 2018; Dhanil & Mufit 2021; Mufit & Fitri 2022) are useful and successful in improving students' grasp of key ideas. Teaching resources that include technology help students better grasp physics concepts.

One technological innovation that has often been developed in the world of education is Augmented Reality. Yılmaz et al. (2018) reviewed the literature on augmented reality technology and its application in education as part of their study. It was observed that the natural sciences, computer and information sciences, mathematics, engineering, and humanities have all used AR technology. The literature made clear that it was most useful in the fields of medical, biology, physics, chemistry, geometry instruction, astronomy, and museums, as well as in story-telling exercises, the teaching of cultural knowledge, engineering, and disability education. It is found that in these domains, it is employed in scenarios including instructing on unseen things and occurrences, exemplifying hazardous circumstances, making abstract ideas concrete, and delivering information at levels where there is a great deal of ambiguity (Yilmaz & Göktaş, 2018). Augmented Reality is often used as a tool for alternative simulations and real experiments, especially real experiments that require expensive equipment and involve large risks in their implementation or experimental simulations for abstract processes (Fatni Mufit, eka Hendriyani, 2023). According to evaluations, using augmented reality (AR) applications in the classroom has many benefits, including the system's flexibility, safety, intuitiveness, and interaction, which help students learn by doing and interacting with the system as they become more familiar with complex

processes that can enhance their sense of existence (Arslan et al., 2020). In classroom physics lessons, augmented reality can be utilized as a teaching tool. Given that physics information is frequently abstract, augmented reality can aid students in understanding the notion of learning material from both macroscopic and microscopic as well as symbolic elements. Users may engage with actual situations and develop fresh perspectives thanks to augmented reality.

To improve students' comprehension of the thermodynamics subject, integrated augmented reality teaching resources and cognitive conflict-based learning methods must be used. According (Mufit, 2018) the cognitive conflict learning model can benefit students by improving their conceptual understanding, dispelling myths, fostering a positive attitude towards learning physics, and boosting their motivation to learn. It can also facilitate the learning of physics concepts, develop critical and creative thinking skills, and increase the amount of learning activities that students engage in (Setyowati & Subali, 2011). Based on the background that has been explained, the objectives of the research are 1. Knowing the teaching materials needed by schools, 2. Knowing the learning models needed by schools, and 3. Knowing students' conceptual understanding of thermodynamics material.

METHODS

This study is preliminary in nature. This study is preliminary in nature. This research uses descriptive quantitative research methods. Quantitative research methods are a method based on the philosophy of positivism, used in examine the sample and research population. Quantitative research is research that presents data in the form of numbers as results his research. The descriptive research method is an internal method research into the status of a human group, an object, a condition, a thought, or current events (Sugiyono, 2013). Descriptive methods are used to create a picture or a systematic, factual and accurate description of a phenomenon There is. Quantitative descriptive research is research that describes variables as they are supported by data in the form of numbers resulting from actual conditions.

In the initial stage, researchers collected information about the teaching materials used in schools, especially thermodynamics material. Apart from that, researchers also analyzed journals regarding misconceptions that often occur in thermodynamics material. The preliminary research stage was through needs analysis by distributing questionnaires to teachers and students of SMA A. The results of the data analysis were in the form of quantitative and qualitative. This needs analysis was carried out to determine students' needs for learning media in order to increase students' understanding of concepts and remediate students' misconceptions about thermodynamics material. Analysis of learning device needs was carried out on 72 students at SMA A Padang and 3 teachers at SMA A Padang. The journal analysis consists of 4 published journals on understanding the concept of thermodynamic material.

The learning implementation analysis questionnaire consists of 46 questions on thermodynamics material with 4 choices, namely 1: strongly disagree; 2 : disagree; 3 : agree; 4 : strongly agree. The indicators for the educator questionnaire for analysis of the implementation of physics learning on thermodynamics material consist of 5 indicators; 1) the need for teachers to use an independent curriculum; 2) the need for teachers to use learning models on thermodynamics material; 3) the teacher's need to identify students' conceptual understanding of thermodynamics material; 4) the need for teachers to use teaching materials and media on thermodynamics material; 5) the need to use Augmented Reality (AR) technology in thermodynamic material.

Student questionnaire analyzes the needs for physics learning tools on thermodynamics material which contains 4 indicators with 40 questions. This student questionnaire consists of

4 choices, namely 1): strongly disagree; 2) : disagree; 3) : agree; 4) : totally agree. There are 3 indicators in the student questionnaire regarding the analysis of needs for physics learning tools, namely, 1) students' difficulty understanding thermodynamics material; 2) the need for students to use printed teaching materials on thermodynamics; 3) the need for students to use Augmented Reality (AR) technology learning media on thermodynamics material. In the analysis of the selected journals, there are four journals on conceptual understanding of thermodynamics material, namely the journal Sekarani et al., (2021), MK Yaqin et al (2017), Yessi (2016), Fakhruddin et al., (2018).

The percentage values obtained from the data processing results were analyzed into several categories, namely: 80%-100% in the very good category; 70%-79% in the good category; 60%-69% sufficient category; and <60 in the less category. The percentage results of the analysis of educators' questionnaires regarding the implementation of physics learning and the analysis of student questionnaires regarding the need for physics learning equipment use the following equation:

$$percentage = \frac{score\ obtained}{maximum\ score\ x\ number\ of\ students} x100\%$$

RESULTS AND DISCUSSION

Results

The results of distributing questionnaires given to 3 teachers at SMA A Padang City showed almost the same problems in different schools. The general problem is still applying the direct learning model, and not having a specific model for identifying student misconceptions. The questionnaire given to teachers has 5 components and can be seen in Table 1 and Table 2. The results of the questionnaire given to teachers can be seen in the Table:

Tabel 2. Analysis of the Implementation Of Physics Learning at SMA A

	Indikator	Percentage (%)
1	The need to use an independent curriculum in schools	75
2	The need to use learning models in thermodynamics material	75
3	The need to identify students' understanding of concepts in thermodynamics material	68
4	The need to use teaching materials and media on thermodynamics material	71
5	The need for using augmented reality technology in thermodynamic material	70

The results of distributing questionnaires to 137 students consisting of 65 students at SMA A in Padang City, showed almost the same problems in different schools. In general, students still have difficulty in the learning process on thermodynamics material, this is because printed books as a learning resource in the independent curriculum are not enough. The questionnaire given to students consists of 3 components and can be seen in Table 3.

Table 3. Analysis of the Need For Physics Learning Equipment at SMA A

	Indicator	Percentage (%)
1	Students have difficulty understanding thermodynamics material	77
2	The need for students to use printed teaching materials on thermodynamics	73

3	Students need to use Augmented Reality technology learning media on thermodynamics material	81

The second preliminary study is an analysis of students' conceptual understanding of thermodynamics material through journal analysis. Analysis of students' conceptual understanding of thermodynamics material was carried out in four journals presented in Table 4.

Table 4. Percentage of Students' Understanding of Concepts in Thermodynamics Material

Article	Understand the Concept (%)	Misconceptions (%)	Do not understand the concept (%)	Doubtful (%)
(Sekarani et al., 2021)	36.3	37.7	22.3	3.7
(MK Yaqin et al., 2017)	11.2	22.9	63.9	1.9
(Yessi, 2016)	23.3	16.9	44.2	26.6
(Purnama et al.,2018)	10.5	17.6	54.7	17.2

Table 1.1 above indicates that there are known to be misunderstandings regarding thermodynamics content. Table 1 illustrates the low level of conceptual understanding among students, which falls between 10.5% - 36.3%, misconceptions fall between 16.9% - 37.7%; conceptual ignorance falls between 22.3% - 63.9%, and conceptual understanding but uncertainty falls between 1.9% and 26.6%. Compared to pupils who grasp the topic, a greater proportion of students have misunderstandings and lack conceptual knowledge.

Discussion

After filling out a questionnaire on the implementation of physics learning at school by teachers in two different schools in Padang City, as well as filling out a questionnaire on the need for learning equipment by students and analyzing journals understanding concepts in global warming material. Implementation of the independent curriculum at SMA A in the city of Padang 75. The independent curriculum is a new curriculum based on one of the policies of the Minister of Education and Culture, known as Merdeka Belajar Kampus Merdeka (MBKM). Supported by the opinion of Rahayu et al. that driving schools with an independent curriculum are schools with the enthusiasm to move for the change they want to achieve (Rahayu et al., 2022). This curriculum is very different from the previous curriculum, teachers also feel that there are many obstacles experienced during implementation and the need for special training in implementing the independent curriculum in schools. The difficulty of students in understanding thermodynamics at SMA A Padang City is 77%. This happens because the available teaching materials are still limited and learning is still teacher-centered.

Difficulties experienced by students in the learning process can also be overcome by applying models that are appropriate to the material to be taught. The learning model is a form of learning that is typically presented by the teacher, illustrated from start to finish. A learning model is a frame for implementing a learning approach, method and technique (Putra, 2008). The existence of a learning syntax is one of the characteristics of the learning model (Mufit, 2018). Syntax aims to provide guidance in achieving the goals you want to achieve during the

learning process. In fact, teachers at SMA A Padang City have implemented a learning model that is 75% in accordance with the thermodynamics learning module. However, teachers do not apply special models to overcome misconceptions that occur in thermodynamics material. The model that is often used is Problem Base Learning (PBL), but this model cannot be applied to all learning materials. The cognitive conflict model is very suitable to be applied in learning because it can increase understanding of concepts and remediate student misconceptions (Mufit et al., 2023).The cognitive conflict model is the process of students discovering a concept when faced with conflict phenomena that exist in their thinking (Mufit, 2018). Learning with a cognitive conflict approach can make students more motivated in learning (Sirait, 2012). So cognitive conflict strategies can build students' abilities and motivate students in learning to discover a concept through conflict in their minds.

In identifying students' conceptual understanding of thermodynamics material at SMA A Padang City, 68% has not been implemented so special attention is needed. Teachers have not fully identified students' misconceptions. In fact, it can be seen from the teacher's need to use printed teaching materials and learning media on thermodynamics material at SMA A Padang City that it is 71%, this is because in the independent curriculum, only one printed teaching material on thermodynamics material is available, namely a science book. Apart from that, there are no teaching materials that can overcome students' misconceptions, there are no teaching materials that are integrated with technology, and there are no teaching materials that can visualize abstract material. This is also supported by the students' need for teaching materials at SMA A Padang City which is 73%. According to students, the available books and media are not enough to understand thermodynamics material, 3D stimulus presentation is needed in studying thermodynamics, and the presence of pictures, 3D animations, or videos will enable students to remember the information studied.

If we look at the need for teachers to use teaching materials that are integrated with technology such as Augmented Reality (AR), it is 70% and the need for students to use printed teaching materials that are integrated with Augmented Reality (AR) technology is 81% at SMA A. The reason for this is because augmented reality (AR), which is integrated into the instructional materials, has never been utilized in a classroom. Applications known as augmented reality (AR) integrate the real and virtual worlds in two or three dimensions, projecting the images onto a real space simultaneously (Dedynggego et al., 2015). AR has three advantages which cause this technology to be chosen by many developers: 1) It can broaden the user's perception of an object and provide a "user experience" for the 3D objects displayed 2) Allows users to carry out interactions that cannot be done in the real world 3) Makes it possible to using various tools (devices) according to needs and availability (Ashari et al., 2022). Not only that, AR is also a medium that can improve students' high-level thinking skills (HOTs) such as problem solving skills, critical thinking skills and creative thinking skills (Huda et al., 2020). So, by implementing AR in teaching materials, it is hoped that it will attract more students' interest in learning and increase students' understanding of concepts.

The results of the analysis from four journals show that in thermodynamics material there are still frequent misconceptions. Misconceptions that occur in thermodynamics are in the ozone layer depletion sub-matter and global warming sub-matter. Similar problems were also found in several articles, 1) In the research of Sekarani et al,. (2021) Thermodynamics material experiences misconceptions on the subject of ideal gases, First Law of thermodynamics, Second Law of thermodynamics (Sekarani et al., 2021). Meanwhile, in the research of Fakhruddin et al. (2018) misconceptions in thermodynamics material occur on the subject of work and processes in thermodynamics, the First Law of Thermodynamics, the Thermodynamic Cycle, and the Second Law of Thermodynamics. The cause of misconceptions on this subject is due to students' low initial conceptual knowledge (Fakhruddin Z, 2018), 2) Mufit, F et al., that learning is still teacher-centered, that there is still a lack of conceptual

understanding among pupils, and that there is still a lack of new literacy and disaster literacy integration in the curriculum. As a result, a way to create physics teaching resources that combine catastrophe and new literacy is provided in order to improve students' conceptual understanding in line with 21st-century needs (Mufit et al., 2020), 3) Mufit et al., researchers found that pupils had a hard time grasping concepts related to motion in general and rectilinear, parabolic, and circular motion in particular. A contributing factor is that prior education mostly relied on the lecture format, during which lecturers preemptively addressed students' misunderstandings (Mufit et al., 2022). The lack of information teachers have when evaluating pupils' conceptual knowledge is one of the reasons for misunderstandings. Aside from that, when it comes to using assessment tools, instructors have not applied scientific literacy abilities to the fullest extent possible (Dirman dan Mufit, 2022).

CONCLUSION

From the results of the data analysis that has been carried out, it can be seen that the use of the independent curriculum at SMA A Padang City has been implemented well and is suitable for implementation in schools today. Teaching materials for thermodynamics are still limited, namely the learning resource used is only one book published by the Ministry of Education, Culture, Research and Technology entitled Natural Science Book which is combined with Chemistry and Biology lessons. Teachers do not yet have a special model for identifying student misconceptions, therefore the cognitive conflict model is suitable to be used to increase students' understanding of concepts and remediate student misconceptions. Apart from that, the role of technology in the 21st century is also very necessary, the media that teachers often use is PowerPoint (PPT), so that teaching materials with new innovations that are integrated with technology such as Augmented Reality (AR) can be used to attract students' interest in reading. Students also really agree and are interested if thermodynamics teaching materials are integrated with technology. Therefore, with this preliminary research, it is necessary to develop cognitive conflict-based teaching materials integrated with Augmented Reality in thermodynamics material to increase high school/MA students' understanding of concepts.

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