

**NEEDS ANALYSIS FOR DEVELOPMENT OF DIGITAL TEACHING MATERIALS WITH AUGMENTED REALITY FOR OPTICAL INSTRUMENTS MATERIALS**Indah Saputri¹, Asrizal^{1*}¹ Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia
Corresponding author. Email: asrizal@fmipa.unp.ac.id**ABSTRACT**

The use of instructional materials in education is highly crucial to achieve the success of a quality learning process. This study aims to analyze the need for the development of digital instructional materials using Augmented Reality (AR) for the topic of optical instruments. The study investigates five main aspects: physics learning issues, student learning results, student characteristics, learning objectives, and challenges related to the optical instruments topic. The research subjects include three physics teachers and eleventh-grade students from Senior High School (MAN) 1 Padang City. Data collection techniques used in this study comprise interviews, questionnaires, documentation, and literature review. The collected data, analyzed with appropriate instruments, are subjected to descriptive statistical analysis techniques. Based on the data analysis, the following results are obtained: 1) students are no longer interested in using printed instructional materials, and the existing teaching materials do not align with the school's context, 2) student physics learning results are categorized as low, 3) internal factors such as interest, motivation, and learning styles among students are still underdeveloped, 4) the learning objectives designed by teachers inadequately consider appropriate learning behaviors for the competency levels of eleventh-grade students in fundamental knowledge and skills, 5) the average scores in the physics National Examination (UN) for the optical instruments topic have been consistently decreasing each year, falling below the standard passing grade, 6) in conclusion, it can be inferred that the development of digital instructional materials using AR for the optical instruments topic is highly necessary for both teachers and students.

Keywords: Digital teaching materials; augmented reality; optical instruments

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I. INTRODUCTION

Education is a crucial benchmark for assessing a nation's progress. Indonesian National Education in the 21st century aims to realize the nation's ideals, including creating a prosperous and content society, holding an honorable and equal position among other global nations, and fostering a society with high-quality human resources. This includes individuals who are independent, willing, and capable of realizing Indonesia's national aspirations. Through education, the aim is to cultivate skilled human resources capable of thriving and competing in the challenges of the 21st century [1]. The government has undertaken various initiatives in the field of education during the 21st century, particularly focusing on curriculum and learning strategies. The Minister of Education and Culture's Regulation No. 66 of 2013 introduced project-based learning as a strategic approach to nurturing 21st century skills. These skills encompass critical thinking, collaboration, communication, and problem-solving abilities [2]. Students are expected to solve real-world problems, which enables them to generate creative outputs by applying their acquired knowledge. In the pursuit of creative ideas, students and educators alike must also stay attuned to the advancements in Science and Technology (IPTEK) during this era of globalization.

The learning material that cannot be omitted from the advancement of Science and Technology (IPTEK) is related to Natural Sciences [3]. Physics is one of the many branches of knowledge included in the Natural Sciences curriculum. Physics plays a significant role in human life and can be applied in everyday situations. It also provides students with an opportunity to deeply understand how physics operates in daily life and the real world. In physics education, students will encounter real-world situations where they have to apply physics concepts to design, conduct, and evaluate experiments or physics tasks. Therefore, it is crucial for students to master the concepts in physics. Proficiency in physics concepts becomes essential to enhance students' understanding.

To address the issue of students' understanding of physics concepts, preparation and strategies are required, including preparing students with the necessary needs and objectives to be achieved [4.1]. Instructional materials are essential teaching tools to fulfill the learning requirements. These materials can take the form of printed materials, audio, audiovisual aids, and

interactive digital teaching materials. Physics content, which tends to be abstract, demands innovative teaching approaches from educators. One of these approaches is utilizing digital teaching materials [5]. Digital teaching materials provide flexibility in learning for students. Appropriate teaching materials will enhance students' comprehension of the subject matter to the fullest extent, thereby fostering the development of their skills. Hence, the instructional materials employed by teachers significantly influence students' skills and conceptual understanding during the learning process.

Many efforts have been made to enhance conceptual understanding and develop students' skills. However, the actual situation observed in the field has not aligned with the desired ideal conditions. This is evident from the findings of literature studies, which indicate that many students struggle to comprehend the subject of physics. The teaching and learning process often relies solely on textbooks, and students are subsequently tasked with solving problems that involve only rote memorization of formulas. Consequently, students find it challenging to grasp the presented material. This is substantiated by the fact that 78.2% of students encounter difficulties in understanding physics concepts [6]. Thus, addressing the challenges in comprehending physics concepts is a pertinent issue that necessitates solutions while considering a more engaging and innovative teaching and learning process.

The solution to address this issue is through the development of instructional materials by leveraging technology that aligns with the learning content. The evolved instructional materials are no longer in printed form but are digitally-based, incorporating new innovations to prevent students from merely solving problems based on formulas. One of the technologies that can be harnessed in the development of digital teaching materials is Augmented Reality (AR). The utilization of AR in physics education has the potential to enhance students' conceptual understanding [7]. Employing AR as a learning tool makes the teaching and learning process more engaging and enjoyable for students. An engaging and innovative learning experience can boost students' motivation and enthusiasm for studying physics. By being immersed in an enjoyable learning process, students are more likely to achieve better results and actively participate in skill-building.

To support the achievement of the proposed solution, conducting theoretical studies is essential as a foundation for development. The first theoretical aspect pertains to digital teaching materials. Digital teaching materials are materials created using specific applications to be accessed through digital devices [4.2]. Digital and interactive teaching materials can be utilized by students both in classroom learning and for independent study, without the presence of a teacher or tutor [8]. Therefore, digital teaching materials represent an innovative instructional approach that leverages technology through specific applications, accessible via digital devices, and can be employed by students within the classroom or independently, significantly impacting students' learning activities. Teaching materials are an essential and vital source required for learning to enhance teacher efficiency and improve student performance. The presence of teaching materials makes learning more engaging, practical, and realistic. Additionally, the utilization of teaching materials in the learning process enables both teachers and students to actively participate, thus rendering the learning process more effective [9].

Digital teaching materials possess several characteristics. The characteristics of digital-based teaching materials include: (1) harnessing the advantages of computers, (2) utilizing multimedia technology, (3) leveraging electronic technology, (4) utilizing self-contained teaching materials stored on a computer, accessible by educators and learners anytime and anywhere, (5) employing interactive data exchange that can be viewed on a computer at any time [10]. Therefore, teaching materials that align with these characteristics are a compilation of materials gathered from various learning sources and are systematically organized. With these characteristics, digital teaching materials can become effective tools in enhancing students' learning experiences and supporting the development of their conceptual understanding and skills.

Digital teaching materials also come with several advantages. The advantages of digital teaching materials are as follows: (1) providing educators with ease in explaining abstract concepts during the teaching process, (2) transforming learners' roles from passive to active, fostering interest in the discussed subject matter, (3) enabling learners to study or review teaching materials at any time as the materials can be stored on a computer, (4) educators and learners can use structured and scheduled teaching materials or instructional guidelines through an intranet or internet network, allowing them to assess each other's progress in studying the materials, (5) the availability of e-moderating facilities where educators and learners can easily communicate through the internet regularly or at any time without being restricted by distance, place, or time [11]. The advantages of digital teaching materials facilitate convenient communication and interaction for both teachers and students through internet facilities, fostering group discussions and individual interactions.

The second theoretical study pertains to Augmented Reality (AR). AR can overlay virtual objects onto the real world in real-time. The use of AR aims to construct a new environment, either directly or through a medium, ultimately leading the user to perceive the environment they create as a reality [12]. AR technology serves as a means of conveying a message to its users. AR enables students to actively interact with learning content. Students can manipulate AR objects, explore virtual environments, or engage in interactive simulations. This interaction enhances student engagement in the learning process and aids in building better understanding [13]. Therefore, it can be concluded that AR falls under the category of technology that engages in communication by merging the real world with the virtual world, which can be leveraged for creating educational content.

In this paper, the researcher has chosen the topic of optical instruments as the subject under investigation. Considering the inherently abstract nature of optical instrument concepts, the utilization of AR technology in instructional materials becomes essential to support a more effective and efficient learning process. This approach represents a means by which AR technology addresses the challenges of explaining complex physics concepts directly. The integration of AR into digital teaching materials for physics can serve as an effective tool for enhancing students' comprehension of physics concepts and theories. Through the application of AR technology, students can interact with virtual physics objects in the real world, making the learning experience more engaging, interactive, and relevant to everyday life. Consequently, the researcher deems this aspect crucial for further investigation.

Based on the outlined problem, it can be asserted that a preliminary study is necessary to develop digital teaching materials with AR for the topic of optical instruments. The objective of this research is to explore the necessity of developing digital teaching materials with AR for optical instrument concepts. In light of this research objective, the research question can be formulated as follows: What are the needs of teachers and students regarding the development of digital teaching materials for optical instruments using AR to enhance students' conceptual understanding and project skills?.

II. METHOD

This research employs a quantitative descriptive research method. Quantitative descriptive research is a study that portrays variables as they are, supported by numerical data obtained from real-life situations [14]. In this preliminary study, a needs analysis is conducted. The needs analysis aims to identify and define the foundational issues in school learning, bridging the gap between the ideal and real conditions. The needs analysis consists of several components, including: analysis of physics learning issues, analysis of student learning results, analysis of student characteristics, analysis of learning objectives, and analysis of issues related to optical instrument concepts.

In this research, there are three objects of study: physics teachers, physics instructional materials, and 11th-grade science students. Physics teachers are used to gather information about the issues in physics education at the school. Three physics teachers from MAN 1 Kota Padang were interviewed to understand the problems in physics teaching. Instructional materials constitute the second object to obtain information about the alignment of learning objectives with the desired competencies. The students from MAN 1 Kota Padang are used to determine learning results and student characteristics in physics education.

Data collection techniques employed in this study include interviews, questionnaires, documentation, and literature review. Data on physics learning issues are collected through interviews with physics teachers. Interview guidelines serve as the instrument. Documentation is used to gather information about the alignment of learning objectives with competencies. Questionnaires are distributed to understand the characteristics of each student. Additionally, a literature review is used to identify issues related to optical instrument concepts.

Specific data analysis techniques are utilized to analyze the collected data using appropriate instruments. The analysis technique employed in this study is descriptive statistics. Descriptive statistics involve analyzing data by describing or portraying collected data as is, without aiming to draw conclusions applicable to the general population. Various forms of descriptive statistical data presentation can be used, such as simple tables, frequency distributions, graphs, and explanations of data groups through mode, median, mean, group variation, and standard deviation [15].

The analysis of quantitative questionnaire data begins by determining the highest score for each indicator. Subsequently, the total scores obtained from all samples for each indicator are calculated. The next step involves calculating the percentage value for each indicator. The formula for calculating indicators is as follows:

$$\text{Value percentage} = \frac{\text{total score}}{\text{maximum score}} \times 100 \%$$

The percentage values obtained from data processing are analyzed using the categories presented in Table 1.

Table 1. Alignment of Data Between Learning Objectives and Basic Competencies Tendencies.

Categories	Presentase (%)
Excellent	80 - 100
Good	70 - 79
Enough	60 - 69
Deficient	< 60

(Source : Kemendikbud [16])

The table above serves as a benchmark after the results of the analysis of learning objectives and basic competencies tendencies are obtained.

III. RESULTS AND DISCUSSION

The first results of the preliminary research revolves around issues in physics education. The data collection techniques and instruments utilized were interviews and interview guidelines, respectively. Interviews were conducted with three physics teachers from MAN 1 Kota Padang. The interview components concerning the implementation of physics teaching encompassed six aspects: 1) physics teachers' perspectives on physics education, 2) execution of physics teaching, 3) physics teachers' viewpoints on physics instructional materials, 4) examples of instructional materials employed in physics teaching, 5) challenges faced in physics education, and 6) factors contributing to issues in physics education.

Through the analysis of interview results, six findings can be highlighted. The first finding indicates that 66.67% of physics teachers perceive physics education as challenging for many students, while the remaining 33.33% view it as a subject that poses challenges due to its involvement of abstract concepts and intricate calculations. The second finding reflects unanimous agreement among all physics teachers that the execution of physics education is being attempted in line with educational standards, albeit not entirely optimally. The third finding demonstrates unanimous consensus among all physics teachers that instructional materials are highly significant in physics education, aiding students and providing direction to the learning process. The fourth finding reveals that instructional materials used in physics education include printed materials such as textbooks, printed modules, and worksheets. The fifth finding addresses challenges related to the employed instructional materials, with 33.33% of physics teachers indicating that the materials lead to monotonous learning experiences, another 33.33% expressing that students are no longer interested in printed instructional materials, and the remaining 33.33% stating that the current materials do not align with the school environment. The sixth finding pertains to factors contributing to the issues in physics education, encompassing aspects such as the existing instructional materials being designed based on general school backgrounds rather than tailored to specific school contexts, the absence of new innovations in instructional materials, and teachers' limited ability to independently develop non-printed materials due to inadequate proficiency in using ICT.

The second results of the preliminary research involves an analysis of student learning results. This analysis is based on data provided by teachers regarding the grades attained by students in physics education. The learning results under analysis are derived from the mid-semester examination results of 11th-grade science students in classes XI Natural Sciences (IPA) 1-4 at MAN 1 Padang City, as presented in Table 1.

Table 1. Analysis of Student Learning Results

Indicator	XI IPA 1	XI IPA 2	XI IPA 3	XI IPA 4
Number of students	35	36	31	30
Mean	52.87	50,74	53,98	50,96
Modus	55	50	60	50
Median	50	50	55	50
Minimum	15	20	30	15
Maximum	90	88	90	80
Range	75	68	60	65

From the data presented in Table 1, we can discern the student learning results in physics education. The analysis of mid-semester examination scores for 11th-grade science students reveals that XI IPA 1 achieved an average score of 52,87, falling within the sufficient category XI IPA 2 attained an average score of 50,74, categorized as good; XI IPA 3 recorded an average score of 53,98, also classified as good; and XI IPA 4 obtained an average score of 50,96, categorized as sufficient. The range of scores from the mid-semester examination varied between 15 the lowest and 90 the highest among the four classes. Notably, only two out of the four classes achieved good learning results, while the remaining two classes received sufficient results. Based on the acquired data, it can be inferred that students encounter difficulties in learning physics.

The third results of this preliminary research pertains to student characteristics. The data collection instrument used for this aspect was a questionnaire. Student characteristics in the affective domain were measured using four indicators: 1) student background (SB), 2) student interest (SI), 3) student motivation (SM), and 4) student learning style (SL). Data on student characteristics were obtained through questionnaire analysis administered to 11th-grade science students in classes XI IPA 1 and 2. The analysis of student characteristics is depicted in Figure 1.

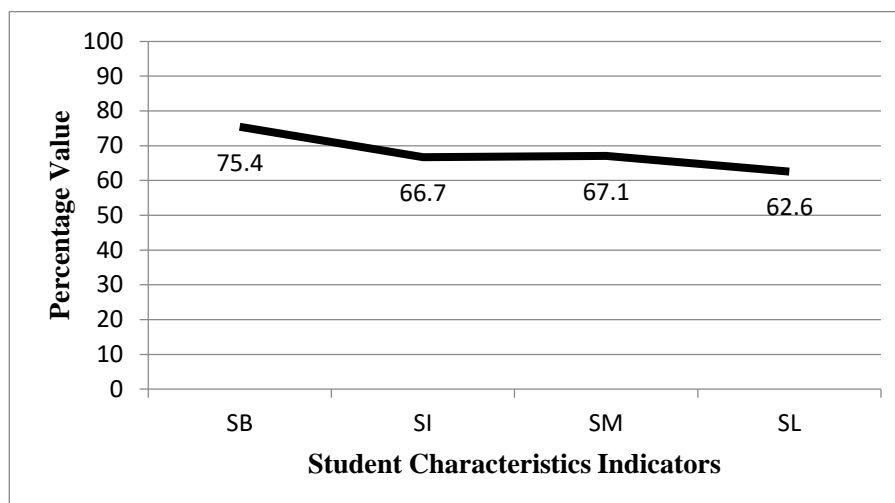


Fig 1. Student's Characteristics

From the data presented in Figure 3, we can discern the characteristics of 11th-grade science students at MAN 1 Kota Padang in physics learning. According to the data, it can be explained that the indicator of student background achieved a percentage of 75.4% and falls within the good category. The indicator of student interest in learning attained a percentage of 66.7% and is categorized as sufficient. The analysis also reveals that student motivation in learning falls within the sufficient category, with a percentage of 67.1%. As for the indicator of student learning style, it obtained a percentage of 62.6%, also falling within the sufficient category. This can be interpreted to mean that the internal factors of students have not fully supported the process of physics learning in order to achieve optimal learning results. This significantly impacts the smoothness and success of the learning process, aiming to achieve all planned learning objectives. Therefore, paying attention to student characteristics in learning is highly essential.

The third results of this preliminary research pertains to the objectives of physics learning. This study focuses on the Lesson Plan Documents RPP as the subject. Research that utilizes documents as subjects falls under content analysis. The data source in this study is obtained from the Lesson Plan Documents RPP of physics teachers at MAN 1 Padang City. The data source specifically targets the Lesson Plan Documents RPP for 11th-grade physics classes, particularly in the topic of optical instruments. The indicators for learning objectives consist of: 1) The objective of learning considers the learners being taught (AU), 2) The objective of learning considers the learning behavior on the basic competence (BE), 3) The objective of learning considers the learning conditions that assist learners in achieving learning behavior (CO), 4) The objective of learning considers the expected level of achievement (DE), and 5) The objective of learning encompasses the development of knowledge and skills (DK). The presentation of data regarding the alignment of learning objectives with basic competence is depicted in Figure 2.

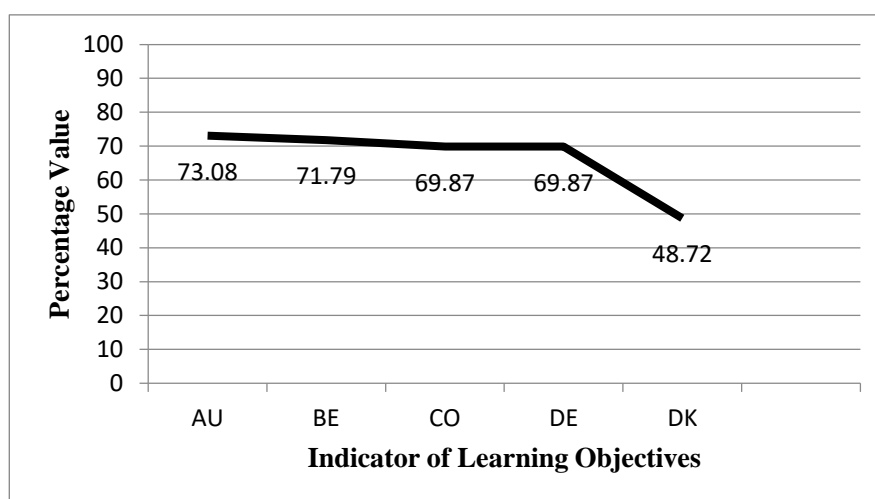


Fig 2. Alignment of Learning Objectives with Basic Competence

Based on the data in Figure 1, it can be inferred that learning objectives can be achieved if all six indicators are fulfilled. The analysis results for the first statement, The learning objective considers the learners being taught, obtained a percentage of 73.08% with a suitable category. The analysis found that on average, teachers mention the students being taught for one basic competence. This reflects that the learning objectives designed by the teachers consider the learners being taught. The second statement, the learning objective considers the learning behavior on basic competencies, obtained a percentage of 71.79% with a

suitable category. On average, teachers use operational verbs, reflecting that the learning objectives designed by the teachers consider the expected learning behaviors to achieve basic competencies.

The third statement, the learning objective considers the learning conditions that assist learners in achieving learning behavior, obtained a percentage of 69.87% with a suitable category. On average, teachers mention learning conditions that can help learners achieve learning behavior, reflecting that the learning objectives designed by the teachers consider the realization of appropriate learning conditions to achieve learning behaviors. The fourth statement, the learning objective considers the expected level of achievement, obtained a percentage of 69.87% with a suitable category. On average, teachers mention the expected level of achievement according to the learning conditions. This reflects that the learning objectives designed by the teachers consider the appropriate level of achievement according to the applied learning conditions.

The fifth statement, the learning objective encompasses the development of knowledge and skills, obtained a percentage of 48.72% with a less suitable category. Operational verbs were found in the basic competencies of knowledge and skills, on average below the minimum threshold of XI-grade students' ability levels. This indicates that the learning objectives designed by the teachers insufficiently consider the learning behaviors suitable for the XI-grade students' ability levels in the basic competencies of knowledge and skills.

The fifth results of this research concerns issues in the topic of optical instruments. The research method used is literature review. This literature review focuses on the National Examination (UN) scores in the physics topic of optics at MAN 1 Padang City. The UN data extracted represents the average percentage at each level, from educational units, districts/cities, provinces, to the national level. The UN scores analyzed cover the years 2015-2019. The percentage of correct answers by students in the UN physics examination on the optics topic at MAN 1 Kota Padang can be seen in Figure 3.

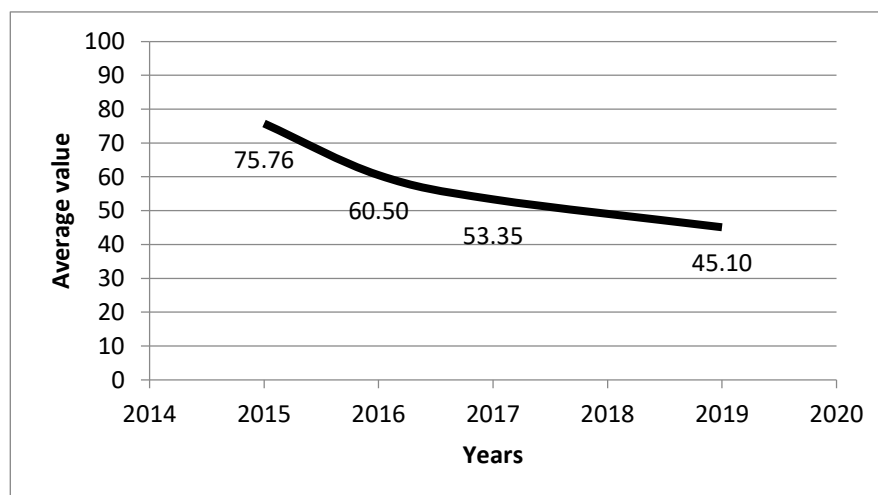


Fig 3. National Examination Scores in Physics Optics Topic

Based on the data presented in Figure 3, it can be observed that the average scores of the National Examination (UN) in physics for the topic of optics have experienced a decline and are increasingly falling below the graduation achievement standard. The standard passing grade for students is 55 on a scale of 0-100. The analysis results show that in the year 2015, the average score obtained was 75.76, indicating that it met the graduation achievement standard. However, in the subsequent year, 2016, the average score dropped to 60.50, yet still meeting the graduation achievement standard. Furthermore, in the following years, the average scores remained stagnant without improvement. In 2017, students only achieved an average score of 53.35, indicating that the average score had not yet reached the graduation achievement standard. In the UN of 2018, it was found that the optics topic was not included in the examination, resulting in the absence of average scores for that year. However, in 2019, the optics topic was reintroduced in the examination, but the average score obtained was only 45.10, signifying that the scores had not yet met the graduation achievement standard. This highlights the existence of difficulties among students in comprehending the optics topic.

The findings of this preliminary study can serve as the foundation for the development of digital learning materials using Augmented Reality (AR) for the topic of optical instruments. From the initial research, issues arose where students were no longer interested in using printed learning materials, which made the learning process feel monotonous. Additionally, teachers indicated that the existing learning materials did not align well with the school environment. To address these issues, a solution was proposed involving the development of digital learning materials utilizing AR technology. This approach aims to make the learning experience more engaging and adaptable to the school context. Furthermore, the second set of findings indicated that student learning results in physics were relatively low. The utilization of appropriate learning materials is crucial to achieving a high-quality learning process [17.1]. The success of incorporating digital learning materials is demonstrated by a study conducted by Savitri (2022), revealing that digital learning materials could enhance students' conceptual understanding based on high N-Gain test results and positive student responses [18]. These findings are further supported by the results of Aryanta's research (2021), which concluded that physics learning materials based on AR were validated, practical, and effective in

enhancing students' conceptual understanding [19]. The third finding suggests that internal factors such as interest, motivation, and learning styles among students are still at a low level. Quality learning materials can assist students in comprehending concepts more effectively, boosting their interest in learning, and motivating them to achieve predetermined learning objectives [20.1]

The fourth finding highlighted that the instructional objectives designed by teachers need to more adequately consider learning behaviors that are suitable for the skill level of Grade XI students in terms of knowledge and skills. Appropriate learning materials play a pivotal role in supporting the achievement of learning objectives [20.2]. Through the application of Augmented Reality (AR) technology, students can engage in project simulations, requiring them to design, execute, and evaluate physics projects within a virtual environment. This provides an opportunity for students to develop project-related skills [21]. The fifth study demonstrated that the average UN scores in physics for the topic of optical instruments have experienced a consistent decline each year, falling below the established passing grade standards. One potential solution to address this issue is the development of learning materials equipped with AR technology. As evidenced research by Saputra (2017 AR-enhanced learning materials related to optical instruments can enhance students' knowledge [22]. Learning materials serve as an essential medium for teachers to fulfill their roles in the learning process [17.2]. In conclusion, the development of digital learning materials using AR for the topic of optical instruments is greatly needed by both teachers and students.

IV. CONCLUSION

Based on the data analysis conducted, it can be concluded that there are five findings from the preliminary research at MAN 1 Kota Padang. First, the analysis of issues in physics education indicates that students are no longer interested in using printed learning materials, resulting in a monotonous learning experience. Teachers have also expressed that the current learning materials do not align with the school's context. Second, the analysis of student learning results reveals that students' performance in physics is relatively low. Third, the analysis of student characteristics demonstrates that internal factors such as interest, motivation, and learning styles are still at a low level. Fourth, the analysis of learning objectives indicates that the instructional goals designed by teachers inadequately consider learning behaviors suitable for Grade XI students' skill levels in knowledge and skills. Fifth, the analysis of issues related to the topic of optical instruments highlights that the average scores of the National Examination in physics for this topic have consistently declined over the years, falling below the established passing grade standards. Consequently, it can be inferred that the development of digital learning materials using AR for the topic of optical instruments is greatly needed by both teachers and students.

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