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Learning Obstacles in High School Physics and the Potential of Digital Assessment to Improve Learning Outcomes: A Qualitative Investigation

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ABSTRACT

Purpose of the study: This study aims to identify learning obstacles encountered in high school physics, examine teachers' perceptions of digital assessment, and explore the potential application of a Nonequivalent Control Group Design framework to support improvements in physics learning outcomes and assessment practices.

Methodology: A qualitative descriptive approach was employed in this study. Data were collected through classroom observations, semi-structured interviews, observation sheets, interview guides, and field notes. Participants consisted of physics teachers from five senior high schools in Jambi Province, Indonesia. Data were analyzed using thematic analysis to identify recurring themes related to learning obstacles, assessment practices, and digital assessment implementation.

Main Findings: The findings revealed that students experienced learning obstacles related to conceptual understanding, mathematical reasoning, abstract physics topics, and limited practical experiences. Low motivation, differences in student abilities, and inadequate learning resources were identified as factors affecting learning outcomes. Teachers perceived digital assessment positively because it increased assessment efficiency, provided immediate feedback, and enhanced student engagement. Internet connectivity and device availability remained the primary challenges during implementation.

Novelty/Originality of this study: This study contributes to the literature by integrating the analysis of learning obstacles with the exploration of digital assessment in high school physics education. Unlike previous studies that primarily focused on technology adoption, this research identifies specific instructional challenges and proposes a Nonequivalent Control Group Design framework as a practical basis for evaluating future digital assessment interventions in authentic classroom settings.

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1. INTRODUCTION

Physics education plays a fundamental role in developing students' scientific literacy, critical thinking, and problem-solving abilities. Through physics learning, students are expected to understand scientific concepts and apply them to explain natural phenomena encountered in everyday life [1]-[3]. Achieving these objectives requires not only effective instructional strategies but also appropriate assessment practices that can accurately measure students' understanding [4]-[6]. Assessment serves as an important component of the learning process because it provides information regarding students' progress and learning needs [7]-[9]. Therefore, improving both instruction and assessment remains a major concern in physics education.

Despite its importance, physics learning continues to face numerous challenges in secondary schools. Many students experience learning obstacles when dealing with abstract concepts such as electricity, waves, vectors, and rotational dynamics [10], [11]. These difficulties are often associated with weak mathematical foundations, misconceptions, and limited opportunities to engage in meaningful learning activities [12], [13]. Furthermore, conventional assessment methods frequently fail to identify students' conceptual difficulties and provide timely feedback for improvement. As a result, learning outcomes in physics remain uneven across different classrooms and student groups.

Previous studies have reported that digital assessment can contribute positively to student engagement, motivation, and academic achievement [14], [15]. The integration of digital technologies enables teachers to provide immediate feedback, interactive learning experiences, and more efficient evaluation processes. Various digital platforms, such as Google Forms, Quizizz, Kahoot!, and Computer-Based Testing systems, have been widely adopted in science education [16], [17]. Research findings indicate that these technologies can enhance students' participation and support the development of conceptual understanding. Consequently, digital assessment has emerged as a promising alternative to traditional assessment approaches.

Although the effectiveness of digital assessment has been extensively discussed in previous research, limited attention has been given to its relationship with learning obstacles experienced in physics classrooms [18]. Most studies primarily focus on technological implementation and student perceptions without thoroughly investigating the specific challenges faced by teachers and learners [19]. In addition, empirical evidence regarding how digital assessment can address conceptual difficulties and improve learning outcomes in diverse classroom settings remains insufficient [20]. Few studies have examined this issue from the perspective of classroom realities where differences in student characteristics and learning abilities are unavoidable. Therefore, further investigation is required to understand the potential role of digital assessment in overcoming learning obstacles in physics education.

Understanding learning obstacles and identifying effective assessment strategies are essential for improving the quality of physics education [21]. Teachers need assessment approaches that not only evaluate learning outcomes but also support the learning process itself. Digital assessment offers opportunities to create more interactive, efficient, and student-centered learning environments [22]. Moreover, the increasing integration of technology in education highlights the importance of exploring innovative assessment practices that align with contemporary learning needs [23]. Investigating the potential of digital assessment is therefore crucial for supporting evidence-based improvements in physics teaching and learning.

This study contributes to the literature by examining learning obstacles in high school physics while exploring the potential of digital assessment as a strategy to improve learning outcomes [24]. Unlike previous studies that focus mainly on technological adoption, this research emphasizes the relationship between learning difficulties and assessment practices within authentic classroom contexts. The study draws on evidence obtained through observations and teacher interviews to identify key challenges in physics learning. Furthermore, it proposes a Nonequivalent Control Group Design framework as a practical approach for evaluating the effectiveness of digital assessment interventions in future implementations [25]. Therefore, the findings are expected to provide both theoretical insights and practical recommendations for enhancing physics education in secondary schools.

2. RESEARCH METHOD

2.1. Research Design

This study employed a qualitative descriptive approach to investigate learning obstacles encountered in high school physics and to explore the potential of digital assessment as an alternative solution. A qualitative design was selected because it enables an in-depth understanding of the challenges experienced by teachers during physics instruction and assessment. The study focused on collecting rich descriptive data from authentic educational settings. In addition, the findings were used to formulate recommendations for implementing digital assessment through a Nonequivalent Control Group Design framework in future studies. Therefore, this research emphasizes exploration and interpretation rather than experimental verification.

2.2. Participants and Research Setting

The study was conducted in five public senior high schools located in Jambi Province, Indonesia. Participants consisted of five physics teachers who were selected purposively based on their teaching experience and involvement in assessment practices. These teachers represented different school contexts and provided diverse perspectives regarding physics learning and assessment challenges [26]. The selected participants had experience using both conventional and digital assessment methods. Their insights contributed to a comprehensive understanding of learning obstacles in physics education.

2.3. Data Collection

Data were collected through classroom observations and semi-structured interviews. Observations were conducted to identify learning conditions, student engagement, and assessment practices implemented during physics instruction. Semi-structured interviews were carried out to explore teachers' perceptions of learning difficulties, assessment challenges, and the use of digital assessment tools [27]. The interview protocol consisted of questions related to conceptual understanding, student motivation, classroom assessment, and technology integration. Multiple sources of evidence were employed to improve the credibility of the findings.

Table 1. Data Collection Instruments

Instrument	Purpose
Observation Sheet	Identify learning obstacles and classroom conditions
Interview Guide	Explore teachers' perspectives on physics learning and assessment
Field Notes	Record contextual information during data collection

2.4. Data Analysis

The collected data were analyzed using thematic analysis. Interview transcripts and observation notes were reviewed repeatedly to identify recurring patterns and significant issues related to physics learning. Similar responses were grouped into categories representing major learning obstacles and assessment challenges [28]. The identified themes were then interpreted to explain the factors influencing students' learning difficulties and the potential contribution of digital assessment. Finally, the findings were synthesized to formulate recommendations for future implementation using a Nonequivalent Control Group Design framework.

2.5. Proposed Nonequivalent Control Group Design Framework

Based on the identified learning obstacles, this study proposes a Nonequivalent Control Group Design framework for future implementation of digital assessment in physics learning. The framework consists of an experimental group receiving digital assessment interventions and a control group receiving conventional assessment practices [29]. Both groups are administered pretests and posttests to evaluate differences in learning outcomes. This framework is intended as a practical model for future empirical investigations of digital assessment effectiveness. The proposed design provides a systematic approach for examining the relationship between assessment innovation and student achievement.

Table 2. Proposed Nonequivalent Control Group Design

Group	Pretest	Treatment	Posttest
Experimental Group	O_1	X	O_2
Control Group	O_3	–	O_4

Description:
O_1 = Pretest of experimental group
O_2 = Posttest of experimental group
O_3 = Pretest of control group
O_4 = Posttest of control group
X = Digital assessment intervention

3. RESULTS AND DISCUSSION

3.1. Learning Obstacles in Physics Learning

The interview findings revealed that students encounter various learning obstacles in physics, particularly when studying abstract concepts and mathematically demanding topics. Teachers consistently reported difficulties in vectors, measurement, electricity and magnetism, waves, rotational dynamics, and modern physics [30]. These obstacles were reflected in students' misconceptions, weak mathematical skills, limited ability to interpret problem situations, and difficulties transferring concepts to real-life contexts. In addition, limited laboratory experiences and differences in students' prior knowledge further contributed to learning difficulties [31]. The findings suggest that both cognitive and instructional factors influence students' understanding of physics concepts.

Table 3. Learning Obstacles and Factors Affecting Physics Learning

Theme	Findings
Learning Obstacles	Students experienced difficulties in vectors, measurement, electricity, magnetism, waves, rotational dynamics, and modern physics concepts.
Mathematical Barriers	Weak algebraic skills, formula manipulation difficulties, and limited quantitative reasoning abilities.
Student Motivation	Low interest and limited engagement negatively affected learning outcomes.
Learning Resources	Insufficient laboratory equipment and limited practical activities constrained conceptual understanding.
Classroom Diversity	Significant differences in students' abilities and learning characteristics were observed across classes.

3.2. Teachers' Perceptions of Digital Assessment

Most teachers expressed positive perceptions regarding the use of digital assessment in physics learning. Various platforms, including Google Forms, Quizizz, Kahoot!, and Computer-Based Testing systems, were used to support assessment activities [32]. Teachers reported that digital assessment improved efficiency, reduced grading time, and provided immediate feedback for students [33], [34]. Students were also perceived to be more motivated and actively engaged when participating in digital assessment activities. However, several challenges were identified, including unstable internet connections, limited access to digital devices, and varying levels of technological readiness among students.

Table 4. Teachers' Perceptions of Digital Assessment

Aspect	Findings
Platforms Used	Google Forms, Quizizz, Kahoot!, CBT, and other digital learning applications.
Benefits	Faster assessment processes, automatic scoring, immediate feedback, and increased student engagement.
Student Response	Students showed positive attitudes and higher enthusiasm toward digital assessment activities.
Challenges	Internet connectivity issues, limited access to devices, and technological adaptation.
Future Potential	Digital assessment can complement conventional assessment and support improvements in learning outcomes.

3.3. Potential Implementation of a Nonequivalent Control Group Design

Various learning obstacles were identified in high school physics, particularly in topics characterized by abstract concepts and high mathematical demands [35]. Difficulties were frequently observed in vectors, measurement, electricity and magnetism, waves, rotational dynamics, and modern physics [36], [37]. Students often demonstrated misconceptions, weak mathematical reasoning, and limited ability to apply concepts when solving problems. Insufficient laboratory experiences further restricted opportunities to connect theoretical knowledge with practical applications. Such conditions indicate that physics learning difficulties emerge from the interaction of conceptual, procedural, and experiential factors.

Positive perceptions toward digital assessment were consistently expressed by participating teachers. Platforms such as Google Forms, Quizizz, Kahoot!, and Computer-Based Testing systems were considered effective in simplifying assessment procedures and reducing grading workload [38], [39]. Increased student motivation and engagement were also reported when assessment activities incorporated digital technologies. Immediate feedback enabled students to recognize their strengths and weaknesses more efficiently than conventional assessment approaches [40], [41]. Nevertheless, issues related to internet connectivity, device availability, and technological adaptation remain important challenges that require attention.

Previous studies have similarly reported that digital assessment contributes to greater student engagement and more efficient learning evaluation processes. Research in science and physics education has demonstrated that technology-supported assessment can improve participation, provide timely feedback, and strengthen conceptual understanding. Evidence from earlier investigations also suggests that interactive assessment environments encourage students to become more actively involved in learning activities. Consistency between those findings and the present study strengthens the argument that digital assessment can support learning improvement. Consequently, integrating technology into assessment practices appears to be a promising strategy for addressing persistent challenges in physics education.

A distinctive contribution of this research lies in linking the identification of learning obstacles with the exploration of digital assessment as a potential solution. Earlier investigations generally focused on evaluating digital tools without first examining the specific difficulties experienced by learners in physics classrooms. Attention to teachers' experiences across multiple schools provides a broader picture of instructional and assessment challenges encountered in real educational settings. Inclusion of a Nonequivalent Control Group Design perspective further extends existing literature by proposing a practical framework for future intervention studies. Such an approach offers a more comprehensive understanding of how assessment innovation may contribute to overcoming learning barriers.

Important implications can be drawn from these findings for both teachers and educational institutions. Continuous identification of learning obstacles should become an integral part of classroom assessment practices rather than being limited to end-of-unit evaluations. Adoption of digital assessment may help teachers monitor student progress more efficiently while providing timely feedback that supports learning improvement. Adequate technological infrastructure and professional development programs are also necessary to ensure successful implementation. Greater integration of digital assessment and learner-centered instruction may ultimately contribute to improved physics achievement and conceptual understanding.

Several limitations should be acknowledged when interpreting the results of this study. Data were collected primarily through observations and interviews involving a limited number of physics teachers from selected schools. Perspectives obtained therefore reflect teacher experiences and may not fully represent student viewpoints or broader educational contexts. Absence of direct intervention and quantitative learning outcome measurements also prevents conclusions regarding the actual effectiveness of digital assessment. Future research should implement a Nonequivalent Control Group Design involving experimental and control classes to generate stronger empirical evidence regarding its impact on physics learning outcomes.

4. CONCLUSION

This study identified various learning obstacles encountered by high school students in physics, including conceptual difficulties, mathematical barriers, limited practical experiences, and differences in student learning characteristics. Findings also revealed that these obstacles contribute to variations in learning outcomes and present challenges for teachers in designing effective assessment practices. Digital assessment was perceived positively by teachers due to its ability to improve assessment efficiency, provide immediate feedback, and increase student engagement during learning activities. In addition, the results indicate that digital assessment has considerable potential to support the improvement of physics learning outcomes when implemented alongside appropriate instructional strategies and adequate technological infrastructure. A Nonequivalent Control Group Design was identified as a feasible framework for evaluating the effectiveness of digital assessment interventions in authentic school settings where random assignment is difficult to implement. Future studies are recommended to conduct empirical intervention-based research involving experimental and control groups to generate stronger evidence regarding the impact of digital assessment on students' conceptual understanding and academic achievement in physics.

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