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Assessment Method of Teaching Physics in Secondary & High School: A Review

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Abstract

This article review focuses on various assessment methods used in secondary and high school in physics education by examining studies published in prominent journals from 2021 until 2025 and groups them under four main themes; Cognitive and Conceptual Understanding Assessments, Formative and Diagnostic Assessments, Technology-Enhanced Assessments, and Practical, Performance-Based, and Alternative Assessments. This review reveals that cognitive assessments are useful for identifying how students thinks and how well they understand key concepts. Formative and diagnostic tools offer insights into students' learning progress and identify misconceptions. Technology-based assessments make feedback more interactive and increase student involvement. Performance-based and alternative assessment give students the chance to apply knowledge in real-world contexts. The result of recent studies suggest that relying on just one type of assessment is not enough. Instead, using a mix of assessment methods provide a more complete picture of student learning. It also helps teachers adjust their instruction more effectively. A variety of assessment practices not only increase academic outcomes but also encourage deeper thinking, personal reflection and better preparation for future study and professional paths in STEM.

Keywords: Physics Education, Assessment Methods, Conceptual Understanding, Formative Assessment, Technology-Enhanced Assessment, STEM Education

Introduction

Physics is an elective subject that is mandatory for upper secondary students in Malaysia who are following the science stream. This subject is a scientific major that focuses on facts, symptoms and natural phenomena. Its study process requires conceptual understanding and critical reasoning. But in the process of learning physics, students typically find learning it unpleasant because of abstract phenomena and lots of formula (Mellu & Baok, 2020). This difficulty often stems from the disconnection between theoretical concepts and students' everyday experiences, making them to struggle to relate abstract idea to real-world understanding. Majority students view Physics as a difficult subject, mainly due to the learning processes and the students' epistemological belief towards Physics (Ibrahim et al., 2022).

For example, topic in physics such as electricity, mechanics, waves, the concepts are challenging to visualize, difficult for students to understand abstract concepts. This is what causes students believe physics to be challenging and boring (Ismail et al., 2019). In fact, at all educational level, electricity and the related concepts are central to the science and physics curricula (Baptista & Martins, 2023). If problems related to physics are not mitigated, students who wish to pursue studies in physics, engineering and STEM-related field will face problems later on or maybe don't want to further study in STEM field. Loheswar (2024) highlights the urgent need for early STEM education to address Malaysia's engineering labour shortage. It is because country's labour market is expected to continue growing through 2025. Key sectors such as manufacturing, particularly in electrical and electronics are expected to continue driving job creation (Department of Statistics Malaysia, 2025). Department of Statistics Malaysia (2025) also reported that the manufacturing sector ranked second, contributing 34.1 per cent of job creation, which is including sector that is related to physics primarily in electrical, electronic & optical products. However, the topic such as electricity is considered challenging and difficult, one of the main topics studied in Physics. Students usually find the abstract topic of electric circuits to be dull, despite the fact that electricity is essential to today's industrial society (Gottschlich et al., 2024).

This issue highlights the importance of effective assessment method to be implemented into the physics' teaching. As a fundamental component of the teaching and learning process, assessment aims to collect precise data on learners' knowledge and skills (Srour et al., 2024). In addition to track students' progress, assessment offers insightful input that can direct instructional tactics and learning enhancements. Teachers can detect student weakness earlier which give them opportunity to modify their teaching by using well-designed assessment methods such as diagnostic tests, formative feedback and conceptual evaluations. By improving assessment practices, it will enhance students' comprehension, maintain their enthusiasm in physics and eventually assisting them in achieving better results on tests and in their future STEM endeavours. According to Mas Sahidayana, the director of University of Malaya's (UM) STEM Centre "Revamping teaching methods, learning approaches, and assessment techniques are crucial in garnering interest from the current generation towards STEM subjects" (Loheswar, 2024). This statement emphasized the importance of appropriate assessment method to implement in teaching physics.

Problem Background

Assessing students' conceptual comprehension is an essential part of providing effective physics instruction. Beyond simply memorizing numbers and processes, conceptual comprehension shows that a learner can understand the fundamental ideas that underlie physical phenomena like electricity. Without accurate assessment method, teachers may overlook persistent misunderstanding that hinder deeper learning and long-term retention. However, current assessment practices in secondary schools often rely heavily on summative tools such as exams and tests. These assessments prioritize procedural problem-solving over diagnostic or formative methods meant at uncovering student thinking. As a result, many students progress through the curriculum with incomplete understanding, particularly in complex and abstract topics like electricity. Therefore, it is essential to improve assessment practices in schools to ensure that students are not just only performing well on tests but also will completely mastering the conceptual foundations required for further studies and careers in STEM fields.

Problem Statement

Although physics is a core subject in science stream of secondary education, many students still struggle with understanding basic concepts across various topics such as electricity, optics, forces and waves. These conceptual difficulties often persist that lead to misconceptions that traditional assessments fail to detect. Standard assessment practices commonly use or emphasize numerical problem-solving and memorization, which may not accurately represent students' level of comprehension. Despite the importance of assessing conceptual understanding had been recognized, there remains a lack of clarity regarding which assessment methods are most effective in diagnosing learning problems and supporting teaching strategies. Teachers may overlook critical gaps in student learning if they implement without targeted and conceptually focused assessment strategies. This situation can limit opportunities to strengthen foundational knowledge and improve long-term outcomes in physics education.

Aim and Research Objectives

The aim of this study is to explore and analyse assessment methods used to evaluate secondary school students' comprehension in Physics. This research focuses to identify commonly used assessment methods, evaluate their effectiveness in addressing student learning, highlight best practices in conceptual assessment and suggest practical implications for teaching and future research. The research objectives are as follows:

1. To highlight best practices in designing assessments focused on conceptual understanding and related skills.
2. To propose implications and recommendations for improving teaching strategies using assessment in physics education.

Research Questions

To guide this investigation, the following research questions serve as the framework:

1. What are the assessment methods used in teaching physics in secondary and high schools?
2. Which of these assessment methods are most effective in identifying and addressing learning problems students face in physics?
3. What are the best practices for designing assessments that target and strengthen conceptual understanding and other skills in physics?

Assessment Methods Used in Teaching Physics

This section discusses identified assessment methods that have been implemented in teaching physics. Based on a review of diverse assessment practices in secondary school and high school physics education, four themes have been identified to categorize the various methods used. These themes reflect the different purposes, formats and pedagogical goals of assessment strategies in physics classrooms. Grouping the assessments in this way helps clarify how different methods contribute to conceptual understanding, skill development and instructional improvement. These themes offer a thorough framework for assessing students' comprehension, guiding instruction and improving outcomes in physics education. Table 1 shows the themes and associated assessment methods in Physics education.

Table 1
Thematic Categories and Associated Assessment Methods in Physics Education

Theme 1: Cognitive and Conceptual Understanding Assessment	- Critical Thinking Assessment (CTA) - Physics Problem-Solving Ability Test (PPSAT) - Concept test (multiple-choice test) - Two-tier multiple-choice assessments - Multiple-choice concept questions - Subject-specific academic tests - Assignments, presentations, traditional games - Essay test - Written papers
Theme 2: Formative and Diagnostic Assessment Techniques	- Competency-based assessment - Diagnostic tests - Formative assessments using clicker-based technology - Solution-Oriented and Process-Oriented Formative Assessment - Test of inquiry skills - Pre-test and Post-test - Monitoring tools & reflective lessons - Observation - Data test - Misconception tier diagnostic technologies
Theme 3: Technology-Enhanced Assessment Methods	- ICT-based assessments - Clicker sessions with peer discussion - Online diagnostic tools - Interactive performance tracking platforms
Theme 4: Practical, Performance-Based, and Alternative Assessments	- Lab reports and practical tests - Performance-based tasks - Oral examinations - Silent video analysis - Creation of traditional games - Discussion - Presentation - Report or multimodal response (from experiment) - Research Investigation report

Theme 1: Cognitive and Conceptual Understanding Assessment

This theme encompasses assessment methods that are intended to measure students' understanding of physics concept and their ability for critical thought and solve the problems. Instead of just asking students to memorize procedures or formulas, these assessments often aim to determine how well students understand fundamental concepts. For instance, Critical Thinking Assessment (CTA) and Physics Problem-Solving Ability Test (PPSAT) which examine the relationship between critical thinking and ability to solve physics problems of the students (Abeden & Siew, 2022). CTA focuses on general critical thinking, while PPSAT's focus is assessing specific physics problem-solving skills. A study from Abeden & Siew (2022) shows a strong positive correlation between those two assessments. These assessments indicate that students with stronger critical thinking skills will excel in physics problem-solving tasks.

To assess students for a particular topic, it is a good choice to use a concept test. For example, the study by Liu et al. (2022) used a multiple-choice concept test designed to assess

students' levels of knowledge integration when learning about electric circuits. Moreover, it targeted the knowledge integration process by measuring students' ability to connect macroscopic concepts (voltage, current, resistance) with microscopic models (charge flow, electric field interactions). Similarly, Lichtenberger et al. (2025) used multiple-choice concept questions on concepts about velocity. This is to provide students with more detailed and objective feedback about their conceptual knowledge (Lichtenberger et al., 2025).

In particular topic, for example in electricity, Ivanjek et al. (2021) demonstrated the study that used a two-tier multiple-choice assessment (2T-SEC Test). Assessing students' conceptual understanding of simple electric circuits was the main focus. This process helped educators to effectively address misconceptions and provided them insight into students' thought processes. In China, the research of subject-specific academic tests conducted by Zhang et al. (2021) shows that in that assessment, students struggled with application-based problems. The significantly declining scores in physics test between Grade 11 and Grade 12, indicates a decline in conceptual understanding over time.

In Queensland, Australia, there is another type of assessment namely external assessments (EA) in Physics for senior secondary students. In the study conducted by Madden & Salmon (2024), they mentioned that this assessment is written papers consisting of multiple- choice and short-response items. However, it only addresses objective 1, which is to describe and explain scientific concepts. Putranta et al. (2022), on the other hand, highlighted the assessment in Indonesia through traditional games designed by students. These games involve physics concepts such as Newton's laws, motion, and forces. Students have been given an assignment to create the games. After that, they have the presentation while explaining their underlying physics concepts. It has been reported that it can foster engagement, strengthen conceptual understanding and help students relate physics to real-world contexts.

Theme 2 : Formative and Diagnostic Assessment

Formative and diagnostic assessment are important for promoting students' learning throughout the teaching process. These methods are used to track student development, identify misconceptions and guide prompt educational adjustments. In addition to measuring, they aim to enhance learning by offering feedback and guiding remediation before final assessments. For instance, competency-based assessment that aims to measure not just knowledge retention but also higher-order thinking skills such as reasoning, application, and scientific communication (Srour et al., 2024). By linking diagnostic tests with competency-based assessments, the study advocates for a more precise, skills-oriented education model in physics. The main conclusion from this study is that many students have trouble using analytical reasoning, proving their understanding and communicating scientific results. Competency-based assessment enables teachers to design remedial actions, ensuring students progress toward skill mastery rather than just achieving passing grades.

Another assessment in this theme is formative assessments using clicker-based technology. This method allowed for frequent, low-stakes testing with immediate feedback, helping students assess their understanding while reducing anxiety (Molin et al., 2021). The advantage of using this method is students could respond without fear of embarrassment, which encouraged honest participation. Meanwhile, research by Ropohl & von Aufschnaiter

(2022) discusses Solution-Oriented Formative Assessment and Process-Oriented Formative Assessment. The function of solution-oriented assessment is to evaluate students' answers to specific tasks and process-oriented assessment observes how students arrive at those answers, providing deeper insights into their thinking.

Another study has also explored how formative assessment can enhance specific competencies such as inquiry skills. For example, test of inquiry skills has been the focus of study of Ganajová et al. (2021), where it was mentioned that the initial level of inquiry skills among students was low. However, when exposed to formative assessment (FA) methods, the experimental group significantly outperformed the control group in inquiry skill development. The research confirms FA enhances inquiry-based learning even within traditional teacher-centered instruction.

Pre-test and post-test are among the most well-known assessments that have been used widely in educational field. For example, Wei et al. (2024) conducted a study using pre-test and post-test to examine the effectiveness of recorded video versus narrated animation in teaching physics problem-solving, particularly considering the difficulty level of the problems. The study concluded that, regardless of problem difficulty, recorded videos with a teacher's face were not significantly more effective than narrated animations without a teacher's face (Wei et al., 2024). Similarly, Kade et al. (2024) also implemented pre-test and post-test but in different context. They explored the effectiveness of technology-driven simulations in improving high school students' practical skills within physics education particularly in mechanical measurement. The study found that simulations significantly enhanced students' accuracy and comprehension of mechanical measurements. Visual and kinesthetic learners benefit the most from simulations before engaging in physical experiments (Kade et al., 2024).

The monitoring tool is one of assessment method that have been used in physics education. It is a booklet which students tracked their learning progress and reflect on their conceptual understanding (Lichtenberger et al., 2025). In Lichtenberger et al.'s (2025) study, the booklet included structured prompts related to key kinematics concepts, helping students recognize gaps in their comprehension. In addition, reflective lesson serves as another assessment methods, used in a targeted session where teachers address misconceptions identified in the diagnostic test and reinforce conceptual restructuring. The reflective lesson supports students on their way to becoming self-directed learners (Lichtenberger et al., 2025). To support this process, the reflective lesson, they developed a set of problems for each concept to help teachers choose those that meet the needs of their students.

Gunawan et al., (2024) used an observation sheet as their assessment technique. The observation sheet focuses on assessing critical thinking skills. It has been used sheet alongside test assessments to analyze students' engagement and reasoning throughout the learning process. The key aspects of the observation including (1) Tracking students' interactions with learning materials, worksheets, and instructional activities, (2) Analyzing responses during classroom discussions and (3) Evaluating problem-solving approaches and reasoning patterns demonstrated in the learning module.

The data test is one of internal assessment techniques introduced in the Queensland Physics 2019 syllabus (Madden & Salmon, 2024). It is a 60-minute exam that evaluates students' ability to process, analyze and interpret experimental data. The test is structured around datasets derived from classroom practicals, ensuring that students engage with real-world physics scenarios. Ma et al. (2025) reviews the diagnostic tools that assess students' understanding at multiple levels. The Misconception Tier Diagnostic Technologies (MTDTs) is most widely applied in physics with four-tier diagnostic technology being the most effective in identifying misconceptions. These tools are common in high school and higher education but are rarely applied in primary education.

Theme 3 : Technology-Enhanced Assessment

Technology-enhanced assessments offer dynamic and engaging ways to assess student learning as a result of the rise of digital tools in education. Smeets (2022) discusses the Dutch central physics exams, which use ICT-based assessments that combine both ICT-supported assessments and traditional paper-based questions. In these assessments, students are assigned project task where they are allowed to use software such as COACH for video analysis, measurement, modelling and simulations. The exam includes sections where students answer the questions on paper while simultaneously working using ICT tools. The digital component focuses on applying learned skills in problem-solving situations.

Misconception Tier Diagnostic Technologies (MTDTs) are online diagnostic tools with high reliability and validity which being used to detect misconceptions among students in physics (Ma et al., 2025). MTDTs are evolving towards large-scale online application thus will improve accessibility. Another technology-based assessment is the clicker as mentioned in Molin et al.'s (2021) study under Theme 2. In this method, student responses are collected and displayed using IT software. This make use of clicker easier because it allow teachers to provide instant explanatory feedback on common mistakes (Molin et al., 2021). In a study by Lichtenberger et al. (2025), students in the formative assessment (FA) group, who participated in clicker sessions, demonstrated better conceptual understanding. Clickers encouraged students to engage in discussions before answering, promoting a more interactive and engaging learning experience (Molin et al., 2021).

Theme 4 : Practical, Performance-Based and Alternative Assessments

This theme focuses on authentic and hands-on assessment methods that allow students to apply their knowledge in physics in relevant context. By assessing students' skills as well as their knowledge, these methods offer a more comprehensive picture of their competency. Lab reports is one of the most commonly used assessment tool wordwide. However, a study by Cini & Musumeci (2021) reported that lab reports alone do not provide sufficient feedback on students' practical skills. Thus, implementing practical tests as additional assessment can offer better insight into students' ability to think scientifically and handle unexpected situations during experiments (Cini & Musumeci, 2021). Practical tests should complement lab reports rather than replace them.

Putranta et al. (2022) incorporate performance-based tasks as part of assessment in physics learning by giving tasks to students to create traditional games related to physics concepts. This approach indicates that students are evaluated not only through written tests but also their ability to apply physics concepts practically. Similarly, the study by Kade et al.

(2024) also focuses on performance-based test which assessed practical skills through tasks related to mechanical measurement, such as determining acceleration and force using different tools.

Another type of assessments have been used is oral examinations in distance physics education, particularly the use of silent video tasks as an alternative assessment method (Velmovská & Gorčáková, 2022). However oral examinations are actually uncommon due to time constraints and concerns over objective grading. Teachers mainly use them to assess students' verbalization skills and reduce anxiety compared to written tests. For silent videos, students used recorded commentary as the method to explain an experiment or phenomenon. According to Velmovská & Gorčáková, (2022), the higher-order thinking skills and understanding of concepts can be enhanced through this method.

Creation of traditional games which is the focus of study from Putranta et al., (2022), also being put in this category. The games highlighted include *tulup*, *benthik*, *bekelan*, *sulamanda*, *egrang*, *sekonan*, *jeblugan*, and *gobak sodor*, each of which was linked to relevant physics concepts. The study underscores the importance of integrating cultural elements into education to make learning more engaging and meaningful.

In Internal Assessment (IAs) implemented in Queensland, Australia, an assessment method such as written Research Investigation report or multi-modal responses are used. These assessments is the presentation of students' findings. It evaluates students from their task that is performing the new experiment (usually working in groups) and then individually analyse, interpret and evaluate the results (Madden, D., & Salmon, A. (2024).

Discussion

This paper explores the diversity forms of assessment practices in physics education in schools. The analysis of methods grouped into four thematic categories as discussed in previous section. The findings reveal that no single method is actually sufficient to fully capture understanding. It is important to use a mix of different assessment methods rather than relying on just one. This will help students to foster meaningful learning and long-term retention in physics (Abeden & Siew, 2022; Lichtenberger et al., 2025).

Assessments that target conceptual and cognitive understanding, such as concept inventories, two-tier multiple-choice questions and critical thinking test, have been proven effective in identifying students' reasoning patterns and misconceptions (Ivanjek et al., 2021; Lichtenberger et al., 2025). These tools present valuable benefits in physics, especially to understand abstract topics that require higher-level thinking. Abeden & Siew (2022) for example, found that students with stronger critical thinking skills tended to do better in physics problem-solving. Similarly, Liu et al. (2022) demonstrated that concept tests evaluating knowledge integration revealed whether students could connect macroscopic and microscopic models of electric circuits.

Formative and diagnostic assessments are frequently used by teachers to identify student misconceptions and adjust their lesson plans. Diagnostic tests, reflective lessons and the monitoring tool (Lichtenberger et al., 2025) help teachers adjust their teaching approach and support student progress. Misconception-tier diagnostic technologies (MTDTs) especially

four-tier assessments, offer high reliability in identifying persistent misconceptions in physics topics (Ma et al., 2025). Studies such as Srour et al. (2024) and Ganajová et al. (2021) emphasized the role of competency-based and inquiry skill assessments in promoting higher-order thinking skill and scientific reasoning. This highlights the educational implications of including assessment into the teaching and learning process.

Technology-enhanced assessments offer additional benefits such as student involvement, immediate feedback and interactivity. According to studies by Molin et al. (2021) and Lichtenberger et al. (2025), using clicker-based assessments not only reduced student anxiety but also encouraged peer discussion and participation. This process leads to improve deeper understanding of the concepts. Smeets (2022) investigated the ICT-based assessment in central physics exams. In that exams, students used software like COACH for simulations and data modelling. The finding shows that technology can support meaningful and practical assessment tasks. Similarly, Ma et al. (2025) observed that MTDTs are now being developed on a larger scale of digital formats. These advancements make the tools more widely accessible in various educational contexts.

Practical and performance-based assessments provide students with opportunities to apply their knowledge in real-world contexts and communicate their findings. Lab reports when combined with practical tests, offer a full picture of students' scientific competence (Cini & Musumeci, 2021). Additionaly, alternative assessments such as traditional game design (Putranta et al., 2022), oral exams, and silent video commentaries (Velmovská & Gorčáková, 2022) provide students with multiple ways to demonstrate understanding especially in diverse educational settings. These methods promote higher-order thinking skills and students engagement. For example as shown in study where students connected cultural activities to physics concepts (Putranta et al., 2022).

However, there are several challenges to implement diverse assessment strategies in physics education. For example, teachers often encounter limitations in terms of time (Velmovská & Gorčáková, 2022), familiarity with effective assessment methods, access to technology resources (Madden & Salmon, 2024) and equity in ICT access across schools (Smeets, 2022). Inconsistent implementation and continuous reliance on traditional examinations weakened the effectiveness of innovative assessments. Furthermore, without strong institutional support and ongoing professional development, many educators feel it is challenging to align assessments with teaching goals and student needs. Even with these challenges, the findings highlight the importance of using a balanced, thoughtful approach to assessment. When used carefully, diverse assessment methods can improve teaching effectiveness, help students' gain a deeper understanding of the concepts.

Conclusion

This review has shown that assessments play important role in supporting effective physics education at school level. A more comprehensive understanding of students' learning can be identified by using a variety of assessments methods. Assessments are not only evaluating knowledge and skills but also can identify misconceptions, promote engagement and encourage deeper thinking. Each theme of assessment brings specific and different meaning and value. First, conceptual tools reveal how students can understand key ideas. Second, formative and diagnostic methods which guide instruction and support ongoing

learning. Third, technology-enhanced assessments that increase engagement and feedback. Fourth, practical or alternative assessments that connect learning process in the classroom with real-world situations. The combination of these themes creates a more effective assessment methods compared to traditional assessments.

It is important for educators to use various assessment methods into their teaching to improve student learning outcomes in physics. School and education systems must also support this by providing time, resources and training. This will ensure assessments are used effectively. Teachers should be given freedom to choose appropriate assessments which not just a tool for grading. This help teachers to use assessments as ongoing process that informs instruction, supports student reflection and also promotes continuous improvement. When assessment is aligned with learning objectives and responsive to student needs, they can influence engagement and academic success. Assessment should be seen as a natural part of learning in classroom and not a source of anxiety. This can encourage students to take ownership in their learning progress. Moreover, enhancing assessment practices is not just about measuring learning but also supporting and improving it. It opens the way for students to become confident, capable and curious learners in science. The impact is, this builds a stronger foundation for participation in STEM fields and careers.

In addition, by combining assessment techniques that go beyond conventional testing and more closely align with constructivist and inquiry-based learning paradigms, this review advances the theoretical understanding of physics education. By categorizing assessment methods into cognitive, formative, technological, and performance-based domains, the study provides a strong foundation for educators to better understand students' conceptual understanding and learning development. In this context, the results highlight urgent issues in Malaysia's STEM pipeline, where abstract topics in Physics like electricity frequently discourage student performance and interest. The integration of diverse and targeted assessment approaches has useful applications for both instructional improvement and policymaking, ultimately supporting national goals to boost STEM participation and proficiency.

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