**European International Journal of Pedagogics (ISSN: 2751-000X)**

Received: 14 March 2026 | Accepted: 04 April 2026 | Published: 29 April 2026

**DOI:** 10.55640/eijp-06-04-50

**RESEARCH ARTICLE**

# Developing Assessment Competence of Future Physics Teachers Based on Pisa And Timss

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**VOLUME:** Vol.06 Issue04 2026

**PAGE:** 243-247

## Abstract

The preparation of future physics teachers increasingly requires strong assessment competence aligned with international standards such as PISA and TIMSS. These programmes emphasize not only content knowledge, but also scientific literacy, problem-solving, and reasoning skills. Therefore, this study proposes an integrative methodological model for developing assessment competence, combining physics content, pedagogical knowledge, international assessment frameworks, and reflective practice. The model includes motivational, cognitive, operational, analytical, and reflexive components, and is implemented through staged training from theory to practicum. As a result, future teachers are prepared to design valid, context-based, and competency-oriented assessment tasks.

**KEYWORDS**

Future physics teachers, assessment competence, assessment literacy, PISA, TIMSS, international assessment.

## INTRODUCTION

The modernization of education has made assessment one of the central categories of teacher professionalism. Previously, assessment was often treated as a technical act of checking whether students remembered facts, formulas, or definitions. However, under contemporary educational conditions, such a narrow understanding is insufficient. Assessment now functions as a complex pedagogical mechanism through which teachers diagnose understanding, reveal misconceptions, guide learning trajectories, provide feedback, and make evidence-based instructional decisions. Accordingly, for future physics teachers, assessment competence is not an auxiliary skill but a core component of professional readiness. This is especially true because physics, unlike some disciplines that can rely more heavily on reproduction, requires students to explain phenomena, interpret evidence, use models, justify claims, and transfer knowledge into unfamiliar situations. These demands closely correspond to the logic embedded in international large-scale assessments.

In this context, PISA and TIMSS are especially valuable because they represent two complementary perspectives on educational quality. PISA, coordinated by the OECD, measures whether 15-year-olds can apply their knowledge and skills to real-life challenges; in science, it emphasizes engaging with science-related issues as reflective citizens and highlights competencies such as explaining phenomena scientifically, evaluating and designing scientific enquiry, and interpreting data and evidence scientifically. TIMSS, by contrast, is a long-running IEA study of mathematics and science achievement at the fourth and eighth grades, organized around content domains and cognitive domains such as knowing, applying, and reasoning. Therefore, while PISA foregrounds transfer, literacy, and contextualized problem-solving, TIMSS offers a clearer structure for aligning assessment with curriculum and cognitive progression. When taken together, these frameworks provide a powerful basis for building the assessment competence of future physics teachers [4, 65-77].

Nevertheless, teacher education programmes often address assessment in fragmented ways. In many cases, future teachers study testing as a separate theoretical topic, observe classroom assessment during practicum, and only later attempt to design their own tasks. As a result, the relationship between learning outcomes, scientific practices, cognitive demand, scoring criteria, and feedback remains underdeveloped. Recent scholarship on teacher assessment literacy similarly suggests that assessment preparation is essential but still unevenly implemented in initial teacher education, and that stronger alignment is needed between teacher preparation and contemporary models of assessment competence. Furthermore, reviews of formative assessment literacy stress that teachers need not only technical knowledge of instruments, but also the capacity to interpret evidence, support learning, and make pedagogically sound judgments. Thus, the problem is not simply the absence of assessment content, but the absence of an integrated developmental logic.

For that reason, the idea of an integrative methodological model becomes especially relevant. In the present article, this model is understood as a structured system that combines several mutually reinforcing dimensions: first, disciplinary knowledge in physics; second, pedagogical and psychological foundations of learning; third, knowledge of international assessment frameworks; fourth, practical experience in task design, scoring, and interpretation; and fifth, reflective and value-oriented attitudes toward fair and meaningful assessment. This model is integrative because it overcomes the traditional separation between "what to teach," "how to teach," and "how to assess." Instead, it treats these as interdependent elements of one professional system. The model proposed here is an original synthesis derived from international assessment frameworks and recent work on teacher assessment literacy [5, 324-328].

The first foundation of this model is the goal-oriented dimension. The ultimate purpose is to prepare future physics teachers who are able to construct, use, and interpret assessment in ways that promote students' conceptual understanding, inquiry competence, problem-solving ability, and scientific reasoning. Consequently, assessment competence should be defined more broadly than the ability to write test questions. It should include the ability to identify the construct being measured, align assessment with learning outcomes, select an appropriate format, ensure cognitive adequacy, establish transparent criteria, interpret student responses, and use results for improvement. In other words, competent assessment practice begins before the task is written and continues after results are obtained. Such a view is fully consistent with contemporary scholarship, which treats assessment literacy as a multidimensional professional competence rather than a narrow technical skill.

The second foundation is the content dimension, which should be built around the intersection of physics content and international assessment logic. Future physics teachers need strong understanding of core topics such as mechanics, thermodynamics, electricity, waves, optics, and modern physics. Yet this alone is insufficient. They must also learn how these topics can be transformed into assessable competencies. For example, a traditional content-based item might ask students to recall Ohm's law, whereas a PISA-oriented item would place electrical reasoning in a real-life context and require interpretation, justification, or evidence-based decision-making. Similarly, a TIMSS-oriented item might organize the same content according to whether the learner is expected to know, apply, or reason. Therefore, teacher preparation should explicitly train future physics teachers to move from content units to competency-based assessment blueprints [1].

The third foundation is the structural-component dimension of assessment competence. In the integrative model, this competence may be divided into five interrelated components. The motivational-axiological component reflects the future teacher's awareness that assessment is ethically significant and pedagogically influential. The cognitive component includes knowledge of assessment principles, international frameworks, validity, reliability, and levels of cognitive demand. The operational-design component involves writing items, creating rubrics, choosing formats, and planning feedback. The analytical-interpretive component concerns reading student responses, identifying errors, and drawing instructional conclusions from evidence. Finally, the reflective-corrective component enables future teachers to evaluate their own assessment decisions and improve them. This component structure is especially useful because it prevents reduction of assessment competence to one isolated technique and instead presents it as a dynamic professional formation [3].

Moreover, for future physics teachers, the analytical-interpretive component deserves special attention. Physics learning often reveals hidden misconceptions that cannot be captured through simple right-or-wrong marking. A student may arrive at the correct numeric answer with flawed reasoning, or may produce an incorrect answer that nevertheless shows partial conceptual understanding. Therefore, assessment competence in physics requires attention to explanations, models, diagrams, data interpretation, and reasoning chains. This is precisely why the PISA framework's emphasis on evidence interpretation and scientific explanation is so valuable, and why TIMSS's differentiation among knowing, applying, and reasoning is equally useful. Together, they encourage teachers to see student performance as structured evidence rather than as a mere score.

From a methodological perspective, the proposed model should be implemented in stages rather than through one isolated course. At the diagnostic-orientational stage, teacher educators identify the initial understanding of assessment among future teachers and introduce them to the purposes, language, and logic of international assessment. At the conceptual-analytical stage, students study PISA and TIMSS frameworks, principles of scientific literacy, cognitive demand, and criteria-based evaluation. At the design-simulation stage, they create assessment tasks, scoring guides, and feedback protocols, and then test these through workshops or microteaching. Finally, at the practicum-reflective stage, they apply these tools in school contexts, analyse student work, compare expected and actual performance, and revise their assessment decisions. Such staged progression is pedagogically sound because it moves from awareness to understanding, from understanding to design, and from design to reflective application [2].

At the same time, the model should rely on several didactic principles. First, the principle of integration requires that assessment be taught together with physics content and teaching methods, not separately from them. Second, the principle of contextualization requires that tasks connect physics concepts to authentic situations, especially in line with PISA's real-life orientation. Third, the principle of cognitive progression requires that tasks vary in complexity and reflect levels similar to TIMSS cognitive domains. Fourth, the principle of evidence-based feedback requires that assessment results be used to support learning rather than only classify learners. Fifth, the principle of reflection requires future teachers to examine not only student mistakes but also their own task quality, rubric clarity, and interpretive judgments. When these principles operate together, assessment becomes a means of professional thinking rather than administrative routine.

An important advantage of the integrative model is that it helps future physics teachers combine the strengths of PISA and TIMSS instead of viewing them as competing systems. In practical terms, this means that one and the same physics topic can be assessed through multiple lenses. For instance, while studying force and motion, future teachers can create TIMSS-like items that measure knowing, applying, and reasoning within curriculum content, and they can also design PISA-like tasks that require students to interpret motion in a social, technological, or environmental context. Similarly, while working with electricity, teachers can construct rubric-based explanation tasks, data tables, graphical interpretation activities, or argumentation prompts. As a result, assessment design becomes richer, and future teachers learn that no single format can capture the full complexity of physics understanding.

Furthermore, the model should include assessment design laboratories as a core instructional format. In such laboratories, future teachers analyse sample international items, identify the measured construct, determine the cognitive demand, rewrite weak questions, construct distractors, and develop analytic rubrics for open responses. This approach is methodologically significant because it transforms abstract knowledge into situated professional action. It also allows teacher educators to scaffold the development of design sensitivity: Why is one task more valid than another? Why does one rubric reveal evidence more clearly? Why does one context motivate reasoning better? Through repeated comparative analysis, future teachers begin to see assessment quality not as intuitive preference but as a justifiable pedagogical decision.

In addition, microteaching and lesson-study formats can strengthen the model considerably. When future physics teachers teach short lessons and then assess peers or school students using their own tasks, they begin to understand a crucial pedagogical truth: assessment is inseparable from instruction. A task that appears excellent on paper may fail if the instructions are unclear, if the cognitive load is excessive, or if students interpret the context differently than expected. Therefore, practical rehearsal is necessary. Reflection after microteaching should focus on such questions as task alignment, response quality, common misconceptions, feedback usefulness, and fairness of scoring. In this way, the model moves beyond theoretical literacy toward enacted competence.

The digital dimension of the model is equally important. Contemporary assessment increasingly involves digital environments, online item delivery, automated data collection, and the interpretation of multiple forms of evidence. Reviews of digital assessment literacy indicate that teacher competence now includes abilities related to digital assessment design, platform use, data handling, and informed pedagogical decision-making in technology-rich environments. Therefore, future physics teachers should learn not only how to create paper-based tasks, but also how to construct digital quizzes, simulation-based prompts, virtual-lab evidence tasks, and electronic rubrics. Since physics education often uses graphs, dynamic processes, and simulations, digital assessment can be particularly powerful when it is pedagogically guided rather than technologically driven.

Another strong aspect of the integrative model is its capacity to foster diagnostic fairness and pedagogical ethics. International assessments are not valuable merely because they rank systems; they are also important because they push educators to clarify what counts as meaningful evidence of learning. Future physics teachers must therefore be trained to avoid assessment practices that privilege memorization over understanding, speed over reasoning, or form over meaning. They should learn to formulate clear criteria, reduce construct-irrelevant difficulty, and recognize that students may demonstrate understanding in different yet valid ways. In physics, where diagrams, formulas, verbal explanations, and experimental reasoning can all represent knowledge, fairness requires careful construct definition and scoring sensitivity. Thus, ethical assessment is not separate from technical assessment; rather, it is embedded within it.

If implemented systematically, the proposed model can lead to measurable changes in teacher preparation outcomes. At the initial level, future teachers gain awareness of the difference between content checking and competency-based assessment. At the intermediate level, they learn to analyse PISA- and TIMSS-type items and adapt them to physics topics. At the advanced level, they become able to design their own valid tasks, develop scoring criteria, interpret student evidence, and use results formatively. Finally, at the highest level, they can integrate classroom assessment, international benchmarking logic, and reflective professional judgment into one coherent teaching strategy. These outcome levels are inferential extensions of the literature and frameworks rather than official OECD or IEA categories. Still, they align well with the broader conception of teacher assessment literacy presented in recent scholarship.

At the institutional level, this model also has implications for curriculum design in higher pedagogical education. Courses such as physics teaching methodology, educational measurement, pedagogy, digital education, and school practicum should not operate in isolation. Instead, they should be linked through common performance tasks and shared competence indicators. For example, a methods course may require future teachers to design a lesson sequence on energy, while an assessment module asks them to create PISA-like contextual tasks and TIMSS-like cognitive-level items for that sequence, and the practicum requires classroom piloting and reflective revision. Such coherence would make teacher education more authentic and more professionally transformative.

## CONCLUSION

In conclusion, the development of assessment competence in future physics teachers requires a shift from fragmented training toward an integrative methodological model. Such a model should synthesize physics content, pedagogical reasoning, international assessment frameworks, digital tools, feedback practices, and reflective analysis. PISA contributes the logic of scientific literacy, transfer, and real-life application; TIMSS contributes structured content-cognitive alignment and progression in science achievement. Therefore, when these frameworks are pedagogically integrated rather than mechanically copied, they can significantly enrich teacher education. Most importantly, they help prepare future physics teachers who are able not only to measure learning, but also to understand it, support it, and improve it. Consequently, the proposed integrative model should be viewed as a strategic direction for modernizing physics teacher education in line with contemporary international standards and the broader goal of forming scientifically literate, analytically capable, and educationally responsible teachers.

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