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Developing a TPaCK Textbook to Support the ScaPro-PjBL Model: Preparing Pre-Service Physics Teacher Competencies in Distance Learning for SDG 4

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ABSTRACT

Objective: To evaluates the validity and practicality of a TPaCK textbook as supporting material for the Scaffolded Product in Project-Based Learning (ScaPro-PjBL) model to train pre-service physics teachers' TPaCK competencies. This study contributes to Sustainable Development Goal 4 (SDG 4) by promoting quality education through technology-integrated and competency-based teacher preparation. The textbook supports three learning phases: essential questions, project design with timelines and checkpoints, and tutorials on subject-specific techniques. **Method:** The textbook development followed Plomp's stages of preliminary research, development/prototyping, and assessment. The textbook has five chapters on the TPaCK concept, framework, application in physics distance learning, supporting technology, and TPaCK products. Validity was assessed by three experts using the Indonesian National Agency of Education Standards (NAES) criteria for content, presentation, language, and graphics, with scores ranging from 1 to 10. Reliability was calculated using ICC(3,k) and Cronbach's Alpha. Practicality was tested through limited (21 students) and extensive (98 students) trials using questionnaires 1-4, with similar reliability analyses. **Results:** The TPaCK textbook was categorized as valid and practical. It supported students in understanding concepts, designing TPaCK-based learning products, identifying project requirements, applying technical tutorials, and developing digital learning products such as lesson plans, worksheets, videos, and formative assessments. Conceptual and procedural scaffolding improved learning processes and technology integration. **Novelty:** This textbook provides a structured scaffold for ScaPro-PjBL implementation in preparing pre-service physics teachers for distance learning. It functions as instructional support, a practice guide, and a tool for developing TPaCK competencies aligned with SDG 4.

INTRODUCTION

TPaCK is a complex knowledge framework because it requires mastery of transformative skills. It combines three core components: content knowledge (CK), pedagogy (PK), and technology (TK) (Koehler & Mishra, 2009). The framework can support pre-service teachers in designing and implementing high-quality and effective ICT-based learning (Jiménez Sierra et al., 2023; Weidlich & Kalz, 2026). Its scope includes pre-service teachers' ability to select appropriate technological devices (hardware and software), adjust pedagogical strategies to the characteristics of the material, and adapt learning to specific educational contexts, including social aspects, resources, and content (Aslan et al., 2025; Brianza et al., 2022). TPaCK is situated, meaning that technological, pedagogical, and content knowledge must be understood and applied within a specific educational context to produce effective learning (Nguyen et al., 2025; Petko et al., 2025). Distance learning is a relevant option for addressing the needs of digital transformation in higher education and teacher preparation for 21st-century competencies, in line with the University 4.0 model and the demands of the information industry (Abdulayeva, 2024; Gümüş, 2022; Jugembayeva & Murzagaliyeva,