

Transforming 21st Century Science Education: A Diagnostic Instrument for Higher Order Thinking Skills (HOTS) Based on the TPACK Framework

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Abstract

In response to the cognitive demands of 21st-century science education, this study develops and validates a Higher Order Thinking Skills (HOTS) assessment instrument grounded in the Technological Pedagogical Content Knowledge (TPACK) framework. HOTS—encompassing analytical, evaluative, and creative thinking—are essential for fostering deep conceptual understanding and problem-solving abilities in physics learning. However, empirical evidence indicates that students' HOTS remain suboptimal, particularly in tackling complex physics tasks. To address this gap, pedagogical interventions such as Problem-Based Learning (PBL) and active learning are recommended for their potential to stimulate high-level cognitive engagement. Using a quantitative survey design, the study involved 289 tenth-grade students who had completed physics instruction. An initial 22-item Likert-scale instrument was constructed based on HOTS indicators and TPACK dimensions. Exploratory Factor Analysis (EFA), employing Principal Component Analysis (PCA) with Varimax rotation, yielded a Kaiser-Meyer-Olkin (KMO) value of 0.928 and a significant Bartlett's Test of Sphericity, confirming data suitability. Three core factors emerged: HOTS-A (Analysis), HOTS-EK (Evaluation and Creation), and HOTS-TPACK, each demonstrating reliability coefficients above 0.7. Twelve items were retained as valid and reliable indicators of students' HOTS perceptions in science learning. The validated HOTS-TPACK instrument serves as a diagnostic tool for evaluating the effectiveness of science instruction in cultivating higher-order thinking. This research contributes to curriculum development and instructional strategies that are responsive to students' cognitive needs in the digital age. The integration of PBL and active learning is strongly recommended to enhance HOTS acquisition and foster transformative science education.

Keywords: Higher Order Thinking Skills (HOTS), Technological Pedagogical Content Knowledge (TPACK), Science Education, 21st Century Skills