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Journal of Innovative Technology and Sustainability Education
Homepage : https://journal.i-ros.org/index.php/JITSE
Email : jitse@i-ros.org
e-ISSN 3109-2454
Vol. 2, No. 1, April 2026

Digital Learning Factory for Developing 21st-Century Competencies in Physics Teacher Education toward SDG 4

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DOI : https://doi.org/10.63230/jitse.2.1.126

Sections Info

Article history:
Submitted: February 23, 2026
Final Revised: March 10, 2026
Accepted: March 10, 2026
Published: April 13, 2026

Keywords:
21st-Century Competencies;
Learning Factory;
Physics Education;
Preservice Physics Teachers;
Systematic Literature Review.

ABSTRACT

Objective: *This study aims to conduct a Systematic Literature Review (SLR) on the implementation of the Learning Factory (LF) model in physics education, particularly for the development of 21st-century competencies among preservice physics teachers.* ***Method:*** *Using the PRISMA framework, the review analyzed literature published between 2020 and 2025. Articles were identified using Publish or Perish software with Google Scholar as the primary database. A total of 32 relevant journal articles were systematically screened, extracted, and synthesized using thematic narrative analysis.* ***Results:*** *The review reveals that the Learning Factory (LF) is a promising instructional approach that effectively integrates theory and practice through project-based and experiential learning in simulated real-world environments. LF enhances critical thinking, creativity, collaboration, communication, and digital literacy, which are core competencies in 21st-century education. However, its implementation in teacher education still faces several challenges, including limited infrastructure, lack of faculty training, and misalignment in assessment systems.* ***Novelty:*** *This study contributes by systematically mapping the role of the Learning Factory model in physics teacher education, which remains relatively underexplored in existing research. The findings highlight LF's strategic potential to bridge the gap between theory and practice and provide recommendations for curriculum design, faculty development, and institutional collaboration.*

INTRODUCTION

Education in the 21st century has undergone substantial transformation, necessitating fundamental changes in teaching approaches. There is a growing global demand for graduates who not only possess conceptual knowledge but also demonstrate critical thinking, creativity, collaboration, and problem-solving skills. These expectations present significant challenges for higher education institutions, particularly those responsible for preparing future teachers as primary agents of educational change. This situation underscores the urgent need to design instructional models that are not only effective in delivering content but also responsive to the demands of the job market and the dynamics of a digitally driven society. One approach that has gained widespread attention in addressing these challenges is the Learning Factory (LF) model. The Learning Factory is an innovative pedagogical approach that integrates theoretical instruction with hands-on practical experience by simulating real-world work environments. Originally developed within technical and vocational education contexts, the LF model is now being adapted across various disciplines, including physics education. In practice, LF shifts traditional passive teaching methods toward more interactive, contextual, and experiential learning processes. This makes it a relevant model for preparing prospective physics teachers who must not only master scientific concepts but also acquire pedagogical, professional, and technological competencies aligned with 21st-century education demands (Thái et al., 2021).