World Academy of Science, Engineering and Technology
International Journal of Educational and Pedagogical Sciences
Vol:19, No:08, 2025

Particle Observation in Secondary School Using a Student-Built Instrument: Design-Based Research on a STEM Sequence about Particle Physics

Authors : J.Pozuelo-Muñoz, E. Cascarosa-Salillas, C. Rodríguez-Casals, A. de Echave, E. Terrado-Sieso

Abstract : This study focuses on the development, implementation, and evaluation of an instructional sequence aimed at 16–17-year-old students, involving the design and use of a cloud chamber—a device that allows observation of subatomic particles. The research addresses the limited presence of particle physics in Spanish secondary and high school curricula, a gap that restricts students' learning of advanced physics concepts and diminishes engagement with complex scientific topics. The primary goal of this project is to introduce particle physics in the classroom through a practical, interdisciplinary methodology that promotes autonomous learning and critical thinking. The methodology is framed within Design-Based Research (DBR), an approach that enables iterative and pragmatic development of educational resources. The research proceeded in several phases, beginning with the design of an experimental teaching sequence, followed by its implementation in high school classrooms. This sequence was evaluated, redesigned, and reimplemented with the aim of enhancing students' understanding and skills related to designing and using particle detection instruments. The instructional sequence was divided into four stages: introduction to the activity, research and design of cloud chamber prototypes, observation of particle tracks, and analysis of collected data. In the initial stage, students were introduced to the fundamentals of the activity and provided with bibliographic resources to conduct autonomous research on cloud chamber functioning principles. During the design stage, students sourced materials and constructed their own prototypes, stimulating creativity and understanding of physics concepts like thermodynamics and material properties. The third stage focused on observing subatomic particles, where students recorded and analyzed the tracks generated in their chambers. Finally, critical reflection was encouraged regarding the instrument's operation and the nature of the particles observed. The results show that designing the cloud chamber motivates students and actively engages them in the learning process. Additionally, the use of this device introduces advanced scientific topics beyond particle physics, promoting a broader understanding of science. The study's conclusions emphasize the need to provide students with ample time and space to thoroughly understand the role of materials and physical conditions in the functioning of their prototypes and to encourage critical analysis of the obtained data. This project not only highlights the importance of interdisciplinarity in science education but also provides a practical framework for teachers to adapt complex concepts for educational contexts where these topics are often absent.

Keywords : cloud chamber, particle physics, secondary education, instructional design, design-based research, STEM
Conference Title : ICPEL 2025 : International Conference on Physics Education and Learning
Conference Location : New York, United States
Conference Dates : August 09-10, 2025