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Designing and validating a virtual reality prototype for photoelectric effect experiments

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Abstract

The photoelectric effect, which reveals the emission of electrons from material when exposed to light, is a foundational experiment in quantum physics that elucidates the interaction between light and matter. However, the lack of laboratory equipment and the difficulty of the experiment frequently prevent its conduct in educational settings. To address these challenges, this study developed and validated a virtual reality (VR) prototype designed to simulate the photoelectric effect experiment. The VR tool enables students to manipulate key variables such as light frequency and intensity, observe electron emission, and investigate the responses of various metals in real-time. The study adopted a research and development methodology, which involved iterative design, development, and validation by a panel of experts. The prototype was assessed on criteria including accuracy, educational value, and usability. The

results indicate that the VR prototype accurately simulates the photoelectric effect. Validation data confirmed the educational effectiveness of the tool, which received high ratings for engagement and visual quality. While VR offers a flexible, scalable, and safe environment for exploring complex quantum phenomena, it is positioned as a complementary tool to enhance, rather than replace, traditional laboratory experiences. This approach is particularly valuable for institutions and high schools where expensive equipment may not be available. Future work will focus on expanding the scope of the VR tool to cover additional quantum experiments and improving user comfort to ensure broader accessibility for diverse educational settings.