Chapter 11
An Online Course of Dynamics and Kinematics Physics Education Using eXtended Reality (XR) Technologies.

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ABSTRACT

This chapter discusses the use of extended reality (XR) for the design and development of online learning applications using real-time physics simulations. The authors propose an instructional design based on the ARCS motivational model to improve aspects of the presentation, organization, and distribution of learning content for an online XR learning application, which presents an interactive and exploratory learning environment for physics education, through a real-time physics simulator of dynamics and kinematics. Depending on the characteristics of a XR-compliant device and platform, the authors can offer XR experiences that range from augmented reality (AR) to non-immersive and immersive virtual reality (VR) environments in a single application, being available to any device with internet capabilities. To evaluate the instructional design of the XR application, the authors present an assessment using the John Keller´s attention, relevance, confidence and satisfaction (ARCS) learning motivation model, which allows to analyze the correlation between student's motivation and the learning technique.

DOI: 10.4018/978-1-6684-8646-7.ch011

INTRODUCTION

Since the COVID-19 pandemic, there has been a unique growth in the development of online learning methodologies, as this crisis led education systems around the world to seek alternative ways of education outside the classroom, through hybrid or virtual models of distance learning (Alqahtani & Rajkhan, 2020). These platforms make it possible to hold meetings in remote digital classrooms, to have distribute digital learning content, as well as to a wide range of formal courses and lessons in real time or self-managed with online counselling and support services. However, some new developments go further than the basics for the creation of online learning platforms, exploring more innovative uses of technology to deliver new methods of digital education. One such tend, principally influenced by the growth of online applications and remote learning, is the use of spatial and immersive computing technologies denominated as Extended Reality (XR), which represents the integration of Augmented Reality (AR) and Virtual Reality (VR) development as a single concept.

These XR technologies provide a scale of digitalization of the real world, as AR is focused to superpose digital information in reality, while VR simulates and replaces partially or completely the real world (Maclntyre & Smith, 2018). As such, XR technologies present distinctive characteristics of immersion, visualization, and interactivity, depending on how an approach uses visual, auditory, tactile, and even physical elements to stimulate an individual's perceptions, as well as the characteristics and limitations of the device or platform on which XR activities are performed. XR development also explores the technological implications and potential of using online services to provide cross-platform web implementations, as well as to deliver digital, interactive, and immersive environments through internet (Nesenbergs et al., 2021; Qiao et al., 2019; Ratclife et al., 2021a). Under this premise, it is possible to provide users with the opportunity to interact with educational content by developing online XR learning tools.

On the other hand, physics, as a field of learning in STEM education, includes abstract concepts that are difficult to explain or understand, in which students face various difficulties during the learning process and problem solving. This has attracted the interest of researchers and developers towards the use of XR technologies for the creation of learning and teaching tools for physics learning (Alnagrat et al., 2021), whose capabilities allow increasing the overall spatial representation and visualization of physics concepts, as these offer a potential favoring the comprehension, retention and understanding of the information obtained, as well as having an impact on the motivation of students. XR technologies have the capacity to offer immersive experiences to users, and their use aims to decrease the difficulties and challenges encountered in the teaching of physics, while improving the user's sensory perceptions and the way information is obtained. Either through AR methodologies, which consists of superimposing digital elements on the real world, being dynamically interactive with a real physical space; or recreating a totally virtual and immersive environment in VR, where users experience in isolation from reality.

Therefore, this chapter aims to describe the design and development of a use case scenario of an online learning application focused on teaching physics. We propose a framework and the design process of an interactive online learning application that uses real-time physics simulations for teaching dynamics and kinematics topics. This online application leverages XR capabilities such as adaptability and scalability of digital learning materials depending on the platform or device used by the end user, allowing the learning environment to be presented in AR or VR presentation modes for a seamless experience. This chapter is organized as follows. The first two sections describe a literature background about the concepts and technologies needed for the development of XR applications, and how to implement XR for