



Exploring Pre-service Elementary Teachers' Technological Pedagogical Content Knowledge in Developing and Using Virtual Reality Materials Reflecting Spatial Thinking in Astronomy Class

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Abstract

Literature indicates that virtual reality (VR) effectively supports and enhances spatial thinking in astronomy education. This study examines how pre-service elementary teachers' technological pedagogical content knowledge (TPCK) characteristics manifest during astronomy VR material's development and utilization. Nine sophomores, organized into three groups, were observed as contrasting cases. They created VR materials based on their knowledge of technology, astronomy, spatial thinking, and inquiry teaching and used them in micro-teaching sessions. Our analysis focused on TPCK aspects of VR material development and teaching practice. While one group concentrated solely on technological features, failing to represent celestial motion effectively and leading to ineffective lessons clearly, the others successfully represented astronomical phenomena using VR, reflecting spatial thinking. Additionally, one group fostered student-centered inquiries using VR, whereas the others used it merely for knowledge transfer. The difference lay in whether pre-service teachers (PSTs) clearly envisioned employing technology pedagogically during VR material development. Based on the research results, we proposed practical considerations and reflective questions for producing VR materials related to astronomical phenomena and utilizing them in class.

Keywords Technological pedagogical content knowledge · Virtual reality · Spatial thinking · Astronomy learning

Introduction

Spatial thinking is integral to astronomy's development (National Research Council (NRC), 2006), with learners' ability to think spatially significantly impacting astronomy learning. Spatial thinking fundamentally enhances students' astronomical understanding (Plummer, 2014). Many studies have emphasized that students need to engage in spatial thinking to comprehend the causes of lunar phases, seasonal changes, and the apparent motion of the sun and stars

(Plummer et al., 2016; Sneider et al., 2011; Subramaniam & Padalkar, 2009; Türk, 2016). Nevertheless, as spatial thinking involves higher-order cognition, many students face challenges in thinking spatially, subsequently affecting their scientific understanding of astronomical phenomena (Cole et al., 2018), necessitating educational approaches to support students' spatial thinking in astronomy learning.

Recent technological advances offer effective ways to promote students' spatial thinking (Baumgartner et al., 2022; Fowler et al., 2022). This study focuses on virtual reality (VR), which allows learners to think spatially about astronomical phenomena. The popularization of 360° cameras and web-based virtual tour creators has allowed average users to create VR materials without significant technological barriers (Huh, 2020; Ng et al., 2023). Previously, teachers had to rely on pre-made VR resources developed by technology experts, which could sometimes limit classroom applications because the resource does not fully align with the actual class situation or cater to specific user needs. However, technological advancements enable teachers to

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