Spatializing STEM Learning for Kindergarteners through Spatial Play Activities: A Controlled Experiment

Young children's spatial skills influence their later achievements in science, technology, engineering, and mathematics (STEM), but early childhood education in Hong Kong often neglects spatial skills. Children are more likely to achieve long-term development of spatial skills through a contextualised curriculum with spatialisation elements than through short-term decontextualised spatial training. Hence, it is important to develop an age-appropriate, play-based curriculum that incorporates spatial learning to develop kindergarteners' spatial skills. Our pilot studies indicated that spatialized STEM content (e.g., creating a 3D map) enables children to navigate, recognise, visualise, and represent spatial relationships within their physical and visual environments, which can improve their spatial skills (*Hu et al., 2024). However, no controlled experiments have tested the effectiveness of a spatializing STEM curriculum on young children's spatial learning. In addition, teachers often lack knowledge in spatialized curriculum, which must be addressed through a situated professional development (SPD) program that supports the coherence of knowledge and application. To address this research gap, this mixed-methods study will determine the effectiveness of a spatializing STEM curriculum, alongside an SPD program for teachers, in enhancing kindergarteners' spatial skills. Three levels of the SPD program will be implemented: 1) understanding the spatial learning; 2) comprehensive implementation; and 3) projection level to develop spatial learning in kindergarten classes. This controlled experiment will examine the effectiveness of our proposed spatializing STEM curriculum and SPD program by evaluating children's spatial learning outcomes across three conditions: (a) teaching as usual (control), (b) teaching with a spatial concept package (treatment 1), and (c) teaching with an SPD package and spatializing STEM curriculum (treatment 2). We will recruit 54 teachers to support the spatial learning of 549 kindergarteners. All children will complete pre- and post-test spatial tests, and we will analyse these data using difference-in-differences multilevel structural equation modelling with residual centring. In the qualitative part, we will collect classroom recordings during and after the intervention and interview teachers about their implementation processes and outcomes. We will analyse these qualitative data using thematic analysis. This proposed project will fill a knowledge gap by determining the impact of spatialized STEM curriculum on young children's spatial skills. Additionally, this initiative will empower teachers to integrate spatial learning into children's daily lives. The evidence-based findings will provide significant benefits to kindergarteners, teachers, and curriculum policy-makers in preparing future STEM learners from an early age.