Learning Gains and Constraints Resulting from Haptic Sensory Feedback among Preschoolers' Engagement during Science Experimentation

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Abstract : Embodied cognition and additional (touch) sensory channel theories indicate that physical manipulation is crucial to learning since it provides, among others, touch sensory input, which is needed for constructing knowledge. Given these theories, the use of Physical Manipulatives (PM) becomes a prerequisite for learning. On the other hand, empirical research on Virtual Manipulatives (VM) (e.g., simulations) learning has provided evidence showing that the use of PM, and thus haptic sensory input, is not always a prerequisite for learning. In order to investigate which means of experimentation, PM or VM, are required for enhancing student science learning at the kindergarten level, an empirical study was conducted that sought to investigate the impact of haptic feedback on the conceptual understanding of pre-school students (n=44, age mean=5,7) in three science domains: beam balance (D1), sinking/floating (D2) and springs (D3). The participants were equally divided in two groups according to the type of manipulatives used (PM: presence of haptic feedback, VM: absence of haptic feedback) during a semi-structured interview for each of the domains. All interviews followed the Predict-Observe-Explain (POE) strategy and consisted of three phases: initial evaluation, experimentation, final evaluation. The data collected through the interviews were analyzed qualitatively (open-coding for identifying students' ideas in each domain) and quantitatively (use of non-parametric tests). Findings revealed that the haptic feedback enabled students to distinguish heavier to lighter objects when held in hands during experimentation. In D1 the haptic feedback did not differentiate PM and VM students' conceptual understanding of the function of the beam as a mean to compare the mass of objects. In D2 the haptic feedback appeared to have a negative impact on PM students' learning. Feeling the weight of an object strengthen PM students' misconception that heavier objects always sink, whereas the scientifically correct idea that the material of an object determines its sinking/floating behavior in the water was found to be significantly higher among the VM students than the PM ones. In D3 the PM students outperformed significantly the VM students with regard to the idea that the heavier an object is the more the spring will expand, indicating that the haptic input experienced by the PM students served as an advantage to their learning. These findings point to the fact that PMs, and thus touch sensory input, might not always be a requirement for science learning and that VMs could be considered, under certain circumstances, as a viable means for experimentation.

Keywords : haptic feedback, physical and virtual manipulatives, pre-school science learning, science experimentation
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