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Using Variation Theory in a Design-based Approach to Improve Learning Outcomes of Teachers Use of Video and Live Experiments in Swedish Upper Secondary School

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Abstract : Conceptual understanding needs to be grounded on observation of physical phenomena, experiences or metaphors. Observation of physical phenomena using demonstration experiments has a long tradition within physics education and students need to develop mental models to relate the observations to concepts from scientific theories. This study investigates how live and video experiments involving an acoustic trap to visualize particle-field interaction, field properties and particle properties can help develop students' mental models and how they can be used differently to realize their potential as teaching tools. Initially, they were treated as analogs and the lesson designs were kept identical. With a design-based approach, the experimental and video designs, as well as best practices for a respective teaching tool, were then developed in iterations. Variation theory was used as a theoretical framework to analyze the planned respective realized pattern of variation and invariance in order to explain learning outcomes as measured by a pre-posttest consisting of conceptual multiple-choice questions inspired by the Force Concept Inventory and the Force and Motion Conceptual Evaluation. Interviews with students and teachers were used to inform the design of experiments and videos in each iteration. The lesson designs and the live and video experiments has been developed to help teachers improve student learning and make school physics more interesting by involving experimental setups that usually are out of reach and to bridge the gap between what happens in classrooms and in science research. As students' conceptual knowledge also rises their interest in physics the aim is to increase their chances of pursuing careers within science, technology, engineering or mathematics.

Keywords : acoustic trap, design-based research, experiments, variation theory
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