RECENT DISSERTATIONS

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High School Students' Conceptual Coherence of Qualitative Knowledge in the Case of the Force Concept
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Abstract

The theoretical research aims were to characterise students' conceptual coherence of qualitative knowledge in the case of the force concept, and how it can be evaluated. Students' conceptual coherence can be divided into three aspects: representational coherence, which is the ability to use multiple representations and move between them; contextual coherence, i.e. the ability to apply concepts in a variety of contexts (familiar and novel), and conceptual framework coherence, which addresses the relations - integration and differentiation - between relevant concepts. Certain groupings of the Force Concept Inventory (FCI), the Force and Motion Conceptual Evaluation (FMCE), and the Test of Understanding Graphs - Kinematics (TUG-K) questions were used to probe students' contextual and representational coherence of the force concept. Written extended response questions and interviews were also used in addition to multiple choice tests to provide complementary data.

The empirical part of the dissertation consists of designing a teaching approach (Interactive Conceptual Instruction (ICI)) and teaching sequences for kinematics and the force concept. The ICI approach involves several features or components: conceptual focus (concepts are introduced and rehearsed before quantitative problem solving), the use of multiple representations in varying contexts, classroom interactions (peer instruction), research-based materials, use of texts (reading before formal treatment), and concept maps.

An empirical study was conducted to test the effectiveness of the ICI teaching. The study involved two pilot and two study groups in Kuopio Lyseo High School: Preparatory International Baccalaureate students (age 16; npilot = 22 and nstudy = 23) and Finnish National Syllabus students (age 17; npilot = 52 and nstudy = 49). The pilot groups followed the ICI approach without a focus on forces as interactions whereas the study groups followed the ICI approach with a focus on forces as interactions. The study groups were taught to think of forces as interactions through the systematic use of a modified version of the 'Symbolic Representation of Interactions', which provided a bridging representation to more abstract free-body diagrams. Otherwise, introductory mechanics was taught largely in a similar manner to the pilot and study groups.

Statistical testing, normalized gain, and effect size were used to analyse the statistical and practical significance of the changes along different dimensions of the force concept. The most impressive conceptual gains were made in verbal representation of Newton's first and third laws, and contact force. Focusing on forces as interactions proved to be very effective: all indices showed that the study groups had much better results in Newton's third law than the pilot groups. However, the data in this study suggest that focusing on forces as interactions does not necessarily enhance students' conceptual understanding of the force concept in dimensions other than Newton's third law.

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