1. PUBLISHABLE SUMMARY

Conceptual change is a core feature of learning science. It reflects the knowledge transformation and development that occurs during the learning process. Educational researchers have shown that a key difficulty in teaching science, particularly physics, is how to bring about conceptual change; namely how to lead students to accept scientific conceptualizations that often differ from experiences students have on the scale of their everyday experience or their naive views of phenomena (Duit & Treagust, 2003). Analogical reasoning plays a central role in the process of conceptual change, which is a key part of scientific discovery (e.g., Dunbar, 1997; Gentner et al., 1997). Instruction of complex concepts in science, and especially in physics, often involves some use of analogies (Dagher, 1995), and educational researchers have argued that analogies can guide students towards conceptual change (e.g., Brown & Clement, 1989; Duit, Roth, Komorek, & Wilbers, 2001). The project goal is to understand how.

The theoretical framework that guides this project is the Knowledge in Pieces Perspective on Conceptual Change (diSessa, 1993). The objectives are to develop an empirically based theory that *explains* how and to what extent instructional analogies affect conceptual change during the acquisition of new knowledge in physics; (2) derive practical recommendations from this theory regarding the use of analogical reasoning when teaching science, and particularly when teaching physics in high school and at the introductory undergraduate level.

During the outgoing period of this research, 6 clinical interviews (diSessa, 2007) were conducted with high school students using an enriched and elaborated version of Clement & Brown's bridging tutoring sequence of the existence of the normal force. Changes and additions were implemented to provide better triangulation of the students' particular knowledge structures and the contexts in which they were used. Changes included additional analogies, and experimenting with the physical artefacts employed in the analogies (springs, flexible boards, etc).

A model of explanations and change in explanations was developed through a bottom-up analysis with high temporal resolution. The model draws on diSessa's (1993) model of p-prims and focuses on core elements that provide those judging an explanation with a sense of satisfaction. The model is used to explain why a well known canonical instructional sequence in physics (Minstrell, 1982) is so effective (Kapon & diSessa, 2010), to account for individual differences in response to instructional analogical sequences (Kapon & diSessa, 2010, 2012), and to account for aspects in the emergence of novel knowledge structures prompted by instructional analogical sequences (Kapon & diSessa, 2012).

The evaluation of the degree to which the candidate transferred knowledge is applicable to the target domain and whether the analogical inference seems plausible are acknowledged as important aspects in cognitive models of analogies. However, these models consider evaluation as mediated chiefly by structural similarity across domains (Falkenhainer, Forbus, & Gentner, 1986) and pragmatic goals (Holyoak & Thagard, 1989). An important finding emerging from the current research is that the activation of prior knowledge in the form of simple schemes, termed explanatory primitives, strongly affects the learner's acceptance or rejection of an analogical inference. The findings also highlight the advantages of knowledge analysis as a research method in educational research, and enhance our understanding of the nature of effective instruction.

The above analysis raises additional, detailed questions about reasoning prompted by instructional analogies. For instance what aspects of the interaction with the instructor, peers, and objects in the learning environment activate a particular explanatory primitive, convince a learner to shift preferences from one primitive to another, and later use the primitive in the construction of new understanding? Such questions are critical for generating instructional implications and suggest that augmenting knowledge analysis with interaction analysis (e.g., Goodwin, 2000) can promote our understanding of how instructional analogies can lead to conceptual change as well as help us generate effective instruction (Kapon, 2012, Kapon, in preparation).

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