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Link Maps and Map Meetings: A theoretical and experimental case for stronger scaffolding in teaching physics novices

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Abstract

This thesis critiques and extends the current trends in both physics education specifically and the wider field of education generally. It has three parts: development of theory, development of a learning environment that is consistent with theory, and the naturalistic trial of this environment.

Physics Education Research (PER) does not rest on a solid theoretical framework, at least not as theory is understood by physicists. Hence, I integrate the theoretical foundations of neuroscience, cognitive psychology and education, and argue that, at a fundamental level, they all agree on the basic tenet of human learning: that each individual constructs her own knowledge. There is no alternative. I subsequently discuss how this informs teaching, arguing for stronger scaffolding for physics novices. I also emphasise and explain the importance of considering prior knowledge. Empirical findings from PER are included, as is self-efficacy, an area of motivation. I conclude that all of these five fields should be considered in physics education, and that future work should continue the integration and refinement of these different elements.

Based on the theoretical understanding of human learning, I developed a learning aid for first year physics students: Link Maps. Link Maps focus on the relatively few, but frequently occurring, core concepts that are covered in first year physics and the myriad of links between these. Temporal consistencies in the presentation of concepts across Link Maps result in strong links not only occurring within maps but also between them. Thus, together the Link Maps form an abstract 'hypermap' or Link Map network, reflecting the integrated nature of physics knowledge.

Link Maps were implemented in Map Meetings, which are relatively scaffolding tutorials. First year students in four different physics courses were allocated to either Map Meetings or the existing inquiry based physics tutorials. Data on students' tutorial attendance, self-efficacy and examination performance were collected, and qualitative feedback was obtained through interviews and focus groups, short answer questions in questionnaires, tutorial observations by physics education experts, and student-staff liaison committee meetings. Triangulation of results revealed that Map Meetings were considered more valuable by the students, both in terms of student attendance and qualitative feedback; had a more positive effect on students' self-efficacy; and resulted in fewer students at risk of failing the course with the lowest assumed prior knowledge.

This thesis demonstrates that the theory underlying physics education can be made more coherent than it currently is. Against popular beliefs, a more scaffolding educational environment improved the learning and motivation of first year physics students – especially the novices with the lowest prior knowledge – which reinforces the value of the theoretical approach.

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