School of Applied Sciences

Evaluation of a University Physics Studio Learning Environment: The Interrelationships of Students’ Perceptions, Epistemological Beliefs and Cognitive Outcomes.

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Abstract

Physics learning has been the focus of much research over the last few decades. One line of such research has had knowledge about physics conceptual understanding as its object. Conceptual physics learning is found to be enhanced by the use of a variety of interactive engagement teaching and learning strategies. Another line of research in physics education has been through the development of computer-based learning environments as alternatives to traditional lecturing approaches. One such development has been that of a ‘physics Studio’ in which computer software delivers content and facilitates activities and communication, and instructors adopt a tutoring or learning facilitator role rather than lecturing role.

Curtin University of Technology has drawn on both lines of research, resulting in the creation of a Physics Studio. In addition, a constructivist philosophy has provided guiding principles underpinning the conduct of first year physics classes. The aim of this study has been to evaluate students’ physics learning in first year Studio classes. In particular, the aim has been to examine the role of students’ epistemological beliefs (beliefs about knowledge and knowing) and their perceptions of the learning environment, in that learning.

The study is situated across the fields of psychology and physics education research. It uses an ex-post facto comparative research design together with a qualitative methodology to compare students in Studio classes with those in physics classes in a traditional lecture stream. The use of multidimensional scaling as a technique for reducing complex data to a visual form for the purpose of describing and investigating the Studio learning environment is also explored.

Findings from this study suggest that a Studio approach that incorporates student-centred, social constructivist teaching and learning behaviours can result in improved learning for students in a discipline such as physics, which is normally associated with authoritative and didactic teaching.

The results indicate that most students responded positively to the characteristics of the Studio approach. Their learning outcomes and improvement in conceptual understanding exceeded those of students in the traditional lecture classes. Students’ beliefs about the structure of knowledge affected their cognitive
outcomes through their preference for particular learning strategies. Students with ‘naïve’, positivist epistemological beliefs were more likely to choose a narrow range of learning strategies and to have poorer cognitive outcomes. Students with more ‘sophisticated’, constructivist epistemological beliefs were more likely to choose a wider range of learning strategies and to have better cognitive outcomes.

There is evidence from this work that the constructivist learning environment influences students’ epistemological beliefs, and that their beliefs influence the way they respond to the learning environment. Using multidimensional scaling, spatial configurations of learning environment parameters for Studio and traditional groups, although structurally similar, were visibly different. In particular, the preferred learning environment of Studio students formed a complex web of interrelationships, whereas the preferred learning environment of students in the traditional course formed a simpler pattern with minimal interrelationships among parameters.

Other factors affecting the responses of students to the constructivist learning environment were their perceptions of the nature of the subject matter as represented by assessment tasks, and their expectations about the role of instructors. Some students were unable to change their epistemological beliefs and learning patterns to fit teachers’ expectations.

These findings have implications for teachers of physics who adopt or wish to adopt constructivist rather than didactic teaching methods, and for those implementing Studio approaches. An instructor’s best efforts to implement alternative teaching approaches and methods can be circumvented by the beliefs and attitudes of students if they are inconsistent with the epistemology implicit in the teaching methods. For example, students with naïve beliefs in the structure and certainty of knowledge need guidance and experiences that provide validity for different ways of learning physics. Students also need help to understand the concept of, and to value, self-reflective learning practices. Finally, learning in a Studio class is enhanced for students whose beliefs are consistent with, or change to suit, the philosophy underpinning instruction.
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# Abbreviations

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<th>Term or acronym</th>
<th>Meaning</th>
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<tr>
<td>CO</td>
<td>Cognitive outcome</td>
</tr>
<tr>
<td>CK</td>
<td>Certain Knowledge (epistemological belief dimension)</td>
</tr>
<tr>
<td>EA</td>
<td>Expert Authority (epistemological belief dimension)</td>
</tr>
<tr>
<td>EB</td>
<td>Epistemological belief</td>
</tr>
<tr>
<td>FA/QL</td>
<td>Fixed Ability/Quick Learning (epistemological belief dimension)</td>
</tr>
<tr>
<td>FMCE</td>
<td>Force and Motion Conceptual Evaluation</td>
</tr>
<tr>
<td>IE</td>
<td>Interactive engagement (teaching strategies)</td>
</tr>
<tr>
<td>IT</td>
<td>Information technology – meaning computers and related technologies used for all forms of communication.</td>
</tr>
<tr>
<td>LE</td>
<td>Learning environment – restricted to a classroom learning environment and not computer software.</td>
</tr>
<tr>
<td>Map</td>
<td>Spatial configuration of correlations among variables produced by multidimensional scaling</td>
</tr>
<tr>
<td>MDS</td>
<td>Multidimensional scaling</td>
</tr>
<tr>
<td>MPEX</td>
<td>Maryland Physics Expectations Survey</td>
</tr>
<tr>
<td>PW101</td>
<td>First semester physics unit – Particle and Waves 101</td>
</tr>
<tr>
<td>QEB</td>
<td>Questionnaire on Epistemological Beliefs</td>
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<tr>
<td>QM Test</td>
<td>Quantum Mechanics test</td>
</tr>
<tr>
<td>R</td>
<td>A symbol for dimensionality (see section on multidimensional scaling)</td>
</tr>
<tr>
<td>RMS</td>
<td>Root mean square</td>
</tr>
<tr>
<td>RPI</td>
<td>Rensselaer Polytechnic Institute</td>
</tr>
<tr>
<td>RSQ</td>
<td>Squared correlation between distances and disparities in a MDS solution. Represents the proportion of variance in the data accounted for by the MDS model.</td>
</tr>
<tr>
<td>SCR</td>
<td>Student opportunity for communication and reflection – a subgroup of scales on the USCLES</td>
</tr>
<tr>
<td>SI</td>
<td>Studio instruction ‘matched’ group</td>
</tr>
<tr>
<td>SK</td>
<td>Simple Knowledge (epistemological belief dimension)</td>
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<tr>
<td>SMARF</td>
<td>Self-monitoring and reflection form</td>
</tr>
<tr>
<td>SM102</td>
<td>Second semester physics unit – Structure of Matter 102</td>
</tr>
<tr>
<td>SSA</td>
<td>Smallest space analysis – a variant of non-metric multidimensional scaling</td>
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<tr>
<td>TCE</td>
<td>Thermal Concept Evaluation</td>
</tr>
<tr>
<td>TEE PHYS</td>
<td>Tertiary entrance physics examination</td>
</tr>
<tr>
<td>TER</td>
<td>Tertiary entrance rank</td>
</tr>
<tr>
<td>TI</td>
<td>Traditional instruction ‘matched’ group</td>
</tr>
<tr>
<td>TIQ</td>
<td>Teacher interpersonal qualities – a subgroup of scales on the USCLES</td>
</tr>
<tr>
<td>USCLES</td>
<td>University Social Constructivist Learning Environment Survey</td>
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Advice for readers

Chapter 4 is in two parts. Part B contains data analysis that is a precursor to Part A.
Appendix A 7.2 contains a data flow chart to facilitate tracking of data from source to where it is used.