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Re-thinking physics teaching with web-based learning

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ABSTRACT

There is extensive uptake of ICT in the teaching of science but more evidence is needed on how ICT impacts on the learning practice and the learning outcomes at the classroom level. In this study, a physics website (*Getsmart*) was developed using the cognitive apprenticeship framework for students at a high school in Australia. This website was designed to enhance students' knowledge of concepts in physics. Reflexive pedagogies were used in the delivery learning materials in a blended learning environment. The students in the treatment group accessed the website over a 10 week period. Pre and post-test results of the treatment ($N = 48$) and comparison group ($N = 32$) were compared. The MANCOVA analysis showed that the web-based learning experience benefitted the students in the treatment group. It not only impacted on the learning outcomes, but qualitative data from the students suggested that it had a positive impact on their attitudes towards studying physics in a blended environment.

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1. Introduction

Students view physics as a subject that is demanding, theoretical, abstract, and labour intensive (Angell, Guttersrud, Henriksen, & Isnes, 2004). In this large-scale study by Angell et al., students and teachers believed that unlike some subjects where rote learning was sufficient for their success, physics required understanding of abstract ideas. They also reported that educational practices such as chalk and talk lessons were viewed as boring, and students preferred active participation using strategies that involved more opportunities for interaction and discussions. It is probably this perceived difficulty and the way the subject is presented which leads to boredom, disengagement and eventually to poor learning outcomes. In his book "A funny thing happened on the way to the future", the actor Michael J. Fox explained his poor results in mathematics, physics and chemistry to his mum when he was a teenager in the following manner (Fox, 2010):

> In the outright creative subjects (drama, music…) I'd bring home A's. But any subject based on fixed rules, like math or chemistry or physics, sent my grad into freefall…They are absolutes, mom. They're boring… (p. 15)

In Angell et al's study (2004), didactic teaching approaches and poorly structured explanations (e.g., teachers were criticised for not showing the details of how problems were done on the blackboard) were some of the reasons which led students to suggest that pedagogies needed to be more student centred. Students in the focus groups described a good physics lesson as one that offered variations (Angell et al., 2004). The authors also recommended that "physics courses [should be] tailored to the interest, plans and inclinations of various groups of pupils" (p. 702). So the issues raised by Fox (2010) were probably not wholly related to the discipline – it was perhaps the classroom pedagogies that were applied to teach the subject.

With Web 2.0 tools teachers have the option to re-think their pedagogical approaches. Although the uptake of these tools is increasing in classrooms, there is an ongoing need to develop a greater understanding of "the impact of ICT on learning practice – as well as learning outcome" (Crook, Harrison, Farrington-Flint, Tomás, & Underwood, 2010, p. 8). These authors pointed out that the existing literature was unclear about the effectiveness of ICT supported teaching and there was a need for research that "documents the reported experience of integrating technology into ongoing practices of teaching and learning, as they are pursued at the classroom level" (p. 8). Research was also needed which focussed on "pervasive practices" that did not have a "piecemeal" ICT focus "in a corner of the curriculum" (p. 8). They also argued that the classroom teacher was best positioned to capture and document the outcomes of such initiatives. Through such practices

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teachers' can also evaluate their "own learning, their professional practice, and their pupils learning" (Cochran-Smith, 2005, p. 224) and in doing so become reflective practitioners.

This study investigates the impact of teacher produced online materials on students' performance and attitudes in physics classes at a high school in Australia. A website was developed for this purpose and implemented in a blended learning environment. In this environment, online and face-to-face pedagogies are used to deliver course content. The study adopted a mixed methods approach with quantitative pre and post-intervention data complemented with qualitative feedback from open-ended surveys of the students.

2. Background

According to Brown (2006, p. 18), "today's students are comfortable satisfying their immense curiosity on their own". He also acknowledged that this "capacity is essential to their future well being" (p. 18),

> These challenges require that we re-conceptualise parts of our education system and at the same time find ways to reinforce learning outside of formal schooling. Luckily, successful models of teaching and learning already exist that we emulate and build on… (p. 18)

Brown also believed that the Internet was becoming a repository for demand-based learning. Many educators probably agree with this view. Earlier this decade in the U.S., 81% of all higher institutions offered at least one fully online course (Allen & Seaman, 2003). But more recently, an annual growth of more than 20% in online courses and programs has seen an increase in this mode of teaching (Allen & Seaman, 2007). The evolution of web technologies can be attributed to this growth.

The second generation of web design (or Web 2.0) enables users to actively participate as both producers and consumers of information. Web 2.0 fosters social networking and access to technical facilities which is leading to the emergence of new kinds of open participatory learning ecosystems (Brown & Adler, 2008). Web 2.0 tools can enable educators to create websites built on some of the existing models of teaching and learning (Brown, 2006). For instance, websites can be developed using the instructional methods of cognitive apprenticeship to facilitate learning (Seel & Schenk, 2003; Wang & Bonk, 2001). This study therefore has drawn on the instructional methods of cognitive apprenticeship to develop a website that uses the new technologies to provide support and address learner needs on demand (Dennen & Burner, 2008).

2.1. Previous research

Physics students in Angell et al.'s (2004) study indicated that they preferred more learner-centred instructional practices tailored to their needs – these practices can be addressed by using technologies. For this to occur, educators need to re-think the pedagogies associated with teaching physics. Instead of relying on mimetic pedagogy (Kalantis & Cope, 2008) that focussed only on teacher delivered facts in a fixed sequence, there is a need to embed more learner focussed pedagogies. Synthetic and reflexive pedagogies shift the balance of agency in favour of learners and as a consequence they can become more active in the learning process (Kalantis & Cope, 2008).

There is evidence in the literature which suggests that pedagogical shifts driven by ICT can enhance the richness of the learning environment. The noble laureate Wieman has argued "education research, careful measurement, and new technology make it possible to guide most students safely along the path towards a true understanding and appreciation of physics" (Wieman & Perkins, 2005. p. 40). Evidence supporting this optimism is emerging in a number of studies. The use of well researched pedagogical practices has influenced teaching with technology in the UK (Hennessy et al., 2007) where teachers are exploring the use of technologies to encourage students to engage in "What if" explorations using simulations. Simulations also feature in the work of PhET project where some 50 scenarios have been produced which foster conceptual understanding of complex ideas on quantum mechanics (see http://phet.colorado.edu/) (McKagan et al., 2008).

In higher education, web-based tools are becoming increasingly commonplace in teaching science (Singh & Haileselassie, 2010). For example, Singh and Haileselassie developed self-paced tutorials for students in an introductory physics course. According to the students, the interactive and self-paced nature of these tutorials made them very useful in developing their knowledge in Physics. In another study, Moodle was used as the platform for delivering a general physics course in a blended environment for the first time at a university in Spain (Martín-Blas & Serrano-Fernández, 2009). These researchers reported that the web interface enabled them to: (a) effectively organise, deliver, and manage courses and (b) interact easily with students. However, most importantly, those who used the online resources obtained higher scores at the end of the semester. According to Krusberg (2007), emerging technologies were creating new opportunities for cognitive scientists, physicists and researchers to re-think the goals of physics education and how students develop their understanding in the subject. New technologies such as java animations, tutorial systems, and microcomputer based laboratory tools presented "tremendous potential of education technologies" which could be delivered via the Internet (Krusberg, 2007, p. 411). The value of such options lies in the fact that the "juxtaposition of different representations" can lead to deeper understanding of concepts (Schwartz, Martin, & Nasir, 2005, p. 32).

However, purposeless surfing of the net does not improve learning outcomes either (Brooks, Nolan, & Gallagher, 2001) and given the redundancy and complexity of online knowledge, it is not surprising that open surfing on the Internet can be counterproductive and lead to confusion and misunderstanding. What is needed is a framework for instruction in such environments. As an instructional approach cognitive apprenticeship in a blended learning environment frames this research. We hypothesise that a custom designed website can enable teachers to produce their own instructional materials and as a consequence tailor the learning needs of their students (Reid, 2002).

3. The study

This study had two key objectives. First to establish if an initiative involving students engaging with blended instruction incorporating pedagogical principles derived from cognitive apprenticeship accompanied by access to a dedicated website (*Getsmart*) impacted students' learning outcomes. The website was designed specifically to enhance students' knowledge of concepts in physics. Second to determine if students' believed that such an approach influenced their learning outcomes. The study had elements of a self-study that adopted an integrative research approach in which the investigation built "on everyday instances of material and social supports" (Schwartz et al., 2005,

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