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A framework for teachers' integration of ICT into their classroom practice

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ABSTRACT

When attempting to integrate any Information and Communications Technology (ICT) based resource into Post-Primary Schools (High Schools) many potential barriers must be considered. Importantly, many of these barriers revolve around the individual teacher and hence they are an important starting point in understanding the change process in schools. This work describes attempts to integrate an ICT-based resource (a Virtual Chemistry Laboratory) into some science teachers' practice within the Irish education system. From these experiences a working framework has been developed to describe teachers' level of ICT integration into their practice and the factors underpinning this. The framework raises important questions of how teachers may be effectively supported to move between descriptions within the framework. It also highlights the need for change attempts to incorporate mixed strategies for mixed teacher stances on ICT integration.

1. Introduction

The lack of uptake of science in Post-Primary Schools (High Schools) has been a strong cause for concern both in Ireland (Regan & Childs, 2003) and internationally (Barmby, Kind, & Jones, 2008; Bennett & Hogarth, 2009; Hassan, 2008). In publication of the Strategy for Science, Technology and Innovation (2006) Report, the Irish government highlights the need to significantly change the nature of instruction of the Physical Sciences in Post-Primary Schools, in recognition of the continuing decline in numbers taking science subjects through to Senior cycle (16–18 year olds) and beyond to University. The report emphasises the need to focus on investigative approaches, problem-solving, the assessment of practical work and the effective use of ICT. The National Council for Curriculum and Assessment (NCCA) are the government body responsible for implementing these challenging changes and are currently reviewing the Senior Cycle Science Syllabi with a focus on more inquiry based approaches.

This research is looking at the potential of a Virtual Chemistry Laboratory (VCL) to address the issues raised. The use of simulation-based software is becoming more main-stream within science education (Su, 2008; Dalgarno, Bishop, Adlong & Bedgood, 2009 and Jara et al., 2009). Virtual experimentation offers many potential learning gains that can facilitate inquiry approaches: it gives space and time independency, it is low cost and easy to access and overall it shifts the centre of learning from the teachers to the students (Georgiou, Dimitropoulos, & Manitsaris, 2007). Despite these advantages the integration of an ICT-based resource is a complex change process that needs careful consideration of the people it affects most: teachers.

Educational change is dependent on "what teachers do and think – it's as simple and as complex as that" (Fullan, 2007:129). This is not to dismiss other educational stakeholders but to highlight that changes in the student learning experience ultimately reside with teachers. When faced with educational change teachers are less likely to engage with policy documents as "the size and prettiness of the planning document are inversely related to the amount and quality of action" (Fullan, 2007: 41). Instead, the most effective source of help for teachers tends to be other teachers (Fullan, 2007: 133). As re-enforced by Tyack and Cuban (1995:10) teachers look towards resources, practical designs for change and collegial support in bringing about change. Ultimately, successful change processes require a "bias for action" (Fullan, 2007: 41) i.e. conditions under which people become motivated to change.

Structural and cultural changes to schools make little improvement unless the importance of teachers is taken into account from their construction of "the reality of educational practice on a day-to-day basis in their schools and in their classrooms" (Helsby, 1999: 30). This is not surprising as any form of change leads to intensification of teachers' work by adding burdens to a job that is already excessively demanding

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(Hargreaves & Evans, 1997: 4). However, many teachers are interested in adopting change in their classrooms and "will do so under the right conditions" (Fullan, 2007: 60). What is needed for effective educational change is "reculturing" (Fullan, 2007: 25) and this can only come about through the development of shared meaning in the change process which "is at the heart of the matter" (Fullan, 2007: 42).

Moving from internal factors influencing school culture to external factors outside schools adds another dimension to the issues that must be considered. In curriculum reform efforts towards assessment, Trant (1998) highlights various underlying tensions in the Irish education system between teachers, curriculum developers, the Department of Education and Science (DES, now known as the Department of Education and Skills) and teacher unions. He notes the "hostility from the guardians of the system" (p.2). For example, teachers can feel a lack of ownership in curriculum development and therefore do not readily engage with it (Trant, 1998). This lack of ownership relates to the fatalism in a lot of teacher practice (Portelli, 2010). Fullan (2007: 87) re-enforces this notion in that "local school systems and external authority agencies have not learned how to establish a processual relationship with each other". Ultimately, in educational change, a basis of co-operation is needed through partnership that recognises the rights and responsibilities of all involved (Trant, 1998). However, throwing ICT integration into the educational change mix brings about further issues for consideration.

Many barriers must be overcome to bring about successful integration of ICT within Post-Primary School classrooms. Ertmer (1999) described a simple model of two types of barriers, first- and second-order, that are commonly cited as issues in ICT integration. First-order barriers refer to missing or inadequately provided resources such as equipment, training and support. These are barriers that are easily removed once money is provided and hence are usually the barriers concentrated on first in reform efforts. For example, in a multiple case study carried out by Baher (1998) in three universities using a software called CyclePad for thermodynamics education issues were cited such as a lack of computer facilities, constraints of the courses and student scheduling as reasons for difficulties in using the software. Second-order barriers are ones that impact on fundamental change and are typically rooted in teachers' core beliefs and are therefore the most significant and resistant to change. These beliefs revolve around issues relating to teacher–student roles, teaching methods, organizational and management styles and assessment types. Teachers' knowledge of practice, underpinned by beliefs, are difficult to articulate as they are oftentimes tacit and implicit within the practice of teachers (Berry, Loughran, Smith, & Lindsay, 2009).

Zhao, Pugh, Sheldon, and Byers (2002) presented an expanded model of barriers to technology integration. They identified 11 salient factors that influence the success of technological innovations in classrooms. These factors were placed within three interactive domains of the teacher, the innovation and the context. The factors within the first domain, the teacher domain, will be discussed in detail in a later paragraph. The factors in the second domain, the innovation domain, revolved around two areas: distance and dependence. The first area, distance, referred to the deviation of the innovation from the status quo. This encompassed three sub-areas within distance: distance from the existing school culture, distance from existing practice and distance from available technological resources. The second area, dependence, referred to how much an innovation relied on other people or resources, in particular people or resources that are beyond the innovator's immediate control.

The third domain, the context, had three aspects that were of key importance to the impact of an innovation. These were the human infrastructure, the technological infrastructure and the social support. The first aspect, human infrastructure, refers to organizational preparation to support technology integration in the classroom. The second aspect, the technological infrastructure, refers to how much resources are currently available in a school to meet the needs of the innovation. The third aspect, the social support, refers to the extent to which peers support or discourage the innovators.

Various studies on the implementation of ICT innovations in schools highlight factors of success or failure that can be related to Zhao et al. (2002)'s three interactive domains (Brinkerhoff, 2006; Chen, Looi, & Chen, 2009; Lowther, Inan, Strahl, & Ross, 2008; Tondeur, Devos, Van Houtte, Van Braak, & Valcke, 2009). In a study by Tondeur et al. (2009) of 527 primary school teachers in Belgium, they found that schools classified with greater structural and cultural characteristics (context domain) had a greater frequency of educational ICT use. Similarly, it was argued that the development and dissemination of new practice using ICT is not just impacted by the availability of reliable resources but also by a supportive organizational culture (social support factor) and a collegial work environment (Deaney & Hennessy, 2007).

In terms of the Irish context, a study on the historical development of ICT within Irish Post-Primary schools (McGarr, 2009) highlighted significant trends between ICT initiatives and the resulting ICT use in schools. It was found that despite ICT reform efforts little influence on teachers' practice had occurred. Teachers' ICT use had in most cases developed independently of these reform efforts, in particular within informatics subjects where teachers put a greater onus on learning about the particular ICT rather than learning with it. Issues for consideration from the study expressed the need for future initiatives to be presented as teaching and learning initiatives and not as ICT initiatives. Also, it was recommended that future ICT policy needs to be mindful of previous ICT initiatives in schools and how current teacher ICT use affects external ICT initiatives.

When looking at factors that affect technology use the teacher is 'naturally' the first person one can look to (Zhao et al., 2002). In the teacher domain, Zhao et al. (2002) explained three factors associated with the teacher that impacted technology integration in classrooms: technology proficiency, pedagogical compatibility and social awareness. The first factor refers to not just knowledge of the technology but also its enabling conditions. The second factor refers to the compatibility of the teacher's pedagogical beliefs and the technology being used. The third factor highlights the significance in the ability of a teacher to negotiate the social facets of the school culture. The discussion is now going to expand on the second factor mentioned; the compatibility of teacher's pedagogical beliefs and the technology being used. If teachers' use of technology is to change then their beliefs about the technology has to change (Russell, Bebell, O'Dwyer, & O'Connor, 2003).

Within schools some teachers still hold the belief that they can keep out change by shutting the classroom door while other teachers concur that this is too much of a simplistic description of how their work as teachers relate with the wider society (Robertson, 1996: 28 in Goodson & Hargreaves, 1996). More recently, in a study of English secondary-school teachers in core subjects such as English, Maths and Science the teachers did feel the inevitability and acceptance of the role of technology in education (Hennessy, Ruthven, & Brindley, 2005: 185). These teachers however also expressed an air of caution to some forms of technology use portraying a reflective and critical standpoint on the use of ICT to support learning. It is clear that the adoption of any new technology depends on the values and beliefs of teachers about the importance of the ICT for learning (Webb & Cox, 2004, cited by Schibeci et al., 2008: 314).

In a study of science teachers' beliefs and practices (Monsour, 2009), it was highlighted that not all beliefs are reflected in practice. Teachers explained that there are many barriers that hinder them from putting their beliefs into action, for example the changing of teaching approaches under the pressures of preparing students for examinations. Hence, it was explained that an understanding of the role of