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Systems of integration: Using system dynamics to understand technology integration in learning and teaching

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Abstract

This paper presents the use of system dynamics to analyze factors impacting on teachers adoption and integration of technology in learning and teaching. Educational change is a complex and dynamic process, particularly in the area of technology integration. Existing models of teacher integration have not been designed to account for shifting and changing teacher experience, confidence and cultural aspects of technology integration. Therefore, the use of system dynamics is proposed to provide a more informed understanding of these interactions, with the aim to extend existing models of teachers' technology integration. This discussion applies this approach to analyze and model teachers' adoption of laptops in teaching within a large-scale 1-to-1 laptop program in New South Wales, Australia. The research is novel and innovative in its use of system dynamics to understand teacher change. Implications for professional development and school-level support will be discussed.

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Introduction

Increasingly, schools and governments are investing in one-to-one laptop, or more recently tablet computer, programs. Conclusions regarding the improvement of student learning due to continuous access to devices have not been conclusive. However, research has shown that teaching and school factors are more likely to affect student learning than a particular technology (e.g. Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011). This suggests, in order to understand effective integration of technology in teaching, supporting gains in student learning, factors relating to practice and school culture need to be explored. As schools are complex systems, dynamic changes between factors will also influence technology integration. This paper aims to contribute to this area of research investigating the dynamic relationships between factors relating to technology integration in learning and teaching.

Theoretical framework

Conceptual models considering factors relating to teachers' adoption and integration of technology in teaching typically identify factors such as support, school climate, teacher beliefs, pedagogy and expected learning outcomes (e.g. Inan & Lowther, 2010). While they present holistic models of integration, these frameworks have not fully addressed the underlying dynamics of educational change.

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We propose the use of system dynamics to explore teachers' adoption and integration of technology. System dynamics is a methodology used to analyse complex systems. Cause and effect relationships, time delays and feedback loops are accounted for as system behaviour is seen to be a reflection of the underlying structure. Feedback has been described as "the structure surrounding a decision process" (Forrester, 1968). Feola, Gallati & Binder (2012) have used system dynamics to analyse the influence of knowledge (education) as well as social (cultural norms) in decision-making about the adoption of an important practice in a workplace. Hirsch, Levine & Miller (2007) discuss the use of system dynamic modelling to explain the processes of change in schools as new curricula and other innovations are adopted.

Method

Using this theoretical framework we will model the dynamic changes in teachers' experiences and technology integration in a large-scale 1-to-1 laptop program. Data is drawn from the New South Wales (NSW) statewide three-year evaluation (2010-2012) of a 1-to-1 laptop program in secondary schools. This was part of the Australian federal government's 'Digital Education Revolution'. One of the research questions of this evaluation focused on 1) teachers' pedagogy and practice, investigated through a mixed-methods design, including: 1) student, teacher and parent online questionnaires, and 2) five school case studies.

System dynamics models are developed in two main stages: the conceptualisation of relationships between the elements of the system; and the operationalisation of these into equations in order to run simulations (Hirsch et al., 2007). This paper draws on teachers' questionnaire responses over the three years of the evaluation.

Results and discussion

Of the approximately 25,000 full-time secondary-level teaching staff in NSW, 4,604 (18.4%) completed the online teacher questionnaire in 2010, 4,227 (16.9%) in 2011 and 2806 (11.2%) in 2012. Teachers reported using computers 'many times a day' outside of school and '2-4 times a week' in teaching. This increased, but did not show statistically significant change, in the three years.

In regard to confidence, on a 4-point scale, teachers' reported gradually increasing 'agreement' that they could confidently use the laptops from 2010 to 2012, $F(2, 9318) = 42.561$, $p < .001$, $\eta p2 = .009$, but with a very small effect. Confidence using the laptops showed a weaker relationship to laptops use in teaching (2011, $r = .356$, $p < .001$; 2012, $r = .327$, $p < .001$). In regard to pedagogy, use of student-centred lesson, on a 4-point scale, showed a decrease over the three years from 'half or more' lessons in the week in 2010 ($M = 2.08$, $SD = 1.52$) to significantly less in 2012 ($M = 1.83$, $SD = .77$; $F(2,9628) = 60.489$, $p < .001$, $\eta p2 = .012$). Further, differences in

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laptop use were reported between the subject areas as well, with medium effects, in 2011, $F(3,1956) = 14.57, p < .001, \eta p2 = .022$, and 2012, $F(3,1285) = 7.02, p < .001, \eta p2 = .016$. In regard to school culture, on a 4-point scale, teachers reporting stronger agreement that email communication had increased reported more laptop integration (2011, $r = .339, p < .001$ and 2012, $r = .300, p < .001$). Email communication changed between 2010 and 2012, but the effect was not strong, $F(2,9309) = 35.951, p < .001, \eta p2 = .008$. Communication is not directly linked to use of laptops in teaching, but this suggests increased experience and engagement with technology.

Conclusion and significance

In this brief presentation of three key factors arising out of the DER-NSW teacher data sets, the complex relationships between factors is visible. These factors impact on teachers' adoption and integration of laptops and other technologies in dynamic and changing ways. In order to continuously support teachers and learners to effectively integrate technology a model of the dynamics of this system is needed. Specifically, a better understanding of the changing needs of teachers and students as they experience integration, is necessary for effective and appropriate distribution of limited support and resources in small and large-scale technology initiatives.

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