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More than beliefs: Subject areas and teachers' integration of laptops in secondary teaching

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Abstract

The purpose of this paper is to explore the relationship of subject areas to teachers' technology integration. Educational technology research has often identified "culture clashes" to explain differences in technology use between subject areas. These clashes are frequently attributed to core features, values and beliefs held in the subject area cultures, but there has been little research analyzing the relationship between subject areas and integration. Using a validated path model as a conceptual framework, this paper presents an analysis of the relationship between three subject areas (English, Mathematics, Science) and known factors of teacher beliefs and readiness to use technology in teaching, which directly impact on secondary-level teachers' technology integration, over three years. Findings show that time and subject areas are both associated with teachers' readiness, but only subject areas are associated with teachers' beliefs. Implications for practice and future research are discussed.

Introduction

The relationship between teachers' practice, adoption of technology and effective integration is not clearly understood, particularly differences between subject areas. Research has repeatedly identified a need to investigate subject areas as an influencing factor in teachers' use and integration of information and communication technologies (ICTs) in the classroom (see Ertmer & Ottenbreit-Leftwich, 2010; Hew & Brush, 2007; Inan & Lowther, 2010). Using key factors identified in Inan and Lowther's (2010) model of teachers' technology integration, this paper aims to explore possible relationships between subject areas and secondary-level teachers' technology integration through a large-scale Australian one-to-one laptop initiative.

"Each subject in the secondary school is a separate microcosm, a micro-world with varying values and traditions" (Goodson & Mangan, 1995, p. 615). The inclusion of subject areas, as a variable in teachers' technology integration, presents a complex mixture of cultural conventions and personal beliefs. A more nuanced understanding of differences in technology integration between subject areas is necessary if teachers are to appropriately and effectively integrate technology in their practice and achieve specific learning outcomes.

To explore possible differences in technology integration among subject areas, the paper first addresses key factors of teachers' technology integration. This is followed by an examination of teachers' beliefs about technology and readiness to integrate technology in their subject areas, through analysis of teacher questionnaire data collected over three years as part of a one-to-one

Practitioner Notes

What is already known about this topic

- Technology integration does have an effect on students learning outcomes and achievement.
- Teachers' selection and combination of technologies in teaching and learning is influenced by their readiness and beliefs.
- Some subject areas are more likely to integrate technology in teaching and learning than others, but this phenomenon is not well understood.
- Values and beliefs of subject areas are unlikely to be influenced by institutional initiatives to change teaching practice.

What this paper adds

- Confirmation that subject areas do have an effect on technology integration.
- Shows that subject areas contribute to the variance of teacher' beliefs about technology integration independent of the amount of time in a technology-related initiative.
- Demonstration that subject areas are not homogenous and they have unique trajectories over time in a technology-related initiative.

Implications for practice and/or policy

- Subject area beliefs about technology integration are likely to influence frequency of use, suggesting possible "matches" and "clashes" between technology and teachers' beliefs about teaching and learning.
- To support effective practice, ICTs should be "matched" with subject area values and beliefs, as well as learning outcomes and teachers' practice.
- Matches and clashes are likely to be influenced by underlying relations to educational knowledge embodied through teachers' beliefs about practice, as well as curriculum and assessment.

laptop program. Results were aggregated across subject areas, presenting group trends rather than individual change, as individual teachers were not tracked from year to year. Findings suggest possible relationships between subject areas and key factors of technology integration, as well as different trajectories of technology integration in the subject areas over time. The paper concludes with a discussion of implications for teacher change, the possibility of technology integration "matching" or "clashing" with subjects areas and future research to explore how differences in teachers' use of technology may affect student learning.

Background

Increased access to ICTs, including participation in one-to-one laptop programs, has resulted in more use of ICTs, but it has not resulted in significant changes in teaching practice (Ertmer & Ottenbreit-Leftwich, 2010). Therefore, the actual affordances of ICTs, such as new and different ways to experience learning, collaborate and engage in the classroom, are not often made available to students. In the secondary classroom, expected learning outcomes are, predictably, guided by the curriculum and conventions of teachers' subject area. For changes in teachers' practice to occur, they must hold the belief that technology integration supports these learning outcomes.

Subject areas and technology integration

Tamim, Bernard, Borokhovski, Abrami and Schmid (2011) recently conducted a second order meta-analysis of educational technology research over the last 40 years. Their work included a systematic analysis of 25 meta-analyses, totaling 1055 individual studies, including a wide range of ICTs, all school grade levels and postsecondary, as well as most subject areas. Findings showed that, on average, students engaging in learning with technology performed 12% higher than students in a traditional classroom, but this result was highly variable because of surrounding factors. The authors concluded that elements of teaching specific to subject area practices were significant factors likely to impact on technology integration. They go on to state that considerably more research needs to be done in this area.

In this discussion, subject areas are considered to be an area of teaching and learning distinguished by groupings of prioritized knowledge and skills, which are defined by a state or national curriculum. Some ICT tools seem to match with certain subject areas, such as the use of graphing software in Mathematics (Hennessy, Ruthven & Brindley, 2005), visualizations in Science (Webb & Cox, 2004) and language development and writing in English (Silvernail & Gritter, 2007). These tools and practices are accepted because they replicate important aspects of subject practice and core features, and values of the subject culture are not lost (Hennessy *et al*, 2005). In other areas, there seems to be a "culture clash" between the values and beliefs of subject subcultures and technology use (Goodson & Mangan, 1995).

When examining differences between technology integration in subject areas, research has tended to focus on beliefs about pedagogies, content knowledge and teaching strategies (eg, SITES 2006, see Law, Pelgrum & Plomp, 2008). While these are essential components of teaching practice, they only *reflect* core features, values and underlying principles of subject areas. Components of teaching are underpinned and structured by *educational knowledge* (Howard & Maton, 2011). Research has not addressed the underlying principles of educational knowledge: *what* is being taught and learned, thus obscuring significant differences between the subject areas.

Howard and Maton's (2011) recent work on teachers' technology integration has started to address this using social realist theory, where every practice, belief and knowledge claim is: (1) about something and (2) made by someone. Therefore, it is possible to analytically distinguish between these two relations to knowledge through the object or focus (eg, skills, content and practices) or the author or actor (eg, experience, talent or "feel"; Maton, 2014). Together, relations reveal the dominant basis for success in a social context—what one needs to know and what kind of knower one needs to be. Teachers' beliefs about how technologies *support* students to be successful, as well as how *important* it is to use ICTs to gain necessary knowledge, reveal how technology integration relates to success in subject areas. Howard and Maton's work has explored relations underlying teachers' use of technology in Mathematics, which emphasizes skills and procedures, but ICT is not seen as important for success, and English, emphasizing experience and feel for language, and ICTs are believed to support learning. Similar to Goodson and Mangan (1995), they identified a likely "clash" between Mathematics and integration of ICTs, but a possible "match" in English. Their findings suggest it was possible to observe how relations to knowledge underpinning teachers' practice affected beliefs about technology integration. This is an important conclusion. While full analysis of relations to knowledge is beyond the scope of this discussion, we begin this work by exploring the effect of subject areas on integration.

A model of technology integration

Inan and Lowther's (2010) model of teachers' technology integration provides factors through which relationships to subject areas and technology integration can be explored (see Figure 1).

The three school-level variables: overall support, technical support and professional development, and two teacher-level variables: teacher readiness and teacher beliefs are included in the path model. Inan and Lowther (2010, p. 939) define teacher readiness as "teachers' perception of their capabilities and skills required to integrate laptops into classroom instruction" and teacher beliefs as "teachers' perception of laptops' influence on student learning and achievement and impact

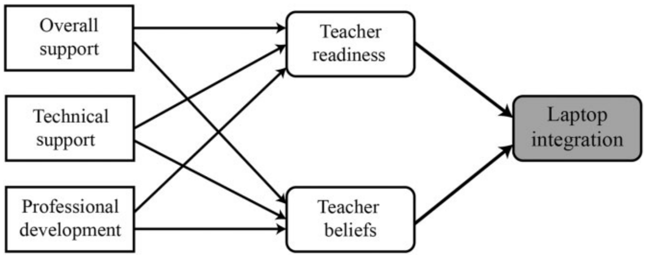

Figure 1: Path model of teachers' technology integration. Adapted from Inan & Lowther's path model (2010, p. 941)

on classroom instruction and learning activities." Perceptions of readiness and beliefs about laptops were measured using the Teacher Technology Questionnaire (see Lowther & Ross, 2000). The resulting model explained 55% of variance in laptop integration. Strong statistically significant direct effects were observed from teacher readiness and beliefs. The researchers suggest future studies should extend their work to include additional variables (Inan & Lowther, 2010). In the current study, the effect of subject areas on teachers' integration of technology is explored, in relation to teacher readiness, teacher beliefs and integration. Whether the effect of subject area is also moderated across time, is also examined in this paper.

Methods

Subject areas and teachers' integration were explored as part of a larger study of Australian teachers and students participating in the Digital Education Revolution initiative, in the state of New South Wales (DER-NSW). The DER was a federally funded program aiming to provide all secondary (Years 9–12) students and teachers with ICTs (Department of Education Employment and Workplace Relations [DEEWR], 2012). Each state chose to implement the program differently. In NSW, the DER was implemented as a one-to-one laptop initiative, providing laptops for all secondary teachers and Year 9 students between 2009 and 2013. Students kept the laptops until they completed high school.

The NSW Department of Education and Communities funded a state-level evaluation of the DER program from 2009 to 2013. The primary research question of this evaluation, relating to analysis presented in this paper, was "How does the DER-NSW program influence teacher pedagogy?" Data were collected over three years (2010–12) through online questionnaires and school cases studies. This design allowed for collection of broad descriptive baseline data, which guided more detailed exploration through case studies.

The evaluation included all public secondary schools across the state (n = 600). Participation in the study was voluntary and there was no control group. In 2010, all secondary teachers and Year 9 students were invited to participate. In subsequent years, all teachers were invited to participate, as well as the same cohort of students. Individual questionnaire participants were not tracked from year to year. Therefore, it is not possible to identify change in individuals. Results from the five case study schools, which are part of the larger study, are not included in this paper.

Participants

The analysis presented in this paper is drawn from 2010–12 teacher questionnaire data. Of the approximately 25 000 full-time equivalent secondary-level teaching staff in NSW, 4604 (18.4%) completed the questionnaire in 2010, 4227 (16.9%) in 2011 and 2806 (11.2%) in 2012. From participating teachers, results from three core subject areas, English, Mathematics and Science, were analyzed in this paper. The subject areas were selected for their representation of achievement in the two main disciplinary areas: Humanities and Sciences. English represents the Humanities, and Mathematics and Science represent the Sciences.

Table 1: Participation in three subject areas (2010–12)

Year	*Subject area*	*n*	*n%*
2010	English	568	12.3
	Mathematics	522	11.3
	Science	673	14.6
2011	English	561	13.3
	Mathematics	506	12.0
	Science	615	14.5
2012	English	389	13.9
	Mathematics	368	13.1
	Science	360	12.8

Table 1 shows that the sample of teachers in each subject area was proportionately similar over three years. These proportions were also representative of the state teaching population.

Measures

The teacher questionnaire contained three main subscales: computer use, teaching and learning, and school culture, with a total of 100 individual items. The computer use scale was adapted from the Programme for International Student Assessment ICT use and familiarity measure (OECD Program for International Student Assessment, 2006). It included items on frequency of use, confidence using laptops and ICT-related tasks, such as Internet searches and data manipulation. The subscale on teaching and learning addressed teachers' pedagogy and beliefs about integration, drawing on the NSW SchoolMap Best Practices Statements (Department of Education and Training, 2002). It also addressed teachers' beliefs about the bases of achievement in subject areas (see Maton, 2014). The school culture subscale drew from the work of Lee, Dedrick and Smith (1991), which considered teachers' satisfaction, efficacy and organizational environment. The compiled questionnaire was pilot tested in 2009 and revised. The reliability of the final teacher questionnaire was determined to be high for each subscale of the instrument, ranging from α .83 to .93.

The analysis presented in this paper draws upon a subset of 16 items from the teacher questionnaire. Items were selected for their alignment with variable descriptions from Inan and Lowther's model. The independent variables in this analysis were year (2010–12) and subject area (English, Science and Mathematics). Years, to be interpreted as "time," was examined to consider if integration was a result of experience and if subject areas showed different trajectories over time. For subject area, teachers were asked to respond in relation to their own practice, as well as nominate their primary content area of teaching. Table 2 presents the dependent variables.

Table 2: Description of variables in the conceptual framework

Variable	*Description*
(Laptop) integration	Teachers' self-rating of how frequently they used a computer (2010) and the laptop (2011–12) in teaching.
Teacher readiness	Teachers' perceptions of their skill level and effectiveness using the laptops in teaching.
Teacher beliefs: importance of computers	Teachers' perceptions of how important it is for them to use computers in their work, as well as for students to use computers in their learning.
Teacher beliefs: supports learning	Teachers' perceptions of how computers support student learning outcomes, eg, creativity, organization, understanding, etc.

The effect of subject area and year on the dependent variables was analyzed using Inan and Lowther's (2010) model as a conceptual framework. In regard to laptop integration, in 2010, teachers were asked about general computer use in their teaching as they had just received their laptops. In 2011 and 2012, teachers were asked specifically about using the laptops in teaching. Teacher readiness was aligned with items addressing teachers' confidence using the laptops in their teaching. In regard to teacher beliefs, "ICT is important" addressed if ICTs were important for success in the subject, while "ICTs support learning" considers how ICTS are related to student learning. Individual items within each measure were significantly correlated (Pearson $r = .34$ to .70, all $p < .01$) and combined into composite variables.

Analysis

Exploratory analysis confirmed that data satisfied assumptions of normality. The effect of year and subject area on dependent variables was explored using a 3 × 3 factorial (3 years [2010–12] × 3 subject areas [Mathematics, English and Science]) between-subject analyses of variance. The main analysis did not seek to compare findings with Inan and Lowther's path model. Rather, the analysis explored possible relationships between teachers' subject areas and known key factors of technology integration.

Results

Table 3 presents descriptive statistics for teachers' responses on each variable, in the three subject areas, between 2010 and 2012. Table 4 presents the main analysis. All follow-up pairwise comparisons are with Bonferroni adjustment controlling α at .05.

Results of the analysis of variance (ANOVA) indicated significant main effects of years and subject area on integration, but no interaction between years and subject area on integration (see Table 4). Follow-up pairwise comparisons revealed that teachers' laptop use between 2011 and 2012 remained consistent, $p > .90$. However, consistent significant differences were observed among all three subject areas on integration over the three years (see Table 3). On average, Science reported a higher frequency of integration than English ($p < .005$), and both ($p < .001$) reporting more frequency of use than Mathematics ($p < .001$, in both comparisons).

In regard to teacher readiness using the laptops, analysis showed main effects of years and subject area, but no interaction between the two (see Table 4). Follow-up pairwise comparisons showed

Table 3: Teachers' results on the four dependent variables

		Laptop integration[a]		*Teacher readiness*[b]		*Teacher beliefs: ICT importance*[b]		*Teacher beliefs: ICTs support learning*[b]	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
2010	English	6.17	2.00	2.69	.70	3.31	.59	2.51	.67
	Mathematics	5.68	2.27	2.61	.70	3.16	.57	2.32	.57
	Science	6.67	1.57	2.80	.63	3.37	.50	2.44	.57
2011	English	5.37	2.65	2.79	.67	3.29	.60	2.43	.69
	Mathematics	4.73	2.78	2.75	.63	3.18	.53	2.30	.57
	Science	5.77	2.59	2.90	.63	3.29	.54	2.37	.62
2012	English	5.45	2.87	2.89	.68	3.35	.59	2.50	.75
	Mathematics	4.68	2.99	2.75	.67	3.18	.56	2.29	.58
	Science	5.60	2.80	2.89	.69	3.26	.56	2.44	.69

[a]Scale 0 = *never*; 1 = *1–3 times a year*; 2 = *once a term*; 3 = *once a month*; 4 = *2–3 times a month*; 5 = *once a week*; 6 = *2–4 times a week*; 7 = *once a day*; and 8 = *many times a day*.
[b]Scale: 1 = *strongly disagree*; 2 = *disagree*; 3 = *agree*; and 4 = *strongly agree*.
ICT, information and communication technology; M, mean; SD, standard deviation.

Table 4: *Year and subject area effects on each dependent variable*

	Year		Subject area		Year × Subject area	
	F	η^2	F	η^2	F	η^2
Integration	66.16***	.032	52.38***	.025	.62	.001
Teacher readiness	15.52***	.008	16.69***	.009	.95	.001
Teacher beliefs: ICT importance	1.00	.000	26.94***	.012	2.56*	.002
Teacher beliefs: ICTs support learning	2.86	.001	23.97***	.012	.49	.001

***$p < .001$, *$p < .05$.
ICT, information and communication technology.

that teachers' confidence significantly increased between 2010 (M [mean] = 2.70, SE [standard error] = .02) and 2011 ($M = 2.81$, $SE = .02$; $p < .001$), with only a small nonsignificant increase between 2011 and 2012 ($M = 2.84$, $SE = .02$; $p > .80$). A closer look into the subject areas revealed consistent significant differences among the three groups over the three years: Science teachers reported more confidence than teachers in English ($p < .05$), and Mathematics teachers reported less confidence than teachers in Science ($p < .001$) and English ($p < .01$). However, English teachers showed an *increase* in confidence between 2011 and 2012 ($p > .05$), albeit not statistically significant, while Mathematics and Science did not report a change ($p > .80$ in both comparisons).

Findings indicated some fluctuation over the three years within the three subject areas on the two teacher beliefs variables: "ICT is important" and "ICTs support learning" (see Table 3). Table 4 shows a main effect of subject area on teachers' belief that "ICTs is important," but no effect of year. An interaction between year and subject area was observed. Pairwise comparisons showed significant differences among all three subject areas in "ICT is important," but unlike integration and teacher readiness, the nature of these differences changed over the three years.

In 2010, Science teachers reported more, but not significantly more, positive beliefs than English teachers ($p > .15$), and both reported significantly more positive beliefs about the importance of ICT than Mathematics teachers ($p < .001$ in both comparisons). In 2011, English and Science teachers reported the same positive beliefs ($p > .90$), while Mathematics teachers continued to show less positive beliefs than both ($p < .01$ for both comparisons). In 2012, English teachers reported stronger (albeit statistically nonsignificant) positive beliefs about the importance of ICT than Science teachers ($p > .10$). Mathematics teachers reported weaker positive beliefs than English teachers ($p < .001$) but not Science teachers ($p > .15$). Over the three years, Mathematics teachers reported relatively the same beliefs across all three years ($p > .90$; see Table 3). English teachers reported an overall nonsignificant *increase* in positive beliefs ($p > .40$), while Science teachers reported a steady *significant decline* in their beliefs about the importance of ICT ($p < .01$).

On how "ICTs support learning," teachers' responses showed nonsignificant shifts in agreement that ICTs supported learning between 2010 and 2012 (see Table 3). The two-way ANOVA indicated a significant main effect of subject area on teachers' beliefs in "ICTs support learning," but no effect of year and no interaction between the two factors (see Table 4). Pairwise comparisons showed consistent significant differences among all three subject areas in "ICTs support learning": English teachers ($M = 2.48$, $SE = .02$) reported *more agreement* than Science ($M = 2.42$, $SE = .02$; $p < .05$) and Mathematics teachers ($M = 2.30$, $SE = .02$; $p < .001$) that ICTs support learning in their subject. Science teachers reported stronger agreement than Mathematics teachers ($p < .001$). It is important to note that these beliefs did not change over the three years, regardless of time using the laptops and other ICTs and increased confidence. Moreover, English teachers reported the strongest agreement that ICTs supported learning and they were the only subject to reflect a strengthening of belief that ICTs were important in learning.

Discussion and conclusion

This paper investigated the possible relationship between subject areas and known key factors of technology integration: teacher readiness and teacher beliefs, both of which have been proven to have a direct impact on technology integration. Years was included in the analysis to observe if the relationship between subject areas and the factors changed over time. Findings show that subject areas contributed to the variance of teacher' beliefs independent of the amount of time participating in the one-on-one laptop program, that subject areas were not homogenous and that they had unique trajectories over time in technology integration initiatives. Ultimately, subject areas *do* matter in technology integration.

We present Figure 2 to illustrate our proposed conceptual model for the relationship among the variables. The proposed model is intended to build upon the significant relationships observed in Inan and Lowther's model.

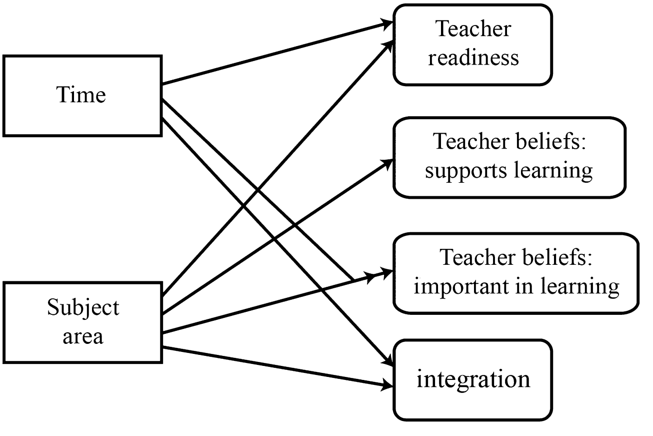

Figure 2: Proposed conceptual model

Results confirmed that year and subject areas had significant associations with integration and readiness. However, only subject areas had a main effect on beliefs. A small interaction between subject areas and years was observed. Results showed no effect of years on beliefs, suggesting the presence of possible features and values of subject areas relating to integration that were durable and independent of organizational initiatives, over the three years (see Artemeva & Fox, 2011). This is not to suggest that values would not change over a longer time period. The model will need to be tested on a different data set to confirm validity of the associations.

However, consistent differences in beliefs about ICTs in teaching and learning among the three subject areas, over the three years, demonstrates that subject areas are not homogenous. This is observed through different trajectories of ICT-related beliefs in the subject areas, such as Science teachers' lessening agreement that ICTs were important and English teachers' strengthening agreement, while Mathematics teachers' belief did not change. English teachers also reported a slight increase in laptop use between 2011 and 2012. Over a longer time line, these patterns are likely to be reflected more significantly in technology integration.

These differences echoed "matches" and "clashes" between technology integration and subject areas discussed in earlier research (see Goodson & Mangan, 1995; Howard & Maton, 2011). At the end of the three years, English teachers showed the strongest positive beliefs about the importance of ICTs and that ICTs supported learning, which suggests a strengthening "match" between the subject area and technology integration. Research has demonstrated that teachers' technology use is motivated by beliefs that ICT supports desired learning outcomes (see Ertmer & Ottenbreit-Leftwich, 2010). However, it is necessary to examine the underlying principles and relations to educational knowledge emphasized in the subject areas to understand *how* ICTs support what is important in learning.

The present study provided an initial investigation of the contribution of subject areas to teachers' technology integration. Further investigation is needed to fully understand the relationship between subject areas and technology integration. In particular, conclusions presented in this discussion will inform analysis of case study data collected as part of the larger project. Case studies explored bases of achievement in the subject areas, pedagogies relating to technology integration and "typical lessons," as well as how practice may have changed as a result of technology integration over the three years. Future research should also extend Inan and Lowther's model to determine if subject area is a factor within teacher beliefs at the teacher level, a cultural factor at the school level or outside the school in the wider disciplines. In addition, further investigation into how ICT supports learning in the subject areas is necessary, specifically considering unique positive and negative trajectories of integration. Understanding the deeper nature of relations to knowledge embodied in teachers' beliefs could help clarify why some subject areas are more likely to integrate technology or are more likely to have students perform certain technology-related tasks. This understanding is of critical importance as educational policy and curricula increasingly position ICT integration and related literacies as generic and undifferentiated across subject areas. As results from this analysis suggest, technology integration is not homogenous across subject areas and should not be treated as such. Relevant and appropriate technology uses that match with underlying principles of subject areas, such as the nature of success and relations to knowledge embodied in technology-related practices, need to be identified and explicated to teachers.

Interpretations of findings presented in this paper are limited because of the voluntary nature of participation, thus teachers' views may be positively or negatively biased, as well as the inability to track change in individual teachers over the three years. Future research should take these limitations into consideration, as well as test the model presented on another data set. Ultimately, this paper has shown that subject areas *do* matter. The next step is to build upon these findings to understand how better "matches" between subject areas and technology integration can be created to best support development of desired learning outcomes and student achievement.

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