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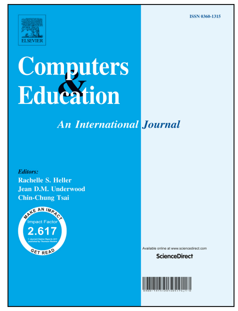

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Technology practices: Confirmatory factor analysis and exploration of teachers' technology integration in subject areas

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1. Abstract

It is thought that gains in student learning from the use of digital technologies are more likely to be related to teachers' practice than the technology itself. In secondary schooling, a key aspect of this is concerned with understanding how digital technologies are used to support teaching and learning in specific subject areas. Subject areas have their own conventions and expectations for learning that will influence teachers' technology use and technology-supported student tasks. The aim of this paper is to present confirmatory factor analysis of a scale considering common technology-related tasks in three subject areas. Data included in the current analysis are teacher questionnaires collected in 2010 (*N* = 3,624), as part of a large-scale one-to-one laptop initiative in Australia. Results from the 2010 data confirm a five-factor structure revealing significant differences in teachers' professional and instructional uses of digital technologies among three core subject areas: English, Mathematics and Science. Trends are confirmed through a second teacher data set collected in 2011 for Wave 2 of the same one-on-one laptop initiative. Implications of these findings in relation to understanding and supporting effective technology integration and areas of future research are discussed.

Keywords: technology integration, teachers practice, subject areas; task types

2. Introduction

The types of technology-related tasks teachers perform in their professional work, and those they ask students to perform as part of learning, are not random. They are underpinned by deep beliefs about teaching and learning, individual and group values, and driven by educational goals and aims. There is a large body of research examining teachers' technology use in relation to beliefs about technology, teaching and pedagogy (Hennessy, Ruthven, & Brindley, 2005; Inan & Lowther, 2010; Miranda & Russell, 2012; Prestridge, 2012); however, technology integration is not only about teachers' individual beliefs or pedagogy. It has been suggested that where teachers struggle to adopt, or seem to resist, technology integration, a contributing factor may be a 'culture clash' between that subject area and use of digital technology (Goodson, Mangan, & Cultures, 1995; Howard & Maton, 2011; Selwyn, 1999). There is a specific need for empirical work examining technologically-related practices in subject areas and the role of digital technologies (Scheuermann, Pedró, & Pedr, 2010; Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011).

This paper addresses the question of differences in teachers' technology use among three subject areas. A major premise of this investigation is that not all digital technologies and related teaching practices are equally useful in all subject areas. The use of digital technologies and related tasks results in unique affordances and effects in the learning environment, such as differences between use of data simulations (e.g. exploring complex systems; e.g. Rutten, van Joolingen, & van der Veen, 2012) and use of an online discussion (e.g. engaging in a critical discussion with peers; Hovardas, Tsivitanidou, & Zacharia, 2014). Each of these may be used in potentially different ways to engage in learning. Whether these differences are real or socially constructed (see Selwyn, 2010), they are a basis for selecting and integrating technology. Teachers are likely to use strategies and tools they *feel* support teaching aims and are relevant to student learning (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012). However, research has also identified that subject areas have an effect on technology integration (Goodson, Mangan, & Cultures, 1995; Hennessy et al., 2005; Howard, Chan & Caputi, 2015; Selwyn, 1999). This suggests that, not withstanding the effects of other predictor variables on teachers' technology use, integration would also be about the specificities of subject areas, content being taught and affordances of digital technologies to support learning in these contexts.

This paper presents a scale measure (Teacher Technology Practices; TTP) addressing a range of common technology-related tasks, including those teachers perform and those they ask students to perform. This measure is then applied to empirically examine some differences in digital technology use among subject areas. To do this, we first present a brief background of research into technology integration in schools and teachers' technology practices. The TTP scale measure is then presented and discussed. Testing of the measure was conducted using data collected as part of a four-year study of Australian secondary teachers within a state-level one-to-one laptop program (2010-2013). Using teacher data collected in 2010 (N = 3,624), a five-factor construct was identified, validated and then used to examine some simple differences in technology practices among three core subject areas: Mathematics, English and Science. Results were compared with a second set of data collected in 2011. It is beyond the scope of the present paper to examine the full 2010-2013 data sets for the longitudinal trends of the identified factor structure. However, future analysis will continue validating the factor structure and examining trends over 2012 and 2013.

Much of the research examining differences in subject areas and digital technology use has been qualitative (Hennessy et al., 2005; Ottenbreit-Leftwich, 2012; Webb & Cox, 2004). The current research builds on existing knowledge of teachers' beliefs, pedagogies and learning contexts to empirically explore some of the different ways technology integration occurs in core subject areas. Understanding 'effective use of technology is a prerequisite to any realization of positive educational outcomes resulting from [technology] resources' (Bebell & O'Dwyer, 2010, p. 7). The research extends current knowledge by providing a framework through which relations among current technologies, teaching strategies and learning can be examined. Finally, we will address how the TTP measure may be used in future research, specifically to explore trends in the 2012 and 2013 data sets, and how the TTP may be improved.

3. Background

Over the past few decades, there has been a dramatic increase in access to information and communication technologies (ICTs) available in school classrooms, but comparable integration of these tools across teaching and learning is still very inconsistent (Ertmer &

Ottenbreit-Leftwich, 2013; Perrotta, 2013). Some of this inconsistency and variation arises from complex questions about effective integration and their effects on learning.

Digital technologies and subject areas

In secondary schooling, a particular area of concern for many teachers continues to be how digital technologies are most effectively integrated in their subject area (Hennessy et al., 2005; Perrotta, 2013; Warschauer, Cotten, & Ames, 2011). Limited understanding of digital technologies and incomplete empirical evidence has resulted in difficulty applying effective instructional methods in different learning contexts (Davies & West, 2014).

That said, research has provided a strong basis for identifying that integration *is* happening (see Inan & Lowther, 2010; Warschauer et al., 2011) and that there is a critical relationship between teachers' beliefs and technology integration (Ertmer & Ottenbreit-Leftwich, 2010). However, there have been relatively few studies investigating technology integration in specific subject areas. A key study in this area is Goodson et al.'s (1995) investigation into the effect of microcomputer use in Canadian classrooms. The authors found that technology use seemed to preference small-group instruction, which resulted in some subject areas being more conducive to technology integration. The authors identified these differences as *culture clashes*. Culture clashes were based on whether teachers believed technology integration was compatible with their subject area (Goodson et al., 1995).

Over the past two decades, other research has come to similar conclusions that values and norms of some subject areas fit better with computers, suggesting fundamental components of the subject area may match or clash with technology integration. Hennessy et al. (2005) found that teachers in some subject areas exhibited a greater commitment to integrating ICTs in their practice. For example, they found that Science teachers felt use of ICTs could support, or even replace, laboratory activities. Yet, English teachers were concerned that ICTs 'seemed to contradict core values of the subject culture' (Hennessy et al., 2005, p. 23). A more recent study looking at Australian secondary teachers' computer use identified differences in frequency of use and perceived value of computer use in English, Mathematics and Science (Howard et al., 2015). Between 2010 and 2012, researchers found that use in Science and Mathematics decreased, but increased in English. Results showed that technology integration was not homogenous across subject areas, which suggests integration may happen differently among subject areas.

While research is starting to unpack some of the broad features of teachers' technology-related practice, such as values and beliefs, it is also necessary to understand subject specific practices. Teaching in different subject areas requires different practices and resources (Ottenbreit-Leftwich, 2012; Spillane & Hopkins, 2013). Many common technologies are quite flexible and general, and they can support a range of learning objectives, while those designed for education often aim to achieve specific learning objectives (Cox & Marshall, 2007). The necessity of understanding how different technologies are used in teaching and learning is highlighted in Tamim et al.'s (2011) meta-analysis of 25 years of educational technology research. They found that improvement in learning when using digital technologies results from a combination of teachers' pedagogy, teaching strategies, curriculum and school culture, rather than the availability of a technology per se. Tamim et al. (2011) call for further research into teachers' practice to better understand these relationships. To do this, empirical tools are needed that can support examination of differences and similarities of teachers' practice with digital technologies across a range of subject areas and contexts.

Teachers' technology practice

In the current discussion, teachers' *technology practice* is the integration and use of digital technologies to perform tasks supporting learning and teaching. 'In order for instruction to support learning, it is essential that we understand the nature of tasks that learners are asked to perform' (Jonassen, Tessmer, & Hannum, 1999, p. 3). There has been some disagreement about which technology-related tasks should be examined when evaluating technology integration and teachers' technology practice. Generally, teachers' technology practice has been studied in relation to two categories: professional and instructional (Cuban, 2001; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010; Russell, Bebell, O'Dwyer, & O'Connor, 2003; Wozney, Venk, Abrami, & Venkatesh, 2006). In some cases, researchers have separated professional purposes and instructional purposes (e.g. Cuban, 2001), arguing that technology use apart from students does not relate to learning. Conversely, Bebell et al. (2004) have argued that teacher preparation activities, such as creating worksheets or preparing slides, while done outside of the classroom, directly support student learning. In their work, the authors address a full range of teacher activities relating to technology use and different technology-related tasks. They measured teachers' technology use across seven dimensions: Preparation, Professional email, Grading, Student use, Student products, Delivering instruction and Accommodation (Bebell et al., 2004). While the seven dimensions present a range of technology-related tasks teachers may perform, they were general and did not relate to specific teaching strategies or learning, such as collaboration or investigation. Bebell and Kay (2010) present a more specific measure of teachers' technology use in their study of a one-to-one program implemented in the northeast United States between 2006 and 2008. In this research, they identified specific use of technology-related teaching strategies for professional tasks, 'use a computer to deliver instruction to your class' and 'make handouts for students using a computer,' and instruction, such as 'create WebQuests or build Internet into a lesson,' 'help students better understand a concept' and 'model relationships' (Bebell & Kay, 2010, p. 20). These categories identify specific tasks teachers' assign using technology. However, they do not relate to what type of learning would be afforded through this task, such as higher order thinking skills or collaboration (e.g. Wozney et al., 2006). Therefore, in their findings, it was difficult to draw conclusions about how technology integration tasks relate to desired learning outcomes.

Ottenbreit-Leftwich et al.'s (2010) qualitative study brings these two sides together in their examination of teacher and student needs, in relation to technology use. First, categories of 'teacher' and 'student' needs can be related to professional and instructional uses of technology. Their research examined eight teachers' use of technology. They found that teachers' needs (professional) were motivated by perceived improvements in efficiency and effectiveness in the work of teaching. Types of tasks identified were: facilitating classroom operations (e.g. online grading, online sharing of student work samples, and communication with parents, etc.), organization, creating specific classroom materials, and engaging in professional development. Teachers' use of technology for students' needs (instructional) were motivated by the aim of engaging and motivating students, improving comprehension and higher-order thinking skills (e.g. visualizations and manipulating data), and in anticipation of skills students would need in future work and learning (e.g. communicating learning, future work, real-world connection). Their qualitative study draws teachers' motivations into relation with specific digital technologies. This provides a basis through which digital technology use can be examined with expected or desired learning outcomes across learning contexts.

The current study is guided by the studies presented above. However, the measures discussed above were not used to examine differences in teachers' practice among subject areas. The TTP measure, presented in the current paper, addresses several key technology practices that fall within professional and instructional categories (see Table 1). Examining teachers' use in their own practice, and what they ask students to do with technology, can provide a framework to then investigate similarities or differences among subject areas.

Examining practice in relation to subject area provides a more nuanced understanding of teachers' values and beliefs relating to technology use. This is particularly important at the secondary school level, where teachers' subject area strongly influences their professional identity and teaching practice (Grossman & Stodolsky, 1994).

4. Theoretical underpinning

Technology integration is not a homogenous practice. It has a specific role, importance and use in the different subject areas. From a social realist perspective, specifically Legitimation Code Theory, it is possible to consider how components of teaching practice *reflect* core features and organizing principles of subject areas (Maton, 2014). Two key features related to learning are: the nature of success and educational knowledge. Individual beliefs and subject area conventions about learning are enacted in the selection, use and/or non-use of different technologies (see Ertmer & Ottenbreit-Leftwich, 2010; Hennessy et al., 2005). These can be observed through choices to use technology, frequencies and patterns of that use.

Theoretically, to support learning teachers choose to use technologies that *match* key features of subject areas. For example, in Mathematics, practicing solving equations is an important component of learning. Therefore, teachers will often feel positively about digital technologies that support students' practice of this skill, such as self-guided tutoring and 'drill and practice' games (Howard & Maton, 2011). The TTP scale provides a mechanism through which some of teachers' technology-related practices can be explored and compared. Individual practices can then be analysed for features and organizing principles and how these related to the subject area, other contextual variables of teaching and learning, and how this affects technology integration.

5. Development of the TTP

The TTP scale was developed as part of a larger questionnaire (102 items) designed to evaluate secondary teachers' beliefs about and uses of digital technologies, in a statewide one-to-one laptop initiative, the Digital Education Revolution in New South Wales (DER-NSW), Australia (for a full discussion of the program see Author/s, 2013). The DER-NSW was part of a federally funded program aiming to provide all secondary students (Years 9-12, Ages 14-18) and teachers with new and upgraded information and communication technologies (ICTs; Department of Education Employment and Workplace Relations, 2012). In NSW, Year 9 students were provided with a personal laptop, beginning in 2008 and ending in 2013. All full-time secondary teachers were also provided with laptops. The NSW Department of Education and Communities (DEC) funded a four-year mix-method evaluation of this program from 2010 to 2013, which included student, teacher and parent online questionnaires and five school case studies. The questionnaires and case studies addressed technology use, beliefs and perceptions of school culture. The data presented in this paper are teacher questionnaire results from 2010 and compared with results from 2011. The DER-NSW research question relevant to the current discussion is: What impact did the DER-NSW laptops have on teachers' pedagogy? The specific research question addressed in the current analysis is: What are the differences in teachers' technology use among subject areas?

The TTP scale comprises technology-related tasks performed by teachers (professional) and those they ask students to perform (instructional). Task types included in the TTP measure were based on NSW DEC technology integration priorities between 2010 and 2013 (see AIS NSW, 2011). Specific items addressing teachers' professional practices were adapted from the Maine Learning Technology Initiative (MLTI) Teacher Survey Form B (Silvernail & Lane, 2004), which included developing learning resources, presenting content and communicating using technology. Items addressing instructional tasks were adapted from the NSW Quality Teaching questionnaire (TPS-QTS; Ramsey, 2000) and the Programme for International Student Assessment (PISA, 2003) student technology questionnaire. These items asked teachers about their use of digital technologies to support higher-order thinking strategies in teaching, e.g. questioning and group collaboration in learning, and also how they ask students to use computers, e.g. to take notes or create a chart. The TTP expanded the PISA measure to consider increasing complexity of technology tasks. For example, teachers were asked if they had students use computers to i) 'research information about people, places and things', ii) 'gather information from different places to solve a problem', and iii) 'gather data or information about a real-life problem'. While not intending to present a true scale of technology complexity, the design allowed for a range of different practices to be identified. Some newer practices, such as 'sharing students' work online' were included in the scale. It is important to include newer uses of technology in teaching to capture a range of practices and examine how they change over time.

Forty-five items were compiled for the initial TTP scale. The scale was pilot tested in four focus groups, with five secondary teachers in each group (N = 20). Focus groups considered the language of each item, their understanding of question intent, relevance to NSW teachers and consistency with existing state-level teaching and technology policy. After this initial pilot stage, 15 items from the TTP measure were removed for redundancy, irrelevance and/or lack of clarity.

The remaining 30 items were piloted a second time using an eight-point response scale, based on a 'rough numerical estimate' (Ajzen, 1991): 'many times a day' (8), 'once a day' (7), '1-3 times a week' (6), 'once a week' (5), '1-3 times a month' (4), 'once a month' (3), 'once a term' (2), '1-3 times a year' (1) and 'never' (0). This scale expanded the five-point PISA scale. Questionnaire items ask teachers to recall i) 'on average, how frequently do you use a computer to perform the following…' (professional); and, ii) 'how often do you require students to perform the following tasks using a computer?' (instructional). The aim of this second pilot study was to determine the independence of items included in the TTP measure.

Twenty-two teachers from four different secondary schools completed the full questionnaire online. Teachers represented the core subject areas of English (*n* = 6), Mathematics (*n* = 3), Science (*n* = 6), History (*n* = 1), Physical Education and Health (*n* = 2) and Other (e.g. Home Economics; *n* = 3). On average they reported using computers in the classroom 'many times a day' (*M* = 7.29, *SD* = 1.15). Results showed that item correlations exceeded .3, but were not larger than .8. All 30 items in the TTP scale were retained in the two sub-scales: professional (10 items) and instructional (20 items) uses.

After the second pilot study, the 30-item TTP measure was distributed to all NSW secondary school teachers through their DEC email account. Of the approximately 25,000 full-time equivalent secondary-level teaching staff across the state of NSW, 4,604 (18.4%) participated in the questionnaire. A subset of 300 cases was randomly selected to conduct exploratory factor analysis, using principal axis factoring and varimax rotation, to hypothesize factor structure. This sample satisfies the 10:1 rule of thumb for conducting exploratory factor analysis (Costello & Osbourne, 2005). In the interest of space, the full analysis is not presented in this discussion. Based on this analysis, a five-factor model for the TTP was hypothesized (see Table 1).

<<insert Table 1 here>>

The hypothesized five-factor model presents three instructional and two professional factors, which demonstrates the two types of teacher practice discussed in previous research (e.g. Ottenbreit-Leftwich et al., 2010; Bebell & Kay, 2010; Wozney et al., 2006). For the instructional tasks, FAL and DAV factors address specific technology-related tasks, while

WCO includes practices where technology supports students work. The professional tasks divide among teachers' online work (OIC), which may support teaching, and their direct work preparing and delivering teaching (PAD).

6. Use of the TTP

The following discussion will address the confirmatory factor analysis of the TTP scale in 2010. The resulting model will then be used to examine trends in the data from 2010 to 2011.

Sample

For the main analysis and testing of the five-factor model, 4,304 participants were initially included in the 2010 teacher data set. Analysis of missing value patterns suggested the data were nonmonotone, in that participants skipped items. Of these missing data, 680 cases were deleted. Remaining missing data were imputed using Mersenne twister (Matsumoto & Nishimura, 1998). Independent t-test and Kruskal-Wallis test show no significant difference between imputations ($p = 1.00$). The final monotone sample used in analysis included 3,624 cases (> 1.5% missing data).

Participating teachers represented a range of subject areas (see Table 2).

<<insert Table 2 here>>

According to the NSW DEC, the participating sample was representative of teacher distribution of core subject area teachers in NSW secondary schools, such as Mathematics, English, Science and Human Society and Its Environment (HSIE). Overall, teachers reported using computers in their teaching '1-3 times a week' ($M = 6.51$, $SD = 1.86$), which was consistent with other studies in the area (see Bebell & Kay, 2010; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010). Full descriptive results for each subject areas across the

30 items included in the initial scale are included in supplementary materials (Supplemental 1).

Reliability and validity

The reliability of the 30-item TTP measure was satisfactory (alpha = .94). Kolmogorov-Smirnov and Shapiro-Wilk tests both showed nonnormality on all items ($p < .01$). However, due to the large sample size ($N > 1000$) normality does not need to be assumed for linear factor analysis models (Amemiya & Anderson, 1990). Factorial validity of the TTP five-factor model was examined using confirmatory factor analysis and maximum likelihood (ML) estimation. ML was used to maximize the probability of a good model fit and has limited bias with large samples (Freedman, 2009).

The goodness-of-fit of this model was assessed by the following fit indices: Adjusted Goodness-of-Fit Index (AGFI); Root Mean-Square Residual (RMR); Tucker-Lewis Index (TLI); Normed Comparative Fit Index (CFI); Parsimony-adjusted Comparative Fit Index (PCFI; Hooper, Coughlan, & Mullen, 2008). Adjusted Goodness-of-Fit Index calculates the proportion of variance accounted for by the estimated population covariance. The statistics is reported between 0 and 1, with acceptable values being > .90. However, AGFI will report a reduced fit for less parsimonious models, such as in social sciences and the statistic is affected by large sample sizes, and is therefore considered in relation to other fit indices (Hooper et al., 2008). The RMR is the square root of the difference between the residuals of the sample covariance matrix and the hypothesised covariance model. This index is appropriate as all items use the same 1-8 range. A value of .50 or less indicates an acceptable model fit (Steiger, 1990). The TLI is a relative fit index, like the Normed Fit Index (NFI). It assesses the model by comparing the Chi-squared value of the model and the null model. Acceptable values for this index should be close to .95 (Hu & Bentler, 1999). The CFI also compares the model with the null model, where the null model variables are assumed to be uncorrelated. The CFI values larger than .9 indicate a good fit, ideally approaching > .95 (Hu & Bentler, 1999). Fit statistics are presented in Table 3.

Upon inspection of the 30-item 5-factor model (Model 1), Item 16t (“On average, how frequently do you engage in self-assessment tasks?”) was deleted. While it identified adequately with its hypothesized factor (WCO; loading of .43), it also cross-loaded on other factors (FAL .37, DAV .21 and WCO .33; df < .2). A second item on the hypothesized FAL (Model 2), 16d (“How often do you require your students to write, send, and receive emails?”), which also cross-loaded on other factors (FAL .55, OIC .41; df < .2), was removed and model fit was achieved (Model 3), as TLI and CFI > .90. The 28-item Model 3 was adequate as both TLI and CFI (.91 and .92, respectively) met or exceeded the recommended criterion of .90. However, item 11c (“On average, how often do you use PowerPoint in classroom instruction?”) showed an overestimation of loading on the OIC factor (1.03) and was therefore removed from the model also. Fit indices for the final 27-item model exceeded recommended thresholds confirming that the model is adequate (see Table 3).

<<insert Table 3 here>>

In addition to model fit indices, factor loadings and squared multiple correlations were examined (see Table 4).

<<insert Table 4 here>>

Squared multiple correlations (R^2) for individual items shows that the model is adequately represented by the observed measures, and between 42% and 96% of the variance on individual items is accounted for by their assigned factors. The combined fit indices, factor loadings and squared multiple correlations supported the factor structure of the TTP scale. Further, all observed variables were found to be significant, with t-values > 1.96 (p < .05). All factor loadings are statistically significant (p < .05). The items on four of the five factors are within the ranges recommended for social science research (> .32; Costello & Osbourne, 2005). All five factors were accepted in the model because individual errors were uncorrelated, all factors were appropriately correlated (all $r > .274$), each indicator only loaded on one factor and covariances did not equal zero (Ullman, 2006). The factors with two indicators, Working Collaboratively (WCO) and Preparation and Delivery (PAD), were retained because they were theoretically appropriate for the domain (Little, Lindeberger & Nesselroade, 1999), reflecting task specificity of teachers' technology use (e.g. Bebell & Kay, 2010).

Online Interaction and Communication (OIC) exhibited low item loading. One possible explanation for this is that over 45% of teachers indicated 'never' having created a website (11d), participating in online discussions (11f), sharing teaching resources online (11g), posting examples of student work online (11i) or using online simulation sites. The factor has been retained in the model because the overall model - including the OIC factor - exhibits a good fit and is representative of the observed data. These practices correlate with a higher frequency of computer use in teaching (r = .23 to .33). This result reflects that the scale design is able to include well-accepted technology tasks (e.g. researching online and using spreadsheets) and newer practices (e.g. participating in online discussions). This is an important aspect of the model, as the landscape of technology use changes rapidly.

Descriptive statistics for the five factors, across the whole sample are presented in Table 5. To further assess the validity and meaningfulness of the five factors, each is examined in relation to other beliefs and frequency of computer use. For this, variables addressing: i) how often teachers use computers in the classroom, ii) if teachers think about how technology enhances learning when planning, and iii) teachers' perceptions regarding the importance of ICTs in teaching and learning were identified (see Table 5 for descriptive statistics).

<<insert Table 5 here>>

Results show that the five factors have good correlation with the three variables (see Table 6).

<<insert Table 6 here>>

As the five factors comprise teachers' frequency of technology-related tasks, it is logical that results would correlate with overall use of computers in teaching. Moreover, in their selection and integration of technologies, research has demonstrated that teachers will think about how technology integration contributes to the social culture of the classroom, teaching and learning (Subramaniam, 2007). If technology-related practices are perceived to be more important in teaching and learning, they are more likely to be used (Ertmer et al., 2012; Miranda & Russell, 2012; Perrotta, 2013). Results demonstrate that the five factors relate to teachers' thinking during their planning about how technology enhances learning. Other research has identified that teachers in different subject areas demonstrate different beliefs about the importance and value of technology in teaching and learning (Hennessy, Deaney, & Ruthven, 2003; Howard et al., 2015).

A series of one-way ANOVAs on the five factors was conducted to explore possible differences in teacher practice among the subject areas (see Table 7).

<<insert Table 7 here>>

In Table 7, Subject Area is treated as the independent variable, which includes three core NSW academic subjects: English, Mathematics and Science. The three key variables and the five factors are treated as dependent variables. Results show that Subject Area had a stronger effect on two of the instructional factors, FAL and DAV. Weaker effects were observed on the remaining instructional factor WCO and the professional factors PAD and OIC. This suggests that Subject Area relates more to perceptions of students' needs to accomplish learning outcomes related to tasks, and less to teachers' professional needs or students' to work in a collaborative learning environment. Mathematics teachers' mean responses were significantly different from those for English and Science teachers on PAD, WCO, OIC and FAL. Teachers in the two latter subject areas did not show significantly different responses on these four factors. The only factor that significantly differed across all three subject areas was DAV. Science teachers reported higher frequency of use on DAV than Mathematics teachers who, in turn, reported higher frequency of use than English teachers.

Next, we examined the stability of the patterns of responding for the three core subject areas via a comparison of the three subject areas on the five factors between 2010 and 2011 (see Table 8). In 2011, 3,992 teachers completed the DER-NSW teacher questionnaire. In regard to the key variables, teachers' reported using the DER-NSW laptops an average of once a week (M = 5.33, SD = 2.70), they reported 'agreement' with 'thinking about technology in teaching and learning' (M = 3.22, SD = 66) and that ICT was Important in teaching (M = 3.31, SD = .56). The 2011 sample included 561 English teachers (14.1%), 506 Mathematics teachers (12.7%) and 615 Science teachers (15.4%). These sample sizes were not significantly different to 2010.

<<insert Table 8 here>>

Results show some small and mostly non-significant changes in frequency of use across the five factors, with some exception in DAV and FAL – the two instructional factors that showed the most variation among subject areas in the 2010 data. Overall, there were no significant changes in Mathematics teachers' practice between 2010 and 2011. Mathematics showed an increase on the FAL factor (ΔM = .16), but it was statistically non-significant. Science and English also reported increases in FAL (ΔM = .24 and M = .25, respectively).

These were both statistically significant changes between 2010 and 2011, but with no significant change between the two subject areas. Significant increases were observed in English and Science teachers' reported practice on the DAV factor between 2010 and 2011. The reported use also remained statistically different between the two subjects. Also noteworthy are the patterns of change in WCO from 2010 to 2011 across the subject areas. As shown in Table 8, despite the non-significant changes in frequencies within English and Science, the difference between the two became significant in 2011.

7. Discussion

The aim of this paper was to present the TTP measure as a tool to examine differences in technology-related teaching practice among subject areas. Results showed preliminary evidence of validity and reliability of the TTP 27-item five-factor model: i) Facilitate Learning (FAL), ii) Data and Visualization (DAV), iii) Working Collaboratively (WCO), iv) Online Interaction and Communication (OIC), and v) Preparation and Delivery (PAD). The hypothesized five factor structure of teachers' professional use of technology (OIC and PAD factors) and instructional use (FAL, DAV and WCO) demonstrated good fit and adequate relations to other variables of technology integration.

Using the TTP to compare three core subject areas, potentially informative differences emerged within teachers' technology-related professional and instructional practices. First, in regard to the specific research question, results confirm that differences exist among the three subject areas and they are consistent over two years. First, findings do suggest a presence of 'culture clashes' among subject areas and certain technology-related practices. These findings demonstrate agreement with previous research (e.g. Goodson et al., 1995; Hennessy et al., 2005; Ottenbreit-Leftwich, 2012; Selwyn, 1999; Webb & Cox, 2004). However, findings from this analysis provide an emerging and more detailed view of teachers' technology use, and how this varies according to different subject areas. An important aspect of this was the strength of effect of subject areas on instructional technology-related practices. However, the relationship among factors of technology integration is complex and must be considered in relation to other key factors of integration. Other research in the area has shown that teachers' beliefs, including pedagogic approach and beliefs about technology, and readiness, affect teachers' frequency of integration (e.g. Ottenbreit-Leftwich et al., 2010). Teachers' beliefs about technology integration, in turn, have been shown to be affected by subject area (e.g. Howard et al., 2015). This suggests that, in conjunction with other important factors such as teachers' pedagogy, beliefs and school leadership, subject area is an important part of teachers' technology use and integration.

Our data suggest that the professional factors, PAD, WCO and OIC, are stable within core subject areas over a two-year period. Across the three subject areas, teachers reported using computers in teaching an average of 1-3 times a week in 2010 and using the DER-NSW laptops an average of once a week in 2011. Results suggest a large portion in both years would be for professional activities, considering that teachers in both years reported using computers for preparation and delivery one to three times a week. This finding supports previous research identifying that teachers were likely to use technology for professional tasks and teaching preparation and delivery (Ertmer et al., 2012; Inan & Lowther, 2010). However, Mathematics teachers reported lower frequencies of use on all professional factors. Mathematics teachers also used laptops less frequently than the other two subjects, which has been previously identified (see Holcomb, 2009). As teachers' professional work, development and access to resources is increasingly available online (Duncan-Howell, 2010; Webb, 2014), these findings suggest implications for how Mathematics teachers may need to change their professional use of digital technologies, not only how they use technology instructionally. Overall, Subject Areas only showed small effects on professional factors.

Changes from 2010 to 2011 for PAD, WCO, and OIC were all non-significant for the three core subject areas.

Larger effects of Subject Area were observed on instructional tasks, specifically on factors FAL and DAV. In English and Science, statistically significant changes were observed on these factors between 2010 and 2011. These two factors can be used to analyze differences in digital technology use related to educational knowledge in the subject areas. For example, the Facilitating Learning factor largely comprises productivity tasks, such as writing and searching for information (see Table 4). English and Science reported similar frequencies performing these tasks. Research has reported school Mathematics being more about problem-solving, understanding and skills practice (Beswick, 2012) rather than writing and research (Howard & Maton, 2011). This similarity may be a result of English and Science, as school subjects, having a task focus on writing: written communication in English (Hennessy et al., 2005; Holcomb, 2009) and creating laboratory reports in Science (Rutten et al., 2012). Mathematics exhibited a lower frequency on this factor. This may reflect a different focus, such as practicing solving equations and graphing.

However, comparisons of subject areas are not so straightforward. While in this example, Mathematics and Science may exhibit differences on school tasks involving word processing and internet research to support learning, at the level of discipline they are more closely related and English demonstrates more difference (Kelly, Luke, & Green, 2008). This shift in disciplinary relation is illustrated through the DAV factor. Here, English and Science demonstrated a more traditional division, with English teachers reporting a much lower frequency of use. Digital technologies supporting data and visualizations tasks, e.g. creating charts, graphs and using simulations (see Table 4), are often aligned with teaching and learning content and conventions in Mathematics and Science (Ruthven, Deaney, & Hennessy, 2009; Rutten et al., 2012; Webb & Cox, 2004). However, frequency of use in

Mathematics was still significantly lower than that in Science. While data and simulations may be less central to traditional teaching practices, visualizations of language, concept mapping and use of multimedia to illustrate concepts or ideas are becoming increasingly more common (e.g. Hwang, Kuo, Chen, & Ho, 2014; Macken-Horarik, 2009). However, in 2011 English and Science teachers show significant increases in data and visualization use, while Mathematics does not change. The current analysis only demonstrates that there are differences among the subject areas on the FAL and DAV factors and some possible matches and clashes. At this point, results do not provide clear explanations for these differences or change. These trends would need to be examined more closely in relation to teachers' beliefs about technology and pedagogy to gain a more complete picture of why and how these tasks are employed. These results *do* provide a basis to understand which types of tasks happen in the subject areas, which can provide a more complete picture of students' total exposure and experience with digital technologies.

The conventions surrounding students working collaboratively (WCO) are less established than writing and working with data, which may be reflected in the effect of subject areas on WCO being much weaker. This may also be a result of English and Science again reporting similar frequencies in 2010 and only marginally difference in 2011. Overall, significant change on this factor was not observed between 2010 and 2011. Interestingly, the correlation of students working collaboratively and more frequent use of technology demonstrate agreement with Goodson et al.'s (1995) findings that small groups are more likely to use computers. However, the WCO factor addressed more general quality teaching practices supported by technology, rather than explicit tasks. These may be aligned with teachers' professional practices related to interaction and communication or other conventions of the subject area, as well as their technological readiness to support this kind of task. Further analysis is required to understand this trend.

Ultimately, results demonstrate that the five factors provide a way to discriminate among different types of technology use, to better understand technology integration in the subject areas. This has implications for understanding links between teachers' practice and how students are asked to use digital technologies across a range of subject areas, where there is overlap and where types of digital tasks may be unique. The comparisons and discussion highlights how the TTP can provide a basis through which differences among subject area in teaching and learning can be examined. In this study, differences among subject areas were stable over two years, with the largest effect being on instructional practices. This simple comparison provides a method to conceptually isolate and explore differences in teachers' technology use across both instruction and professional uses. Identification and examination of these differences provides evidence to investigate deeper questions about conventions of practice, pedagogies and beliefs in subject area teaching.

8. Future research and conclusions

Subject areas are only one piece of the technology integration puzzle and one that requires further exploration. As stated by Bebell and Kay (2010) study results from one-to-one computing programs should not be viewed as a definitive assessment of educational technology, but as an example of potential in teaching and learning. Findings from use of the TTP provides a view of different practices across three subject areas in the DER-NSW study, which can help construct a picture of teachers' technology use and the range of ICT-related skills and practices students experience across different subjects. This analysis contributes to our knowledge of technology integration across teachers' practice and students' potential combined learning experience.

However, it is necessary to identify implications of *how* and *why* teachers' technology-related practices occur differently in subject areas. This is an important step in being able to better understand how instructional goals are - or could be - met through technology integration (Ross, Morrison, & Lowther, 2010). To extend the current research, the five-factor model TTP model will be further validated and examined for invariance in the DER-NSW 2011-2013 teacher questionnaire data sets. Further validation is particularly important to test the strength and stability of the working collaboratively (WCO) and preparation and deliver (PAD) factors, which had only two indicators each (Costello & Osborne, 2005). Initial differences among subject areas will be used as a starting point to explore underlying principles of teachers' beliefs (e.g. Ertmer et al., 2010), perceptions of readiness to use technology (Inan & Lowther, 2010), beliefs about school culture and leadership (Law et al., 2008). Items addressing these factors were part of the DER-NSW teacher questionnaire. Examination across additional subject areas is also needed, to further test and validate the effect of Subject Area on technology integration. This would be particularly interesting in relation to practical-based (e.g. Physical Education and Creative Arts) and non-core (e.g. Business Studies and Modern History) subjects. Research should also consider differences across grade levels and among different schools. Findings will also be triangulated with DER-NSW interview and focus group data from the case studies, addressing the basis of success in subject areas.

A limitation of this study is the range of technologies included in the scales and the number of subject areas in the initial analysis. Additional generic practices, such as those included in Facilitate Learning, should be identified and tested in the model. This is important as technologies enter the educational space and practices will continue to evolve and change (Bebell et al., 2010), and new practices such as the use of interactive maps, social networking and skill practice websites will take on different roles in teaching and learning. As this occurs, future research should build upon tools such as the TTP to include new tools and different 'subject specific' technology practices. An example of this would be 'use of simulations'. In the current analysis, the item was retained in the model, even though it had a low loading on the Data and Visualization factor. The reasoning was that the practice is very specific to Science, and therefore exhibited less of a presence across the whole teacher population. Practices such as these are important in the specific subject areas and should be examined in relation to the more generic and broad TTP factors to understand how they integrate with teachers' wide technology-related practice. There was also an overrepresentation of Technology teachers in the sample, which may have positively biased the sample towards use of digital technologies and affected the factor analysis. In our further validation of the model and future analysis the effect of this will be explored.

We acknowledge that the TTP scale and the range of technology practices addressed are only a part of the technology integration puzzle. However, examination of teachers' professional and instructional practices in relation to subject areas presents a step forward in this area. More instrumentation is needed to measure the effect and impact of technology integration (Scheuermann et al., 2010). The TTP and findings presented in this paper provide a basis for further research into the relationships between subject areas as a factor of technology integration, along with teachers' beliefs, readiness to use technology, school leadership, etc. The ultimate aim of this work should not be for all practices to occur in all teaching contexts, but to understand why some technology practices are selected and integrated, and which are the most effective and useful in supporting teaching and learning.

9. Acknowledgements

<<insert Acknowledgements here>>

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Table 1

Hypothesized TTP factor structure

Factor	Descriptor	# of items
Instructional		
Facilitate learning (FAL)	Teachers have students work with information, content and writing.	6
Working with data (DAV)	Teachers have students work with data and/or visualizations using technology.	5
Working collaboratively (WCO)	Teachers have students work together to negotiate learning using technology.	9
Professional		
Online interaction and communication (OIC)	Teachers participate in discussions, share work and contact parents through various technology tools.	7
Preparation and delivery (PAD)	Teachers use technology and online resources to develop and deliver instruction.	3

Table 2

Distribution of teachers' core subject areas

Subject area	*n*	%
English	452	12.5
Mathematics	414	11.4
Science	561	15.5
Human Society and Its Environment (HSIE)	473	13.1
Physical Education	230	6.3
Creative Arts	260	7.2
Technology (e.g. Programming)	606	16.7
Languages	84	2.3
Other (e.g. Library, teaching assistants)	535	14.8
Missing	9	.2
Total	3624	99.8

Table 3

Fit indices for the proposed model

	CMIN	*df*	AGFI	RMR	TLI	CFI	PCFI
Initial 30-item model							
Model 1	28896.99	395	.77	.46	.81	.83	.75
29-item model							
Model 2	13988.93	339	.87	.34	.90	.91	.76
28-item Model							
Model 3	11937.10	313	.88	.33	.91	.92	.77
27-item Model							
Model 4	18120.35	289	.92	.28	.94	.95	.78

Note. CMIN = chi-square likelihood ratio; *df* = degrees of freedom; AGFI = adjusted goodness-of-fit index; RMR= root mean-square residual; TLI = Tucker-Lewis index; CFI = normed comparative fit index; PCFI = parsimony normed comparative fit index.

Table 4

R^2 and factor loading of the 27-item TTP measure

	R^2	FAL	DAV	OIC	WOC	PAD
16a. Write a first draft	.65	.42				
16b. Edit their written work	.69	.47				
16c. Take notes	.59	.35				
16e. Organise their work	.64	.41				
16f. Research information on people, things, or ideas	.82	.67				
16g. Create simple presentations	.78	.59				
16k. Gather information from different places to solve a problem	.78	.61				
16l. Gather data or information about a real-life problem	.77	.59				
16m. Evaluate the quality of information found on websites	.78	.60				
16o. Represent information visually	.76	.58				
16p. Create a product that incorporates pictures or graphics found on the web	.82	.67				
16q. Use different technology tools to complete a task	.72	.52				
11j. Use online simulation sites	.42		.18			
16h. Enter data into a database or spreadsheet	.92		.85			
16i. Use a spreadsheet to create a table or graph	.96		.91			
16j. Create a database or spreadsheet	.93		.86			
16n. Analyse data or graphs	.76		.57			
11d. Create and/or maintain website(s) for a class	.61			.37		
11e. Communicate with parents and/or students	.55			.30		
11f. Participate in online discussion forums and interact with other educators	.55			.31		
11g. Share your teaching resources online for other educators to access and use	.55			.30		
11h. Engage in self-assessment	.45			.20		
11i. Post examples of your students' work online to share	.62			.38		
16r. Work on a task with one or more classmates to solve a problem	.93				.87	
16s. Explain their thinking to a teacher or classmates	.78				.61	
11a. Research and develop lesson plans and curriculum design.	.86					.74

11b. Develop instructional materials	.80	.64

Note. FAL = Facilitate learning, DAV = Data and visualization, OIC = Online interaction and communication, WCO = Working collaboratively, PAD = Preparation and delivery

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Table 5

Descriptive statistics from 2010 on key variables and five factors

	M	*SD*
Key variable		
Use a computer in teaching	6.50	1.93
Thinking about technology in teaching and learning^	3.19	.67
ICT is important^	3.37	.54
Factor		
Facilitate learning (FAL)	3.81	1.92
Data and visualization (DAV)	2.17	1.93
Working collaboratively (WCO)	4.08	2.33
Online interaction and communication (OIC)	2.44	1.79
Preparation and delivery (PAD)	6.50	1.56

Note. Scale: 0 = never, 1 = 1-3 times a year, 2 = once a term, 3 = once a month, 4 = 1-3 times a month, 5 = once a week, 6 = 1-3 times a week, 7 = once a day, and 8 = many times a day; ^1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly disagree

Table 6

Criterion validity of the TTP

Variable	FAL	DAV	WCO	OIC	PAD
Use a computer in teaching	.469*	.302*	.341*	.370*	.445*
Thinking about technology in teaching and learning planning	.326*	.217*	.282*	.311*	.290*
ICT is important	.344*	.227*	.310*	.338*	.299*

* $p < .01$

Note. FAL = Facilitate learning, DAV = Data and visualization, OIC = Online interaction and communication, WCO = Working collaboratively, PAD = Preparation and delivery

Table 7

Descriptive statistics and ANOVA results from 2010 for key variables, the five factors and Subject Area

	English		Mathematics		Science		ANOVA		
	M	*SD*	*M*	*SD*	*M*	*SD*	*df*	*F*	η^2
Key variable									
Use a computer in teaching	6.17[a]	2.00	5.68[b]	2.27	6.67[c]	1.57	2, 1661	36.39*	.04
Thinking about technology in teaching and learning^	3.15[ab]	.68	3.05[a]	.70	3.21[b]	.62	2, 1455	7.43*	.01
ICT is important^	3.31[a]	.59	3.16[b]	.57	3.37[a]	.50	2, 1668	19.20*	.02
Factor									
Facilitate learning (FAL)	4.03[a]	1.59	1.85[b]	1.62	4.08[a]	1.55	2, 1444	289.43*	.29
Data and visualization (DAV)	1.07[a]	1.47	2.37[b]	1.78	3.26[c]	1.68	2, 1666	258.98*	.24
Working collaboratively (WCO)	4.45[a]	2.19	2.95[b]	2.45	4.27[a]	1.99	2, 1432	60.76*	.08
Online interaction and communication (OIC)	2.37[a]	1.68	1.92[b]	1.67	2.30[a]	1.54	2, 1667	11.67*	.01
Preparation and delivery (PAD)	6.73[a]	1.26	5.84[b]	1.82	6.73[a]	1.36	2, 1666	62.69*	.07

* $p < .01$

Note. Scale: 0 = never, 1 = 1-3 times a year, 2 = once a term, 3 = once a month, 4 = 1-3 times a month, 5 = once a week, 6 = 1-3 times a week, 7 = once a day, and 8 = many times a day; ^1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly disagree

Means in the same row and subtable not sharing the same superscript are significantly different at $p < .05$ in the two-sided test of equality for column means. Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.

Table 8

Comparisons of Subject Area on the five factors between 2010 and 2011

	English		Mathematics		Science		ANOVA		
	M	*SD*	*M*	*SD*	*M*	*SD*	*df*	*F*	η^2
Facilitate learning (FAL)	1.35*[a]	1.64	2.36[b]	1.68	3.46*[c]	1.72	2, 1586	218.49	.22
Data and visualization (DAV)	4.27*[a]	1.75	2.01[b]	1.78	4.33*[a]	1.73	2, 1449	264.65	.29
Working collaboratively (WCO)	4.47[a]	2.22	2.79[b]	2.46	4.14[c]	2.14	2, 1442	69.74	.09
Online interaction and communication (OIC)	2.49[a]	1.79	1.94[b]	1.69	2.45[a]	1.92	2, 1586	14.48	.02
Preparation and delivery (PAD)	6.63[a]	1.56	5.90[b]	2.02	6.75[a]	1.55	2, 1589	36.38	.05

*$p < .05$ difference from 2010 score

Means in the same row and subtable not sharing the same superscript are significantly different at $p < .05$ in the two-sided test of equality for column means.

Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.

Highlights

- Subject areas are a key factor in technology integration.
- The effect of subject areas on technology integration is not well understood.
- A five-factor model of teachers' technology integrated is presented and validated.
- Significant differences were identified among three core subject areas and stable.
- Larger effects of Subject Area observed on instructional practices.

	Vtr2 Subject area you primarily teach.																	
	English		Mathematics		Science		History & Social Science		Physical Education & Healt		Creative Arts		Technology		Languages		Other	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Vtr11a Research and develop lesson plans...	6.84b,d	1.48	5.89a	2.17	6.82b,d,e	1.59	6.95b	1.5	6.43c	1.69	6.68c,d	1.62	6.55c	1.76	6.48c,e	1.85	5.97a	2.41
Vtr11b Develop instructional materials...	6.88b,d	1.43	6.23a	1.81	6.84b,d,e	1.51	7.00b	1.42	6.47c	1.6	6.73d,e	1.57	6.70e	1.54	6.79b,c,d,e	1.53	6.19a	2.15
Vtr11c Use PowerPoint in classroom...	4.16b,f,h	2.45	3.06c	2.74	4.76d	2.6	5.05e	2.39	4.59d,g	2.39	3.86b	2.71	4.27f,g	2.41	4.57d,e,g,h	2.55	3.53a	2.57
Vtr11d Create and/or maintain website...	2.68a,c,d	2.88	2.11b	2.72	2.64a,c,d	2.93	2.89c	2.91	2.88a,c	2.84	2.45b,d	2.89	3.38e	3.05	3.19c,e,f	2.94	2.50a,d	2.95
Vtr11e Communicate with peers/students...	4.05b	2.68	2.62c	2.55	3.51a,e	2.62	3.86b,d,f	2.72	3.76a,b	2.61	3.31e	2.79	3.75a,f	2.72	3.75a,b,e	2.85	3.71a,d	2.97
Vtr11f Participate in online discussion forums...	2.15b,d	2.48	1.67c	2.28	1.95b	2.45	2.00b,d	2.44	2.03b,d	2.36	1.87b,c	2.39	2.75a	2.76	2.47a,d	2.45	2.62a	2.9
Vtr11g Share your teaching resources online...	2.49a,c	2.71	1.90b	2.52	2.58a,c	2.79	2.57a,c	2.78	2.23a,b	2.59	2.01b	2.55	2.75c	2.68	2.73a,c	2.56	2.38a	2.77
Vtr11h Engage in self-assessment...	3.22a,c	2.77	2.80b	2.82	3.13a	2.88	3.23a,c	2.85	3.13a,b,c	2.68	3.20a,c	2.76	3.44c	2.73	3.08a,b,c	2.71	3.23a,c	2.84
Vtr11i Post examples of student work online...	1.63b	2.34	.88c	1.84	1.44a,b	2.31	1.61b	2.33	1.59b	2.22	1.66b	2.37	2.22d	2.61	1.52a,b	2.25	1.21a	2.18
Vtr11j Use online simulation sites...	1.15a,b	2.11	1.55c,h	2.27	3.73d	2.51	1.60c,e	2.39	1.45a,c,h	2.16	1.48c,f,h	2.44	2.10g	2.5	1.10b,h	2.12	1.37a,c,h	2.33
Vtr16a Write a first draft	4.90b	2.32	1.05c	2.05	3.63a	2.66	4.36d	2.41	3.56a	2.52	3.48a	2.49	4.26d	2.58	3.71a	2.54	3.52a	2.86
Vtr16b Edit their written work	5.17b	2.18	1.23c	2.24	4.13d	2.62	4.68e	2.38	4.00a,d	2.56	3.74a	2.46	4.77e	2.48	3.81a,d	2.55	3.78a	2.87
Vtr16c Take notes	5.25b,d	2.58	2.63c	2.96	5.44b	2.6	5.52b	2.55	5.05d,f	2.51	4.12e	2.72	4.90f	2.7	3.92e	3.02	3.23a	3.08
Vtr16d Write, send, and receive emails	4.41b	2.64	2.10c	2.53	3.75a,d	2.71	4.27b,e	2.57	3.99d,e,f	2.61	3.48a	2.73	4.34b,f,g	2.69	3.80a,e,g	2.78	3.47a	2.98
Vtr16e Organise their work	4.85b	2.68	2.63c	2.85	4.87b	2.72	5.10b	2.64	4.74b	2.57	4.02a	2.69	5.10b	2.54	3.96a	2.97	3.66a	3.03
Vtr16f Research information on people, things or ideas	5.41b	1.94	2.71c	2.4	5.55b,e	1.89	5.96d	1.82	5.40b	1.95	5.32b	2.09	5.72e	2.12	4.69a	2.32	4.83a	2.78
Vtr16g Create simple PowerPoint presentations	3.47b	2.09	1.30c	1.86	3.38b	2.03	3.91d	2.01	3.47b	2.07	2.78a	2.23	3.53b	2.26	3.17a,b	2.21	2.75a	2.49
Vtr16h Enter data into a database or spreadsheet	1.60b	2.21	2.70c	1.95	3.38d	1.95	2.63c	2.22	2.68c	2.19	1.32b	2.16	3.41d	2.34	1.68a,b	2.34	2.00a	2.42
Vtr16i Use a spreadsheet to create a table or graph	1.43b	2.08	2.71c	1.9	3.41d	1.93	2.47c	2.13	2.58c	2.1	1.10e	1.94	3.18f	2.28	1.52a,b,e	2.2	1.86a	2.31
Vtr16j Create a database or spreadsheet	1.29b	2	2.52c	1.92	3.05d	1.99	2.32c	2.15	2.47c	2.15	1.14b	1.95	3.11d	2.29	1.39a,b	2.16	1.79a	2.3
Vtr16k Gather information from different places to solve a problem	4.16a,e	2.39	2.31b	2.21	4.66c	2.04	5.08d	2.15	4.44a,c	2.16	3.99e	2.57	4.98d	2.27	3.26f	2.58	4.16a,e	2.84
Vtr16l Gather data or information about a real-life problem	3.71a	2.41	2.12b	2.07	4.42c	2.05	4.82d	2.25	4.21c,e	2.19	3.01f	2.66	4.33c	2.45	2.91f	2.52	3.86a,e	2.87
Vtr16m Evaluate the quality of information found on websites	3.98a,c	2.34	1.75b	2.11	4.09c,f	2.14	4.58d	2.23	3.99a,c,f	2.17	3.49e,g	2.59	4.28f	2.47	3.06g	2.64	3.69a,e	3
Vtr16n Analyse data or graphs	1.91b	2.23	2.81c	2.02	3.90d	2.04	3.85d,e	2.29	3.59e	2.14	1.31f	2.03	3.23g	2.32	1.75b,f	2.28	2.47a	2.52
Vtr16o Represent information visually	3.96b	2.35	2.94a	2.12	4.39c	2.07	4.49c	2.23	3.86b	2.19	3.91b	2.76	4.32c	2.31	3.21a	2.58	3.15a	2.74
Vtr16p Create a product that incorporates pictures or graphics found on the web	4.10b,e	2.23	1.88c	2.15	4.18b	2.14	4.47d	2.18	3.82e,f	2.16	3.98b,e,f	2.58	4.66d	2.28	3.47a,f	2.44	3.41a	2.76
Vtr16q Use different technology tools to complete a task	2.85a	2.38	1.31b	2.02	3.45c	2.23	2.89a	2.37	2.80a	2.28	4.62d	2.63	4.26e	2.4	2.86a	2.54	2.87a	2.72
Vtr16r Work on a task with one or more classmates to solve a problem .	4.70b	2.27	2.66c	2.48	4.47b,d	2.18	4.55b,d	2.2	4.42b,d	2.23	4.35d,e	2.49	4.47b,d	2.37	3.87a,e	2.46	3.66a	2.85
Vtr16s Explain their thinking to a teacher or classmates	4.49b	2.47	3.22a	2.79	4.07c	2.34	4.31b,c	2.39	4.14b,c	2.43	4.03c	2.6	4.38b	2.4	3.42a	2.67	3.48a	2.89

Note: Values in the same row and subtable not sharing the same subscript are significantly different at p< 0.05 in the two-sided test of equality for column means. Cells with no subscript are not included in the test. Tests assume equal variances.(1)

1. Tests are adjusted for all pairwise comparisons within a row of each innermost subtable using the Bonferroni correction.