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INFLUENCES ON THE IMPLEMENTATION OF ICT IN TEACHING IN AUSTRALIA

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Although information and communication technologies (ICT) have changed the environment in which students learn, there is variation among countries, states within countries and schools within states, in the use of ICT in schools. This paper investigates factors associated with variations in the use of ICT in Australian schools, compares the influence of those factors with other countries and interprets variations in ICT use in relation to policy initiatives at national and state level. The implementation of ICT in schools is influenced by policies and practices at national, state and school level. Policies and practices investigated include those concerned with developing teacher expertise, providing access to curriculum resources and building ICT infrastructure. The paper focuses on variations in a federal education structure where there is a high use of ICT (Anderson & Ainley 2010).

Data

The major source of data for the paper is SITES 2006 (Law, Pelgrum & Plomp 2008). Australia participated in SITES 2006 as a benchmarking country having conducted its national survey in 2007. In Australia the achieved a sample was just under 1100 teachers from 301 schools. In total across 23 countries there were just a little fewer than 31,000 teachers from almost 8,300 schools. An outline of the achieved samples is provided in Table 1. These data provide a basis for analysing national patterns of ICT implementation in the teaching of Grade 8 mathematics and science. Policy documents are analysed as a basis for interpreting variations in the use of ICT in Australian schools (MCEETYA 2005).

Analysis

The paper analyses these SITES data in three ways. First, it compares national data for Australia with data from other countries in SITES. Second, it uses logistic regression analysis of SITES 2006 data to investigate teacher-level factors associated with the use of ICT in the teaching of science and mathematics in Australia and other countries. It was hypothesised that teacher use of ICT would be influenced by the subject area in which they taught (science or mathematics), teacher competence in ICT use, by levels of participation in professional development and their perception of obstacles in their school to using ICT. Thirdly it uses Hierarchical Linear Modelling to investigate the contribution of school influences on ICT use by teachers in Australia. The paper also uses other data to explore the ways in the implementation of ICT has been supported in Australian schools and how those policies and practices relate to differences in the use of ICT.

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Table 1 Numbers of Teachers of Grade 8 Mathematics and Grade 8 Science in Achieved Samples for SITES 2006

	Numbers in Achieved Samples				
	Math Teachers	Science Teachers	Total Teachers	Schools with teacher data	Average teachers per school
Australia	547	548	1095	301	3.6
Chile	588	567	1155	528	2.2
Chinese Taipei	855	809	1664	399	4.2
Denmark	392	470	862	263	3.3
Estonia	256	413	669	226	3.0
Finland	589	589	1178	311	3.8
France	454	447	901	250	3.6
Hong Kong, SAR	632	531	1163	283	4.1
Israel	903	754	1657	359	4.6
Italy	689	687	1376	368	3.7
Japan	513	486	999	394	2.5
Lithuania	392	483	875	290	3.0
Norway	338	327	665	244	2.7
Russian Federation	1346	3301	4647	854	5.4
Singapore	503	464	967	164	5.9
Slovak Republic	582	1110	1692	386	4.4
Slovenia	787	789	1576	381	4.1
South Africa	666	622	1288	451	2.9
Thailand	683	679	1362	465	2.9
Moscow, Russian Federation	614	1622	2236	400	5.6
Catalonia, Spain	703	568	1271	356	3.6
Ontario Province, Canada	517	412	929	327	2.8
Alberta Province, Canada	385	361	746	298	2.5
Total	13934	17039	30973	8298	3.7

Results

Descriptive Patterns of ICT in Teaching

<u>ICT Use by Mathematics and Science Teachers</u>

One question in the survey of mathematics and science teachers asked if they had used ICT in any type of teaching activity during that school year. Teachers who answered that they had used ICT were then asked about the impact of ICT-use on them and their students. Table 2 shows the percentages of mathematics and science teachers who reported having used ICT with their classes.

Table 2 Percentages of Teachers of Science and Mathematics at Year 8 in SITES Countries who Reported Using ICT in their Teaching

	Science			Mathematics	
	Percent	Std. Err		Percent	Std. Err
Australia	86.1	1.7	Norway	80.3	2.3
Singapore	83.7	1.7	Denmark	76.8	2.2
Hong Kong, SAR	82.4	1.8	Ontario	75.2	2.3
Alberta	79.2	2.3	Singapore	73.1	1.8
Ontario	75.3	2.3	Hong Kong, SAR	70.2	2.2
Norway	74.2	2.7	**Australia**	68.6	2.5
Denmark	70.0	2.6	Lithuania	62.1	2.8
Slovenia	68.0	2.0	Alberta	62.0	2.5
Chile	65.8	2.5	Italy	57.5	2.1
Lithuania	65.6	2.7	Chile	55.7	2.1
Finland	60.8	2.6	Slovak Republic	51.2	2.2
Italy	58.2	2.2	France	49.1	2.6
Thailand	57.5	2.7	Finland	47.7	2.5
Moscow	57.2	1.9	Moscow	44.8	2.4
Slovak Republic	56.1	2.1	Thailand	44.3	2.6
Spain, Catalonia	55.8	2.2	Russian Federation	40.9	3.5
France	54.4	2.5	Estonia	40.1	3.5
Estonia	53.8	2.6	Slovenia	39.9	2.0
Israel	53.5	2.2	Spain (Catalonia)	38.4	2.0
Russian Federation	48.7	2.7	Chinese Taipei	35.2	1.6
Chinese Taipei	47.7	1.8	Japan	22.8	1.9
Japan	43.8	2.4	Israel	22.3	1.6
South Africa	15.9	1.9	South Africa	18.0	2.0

Note: Standard errors based on replication methods to take account of sample design effects.
Shaded area indicates countries not significantly different from Australia.

There are large differences across the systems. The lowest usage levels were reported by mathematics teachers (18 per cent) and science teachers (16 per cent) in South Africa. At the other end of the spectrum, very high percentages (more than 80 per cent) of science teachers in Australia, Singapore, Hong Kong and Alberta and of mathematics teachers in Norway reported using ICT in their Year 8 teaching.

In terms of science teaching at Year 8 it can be concluded that Australian teachers are high users of ICT together with teachers from Singapore, Hong Kong SAR and Canada (Alberta) and a significantly greater percentage of Australian Year 8 science teachers use ICT in teaching than in 18 other countries.

In terms of mathematics teaching at Year 8 it can be concluded that a significantly smaller percentage of teachers in Australia use ICT than in Norway; a similar percentage of teachers in Australia use ICT as in Denmark, Canada (Ontario), Singapore, Hong Kong, SAR, Lithuania and Canada (Alberta); and a significantly higher percentage of teachers in Australia use ICT than in Italy, Chile, Slovak Republic, France, Finland, Russian Federation (Moscow), Thailand, Russian Federation, Estonia, Slovenia, Spain (Catalonia), Chinese Taipei, Japan, Israel and South Africa.

In a majority of the participating systems (including Australia), the percentage of teachers reporting ICT-use was significantly higher for science teachers than for mathematics teachers within the same system. In the remaining countries the difference in ICT use between science and mathematics teachers was not statistically significant. In general the higher the percentage of science teachers in a country using ICT in Year 8 teaching the higher the percentage of mathematics teachers using ICT in their Year 8 teaching (the between correlation coefficient was 0.84).

Teacher Confidence in Using ICT

The survey of teachers included a series of 16 questions in which teachers rated their own confidence in using various aspects of ICT. The response categories were: not at all; a little; somewhat; and a lot. The aspects of ICT about which the questions were asked covered general use of ICT (8) and pedagogical use of ICT (8)[2]. These items formed one underlying dimension which could be described as 'confidence in ICT use'. The scale was highly reliable (coefficient alpha was 0.96) and it was possible to compute scale scores with an international mean for equally weighted countries set to 50 and a standard deviation set to 10. Table 3 records the mean scores for each education system in SITES.

Grade 8 science teachers in Australia are not significantly different in ICT confidence from those in Singapore, Hong Kong, Alberta, Ontario and Chile and are significantly more confident than other countries in the table. Grade 8 mathematics teachers in Australia are not significantly different from those in Hong Kong, Singapore, Ontario, Alberta, Denmark, Chile and Norway. In all except five of the participating systems the levels of self-reported ICT competence for the science teachers' mean level of self-reported ICT competence was significantly higher than that of mathematics teachers.

[2] General Use of ICT

I can produce a letter using a word-processing program. I can e-mail a file (e.g., the notes of a meeting) to a colleague. I can take photos and show them on the computer. I can file electronic documents in folders and sub-folders on the computer. I can use a spreadsheet program for budgeting or student administration. I can share knowledge and experiences with others in a discussion forum/user group on the Internet. I can produce presentations with simple animation functions. I can use the Internet for online purchases and payments.

Pedagogical Use of ICT

I can prepare lessons that involve the use of ICT by students. I know which teaching/learning situations are suitable for ICT use. I can find useful curriculum resources on the Internet. I can use ICT for monitoring students' progress and evaluating learning outcomes. I can use ICT to give effective presentations/ explanations. I can use ICT for collaboration with others. I can install educational software on my computer. I can use the Internet (e.g., select suitable websites, user groups/discussion forums) to support student learning.

Table 3 Mean Scores for Teacher Confidence in Using ICT for Science and Mathematics

	Science			Mathematics	
	Mean	Std err		Mean	Std err
Singapore	56.2	0.3	Hong Kong, SAR	54.5	0.3
Australia	56.1	0.4	Australia	54.1	0.4
Hong Kong, SAR	55.9	0.3	Singapore	53.9	0.3
Alberta Province, Canada	55.8	0.5	Ontario Province, Canada	53.9	0.3
Ontario Province, Canada	55.7	0.4	Alberta Province, Canada	53.4	0.5
Chile	54.4	0.5	Denmark	52.8	0.4
Norway	54.2	0.4	Chile	52.7	0.4
Denmark	54.0	0.4	Norway	52.6	0.5
Israel	53.7	0.4	Israel	49.7	0.4
Japan	52.4	0.4	Slovenia	49.7	0.3
Estonia	51.3	0.5	Estonia	49.6	0.7
Catalonia, Spain	51.3	0.4	Catalonia, Spain	49.6	0.4
Chinese Taipei	51.0	0.4	Japan	49.4	0.4
France	51.0	0.4	Slovak Republic	49.2	0.4
Slovenia	50.9	0.3	Chinese Taipei	49.0	0.3
Slovak Republic	50.3	0.4	Finland	48.9	0.4
Finland	49.6	0.5	France	47.1	0.5
Italy	47.6	0.4	Italy	46.6	0.4
Thailand	46.6	0.5	Thailand	44.7	0.5
Moscow, Russian Federation	46.0	0.4	Lithuania	43.2	0.6
Lithuania	43.9	0.4	Moscow, Russian Federation	42.6	0.5
Russian Federation	40.2	0.4	South Africa	38.7	0.6
South Africa	40.1	0.5	Russian Federation	38.0	0.9

Note: *Standard errors based on replication methods to take account of sample design effects.*
Shaded area indicates countries not significantly different from Australia.

<u>Participation in ICT-Related Professional Development</u>

Science and mathematics teachers also indicated whether they had participated in professional development activities concerned with ICT. Teachers were asked to indicate whether they had participated in courses concerned with one or more of seven listed areas of development[3]. In replying to the question about ICT-related professional development, teachers not only indicated whether they had participated in an activity in the past year but, if they had not, whether they "would like to attend if a course was available" [4]. On average, levels of participation ranged from 17 per cent (technical courses) to 60 per cent (introductory courses) depending on the course topic but there were no significant

[3] Introductory course for Internet use and general applications (e.g., basic word-processing, spreadsheets, databases, etc.). Technical course for operating and maintaining computer systems. Advanced course for applications/standard tools (e.g., advanced word processing, complex relational databases). Advanced course for Internet use (e.g., creating websites/developing a home page, advanced use of the Internet, video conferencing) . Course on pedagogical issues related to integrating ICT into teaching and learning. Subject-specific training with learning software for specific content goals (e.g., tutorials, simulation, etc.). Course on multimedia operations (e.g., using digital video and/or audio equipment).

[4] Teachers could indicate that they had "no interest", that they "had not participated but were interested" or that "yes they had participated". Responses were scored as either participated (1) or not (0).

differences between science and mathematics teachers. Teacher responses to these seven items were used to form a scale reflecting participation in ICT-related professional development. The scale was transformed so that the mean and standard deviation for equally weighted samples were set to 50 and 10. The median reliability of the scale across countries was 0.77 (with a range from 0.67 to 0.88). Means and standard errors for countries are recorded in Table 4. Those data show that Australia has a relatively low level of participation in ICT-related professional development.

Table 4 Participation in ICT-Related Professional Development

ICT-Related Professional Development			Perceptions of Resource-related obstacles to ICT Use		
	Mean	Std err		Mean	Std err
Chinese Taipei	55.5	0.4	Russian Federation	58.9	0.5
Hong Kong, SAR	53.2	0.4	South Africa	58.5	0.3
Estonia	52.9	0.4	Thailand	57.4	0.4
Israel	52.6	0.3	Moscow, Russian Federation	52.6	0.4
Denmark	52.3	0.5	Chile	52.4	0.3
Lithuania	52.0	0.4	Lithuania	50.6	0.4
Finland	51.0	0.4	Norway	50.6	0.6
Slovenia	51.0	0.3	Estonia	50.4	0.5
Catalonia, Spain	51.0	0.3	Denmark	50.1	0.4
Singapore	50.5	0.3	France	50.1	0.5
Japan	49.6	0.3	Japan	50.1	0.3
Slovak Republic	49.6	0.2	Finland	49.9	0.5
Chile	49.5	0.3	Catalonia, Spain	49.8	0.4
Alberta Province, Canada	49.5	0.5	Ontario Province, Canada	49.5	0.5
Norway	49.3	0.5	Alberta Province, Canada	49.0	0.4
Ontario Province, Canada	49.3	0.4	Slovak Republic	48.9	0.4
Italy	48.8	0.3	Israel	48.7	0.3
Australia	**48.7**	**0.3**	**Australia**	**47.5**	**0.4**
France	48.6	0.3	Italy	47.2	0.3
Thailand	48.6	0.4	Hong Kong, SAR	47.0	0.3
Moscow, Russian Federation	46.2	0.2	Chinese Taipei	46.5	0.2
South Africa	45.1	0.4	Singapore	46.1	0.3
Russian Federation	44.2	0.2	Slovenia	45.3	0.3

Note: Standard errors based on replication methods to take account of sample design effects.
Shaded area indicates countries not significantly different from Australia.

For Australian teachers of science and mathematics and for the international average the four areas of professional development in which there was greatest interest were: subject specific learning systems software for specific content goals, pedagogical issues related to integrating ICT into teaching and learning, advanced Internet use and multimedia operations.

Obstacles to Using ICT in Teaching

Teachers were asked to indicate whether or not a number of factors were an obstacle to them using ICT in their teaching[5]. These were scored dichotomously as 0 (not an obstacle) or 1 (experienced as an obstacle). Teacher responses to the school-related (resource) obstacles formed a scale reflecting the presence of these as obstacles in the scale. The scale was transformed so that the mean for equally weighted country samples was set to 50 and the standard deviation was set to 10. On this scale a high score reflected teacher perceptions that there many obstacles to using ICT for teaching and a low score reflected teacher perceptions that they had not experienced these things as obstacle. Country means have been recorded in Table 4. Australia appears as a country (along with Italy, Hong Kong, Chinese Taipei and Singapore) where teachers perceive few school-related obstacles to using ICT. On average across participating countries the obstacles nominated by mathematics teachers were almost the same as for science teachers.

Other Characteristics of Teachers

Overall there was only a small association between teacher age and ICT use in either science (the correlation was 0.07) or mathematics (the correlation was 0.05). Across all countries there was a small difference in the use of ICT between male and female teachers. For Australia 85 per cent of female science teachers and 87 per cent of male science teachers reported using ICT. This difference is not statistically significant. In mathematics, 66 per cent of female teachers and 72 per cent of male teachers had used ICT. This difference was statistically significant. Overall, in both science and mathematics a slightly greater percentage of male teachers than female teachers had used ICT in Year 8 teaching. In science the difference was 59 compared to 52 per cent and in mathematics the difference was 52 compared to 46 per cent. However, these gender differences were different in different countries. In science there was a greater propensity to use ICT by male teachers in Slovenia, Italy and Chinese Taipei and a greater propensity to use ICT by female teachers in France and Denmark. In mathematics there was a greater propensity for male teachers to use ICT in Slovenia, France and Finland but a greater propensity for female teachers to use ICT in Moscow, Chile and Lithuania.

Computer resources

Table 5 records the ratio of computers to students in schools containing Grade 8 (i.e. secondary schools) in 2007 based on the SITES survey. Those data record computer ratios to students based on all computers, computers that are part of a local area network (LAN), and computers accessible to students (i.e. excluding those only for use in administration or by teachers). Those data confirm the strong level of computing infrastructure in Australian secondary schools. The ratio of all computers per student in Australia is 0.40 and that for student accessible computers is 0.31. On the basis of internet connected computers, LAN networked computers and multimedia computers the ratios were 0.36, 0.36 and 0.30. This means that Australian secondary schools operate with an overall ratio of 2.5 students per computer or, perhaps as a better index, 3.2 students per accessible computer. These data in Table 4 indicate that the level of computers per student in Australia is not significantly different from that in Norway or Alberta (or, in the case of multimedia computers, Singapore).

[5] ICT is not considered to be useful in my school. My school does not have the required ICT infrastructure. I do not have the required ICT-related skills. I My school lacks digital learning resources. I do not have the flexibility to make my own decisions when planning lessons with ICT. I do not have access to ICT outside of the school.

Table 5 Mean Computer to Student Ratio for Countries

	Overall Computer Ratio		Networked Computer Ratio		Student Accessible Computer Ratio	
	Mean	Std err.	Mean	Std err.	Mean	Std err.
Australia	0.40	0.02	0.36	0.02	0.31	0.01
Norway	0.37	0.01	0.32	0.02	0.26	0.01
Alberta, Canada	0.34	0.02	0.28	0.02	0.26	0.02
Singapore	0.28	0.01	0.24	0.01	0.19	0.01
Hong Kong, SAR	0.28	0.01	0.25	0.01	0.19	0.01
Japan	0.26	0.01	0.22	0.01	0.20	0.01
Denmark	0.23	0.01	0.20	0.01	0.19	0.01
Ontario, Canada	0.22	0.02	0.19	0.02	0.19	0.02
Finland	0.21	0.01	0.18	0.01	0.17	0.01
France	0.18	0.01	0.13	0.01	0.14	0.01
Chinese Taipei	0.18	0.01	0.16	0.01	0.11	0.01
Catalonia, Spain	0.14	0.01	0.13	0.01	0.11	0.01
Estonia	0.14	0.01	0.13	0.01	0.09	0.00
Slovenia	0.14	0.00	0.12	0.00	0.09	0.00
Italy	0.13	0.01	0.08	0.01	0.10	0.01
Lithuania	0.13	0.01	0.05	0.01	0.08	0.00
Israel	0.13	0.01	0.06	0.01	0.10	0.01
Slovak Republic	0.09	0.0	0.06	0.00	0.06	0.00
Moscow	0.08	0.01	0.04	0.00	0.05	0.00
Russian Federation	0.08	0.01	0.02	0.00	0.04	0.00
Thailand	0.07	0.00	0.04	0.00	0.06	0.00
Chile	0.06	0.01	0.03	0.01	0.04	0.00
South Africa	0.03	0.00	0.01	0.00	0.02	0.00

Note: Values shaded in Grey are not significantly different from the Australian value.
Systems in *italics* did not satisfy sampling criteria or sampling procedure.

Analysis of Teacher-Level Influences on ICT Use

In order to examine factors associated with the use of ICT, multivariate techniques were used to identify the influence of various factors on the use of ICT in teaching. The reason for using multivariate techniques was that there was no single determinant of the use of ICT in teaching. Instead, there was a range of inter-connected influences on participation. Multivariate analyses provided an assessment of the net effect of each factor considered by controlling for the effects of other factors included in the analysis. In other words they provided an "other things equal" estimate of the effect of one factor if all the other influences were held constant. Logistic regression was used because the outcome (or dependent) variable was dichotomous. For the analyses all continuous independent variables were standardised to a mean of 50 and a standard deviation of 10 but all binary variables remained as categorical. Results of the logistic regression analyses are contained in Table 6.

Table 6 Results of Logistic Regression Analyses for Use of ICT in Teaching in 23 SITES Countries

	Constant		Subject Science/Maths		Competence		Professional Development		Obstacles	
	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error
Australia	-4.48	1.12	**1.03**	0.19	**0.05**	0.01	**0.06**	0.02	**-0.02**	0.01
Chile	**-4.06**	0.79	**0.40**	0.14	**0.10**	0.01	0.01	0.01	**-0.03**	0.01
Chinese Taipei	**-3.36**	0.55	**0.43**	0.11	**0.04**	0.01	**0.02**	0.01	**-0.02**	0.01
Denmark	-0.98	1.02	**-0.47**	0.18	**0.05**	0.01	**0.03**	0.01	**-0.03**	0.01
Estonia	**-4.40**	0.97	**0.50**	0.20	**0.11**	0.01	0.00	0.01	**-0.04**	0.01
Finland	**-3.64**	0.65	**0.58**	0.13	**0.06**	0.01	0.01	0.01	-0.02	0.01
France	**-5.74**	0.79	-0.08	0.18	**0.10**	0.01	**0.04**	0.01	**-0.02**	0.01
Hong Kong, SAR	**-1.60**	0.82	**0.72**	0.17	**0.04**	0.01	-0.01	0.01	0.00	0.01
Israel	-1.60	0.82	**0.72**	0.17	**0.04**	0.01	-0.01	0.01	0.00	0.01
Italy	**-5.71**	0.81	-0.07	0.15	**0.12**	0.01	**0.05**	0.01	**-0.03**	0.01
Japan	**-6.04**	0.83	**0.87**	0.15	**0.08**	0.01	**0.02**	0.01	**-0.02**	0.01
Lithuania	**-3.55**	0.90	0.05	0.16	**0.12**	0.02	0.02	0.01	**-0.04**	0.01
Norway	-2.02	1.06	**-0.58**	0.21	**0.08**	0.02	0.02	0.02	-0.02	0.01
Russian Federation	**-1.65**	0.85	0.16	0.15	**0.10**	0.01	-0.03	0.02	**-0.02**	0.01
Singapore	-1.74	1.06	**0.48**	0.22	**0.07**	0.01	0.01	0.01	**-0.04**	0.01
Slovak Republic	**-4.93**	0.73	0.14	0.13	**0.12**	0.01	0.02	0.01	**-0.04**	0.01
Slovenia	**-6.51**	0.70	**1.31**	0.13	**0.10**	0.01	**0.02**	0.01	**-0.03**	0.01
South Africa	-0.42	0.87	-0.17	0.19	0.01	0.01	0.01	0.01	**-0.03**	0.01
Thailand	**-4.29**	0.87	**0.52**	0.14	**0.09**	0.01	**0.02**	0.01	**-0.02**	0.01
Moscow, Russian Federation	**-3.11**	0.60	**0.26**	0.12	**0.12**	0.01	0.01	0.01	**-0.05**	0.01
Catalonia, Spain	**-4.07**	0.65	**0.77**	0.13	**0.07**	0.01	**0.02**	0.01	**-0.04**	0.01
Ontario Province, Canada	**-3.93**	1.15	-0.03	0.17	**0.07**	0.01	**0.05**	0.01	-0.01	0.01
Alberta Province, Canada	**-3.42**	1.08	**0.87**	0.23	**0.08**	0.02	**0.03**	0.01	**-0.05**	0.01
International Average	**-3.45**	0.15	**0.42**	0.03	**0.08**	0.00	**0.01**	0.00	**-0.03**	0.00

Note: *Standard errors take account of sample design effects using the Taylor series method in the analysis program AM.*
Coefficients that are statistically significant at the five percent level have been shown in bold.

This investigation began with the inclusion of a large number of potential correlates of the pedagogical use of ICT. Those variables that had no statistical association with ICT use (such as gender and age) were removed from the analysis and the final results are reported in Table 6. In this analysis only measures from individual teachers have been included. The measures included in the final analysis were: subject (dichotomous science compared to mathematics); teacher ICT competence (scale described earlier); participation in professional development (scale based on number of areas in which participation was reported); obstacles (scale based on contextual obstacles in schools as reported by teachers).

These data show the regression coefficients and standard errors and the significance level. A positive coefficient means that the factor increased the chances of using ICT in teaching. The significance level indicates the degree of certainty that the relationship existed in the wider population. Table 6 shows in bold results where the significance level (the chance of a false positive) is less than five percent.

The results in Table 6 indicate that the use of ICT is more likely when teachers have a higher level of competence (or confidence) in ICT. This relationship was statistically significant in all countries except South Africa. The regression coefficient the effect of ICT competence in Australia was 1.03 which corresponds to an odds ratio of 1.05 (the exponent of the coefficient). This indicates that a person with a one unit higher score on the ICT competence scale was five per cent more likely to use ICT in their teaching. On average across the 23 SITES countries the regression coefficient was 0.08 which corresponds to an odds ratio of 1.08 with one unit difference on the competence scale corresponding to an eight per cent greater likelihood of using ICT in teaching.

The results in Table 6 also indicate that in 14 of the 23 countries teaching in science was more likely to make use of ICT than teaching in mathematics. In two countries (Norway and Denmark) teaching in mathematics was more likely to make use of ICT than teaching in science and in the remaining seven countries there was no significant difference. In Australia the regression coefficient for subject was 1.03 corresponding to an odds ratio of 2.8. This suggests that the use of ICT was almost three times as likely in science as compared to mathematics.

The influence of participation in ICT-related professional development is less clear. Table 6 records that in 11 of the SITES countries there was a positive association between participation in ICT-related professional development and the use of ICT in teaching and in 12 countries there was no statistically significant effect. In Australia the effect was comparatively strong with a regression coefficient of 0.06 and a corresponding odds ratio of 1.06. Each unit on the professional development scale corresponded to six percent greater likelihood of using ICT in teaching.

Table 6 also shows that in 18 of the SITES countries, when teachers perceive more contextual obstacles (such as poor infrastructure, school and system level impediments[6]) to the use of ICT they are less likely to use that in their teaching. In the remaining five countries the effect was not statistically significant. In Australia the perception of contextual barriers was associated with less use of ICT but the effect was not as strong as for Moscow and Alberta.

In summary the most pervasive and strongest effect on ICT use in teaching was the teacher competence (self-reported) in ICT. The message is clear if ICT is to be more widely used in teaching then the confidence and competence of teachers in using ICT needs to be developed.

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[6] The distinction between teacher-level barriers and school or system-level barriers to ICT is made by Balanskat, Blamire and Kefala (2006) in their review of European research literature

Multi-level Analysis of School and Teacher-Level Influences on ICT Use in Australia

To investigate the school level factors associated with the pedagogical use of ICT it was intended to conduct a multi-level logistical regression using the program HLM6 (Raudenbush, Bryk, Cheong, Congdon & du Toit, 2004). The major school-level variables included in the analysis were the ratio of student-accessible computers to students and the hours of IT support available (the total of hours provided by school-based IT staff and external staff engaged to support the school IT systems).

The extent of missing school-level data complicated these analyses. Across all the schools internationally for which some teacher-data were returned some 25 percent did not have sufficient data to compute the computer-student ratio and 20 per cent did not have sufficient data to compute the total hours of IT support. This was partly because some schools did not return one or both of the Principal or IT Coordinator questionnaire (even though teachers completed the teacher questionnaire) and partly because even though the questionnaire was returned data on these variables were not provided. In Australia the levels of missing data were 39 per cent and 29 per cent respectively.

To check the extent of bias introduced teacher level data were compared between those schools with missing school level data and those with no missing school level data. In three countries (France, Italy and Alberta) there were significantly lower levels of ICT use in schools that did not provide data on computer ratios. In Moscow there was a difference in scores on the perceived obstacles scale between schools with and without missing data on computer ratios (higher scores on the obstacles scale were recorded for those with missing school level data). There were four countries (Slovakia, South Africa, Ontario and Alberta) in which there was a significantly higher perception of obstacles in those schools with missing school data on support hours than other schools. In Australia there did not appear to be any statistically significant differences in teacher-level variables between schools with and without the relevant school-level data.

The multi-level analysis focuses on the Australian data in SITES. The initial analyses indicated that teachers perceived obstacles to using ICT were correlated with the measures of ICT resources (not surprisingly) and so the teacher level variable concerned with obstacles was removed from the analysis reported in Table 6. In addition the level of IT support (person-hours per week) was not significantly associated with ICT use and was dropped from the analysis. The results for the final model are reported in Table 7.

The results in Table 7 show that there is an association between the computer infrastructures (measured as the ratio of student accessible computers to students) in a school and the pedagogical use of ICT, net of the effects of teacher ICT competence, participation in ICT-related professional development and the subject (science or mathematics being taught). The results also show that there is difference in ICT use between science and mathematics (science teachers being twice as likely to use ICT as mathematics teachers) and that teacher ICT competence is associated with greater propensity to use ICT (an eight percent greater likelihood for each scale point). The evidence on the effects of teacher professional development suggests that the extent of participation in ICT-related professional development is not significantly related to greater use of ICT in teaching.

Table 7 Results of Logistic Multi-Level Regression Analyses of Use of ICT in Teaching in Australia: Teacher and School Variables

Variable	Variable type	Regression coefficient	Standard error	Significance	Odds ratio Exp(B)
Constant		-4.861	0.912	0.000	0.001
Teacher Level					
Subject (science cf. maths)	Categorical	0.699	0.220	0.000	2.012
Teacher ICT competence	Scale	0.076	0.014	0.000	1.079
ICT professional development.	Scale	0.023	0.016	0.160	1.024
School Level					
Computer to student ratio	Ratio	1.672	0.707	0.019	5.321

Interpretation in Terms of Policies and Practices

General policies and plans

In Australia the National Goals for Schooling in the 21st Century included the statement that when students leave school they should "be confident, creative and productive users of new technologies, particularly information and communication technologies, and understand the impact of those technologies on society" (MCEETYA, 1999). In 2000, the MCEETYA adopted a school education action plan titled Learning in an Online World (MCEETYA, 2000), which was updated as Contemporary Learning: Learning in an Online World (MCEETYA, 2005). Overall, the plan established areas in which strategies were to be implemented by: developing teacher competence in ICT; implementing an advanced ICT infrastructure in schools; and developing digital resources. These were to be part of a plan for facilitating the uptake and use of ICT in schools and supporting the use of ICT to enhance learning.

The importance of ICT in education was re-iterated in the Melbourne Declaration on Educational Goals for Young Australians which was released in December 2008 (MCEETYA, 2008). The Melbourne Declaration asserted that "in this digital age young people need to be highly skilled in the use of ICT". This represents a continuation of a theme from the earlier Adelaide Declaration of Australia's National Goals for Schooling which stated that when students left school they should be: "confident, creative and productive users of new technologies, particularly information and communication technologies, and understand the impact of those technologies on society" (MCEETYA, 1999).

More recently has been implementation of the "digital education revolution" as a feature of education policy in the national reform agenda. This national initiative involves significant support for improving ICT provision in schools, expanding the use of ICT in teaching and learning and developing the ICT proficiency of young Australians. It includes the provision of computers for all secondary schools with students in Years 9 to 12, supporting the deployment of fibre-to-the-premises broadband connections to Australian schools and professional development for teachers in the pedagogical use of ICT.

Digital Resources

Whereas distribution of resources was initially implemented primarily through removable media such as CD-ROMs, internet-based distribution via websites was evident by 2004. The Le@rning Federation, jointly managed by the Curriculum Corporation and the website education.au, began as a major digital content project for Australian and New Zealand schools. The Le@rning Federation developed specifications for educational soundness and new delivery systems, such as web portals, learning management systems, and content management systems. A number of schools implemented major software packages to support these functions. The Le@rning Federation also developed a "Basic E-Learning Tool Set" to provide schools with the basic functionality for managing learning objectives, until comprehensive learning content management systems could be implemented within jurisdictions. State and territory education authorities also operated various initiatives for providing their schools with digital content. Some initiatives endeavoured to identify existing content and provide cost-effective access for schools. Others involved the development of content to meet the curriculum, professional development, and other educational priorities of education systems. Some schools established programs to support the development of new content by their own teachers.

Networked Resources and Information Gateways

The intention behind Education Network Australia (EdNA) is to enable Australian educational institutions to adopt new information and communication services and technologies and to disseminate and produce content and services relevant to the Australian experience. The EdNA Directory Service provides free access to quality education resources on the internet, for all sectors of Australian education. Effects of geographic isolation are alleviated through this initiative, with the opportunity it affords for collaborative access to national and international curriculum materials. EdNA operates an information gateway—EdNA Online (www.edna.edu.au). Most state authorities have established networks that link schools and education agencies. Through these networks, teachers have access to online resources provided by the state, as well as resources provided through EdNA. In Victoria, networking has been a central priority, with all schools connected to a Wide Area Network, and a range of services including the internet. A digital resource centre has been established as a means of delivering multimedia curriculum resources. These are accessible through the Education Channels and the Department of Education's website. A website (SOFWeb) can be accessed across the state, nationally or internationally, via internet. Electronic mail services have been introduced, so that each staff member has a mailbox.

ICT Competencies of Teachers and Leaders

On the basis of data collected by state education authorities, it appears that around 90% of Australian teachers in 2003 had acquired basic competencies in ICT, and 50% of Australian teachers regarded their own competency as "intermediate" or "advanced." However, there is limited information about the extent to which teachers feel able to incorporate ICT in their teaching. A national review of teaching and teacher education published in 2003 (Lee Dow, 2003) argued that ICT should be used widely in schools, and form part of the repertoire of all teachers. It recommended that teacher education programs prepare prospective teachers to use ICT as a knowledge management tool, and to support student learning. The review also argued that opportunities should be created for teachers to upgrade their ICT expertise.

Conclusions

The advent of ICT has changed the environment in which students develop in ways that impact on the way they learn in schools. Kozma and McGhee (2003) report evidence from 174 case studies in SITES M2 of the uptake of ICT in teaching and learning and the ways in which the use of ICT impacts on teaching and learning practices. They argue that these impacts take place either by facilitating connectedness with other people or information sources and by enabling the creation of products that incorporate a range of resources (such as multimedia).

Analyses of SITES data indicate that Australian science and mathematics teachers are relatively high users of ICT. Use of ICT is greater when teachers have a higher level of confidence in ICT, when there are fewer contextual obstacles (infrastructure, digital learning resources, ICT access) and when there is a relatively higher level of computer provision in schools. The importance of teacher confidence and competence for the effective implementation of ICT in schools has been reported in other studies (Jones, 2004).

The present survey reports that in Australia the teaching of Grade 8 science is more likely to make use of ICT than the teaching of Grade 8 mathematics. Differences in percentage of ICT-using mathematics teachers and science teachers were also found in many other education systems (see also Law et al, 2008; Jones, 2004). In SITES the samples of mathematics teachers and science teachers were taken from the same schools and so the differences could reflect curriculum differences at system level in these areas or differences in the nature of the disciplines. One inference to be drawn from this is that the subject (or discipline) context is an important aspect of the uptake of ICT in teaching. It may be that some subjects lend themselves more readily to the pedagogical use of ICT or that there are stronger traditions of innovation in some subjects than others.

Comparative international studies such as SITES can provide a context for national perspectives on educational issues such as the use of ICT in teaching. When data from SITES in Australia are compared with data from other countries they suggest that ICT has been relatively widely adopted (at least in science and mathematics in secondary schools), that there is a relatively strong provision of computers in schools and that teachers are more confident in their ICT capability than their peers in other countries. However, there are relatively low levels of participation in ICT-related professional development and the participation that does take place does not appear to impact on greater ICT use in teaching. The data also suggest that the implementation of ICT in teaching would be enhanced by building the capacities of teachers as well as improving the resources available to students and teachers.

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