

Integrating ICT into Professional Practice: A Case Study of Four Mathematics Teachers

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The integration of Information and Communication Technologies (ICT) into education is recognised as: providing opportunities for developing skills for the 21st century, having the potential to transform pedagogical practices, and playing a role in reforming curricula. Additionally, it is considered an essential tool for developing understanding about mathematical concepts. The challenge for teachers is to use ICT in ways that promote mathematical thinking and concept development. The literature suggests professional development opportunities are necessary for teachers to equip themselves with the skills to integrate ICT effectively into their teaching and learning practices. This report describes part of a study that focuses on the outcomes of ICT professional development completed by Mathematics teachers from a suburban high school. The case study of four teachers demonstrates that the acquisition of ICT skills does not necessarily translate to the adoption of transformative pedagogical practices. Implications of this study include suggestions for designing future professional development programs.

The integration of Information and Communications Technologies (ICT) into professional practice places great pressures and demands on teachers to provide students with the opportunity to develop the skills required to engage in a progressive society and become life-long learners (CEO Forum, 2001), as well as enhance the learning of current curriculum content. To exploit the potential of ICT fully, resulting in improved student outcomes, there is the need for educators to incorporate those new technologies into their teaching practice (McGehee & Griffith, 2004). To date, this has not been fully realised (Brooker, 2003; Roschelle, Pea, Hoadley, Gordin & Means, 2000) and places an imperative on educators acquiring relevant skills and adopting teaching practices that may challenge their current practices. This is crucial as the positive impact of ICT depends on *how* teachers use ICT in their teaching and learning programs (Kozma, 2003), and Roschelle et al. (2000) state, “Teachers who succeed in using technology often make substantial changes in their teaching style and in the curriculum they use” (p. 91).

Increasingly, efforts are being made to integrate ICT into the curriculum and researchers are calling for the adoption of strategies that will make ICT integral to teaching and learning processes (Roschelle et al., 2000). Reynolds (2001) suggests schools are using ICT as a supplement to classroom activity by accessing existing information and knowledge, rather than as an integral part of pedagogical practice and Ward (2003) goes further to claim that there is limited use of ICT in classroom practices. This indicates a need for teachers to gain an understanding of how ICT can be used to extend students’ thinking and problem-solving skills, rather than just as a publication and research tool. This report sets out to learn how four teachers have integrated ICT into their Mathematics classrooms.

The Context of the Study

The teachers involved in the study were from a suburban high school in Tasmania. The school was using the integration of ICT into teaching and learning as a means of reform

and has made a large investment in developing ICT practices as a culture of learning. ICT enriched learning programs complement other reforms within the school that target student needs and individualise programs for students.

The teaching staff of this particular school had been involved in a number of ICT professional development programs to support teachers to change their teaching practices, with the aim of improving student outcomes and creating a 'virtual school'. All of the teaching staff participated in professional development on the use of: WebCT, webquests, online forums, and online resources. The teachers in this study also completed a course on using multi-media in project-based learning (Department of Education [DoE], Tasmania, 2004). Additionally, another teacher in the school provided mentoring support for the teachers at the school to assist them to develop teaching resources inspired by the professional development programs.

As a result of the professional development programs, teachers were encouraged to gain recognition of their achievements in integrating ICT by gaining accreditation for the 'Embedding Educational Technologies into Professional Practice – Teaching and Learning' (EET) unit through the DoE. The EET unit has five elements of competence: Planning, Management and Assessment; Learning, Teaching and the Curriculum; Educational Resources; Professional Learning and Practice; and Creating a Culture. Within each element, there are four or five specific performance criteria used to guide evidence of achieving competence. To demonstrate competency in the EET unit teachers develop a portfolio that is representative of their practice. The assessment of the portfolio, by the DoE, bases accreditation on recognition of current competencies and is evidence-based. Of the 45 teaching staff at this school, 18 teachers gained accreditation for their EET unit. This was a 40% participation rate compared to 6% statewide (R. Cocker, personal communication, April 7, 2004).

This report uses examples of learning activities and teaching practices from the teacher portfolios created by the participants in the study to support data collected from teacher profiles. The teacher portfolios influenced the teachers' comments but due to space constraints, a detailed analysis of the teacher portfolios will be presented elsewhere.

The Research Approach

The qualitative study, from which this report is taken, utilises an instrumental case study (Stake, 1995) as a strategy of inquiry. It strives to identify the elements of best practice that highlight the possibilities and opportunities for improving the utilisation of ICT in teaching and learning programs, rather than to determine what common practice is. The study is designed to investigate in what ways teachers have integrated ICT into their teaching and learning practice, and the factors that influence the extent to which they have done this.

Participants. The participants in the study were four secondary Mathematics/Science teachers, teaching in a suburban high school in Tasmania. Teachers had to meet two selection criteria to be involved in this study. First, they had to have gained accreditation for their EET unit and second, they had to demonstrate a willingness to participate in the study. All the participants were female. The ratio of female to male Mathematics/Science teachers at the school was four to one. The two male teachers at the school could not be included in the study as they were relatively new to the school and had not participated in the professional development that provided the context for the study.

Instruments. The evidence for the study was collected by using two data collection instruments: a teacher profiling instrument, and teacher portfolios. First, a teacher profiling instrument (adapted from Watson, 2001) that identifies the factors related to integrating ICT into teaching and learning was used to gather data that were both descriptive and quantitative. It was adapted, for the purposes of the study, to reflect the content, curriculum, and teaching practices associated with the integration of ICT into the curriculum. The adapted teacher profile maintains the structure of the original that reflects characteristics of professional practice, that is, professional development, reflective practice, and teachers' backgrounds (Watson, 2001). Sections of the teacher profile also addressed issues related to teacher knowledge in terms of Shulman's (1987) seven types of teacher knowledge: content knowledge; general pedagogical content knowledge; knowledge of learners and their characteristics; knowledge of education content contexts; and knowledge of education ends, purposes and values. The original profiling instrument was designed to be used as a survey or as a semi-structured interview for an area of the Mathematics curriculum: Chance and Data. Other adaptations have been used successfully as an evaluation tool of a professional development program in Numeracy (Watson, Beswick, Caney, & Skalicky, 2005).

Second, the use of a teacher portfolio provided extensive information about the technological skills and ability of the teachers to apply and adapt technology to a specific learning situation. It provided a much better demonstration of how ICT is applied than other modes of evaluation that simply require a recall of classroom instructional practice (United States Department of Education, Office of the Under Secretary, Planning and Evaluation Service, Postsecondary, Adult, and Vocational Education Division, 2000). Of the evidences provided in the portfolios only approximately 20% were related to the teaching of Mathematics. In this report examples from the portfolio will be used to support teacher comments from the teacher profile.

Results

The results of analysing responses to the teacher profiling instrument are presented here. All the participants completed the teacher profiling instrument as a semi-structured interview over a period of 45 minutes. They chose the interview format in preference to providing written responses as they felt writing responses would have taken too much time. The interviews were audio taped and later transcribed. The next section introduces the teachers individually, detailing their background and teaching experience, followed by the collective results of all four teachers in relation to the sections of the profiling instrument. Evidence from the teacher portfolios is used to provide specific examples of how teachers used ICT in their practice as Mathematics teachers. Pseudonyms are adopted for each of the teachers.

Teacher Background. Ashley, Joanna, Kerry, and Lynda collectively have a wealth of teaching experience. At the time of the study, they were teaching Mathematics and Science, however Ashley and Joanna taught an additional subject each. Ashley taught Health and Well Being, whilst Joanna taught Trans-disciplinary Units with a Mathematics and Science focus. Kerry was the only teacher with significant experience with ICT having studied Computer Science at university, and continued with Computer Science as a teaching area specialisation. Lynda, the novice of the group, also completed an ICT course as part of her teacher training. In contrast to the other participants who completed their teacher training in

Tasmania, Lynda completed her teacher training in Queensland. She had, however, only taught in Tasmanian schools. Further details of the teachers' experience and background are summarised in Table 1.

Table 1
Summary of teacher background

Name	Qualifications	Teaching experience	Subject areas taught	Subject areas currently teaching	Grade levels currently teaching
Ashley	B Ed (Mathematics & HPE), M Ed	18 years	Mathematics, Science, HPE, SOSE	Mathematics, Science, Health and Well Being	Grade 10
Joanna	B Sc, Dip Ed (Mathematics & Science)	25 years	Mathematics, Science	Mathematics, Science, Trans-disciplinary Units	Grade 7
Kerry	B Sc, Dip Ed (Computer Science & Science)	10 years	Mathematics, HPE, Science, Computer Science, SOSE, Japanese	Mathematics, Science	Grade 9 & Grade 10
Lynda	B Sc, Dip Ed (Mathematics & Science)	3 years	Mathematics, Science	Mathematics, Science	Grades 9 & Grade 10

Section 1: Significant factors for integrating ICT into teaching and learning. The teachers noted two factors as significant for integrating ICT into the curriculum. First, time was a factor for all teachers. Kerry felt that her teaching work load and professional commitments prevented her from developing as many teaching and learning programs as she would like, whilst Ashley, Joanna, and Lynda found the development of ICT related learning experiences for their students, required them to work at home, to enable them to produce teaching resources.

Second, access was highlighted as an issue for all four teachers. This was described in a number of ways. For the students problems associated with not remembering passwords inhibited their access to resources, and the high demand for good literacy skills to be able to engage with the resources on the World Wide Web also denied some students access to those resources. For the teachers themselves the issue of school structures was highlighted. The booking system whereby computer labs were permanently booked for ICT dedicated subjects posed problems. This issue was compounded by timetable constraints resulting in some classes having little or no access. Additionally, the number of computers and computer labs in the school did not accommodate the high demand for student access and resulted in some teachers not being assured of getting their classes into the computer labs when needed. All four teachers expressed disappointment at not being able to give their students more experiences using ICT. Kerry stated, "...I just haven't bothered doing much this year because I can't get into a computer lab on a regular basis." Ashley, also felt restricted by not being able to access resources on the school intranet from home.

Section 2: Preparing to integrate ICT into the curriculum. All four teachers relied heavily on the Internet to provide both resources and inspiration for their use of ICT in units of work. They used the Internet for researching a topic, collecting resources and providing relevant information for students. Joanna specifically looked for simulations and

interactive activities to enhance her students' understanding of concepts studied but only gave examples of their application in Science. Ashley stated, "To be creative with ICT I like to circumnavigate [the Internet] and get heaps of ideas from here, there and everywhere, then put them together in a unique way."

All four teachers had produced online resources/courses using WebCT but had not been able to utilise them fully due to the access restrictions mentioned above. They did, however, put some resources on the school intranet for ease of access. The examples given by most of the teachers were of worksheets and mathematical games on the Internet. In these instances, the purpose of ICT was to support and reinforce the skills of Mathematics and was not used to develop understanding of mathematical concepts.

Section 3: Preparing to teach a unit of work using ICT. The planning processes for the teachers varied greatly. Kerry described how she used curriculum documents from the Tasmanian Secondary Assessment Board (TASSAB) courses in Mathematics to guide planning of learning sequences for her students. The technology requirements stated in the documentation determined her use of ICT. In planning Trans-disciplinary Units, Joanna described working with other teachers to determine what topics, content, and technology use should be utilised. The 'Water' unit, given as an example, required students to gather information on the Internet, collect data from observations of experiments and investigations, make graphical representations from the data collected, and use the resulting information to make recommendations about appropriate water usage. The unit outline did not detail mathematical understanding as an outcome for the unit nor did it specify which mathematical skills or concepts were enhanced by the application of technology.

Section 4: Teaching practices. In general, the teachers used ICT because it was engaging and provided additional motivation for some students. The teachers indicated that they incorporated ICT into all of their teaching and learning programs, with the amount of class time allocated to students using ICT varying from 10% to 30%. They expressed enjoyment in integrating ICT into their professional practice and found it personally stimulating. They also believed their students had come to expect to use ICT and felt obliged to give them ICT experiences.

Ashley noted ICT provided opportunities for her to "evolve as a teacher." This was evidenced by her commenting on a lesson she witnessed given by a pre-service teacher. In the lesson students collected data and then the pre-service teacher used a projector to display MSExcel on a screen and entered the individuals' data into a spreadsheet, building a larger data set from the whole class. Analysis of the data followed on from this. Ashley said the students were more accountable for their work than usual as they were sharing their data. She went on to comment that the experience supported her view of the benefits of social constructivist learning and was encouraged to include similar learning experiences in her teaching programs. She stated, "I am on a journey and the ICT is able to lift my game a little bit on that journey, in some aspects." Ashley did, however, concede that the activities she had provided in Mathematics utilising ICT previously, were only low-level tasks not extending the students to develop new or deeper understandings of mathematical concepts. She considered her ability to target these outcomes through using ICT would improve as her practice evolved.

Section 5: Advantages of using ICT in teaching. Three of the teachers in this study said that the use of ICT helped students to develop critical thinking, problem-solving and analysing skills. Lynda described how it allowed students to transform information easily

and facilitated individualised learning opportunities. Her examples demonstrated the use of MSExcel to transform data to a graphical representation and the use of MSPowerPoint for students to present their work. Mostly, the teachers' comments on what ICT provided for students were discussed in general terms and specific details were not given. In addition, Kerry was the only teacher to express the view that that she did not think that the computer environment contributed to improving student learning outcomes stating, "...it is about the same whether they are on computers or not."

All teachers agreed that ICT was a motivating environment for most of their students. This contradicted other comments made by the teachers in relation to student behaviour management. All teachers expressed concern that students were often off-task and they encountered difficulties managing students in the online environment.

Section 6: Introducing a new computer application. All teachers described classroom practises that utilised the modelling of new applications to the whole class, followed by the teacher working with students experiencing difficulties, and working with small groups of students. In most cases, a projector displayed the images from a computer screen to enable the whole class to view the demonstration at the same time. Lynda did, however, describe a situation where she would use an expert teacher, other than herself, to introduce the application to a small group of students. These students would then become peer tutors and pass their newly acquired skills to other students. In these circumstances, Lynda saw herself adopting a mentoring role. The example given by Kerry, described a typical lesson for her Mathematics class when students would be using graphics calculators. She said she would "...stand up in front of the class and give a demonstration of what to do and go through a couple of examples." Kerry anticipated this would take five to ten minutes depending on what the specific activity was. The lesson would then progress with "...the students just having a go and working out for themselves how they worked."

Section 7: Confidence. This section of the profiling instrument focused on activities related to integrating ICT into teaching and learning. All the teachers in the study were extremely confident in using ICT in their teaching practice. They felt they could develop resources, provide authentic learning experiences, teach new applications, and provide opportunities for students to work collaboratively. Joanna was, however, the only teacher to give an example of developing collaborative learning experiences. She discussed how she used the webquest scaffolding features to promote students working together for a common purpose. This was part of the Trans-disciplinary Unit, 'Water', described previously.

In relation to teacher confidence levels to choose activities that facilitate the development of stated learning outcomes for students the teachers rated themselves from being moderately confident to highly confident on a Likert-type scale. Lynda, however, contradicted this by adding that her aim was to target higher order thinking skills as outcomes for her students but she lacked the confidence to be able to identify activities that provided the opportunities to do so. None of the teachers provided evidence in the other sections of the profile to support their confidence levels in the development of resources for the development of learning outcomes in Mathematics.

Section 8: Objectives for Using ICT with Your Students. The teachers in this study indicated they mostly used ICT resources and applications for students to master skills just taught, finding out about ideas and information, and giving students the opportunity to

work independently. Additionally, Ashley described the benefit of students learning ICT skills and mathematical concepts at the same time. She did not, however, give details to support this claim. Joanna used digital resources to motivate her students about a topic and to provide a context for units of work. The example given by Joanna was on a Science topic and was not in relation to the teaching of Mathematics. The Science topic did have mathematical content but Joanna did not identify learning outcomes in this area as being an objective for this particular unit. None of the teachers identified Mathematics learning outcomes to be the objective of using ICT.

Section 9: Teacher Skills. The development of teaching resources for students as well as the use of ICT in the management of their teaching practice has allowed the teachers in this study to develop high ICT skills, for most applications. According to the teachers, these include word processing, spreadsheets and data analysis, multi-media presentations, email, search engines and desktop publishing. Applications involving database management and graphics were the areas the teachers identified where they had low skills. They did, however, express confidence that they could learn these applications quickly should they want to incorporate them into their teaching and learning programs.

Section 10: Professional Development. The teachers participated in a number of professional development programs to develop the skills to integrate ICT into their teaching and learning programs. The programs were outlined in the previous section describing the context of the study undertaken.

In relation to future professional development needs, the teachers identified that they needed limited assistance learning new applications and would like to have more time to develop resources, so that they could implement new practices into their teaching. Lynda expressed a desire for professional development to include examples of student work. She felt that this would best demonstrate the benefits of ICT for students. Kerry saw the benefits of having access to an 'expert' at hand when having difficulties. None of the teachers favoured large-scale professional development programs that involved all the teachers from the school, preferring programs that would cater for their individual needs.

Discussion and Implications

In this case, the promise of ICT transforming educational practice had not been fully realised. Overall, the teachers in this study believed they had embraced the use of ICT as an educational tool for their students by providing new and creative learning experiences involving ICT. Whilst their purpose and use of ICT varied from teacher to teacher, they all demonstrated their ability to develop digital resources, publish those resources on the school intranet and communicated with other professionals by email. The teachers also provided many ICT enriched learning opportunities for their students. These included webquests, online course delivery, digital simulations, and interactive games. The teachers had not, however, been able to articulate fully how the use of ICT had been translated into improved learning outcomes not only in Mathematics but also in any of their teaching areas. It appeared they used ICT primarily to support their teaching practice and create resources but had been unable to identify the student learning associated with the use of particular computer applications and ICT environments.

Considering Shulman's (1987) teacher knowledge variables there was limited evidence given of knowledge of learners and their characteristics, and of pedagogical content knowledge in relation to how the application of ICT promotes the development of

mathematical concepts and ideas. This suggests the teachers had not made the connections between the mathematical content, the mathematics learner, and ICT as an educational tool for developing mathematical understanding. Despite this, the teachers in this study through their commitment to their own professional development, good ICT skills, and willingness to use ICT had positioned themselves favorably to develop their practice further.

The results of the case study indicate there are educational implications that may be significant for the developers of professional development programs. To date, most professional development in ICT has focused on the teacher and the development of effective ICT skills. This study demonstrates that the professional development opportunities offered to the teachers on the integration of ICT into professional practice have not addressed their needs as Mathematics teachers. McGehee and Griffith (2004) contend that it is important that teachers develop an understanding of how the technology promotes mathematical thinking to ensure teaching and learning strategies promote a better understanding about mathematical concepts. It is suggested that future professional development programs be designed to allow teachers to construct an understanding of the characteristics of ICT applications and the ways in which they promote mathematical understanding. As suggested by one of the teachers in the study, opportunities to examine exemplars of units of work in Mathematics utilising ICT, with examples of student work, may assist in the understanding of how ICT impacts on student learning outcomes.

References

- Brooker, L. (2003). Integrating new technologies in UK classrooms: Lessons for teachers from early years practitioners. *Childhood Education*, 79(5), 261-269.
- CEO Forum. (2001). Key building blocks for student achievement in the 21st Century. *The CEO Forum School Technology and Readiness Report*. Retrieved April 29, 2004, from <http://www.ceoforum.org/reports.html>
- Department of Education, Tasmania. (2004). *Project based learning using multimedia*. Hobart: Author.
- Kozma, R.B. (2003). Technology and classroom practices: An international study. *Journal of Research on Technology*, 36(1), 1-11.
- McGehee, J., & Griffith, L.K. (2004). Technology enhances student learning across the curriculum. *Mathematics Teaching in the Middle School*, 9(6), 344-349.
- Reynolds, D. (2001). ICT in education: The future research and policy agenda. In *Proceedings of the Building an ICT Research Network Conference*. Retrieved April 29, 2004, from <http://www.becta.org.uk/research/reports>
- Roschelle, J.M., Pea, R.D., Hoadley, C.M., Gordin, D.N., & Means, B.M. (2000). Changing how and what children learn in school with computer-based technologies. *The Future of Children*, 10(2) 76-102.
- Shulman, L.S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57, 1-22.
- Stake, R.E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage Publications, Inc.
- United States Department of Education, Office of the Under Secretary, Planning and Evaluation Service, Postsecondary, Adult, and Vocational Education Division (2000). *Evaluating the technology proficiency programs' graduates: Assessment instruments and design issues*. Washington, DC: Author. Retrieved October 10, 2003, from <http://www.ed.gov/offices/OUS/PES/higher.html#subpt2>
- Ward, L. (2003). Teacher practice and the integration of ICT: Why aren't our secondary school teachers using computers in their classrooms? In *Educational Research, Risks, & Dilemmas. Proceedings of the Conference of the joint New Zealand Association for Research in Education and Australian Association for Research in Education, Auckland*. [CDROM].
- Watson, J. (2001). Profiling teachers' competence and confidence to teach particular mathematics topics: The case of chance and data. *Journal of Mathematics Teacher Education*, 4, 305-337.
- Watson, J., Beswick, K., Caney, A., & Skalicky, J. (2005). *Being numerate in the middle years* (An evaluation report on the targeted professional learning numeracy program for teachers of students grade 5-8, August to November, 2004). Hobart: University of Tasmania.