How are science teachers using their TELA laptop?

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The Digital Horizons: Laptops for teachers scheme provides teachers whose schools opt into the TELA scheme access to a laptop for their exclusive use. This paper reports on a three-year evaluation of the impact of the TELA laptops on teachers' work. The findings of the evaluation suggest teachers are making substantial use of the laptop for tasks such as lesson planning and preparation, reporting to parents and communication with colleagues. Teachers are making some use of the laptop in the classroom for teaching and learning. Science teachers are amongst the most active users of the laptops and the paper details how ongoing access to a laptop changed the way a third year science teacher planned for teaching and subsequently his interactions with students during lessons. Colleagues and the science head of department noted that the teacher provided a role model for what was possible. This case study highlights the importance of leadership and collaboration in supporting the integration of ICT into science teaching and learning.

Introduction

In 2002, the government released its latest ICT strategy: *Digital Horizons: Learning through ICT* (Ministry of Education, 2002b). This outlined the government's goals in relation to ICT as an area of knowledge relevant to all students and it reflects the New Zealand government's commitment to increasing the use of ICT in schools to help improve student achievement and teaching practice (Ministry of Education, 2002a) and to provide students with the skills and knowledge they need to achieve 'personal goals and to be full participants in the global community' (Ministry of Education, 2002a, p. 3). As such, it is predicated on the idea that teacher access to laptops will develop their confidence and competence in the use of ICT and this will have flow-on effects for teaching and learning in schools (Brown, 2004) The *Digital Horizons: Laptops for Teachers Scheme* [TELA] (Ministry of Education, 2002a) is one component of this policy. Initially, the TELA laptops scheme provided full-time teachers in secondary schools (Years 9 to 13) access to a laptop for minimal or no cost. Subsequently, teachers of Years 1 to 8 students have also been able to access a laptop via the scheme provided they were permanent full-time or part-time teachers working with Year 1-8 classes for at least 50% full-time equivalents (FTE).The stated goals of the scheme were to develop teacher confidence and competence in the use of ICT for professional growth and collaboration, for teaching and learning, and for administration. Schools gain access to laptops for their teachers on the condition that the school manages the integration of the laptops into the school environment where this includes providing and meeting the costs of additional ICT infrastructure, professional development and technical support. The Ministry information package for the scheme states that schools' commitment to these requirements is 'essential for an application to succeed' (Ministry of Education, 2002a, p. 4). The *Digital Horizons: Laptops for teachers evaluation,* the results of which are reported in this paper, was set up to evaluate the impact of the laptops on teachers' work.

Teachers with laptops

New Zealand is just one among the many countries (see also Britain, some states in Australia, some districts in the USA, and Singapore) that have provided teachers with laptops for their exclusive use. Evidence is emerging that teachers find that the laptop affords greater access to resources for lesson preparation and provides for the streamlining of management and administrative tasks (Cunningham, Kerr, McEune, Smith & Harris, 2003). There is also some evidence that laptops can support increased communication between teachers, students and parents and greater sharing of information between teachers, and that their portability allows for flexibility in place and time of work (Cunningham, Kerr, McEune, Smith & Harris, 2003). Teachers have reported increases in ICT confidence and competence with perceived positive impacts in the classroom (Cunningham, Kerr, McEune, Smith & Harris, 2003). From such studies a picture has begun to emerge of the positive impacts that laptops can have on teachers' personal and professional development, and the personal and contextual factors that help and hinder their integration of ICT into their professional lives. Some researchers argue that teachers who are confident and competent in using ICT not only appreciate its usefulness but can also envisage possible benefits for their students (Jones, 2004; Zhao & Frank, 2003) whilst others caution teacher response to innovation is never sequential, predictable or even able to be generalized (Windschilt & Sahl, 2002). This said, there is general agreement that teacher integration of ICT into teaching and learning takes time and involves more than the provision of resources and the development of technical skills. Professional development to enhance the use of ICT needs to cater for varying levels of knowledge and expertise and to balance teacher skill and pedagogical needs (Zhao, Pugh, Sheldon & Byers, 2002). In terms of contextual factors, school leadership including a vision for change and planning for action to implement this vision are crucial (Cuban, Kilpatrick & Peck, 2001). Windschilt & Sahl (2002) and Zhao and colleagues (Zhao & Frank, 2003; Zhao et. al., 2002) provide evidence that when the prevailing school culture is one of collaboration and mutual support for change the diffusion of technology innovations is more likely. Teacher use of ICT, particularly any integrated classroom use, requires a reliable technological infrastructure that includes network systems, hardware and software (Cox, Preston & Cox, 1999). Quality on-site technical support is important so that teachers can be confident that ICT equipment will be functional when they need it (Becker, 1998; Jones, 2004).

The research design

The Digital Horizons laptops evaluation study used a mixed-methods approach that incorporates a series of nationwide surveys over three years; regional focus groups over three years, and, in the case of Year 9 to 13 teachers, school-based longitudinal case studies. The initial national Year 9-13 questionnaire was administered towards the end of the 2003 school year (October/November) to a stratified random sample of 20% of the schools involved in the *Digital Horizons: Laptops for secondary teachers* scheme, 81 secondary schools in total. Selection took into account factors such as school type, geographical location, school socio-economic status, and whether the school was urban or rural. The role of the initial questionnaire was to generate baseline data on teacher participants in the scheme and their use of the laptops. Forty-nine schools of the 81 schools in the sample returned completed questionnaires (a return rate of 60% for schools). The numbers of laptop teachers within schools who

responded ranged from two to forty-two with a total of 688 completed questionnaires. This represented a response rate of 54% of teachers with laptops in the schools surveyed, as per data supplied by the respondent schools. The respondents were generally experienced teachers: half had been teaching at a secondary school for more than 15 years. Over half (56%) were over the age of 45 years and more were in the 45-54 year age bracket (40%) than any other group. There were roughly equal numbers of male (47%) and female (53%) teachers. Almost two thirds (62%) of teachers came from main urban secondary schools. Nearly all (99%) of teachers had a teaching role in their school. Over a third (39%) were heads of department or faculty. Only 16% of teachers had responsibility for ICT in their schools. Eighty percent had a computer at home and 40% had had a computer at home for at least six years. This pattern of response was repeated in 2004 and 2005 (Cowie et al., 2006).

The focus group component of the study provides a means for exploring in more depth the issues associated with teacher use of laptops. Group interaction allows for the extended discussion of issues and benefits as participants build on each other's ideas and introduce topics of interest to them (Cohen, Manion & Morrison, 2000). In the first round, six focus groups were conducted to ensure reasonable coverage of issues (Vaughan, Schumm & Siaguh, 1996). Each group was restricted to twelve participants to minimise any negative impacts of group dynamics (Morgan & Krueger, 1993). Focus group schools were selected based upon their geographical location and reasonable proximity to a main centre with due regard given to school socio-economic status, gender, and the school roll. Between six and ten teachers from three or four schools attended each group, a total of 48 teachers from 20 schools. Focus group discussions were held in non-school venues and lasted for up to three hours. The focus group participants held positions in their schools ranging from that of principal to first year teacher. Some described themselves as 'computer freaks' and others said that the laptop was the first computer they had used. While it was not always easy to recruit teachers to participate in a focus group, due mainly to time factors, those attending commented on the positive experience and on the professional development that it had given. Discussion was generally lively and positive.

Case studies provide for a rich description and analysis of what is happening in a bounded system (Bassey, 1999). In this study they allowed for the explication of both teacher use of laptops accessed through the laptops scheme and the context in which the teachers were utilising their laptops. Eight case studies were undertaken in a range of secondary schools.

An overview of the impact of laptops

The findings of the three years of the TELA Year 9-13 evaluation are presented here in terms of teacher use of their laptops for the purposes associated with the TELA goals: collaboration and communication; administration and management, lesson planning and preparation, and classroom use. Several factors emerged as supports and constraints to these teacher uses of the laptops. These factors were: leadership and school organizational support, professional development and school ICT infrastructure. Each factor appeared as salient for each of the uses, although it manifested in different ways for different uses and for different teachers, depending on their knowledge and expertise. These aspects are described under the different uses that teachers made of their laptops for – administration, communication, lesson planning and preparation, collaboration and instruction/classroom use.

- *Teacher use of laptops for administration*

Non-instructional or administrative uses predominated in the questionnaire responses with over half of the respondents overall indicating that they used their laptop for administrative tasks such as writing reports for parents, recording and checking student data. A higher proportion of beginners used the laptop for writing reports for parents than for any other task. In 2005, 65% of all beginners used the laptop for this purpose, 14% more than used the laptop for any other listed task. By 2005, recording and checking student grades were tasks performed by nearly half of those who rated themselves as beginners, two thirds of those who rated themselves as intermediate users, and three quarters of those who rated themselves as expert users. These are administrative tasks associated with teachers' obligations to monitor and report on student progress, which perhaps explains their prevalence. A well-set-up school infrastructure was crucial for teacher use of the laptop for administrative and management functions including reporting, student data entry and internal communication.

- *Use of laptops for communication*

Each year over half of the intermediate user and expert user questionnaire respondents reported that they used the laptops for 'routine communication with colleagues for professional purposes'. As might be expected, the use of email as a means for whole school communication, both formal and informal, was not seen as viable unless all staff had an laptop/computer, easy access to the school network *and* could be relied on to use this facility on a regular basis, with some indication that whole-school communication via email needed to driven by the school leadership. Email played a role in communicating with colleagues in other schools and with teacher organizations for just over two fifths of the questionnaire respondents overall (predominately those who rated themselves as expert users). Many focus group and case study teachers recommended email for this purpose, claiming it allowed for greater flexibility of communication with those outside school than did the telephone or fax. Teachers were now in more regular contact with a wider range of colleagues around the country to plan joint activities, including extra-curricula activities for students and meetings and conferences for teachers. Email was used as a tool for sharing and collaboratively preparing lesson materials. In one case study school the science department was collaboratively planning a new course with colleagues in a school around 100km away. Where teachers lacked home access to the school network, teachers emailed work to and from home and school. Other studies have reported extensive teacher use of email for professional and personal communication suggesting that it provides an engaging entry point for teacher use of ICT, one that includes obvious and immediate feedback and efficiencies.

- *Teacher use of laptops for lesson planning and preparation*

Tasks associated with lesson planning and preparation included the preparation of student handouts, and accessing the Internet and Te Kete Ipurangi (TKI[1]) for curriculum or assessment-related documents. Around three quarters of teachers

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[1] TKI is a bilingual portal-plus web community which provides quality assured educational material for New Zealand teachers, school managers, and the wider education community.

overall (2003-73%: 2004-71%: 2005-78%) had used their laptops to prepare student handouts or worksheets. There was an increase over the three years in the proportion of teachers who had routinely accessed online resources for their lesson preparation (2003-46%: 2004-66%: 2005-69%). Teachers in the focus group and case study interviews were very positive about the benefits of greater access to a range of multimedia resources, including those on educational and other websites, CD ROMs and copies of electronic materials given to them by colleagues. They also appreciated the functionality of the laptops for undertaking research related to units they were teaching. A majority of these teachers used the laptop as their main/only repository for the materials, including lesson and assessment resources. For these teachers the laptop had become a portable office that could be transported easily between school and home. Teachers appreciated being able to design lesson materials at school in collaboration with colleagues, and at home within a family setting. Some reported they now spent more time at home on schoolwork but this was acceptable to them because they were not 'shut away' from their family. On the other hand, three focus groups expressed concerns about 'work creep', and were apprehensive that working at home would become an expectation, rather than a choice.

Departmental mentoring and leadership, either from a head of department and/or ICT expert within a department, was said to be vital to encourage the development and sharing of electronic lesson materials, and the setting up of a well-organised central repository for lesson materials. For example:

> *Rather than standing in the middle of the room and looking around everybody and saying, "Who has got something for this text or novel?" The first thing you actually do is ask for help. The system we have at our school is that of going to the Q-drive and looking in the English folder and then by year group and the topic and see what somebody else has already put there. And our HOD is trying to remind us constantly that every time you develop a new resource, put it there so others can access it and change it for their class needs.*

- *Teacher use of laptops for collaboration*

Laptops provided the flexibility of easily-modifiable resources that could be easily shared and as such were said to fit well with the collaborative culture of many departments. Teachers considered that access to a laptop had led to increased sharing of resources. Teacher commentary suggested that the more teachers within a department with laptops the more likely departmental colleagues were to collaborate using a laptop and so in some instances the TELA restriction on part-time teachers accessing laptops had restricted the use of the laptops for communication and collaboration within a department.

- *Teacher use of laptops in the classroom*

The questionnaire results indicated that teacher use of the laptops in the secondary school classroom, even the use of *PowerPoint* was not widespread. Only 17% of respondents, overall in 2005, reported that they routinely used *PowerPoint* presentations in class. This proportion rose to a third (34%) for those who classified themselves as expert users even though just over three quarters of expert users (72 %) reported easy access to a data projector. Of those who classified themselves as intermediate users only 12% were making routine use; 55% reported easy access to a data projector. None of those who rated themselves as beginners said they used the laptop for *PowerPoint* presentations, although 28% reported easy access to a data

projector. In terms of occasional use, 47% of expert users reported use of *PowerPoint,* compared with 42% of intermediate, and 25% of beginners. However, a majority of focus group and case study teachers, and some questionnaire respondents, reported a significant impact on their teaching, in that the laptops made a substantial difference in student motivation and interest through the inclusion of images and real data, as the following comment indicates:

> *Much more impact…like infectious diseases, you're showing infectious diseases pictures of people with these horrible things…rather than just saying, 'they've got syphilis!'…one of the other science teachers just did a* PowerPoint *on STDs.*

Learning more about how to use the laptop for teaching and learning was the main goal for focus group and case study teachers, and around a third of questionnaire respondents, with increased proportions of expert and intermediate users citing this as their main goal. One of the case study science teachers who had used the laptop extensively in both physics and chemistry classes with applets (mini programs) and animations, felt that the use of ICT technology was often the only way to demonstrate practical experiments such as chemical reactions and explosions. However, he was mindful to not lecturing to the material and emphasized that there still needed to be a strong teacher direction in 'how the material is used to convey information' and what outcomes might be expected. He felt that someone needed to model for teachers the advantages of ICT for teaching and learning to inspire the motivation for change.

In conjunction with professional development, continuity of access to a data projector and/or the Internet was considered a major influence on how the laptops were used in the classroom for teaching and learning.

The response of science teachers
The case study interviews indicated that teachers from different subjects might have integrated the laptops into their work in qualitatively different ways, particularly in relation to use in the classroom for instructional purposes (see also research by Hennessey, Ruthven & Brindley (2004) in the UK, and Bebell, Russell & O'Dwyer (2004) in the USA). From the questionnaire data in 2005 it was interesting to note that the use of the laptop as a teaching tool was most prevalent amongst science teachers (n=98) at all levels of self-reported ability, with 68% of expert users, 49% of intermediate users, and 50% of beginners using the laptop as a teaching tool. In 2005, science teachers (n=96) were second only to ICT/computer teachers (n=42) in routine use of the laptop in the classroom: 25% routine use for accessing the Internet (ICT=40%); 33% routine use to do a classroom presentation (ICT=44%); and 15% routine use with curriculum-specific software (ICT=60%).

Science teachers gave examples of their use of the laptop in lessons that included accessing information on the Internet to answer student questions, such as 'when were the first plants discovered?' On some websites teachers had accessed educational games, such as in human evolution or the study of 'light', they had then downloaded and had their students compete with one another. They also used the laptop with information from the Internet to enhance student understanding of a complex technique and to demonstrate concepts that were difficult to illustrate in the lab. Information from the Internet was used to facilitate classroom discussion, for example, on monotremes. Online current weather and satellite maps, pictures of various bacteria and fungi, biological models, and examples of big cat hybrids, how

they occur and their physical characteristics were typical examples of how science teachers had used the Internet in lessons.

Classroom presentations had been used by science teachers to show chemical reactions which could not be demonstrated in the lab, and to present difficult models such as the structure of an atom; the differences between solids, liquids and gases; and the animation of the digestive system. A science teacher had used the laptop–plus-data projector to show pictures from NASA in a lesson on spacecraft and humans in space. Presentations were also used by science teachers to introduce a topic, or to explore a website with the class. Science students had made presentations of their own work to show the class.

Science curriculum-specific software was being used with the laptop, particularly in physics and astronomy. On physics teacher reported the use of a program that measured the voltage in a solenoid when a magnet passed through it. At the same time, a graph was plotted on the screen – something that could not be done without a laptop. Generating distance/time graphics in physics was also done using software and the laptop. A class could view online the progress of the space shuttle from the NASA site, or see the southern sky at night – the star constellations, the planets, the moon eclipse and the sun eclipse with astronomy software. In addition to software, science teachers were also making use of the laptop with CD ROMs and DVDs for simulations, virtual field trips, and to look at the structure of molecules. Data logging had proven to be useful with some science teachers particularly in experiments and doing titrations in chemistry labs. One Year 10 class had been able to create an interactive periodic table, and another had been split into two groups, with one group of students writing a program with the teacher for building a robot, while the rest of the class built the robot.

Some science teachers had other equipment at their disposal for use in the classroom and had become quite creative in the use of their laptops, such as the teacher who had used the laptop linked to a digital camera focused through a microscope eyepiece to capture CCU images to be integrated into student-centred *PowerPoint* presentations. Another teacher said he was happy to be 'forced' to use the laptop as a teaching tool since the science department had replaced classroom whiteboards with two *Smartboards* and two data projectors.

Again in 2005 the 14 science teachers from seven case study schools were enthusiastic about the use of the laptop-plus-data projector/Internet for teaching science. They reported extensive use of lesson materials that integrated text, simulations, interactives and real-world data (images and video clips) to stimulate student interest and engagement. The use of an interactive whiteboard had allowed at least one science teacher to engage students and to incorporate and build on their ideas. Departmental leadership in one focus group school had been instrumental in making access to images easy for science teachers.

> Our department has a large clip library and is in the process of transferring video footage to DVD. The drawback with videos is that they are difficult to put into lessons versus an edited clip that can be used and repeated easily. They are great for revision also.

As a group, the case study science teachers commented that the development of electronic lesson material had been 'quite a big learning curve', but something that was worthwhile because they saw the laptops as 'building efficiencies' for the future.

The case of Josh as third year science teacher

In this section we describe the case of Josh, a third year science teacher from a co-educational high school with a roll of just over 1100 students. Nearly half of the 63 teachers at the school had laptops from the TELA scheme. Josh rated himself as an 'expert' user of ICT. In his classroom in 2005 Josh had a ceiling mounted data projector, a *Smartboard* and a desktop computer with Internet access. His laptop was set up and connected to the data projector. Josh always had his laptop on during class.

Josh took advantage of the flexibility of provided by the laptop-interactive whiteboard to adapt projected lesson materials in the moment. The wording of student notes was discussed and amended to reflect class consensus. The students recorded the negotiated version of the text, although Josh kept a record of his original notes. Josh had found that static and dynamic images, animations and simulations and real life examples enhanced both student interest and understanding. For instance, the students responded thoughtfully to questions about energy change after seeing a bungy jump; they were engaged by a discussion of tectonic plates having seen video clips and pictures of New Zealand earthquakes and their aftermath; and discussed atomic structure having viewed a simulation of the atom. Overall, Josh had found that images 'sparked student ideas and questions' and he deliberately used them to stimulate student questions, some of which he typed up during the course of ongoing whole class discussions. With his Year 9 science students, Josh used the questions posed by students in one class as exercises for students in his second Year 9 class and vice versa. Josh also went onto the Internet during a lesson to search out material to illustrate and contextualise his explanations of ideas for students who were struggling with concepts.

While Josh was a knowledgeable, confident and enthusiastic user of ICT he cannot be seen in isolation from the science department and school setting. In this case, the HoD science was knowledgeable about ICT but made limited use of her laptop as a teaching tool. However, she recognised Josh as a leader in the area of ICT and enabled his leadership by publicly acknowledging his expertise and providing opportunities for him to demonstrate what he was doing and share ideas and resources. Kate, who was in her second year of teaching, highlighted the support and encouragement she had received from Josh. She had replicated in the classroom some of the things Josh had developed and trialed. The three science teachers who were interviewed reported that there were opportunities to share ideas, lesson material and websites during departmental meetings. This collegial support was important in supporting and extending teacher use of laptops for in teaching and learning science. Teacher professional development in the school was 'self organized' to meet immediate needs and Josh also played an important role in supporting staff from other departments, one that was acknowledged by all the teachers who were interviewed.

Senior management leadership had also contributed to development in Josh's practice. The deputy principal, for instance, had arranged for the school to purchase four *Smartboards* and ensured that one went to Josh. Compared with the situation in 2004 when he only had intermittent access to a data projector, Josh had moved to integrate

ICT into all his lessons in 2005. The principal also supported the use of ICT, but only as one of many initiatives to enhance student motivation and learning. Teachers were expected to word process their report comments and enter their own NCEA assessment data. Some staff could and did access their email from home. The school culture for laptop uses was still evolving. The laptops were thought to have contributed to an improvement in school ICT facilities as more classrooms had been cabled and staffroom facilities had been extended.

Conclusion

In the Digital Horizons: Laptops for teachers evaluation study it was found that science teachers were often enthusiastic about using their laptops to stimulate interest and engage students in lessons. They had found that it facilitated classroom discussion, could be used for generating graphics and for data logging during experiments, and was useful to demonstrate concepts or to show reactions that would otherwise be difficult to illustrate in the laboratory. This paper has illustrated through the experience of one science teacher (Josh) how ongoing access to a laptop can change the way a teacher plans for teaching and subsequently, the nature and focus of a teacher's interactions with students during lessons. Using a laptop-plus-data projector, sometimes in conjunction with a *Smartboard*, Josh incorporated material from the Internet, local newspapers and other texts along with his own life experiences to provide students with experiences of science ideas that were grounded in everyday questions and examples. This case study provides an example of how access to laptop, coupled with teacher enthusiasm and a reasonable level of resourcing, can transform classroom practice. It also highlights the importance of leadership at the departmental and whole school level. The principal and head of department, while not active supporters of the integration ICT into teaching, had created a school culture that supported teacher collaboration, and the exploration and dissemination of practices that might enhance learning.

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