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Augmenting primary teaching and learning science through ICT

Introduction

This study explored how information communication technologies (ICTs) in primary classrooms can enhance the teaching and learning of science. By building on teachers' and students' prior knowledge and experience with ICTs, we investigated how ICT use can structure activities to offer enhanced opportunities for active participation in science. The project generated examples of how ICTs can support subject-relevant ways of exploring and communicating science, and evaluating what has been learnt.

Key findings

1. ICTs augment teaching and learning in science when their use intersects with and supports specific scientific ideas and skills.
2. Visual recording technologies promote independent learning by allowing students to collect, review and revise data.
3. Science investigations that include the use of ICTs for independent work promote student motivation and engagement.
4. Using ICTs in science involves careful preparation for the specific skills that support scientific ways of thinking and investigating.

Major implications

1. ICTs amplify science learning if teachers unpack the scientific ideas to identify specific pedagogical strategies that exploit the opportunities of each ICT.
2. Visually recorded data present instant, immediate and context-rich information that teachers and students can use as a repository for evaluation, analysis and communication.
3. For ICT-supported activities to meet the needs of diverse learners, students and teachers need "sandpit" time to develop competencies to participate in various tasks.
4. Teachers who use ICTs require support tailored to the specific pedagogical, content and technology needs of the topic they are teaching.

The research

In New Zealand, and internationally, claims are being made about the potential for information and communication technologies (ICTs) to transform teaching and learning. Research evidence for this proposition is inconclusive, however (Bolstad & Gilbert, 2006). Much of the literature reports evidence *that* ICTs enhance classroom practice but fails to explain *how* this is achieved. In any case, it seems inevitable that ICTs will have an important role to play in schools in the future. This study contributes to the understanding of how ICTs might be able to transform learning by exploring ways in which ICTs can be employed in primary school science. The "affordances" or opportunities that different ICTs and combinations of ICTs have to offer were a particular focus.

Technological pedagogical content knowledge (TPCK) is emerging as an important area for research and development (Mishra & Koehler, 2006). TPCK involves integrating knowledge about the affordances of technology with pedagogical and content knowledge. Effective use of ICTs requires teachers to orchestrate the interaction of these three aspects (Wright, 2010).

In order to understand the affordances of ICTs and the role teachers can play in helping students exploit them, it is important to investigate the "messiness" of the digital tools being used in science classrooms (Hennessey, 2006). This means looking at "pedagogy in context", as a practice situated in subject-specific approaches and understanding, influenced by the cultural setting and the cognitive, physical and digital tools in that setting. This approach is needed to address "how" and "why" questions, and to identify the roles teachers play in constructing settings conducive to successful learning with ICTs.

Research questions

This study worked with two primary science teachers and their Year 7 and 8 students over 2 years (2009–2010) to explore how teachers use ICT digital tools to support student interest, motivation, expression of ideas and understanding. For this research ICTs include any digital technology the teachers had access to, whether hardware or software, such as the interactive whiteboard (IWB), the Internet or digital cameras.

The research project set out to answer the following questions:

1. What are the existing ideas and experiences primary teachers have about teaching science with the use of ICTs?
2. What are the existing ideas and experiences primary students have about using ICTs in school, in particular when learning science?
3. How do teachers and students use ICTs in the classroom?

Methodology and analysis

Tanya Thompson and Candy Hart, the teachers who took part in this study, had participated in a previous research project (Cowie, Moreland, Jones, & Otrel-Cass, 2008). Both of these experienced practitioners used a variety of digital technologies in their everyday practice. Both were from a state-funded, urban, decile 4, co-educational middle school catering for Year 7–10 students.

The research adopted a collaborative methodology (Armstrong et al., 2005) based on Lesh and Lehrer's (2000) model of iterative video analysis. During the classroom observations the researchers videoed the teachers and their students using ICTs in science lessons. The teachers and researcher(s) present in the classroom identified the initial themes. At team meetings, researchers and teachers discussed the pedagogical rationales for using ICTs when teaching science. During these recorded meetings the team watched and discussed selected sections of videoed observations. The whole team then identified exemplars for dissemination.

The results

The central themes that emerged were how technology can be exploited to add to or enhance the teaching of science, and to unpack the affordances of the specific ICTs used.

ICTs and science ideas

When making sense of scientific ideas, students needed opportunities to work independently and collaboratively. This meant the teachers needed sufficient scientific background knowledge to design learning experiences and tasks that could be also supported through a targeted use of ICTs. When doing this, they had to plan for all students to be involved in tasks to improve their conceptual, procedural, societal and technical knowledge of science. When teachers felt confident and spent time unpacking, planning and preparing for these tasks, they were able to identify activities where ICT provided support or opportunities that went beyond traditional classroom experiences.

Teaching vignette: While teaching the states of matter unit, Tanya discussed with her students the changes of state for water. She knew that although the students were familiar with the various states they found it difficult to articulate precisely what happens during changes of states. When discussing condensation, Tanya talked about familiar experiences such as the steam that forms when water is boiled, or the condensation that forms on the inside of windows during winter. Tanya showed students photos she took for this purpose. Students then engaged in their own observations of the condensation that forms on the sides of a glass filled with water and ice. This took approximately 25 minutes and was followed by a time-lapse YouTube video of the same experiment. The video was only 40 seconds long but the students could relate what the video depicted to what they had just observed. Showing the students the video *after* their own investigation allowed them to make connections with what they had experienced in real time and benefit from seeing the changes highlighted and illustrated in full through the time-lapse video.

ICTs that promote student independence, motivation and engagement in science

When ICTs were used, students were usually motivated and enthused, particularly when they could use digital tools independently to solve problems. Contextual problems created interest and relevance and an authentic need to use digital tools. ICTs that supported tasks with more than one possible solution and opportunities to publicly share, illustrate and/or manipulate findings, provided rich opportunities for students to become more active and absorbed in their learning.

Teaching vignette: When Candy and Tanya's students were using Google Earth for their earth science investigation, the students would frequently use the IWB rather than a computer screen when they wanted to zoom in, manipulate and discuss among themselves and with the teacher or other students what they had found out. When we interviewed the students later, they said they enjoyed using the IWB more than the traditional whiteboard because of the variety of interactive opportunities the IWB offered.

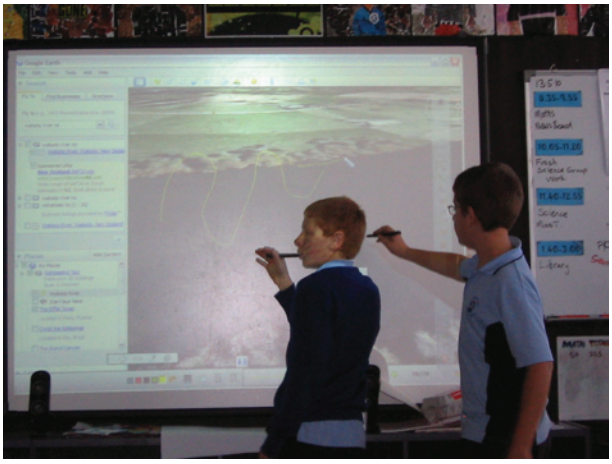

Figure 1: Thinking about river currents using Google Earth and the IWB

Visual digital technologies for science investigations

Digital tools that supported visual meaning-making in science supported student learning. ICTs such as videos, animations, images, maps and models from the Internet, visual thinking software (i.e., concept mapping) and a digital microscope were vehicles for representation, reflection and argumentation. These tools became invested with meaning when they were used and adapted to become part of student and teacher reasoning.

Teaching vignette: When Tanya and Candy's students went on a joint field trip to the nearby river to collect rock samples, they brought their digital and video cameras. They video-recorded a description of the site location and took photos of rocks *in situ* (and later with a scale). The students used video recordings to review information when they were filling out a more in-depth description on paper. The photos the students took were used to record and later compare with photos they took when they broke the rocks open. The recordings personalised each student's investigation and became part of an evolving scientific study. Video recordings of students' descriptions and reflections were also used by the teachers to gain formative insights into student understanding.

Sandpit and reflection time when using ICTs in science

Sandpit time to trial and test new ICTs was important so that the teachers could familiarise themselves with the technology and consider where and when ICTs could be used to support the teaching and learning of scientific ideas.

Teachers included sandpit and reflection time for their students to become familiar with and capable of using digital tools independently and appropriately. Preparation and reflection were important to evaluate where and when ICTs supported the representation, communication and reflection of specific ideas. Actively reflecting on ICT use helped the students to articulate their learning experiences and identified for the teachers where they might need to spend more time developing technical skills.

Teaching vignette: During the second year of the study the teachers ran three online surveys for students to reflect on and identify how they thought specific technologies had helped them learn science. One student highlighted that using the interactive white board was engaging, and another noted that the Internet allowed them to look up rocks to compare and confirm their identification of the ones they had collected.

Major implications

How teachers prepare for classroom instruction in science depends on their knowledge of science and what they know to be potentially difficult for their students. Teaching science with the support of ICTs depends in addition on teachers' knowledge of the affordances of ICTs including the skills students will need to utilise such tools. If ICTs are to offer students opportunities to deepen their thinking and data collection, as well as for science communication, students need to be proficient in the use of digital tools and know how to take advantage of the different ICTs. To achieve this time spent reflecting on how science investigations can be supported through ICTs is essential.

This also means that teachers need to be aware of how different digital tools might promote learning, expand learning experiences, help students relate science to their own experiences, enable data collection, enhance self-management and promote the communication of scientific ideas. Engaging teachers in meta-analysis of their teaching and their students' learning helps them to identify strategies, opportunities and the consequences of using ICT in science classrooms.

The key to creating interesting learning environments with ICTs is to provide opportunities for students where they can apply skills and knowledge across different applications. Tasks with these qualities are engaging and motivating, and provoke students to go beyond simply finding "right answers". However, teachers cannot assume that students know about the range of opportunities ICTs may have to offer just because they are young people: they need to spend time practising with students before they can apply these tools to their learning.

Visual ICTs can be very helpful in communicating and representing ideas in science. At times science can be hard to comprehend because not every natural phenomenon is easily observable. Visual ICTs have the potential to overcome some of these challenges by zooming in or out, or speeding up and slowing down a phenomenon. They can be particularly useful if they are not used as finished products but are seen as "improvable objects" (Ferguson, Whitelock, & Littleton, 2010) where students can add or manipulate aspects that clarify and extend their ideas and thinking.

Teachers need support if they are to identify how and when ICTs can contribute to problem solving , finding answers or communicating ideas as part of student activity. ICTs afford new possibilities for teachers, but these affordances must be used to support pedagogical strategies that can bring about successful learning experiences for students. If teachers make clear to students the advantages ICTs bring to a particular learning process, the students can then expand their opportunities to learn. This means that time needs to be committed for regular reflection and sandpit time in using ICTs. For this to happen, school leadership needs to value and commit to providing regular opportunities for collaboration, sharing and reflection on ICT-based teaching practices that are specific to subject needs (Cowie, Jones, & Harlow, 2006). The collaborative teacher–researcher research process espoused in this study helped to raise teachers' critical awareness and reflection of their practices in science, thereby providing teachers with many of the critical, collaborative opportunities they hoped to foster in their students.

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