Chapter 17
Challenging Opportunities: Integrating ICT in School Science Education

Julie Crough, Louise Fogg, and Jenni Webber

17.1 Introduction

This chapter details a research and ICT-based initiative that helps bridge an identified gap between science that is conducted in the real world and science education in schools. Section 17.1 outlines the challenges of the problem, the context, the purpose and opportunities of the research initiative. Section 17.2 examines the pathways to resolving the problem including the participatory approaches used throughout the project and the research underpinning the resources that were developed. Section 17.3 discusses the diverging pathways involved in developing and implementing the resources. Section 17.4 reflects on the lessons learnt from the research initiative and identifies some potential future directions.

17.1.1 Challenges for Science Education

In northern Australia, the population density is extremely sparse with an average of 0.3 people per square kilometre who live in an expansive area covering 1.5 million

J. Crough (✉)
Research Institute for Environment and Livelihoods, Charles Darwin University,
Darwin, NT 0909, Australia
e-mail: julie.crough@cdu.edu.au

L. Fogg
Northern Territory Department of Education and Training, Curriculum Teaching
and Phases of Learning, GPO Box 4821, Darwin, NT 0801, Australia
e-mail: Louise.Fogg@nt.gov.au

J. Webber
Northern Territory Department of Education and Training,
GPO Box 4821, Darwin, NT 0801, Australia
e-mail: jenni.webber@ntschools.net

K.C.D. Tan and M. Kim (eds.), *Issues and Challenges in Science Education Research: Moving Forward*, DOI 10.1007/978-94-007-3980-2_17,

square kilometres (Garnett et al. 2008; Woinarski et al. 2007). In stark contrast, Singapore has a population density of 6,814 people per square kilometre and a land area of 710.2 square kilometres (Statistics Singapore 2009). Such a sparsely settled region presents considerable challenges where nearly half the schools are located in rural or remote areas, where the teacher retention rates are low, but where challenges for schools in general and science education in particular are high. Other unique demographics that characterise this region create further challenges. In 2007, 39.5% of students enrolled in schools in the jurisdiction of the northern territory (NT) were indigenous, and this percentage is increasing relative to the total student cohort (Department of Education and Training 2008). The Secondary Education Review highlighted the significance of this high proportion of young indigenous people in the NT. In particular, such a demographically young and rapidly expanding indigenous population has responsibility, through the *Aboriginal Land Rights (Northern Territory) Act 1976* for custodianship of 85% of the Northern Territory coastline and half of its land mass. The implications of this for education, and particularly science education for indigenous students, are significant; in order to fulfil responsibilities for 'caring for country', indigenous people will increasingly need to access and engage with Western knowledge systems (Ramsey et al. 2003). Educational technologies provide critical tools for both teachers and students living in these remote areas. For example, the 'schools-of-the-air' that service many remote parts of northern Australia rely on interactive distance learning technologies.

This sparsely settled population of northern Australia lives in a landscape that is dominated by tropical savannas (see Fig. 17.1) covering about 25% of the continent (Hutley and Setterfield 2007). While savanna ecosystems are most commonly associated with the great African plains, with huge herds of animals, they occur in over 20 countries, mainly in the wet-dry tropics (Hutley and Setterfield 2007). Savannas are defined as 'grassy landscapes – woodlands with a grassy ground layer, or grasslands – that occur in tropical areas where the climate is seasonally dry' (Dyer et al. 2001, p. 5). Due to aboriginal occupation for nearly 50,000 years, coupled with relatively recent European settlement in the last 150 years, northern Australia has been bestowed with a great natural legacy where an ecologically functional landscape-scale natural environment has biodiversity of international significance (Woinarski et al. 2007). However, its savanna landscapes are in flux where fire, large grazing animals and invasive species have all been implicated as drivers of adverse change (Woinarski et al. 2007). While this internationally and ecologically significant area includes three World Heritage Areas, Kakadu, Purnulula and Einasleigh, it has remained largely ignored as a focus for quality, web-based and accessible educational resources.

However, many of the challenges facing science education in Australia's savannas are mirrored elsewhere. Science education, not only in Australia but also in many other parts of the world, faces other challenges as political influence intensifies on education and mandated testing (especially in Literacy and Numeracy). Similar concerns for science education are echoed by Rodriguez and Zozakiewicz (2010) who warn that science education is becoming an 'endangered species' in the United States due to the strong emphasis on literacy skills and standardised tests in isolation

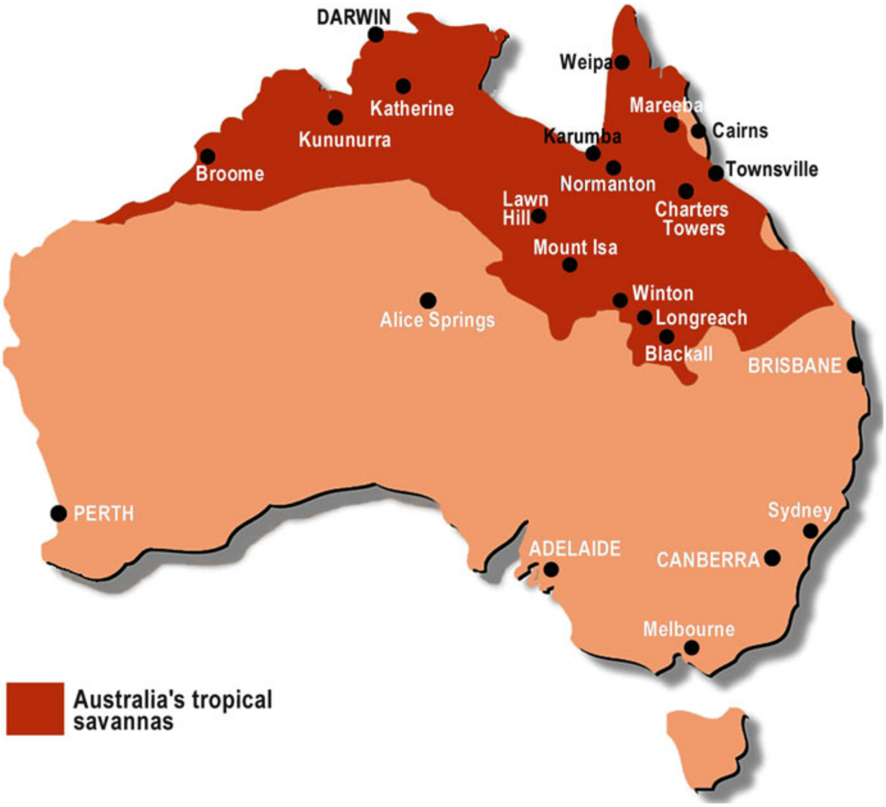


Fig. 17.1 Map of Australia's tropical savannas

from specific content areas. While science education faces considerable challenges throughout the world, many of the issues are similar in Australia. In 2001, *The Status and Quality of Teaching and Learning of Science in Australian Schools* identified the need to provide quality curriculum resources for lower secondary teachers and raised the concern of the lack of an interesting, relevant and challenging curriculum that actively engages students (Goodrum et al. 2001). Another study in 2005 commissioned by the Deans of Science found that a large percentage of teachers had not completed a major 3-year undergraduate degree in the science subject for which they were responsible (Fensham 2006). In 2007, Tytler highlighted the mismatch of science that was taught in school with how science exists in the real world (Tytler 2007). Furthermore, Tytler (2007) identified the growing necessity to bridge the gap between scientific research and science education. These issues and concerns are further exacerbated in northern Australia. The need to increase student engagement in science that is relevant and provides a meaningful and contemporary context is a significant challenge particularly in rural and remote areas where there are difficulties securing teachers, let alone qualified science teachers. Access to appropriate curriculum resources that are relevant and current to the environment in which the teachers and students live is also a considerable challenge. Not only has this been a limiting factor for teaching and learning science in remote schools but also for teachers and students in many urban schools.

17.1.2 Opportunities for Science Education

17.1.2.1 New Curriculum Pathways

In response to the aforementioned research and other studies and concerns, the new *Australian Curriculum: Science* has been developed. It focuses on the personal and practical relevance of science to students and addresses contemporary science issues. This gives teachers the basis for teaching science in a way that will engage students in meaningful ways and prepare them to use science in everyday life. The strand *Science as a human endeavour*, a relatively new development for science education in Australia, includes content with a focus on contemporary and future issues relevant to Australian students' lives, for example, sustainability, water in Australia, health, genetics applications, renewable energy, global warming, climate change, technological innovation and engineering (Australian Curriculum Assessment and Reporting Authority 2010). As this new curriculum is implemented throughout Australia, it will become increasingly necessary for teachers to not only integrate this new strand with the other two strands, *Science understanding* and *Science enquiry skills*, but also to ensure that science is relevant and engaging for their students, including studying local contexts where students can make better sense of the ideas to be learnt (Australian Curriculum Assessment and Reporting Authority 2010).

17.1.2.2 Partnership Pathways

In response to such needs at both a national and large regional level, the project – Tropical Savannas Knowledge in Schools – was created to develop relevant, current, interactive and authoritative resources for sustainability in northern Australia. It was the first collaborative online project for the Northern Territory Department of Education and Training (NT DET) as well as the first project between the Tropical Savannas Cooperative Research Centre (TS-CRC) and NT DET. Thus, no models to adopt or adapt were available that could guide the design-based research and resource development. From the outset, however, this research initiative had two key directives from NT DET: it needed to be an online project in terms of outputs (to provide access to all schools, especially those in remote areas) as well as support for the newly implemented outcomes-focused Northern Territory Curriculum Framework. Subsequently, the output of such a collaborative project would be the creative development of a dedicated website for schools. It would be designed with teachers and students, as well as scientific researchers, educational designers and ICT professionals, to address this identified need and help bridge the gap between savanna science and science education in schools.

Cooperative Research Centres (CRCs) are an Australian Government initiative established in 1990 to strengthen collaborative research links between industry, research organisations, educational institutions and relevant government agencies. The Tropical Savannas CRC (TS-CRC), with its 16 partner organisations – including Charles Darwin University – focuses research on sustainable land-management issues in northern Australia. Therefore, through its extensive research partnerships, the TS-CRC provided the opportunities to collaborate with many scientists from disciplines ranging from archaeologists to zoologists.

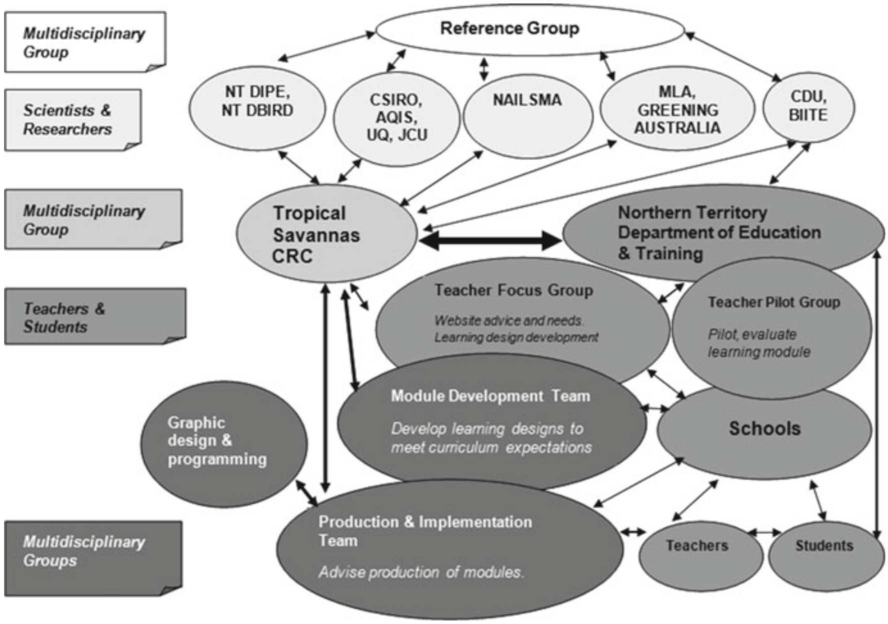
17.2 Converging Pathways: ICT, Science Education and Savanna Science

17.2.1 ICT Affordances

Not only do computer-based learning environments provide access to all schools in the Northern Territory, irrespective of their remoteness, but they also provide an opportunity to adopt different approaches to learning in science education. Research supports that constructivist beliefs are more conducive to technology integration than traditional beliefs. Becker and Ravitz (1999) identify 'constructivist-compatible' instructional activities that include: designing activities around teacher and students' interests; engaging students in collaborative group projects in which skills are taught and practised in context, rather than sequentially; focusing instruction on students' understandings of complex ideas rather than on definitions and facts; teaching students to self-consciously assess their own understanding; and engaging in learning in front of students, rather than presenting oneself as fully knowledgeable. These constructivist approaches are also supported by research on effective learning that emphasises the following three principles: learning is enhanced when learning opportunities are tailored to an individual's current levels of readiness; learning is more effective when it leads to deep understandings of subject matter; and learning is more effective when learners are supported to monitor and take responsibility for their learning (Bransford et al. 2000). Thus, it was essential that the ICT resources that were developed for the project needed to embrace constructivist pedagogies.

17.2.2 Participatory Approaches

Collaborative and participatory research methodologies were integral to the design and development of the *EnviroNorth: Living Sustainably in Australia's Savannas* website.



Acronyms

AQIS -Australian Quarantine Inspection Service
BIITE -Batchelor Institute of Indigenous Tertiary Education
CDU–Charles Darwin University
CSIRO-Commonwealth Scientific Industrial Research Organisation
JCU-James Cook University
MLA-Meat and Livestock Australia
NAILSMA-North Australian Indigenous Land &Sea Management Alliance
NT DIPE, DBIRD-Dept of Infrastructure Planning & Environment,
Department of Busi-ness, Industry & Resource Development
UQ–University of Queensland

Fig. 17.2 Participatory framework for *EnviroNorth* initiative

A framework was developed to facilitate the collaborative and participatory nature of the project (see Fig. 17.2). Small multidisciplinary teams were formed at various junctures in the project. Teachers and students were engaged in the project at various stages including small teacher pilot groups who provided timely and constructive feedback. Scientists and other researchers were engaged in advising the project at strategic points. In particular, their extensive knowledge and experience was sought during the design and development phases of the learning modules and thus embedded in the resources. While key teachers have been involved in the initiative since its inception, they have continued to provide constructive feedback and champion exemplary science education practices in their respective schools and regions. The collaborative nature of the Tropical Savannas CRC facilitated access to both researchers and scientific research in the real world. The overall concept and overarching

Table 17.1 Pedagogical, design and development features of *EnviroNorth* initiative

EnviroNorth	Pedagogical features	Multimodal literacy features	Design and development process
Teach savannas	Curriculum links Teaching for understanding framework Assessment	Scientific articles Graphic organisers Videos Transcripts Templates Field guides	Co-designed with and for teachers, plus ICT professionals
Learn savannas	Enquiry-based Scaffolding Characters/researchers as tutors Concepts interconnected Contextual learning Pedagogical content embedded Multiple perspectives – including indigenous Democratic and prescriptive learning environments Multi-disciplinary Open-ended performance task	Interactive modules integrating: Videos Audio Animation Graphics Artefacts Imagery Simulation	Informant co-design with teachers, students, scientists, graphic artists, programmers and other researchers Research-based design
Savanna windows	Issues-based content Student/teacher guided enquiry Multiple perspectives Cross disciplinary	Subject and geographically based articles Images Graphs	Co-authored with science communicators, scientists and other researchers

website, *EnviroNorth*, drew heavily from ethnography, user observation and user testing approaches to inform its design, structure and development (Futurelab 2004).

17.2.3 Pathways for ICT, Science Education and Savanna Science

The website resources, *EnviroNorth: Living Sustainably in Australia's Savannas*, include three key sections: *Teach Savannas, Learn Savannas* and *Savanna Windows*. Table 17.1 provides a summary of the pedagogical, multimodal literacy features, the design and development process. At the heart of the *EnviroNorth* web site are the interactive multimodal learning modules. These modules support knowledge construction and enable learning (by embedding authentic tasks and resources) that are related to context, to practice (Oliver and Herrington 2001) and to the physical world in which the students live (i.e. northern Australia). The learning modules, *Savanna Walkabout* and *Burning Issues* use an enquiry-based approach to engage students in issues that reflect the challenges of researchers in the real world. These issues focus on biodiversity conservation, environmental management and climate change and sustainable resource use in the tropical savannas. By way of example, Table 17.2 provides a summary of the integrated enquiry, essential questions and learning outcomes for *Savanna Walkabout*. The learning modules, based on learning design, have been co-designed with teachers, researchers and students to represent credible activity and resemble the contexts in which the knowledge that the users are learning can be realistically applied (Herrington et al. 2003).

17.2.3.1 Learning Modules

The learning modules, *Savanna Walkabout*, *Burning Issues* and more recently, *Outback Mobs* were underpinned by current research in educational technology (including: Futurelab 2004; Haughey and Muirhead 2005; Hedberg and Harper 1997; Jonassen 2000; Herrington et al. 2007; Ma and Harmon 2009; McLoughlin and Oliver 2000; Oliver and Herrington, 2001), science and sustainability education (including: Goodrum and Rennie 2007; Tytler 2007; Fensham 2006; Aikenhead 2006; Australian Government Department of the Environment and Heritage 2005; Goodrum et al. 2001) and scientific research conducted in northern Australia (including: Hutley and Setterfield 2007; Woinarski et al. 2007; Whitehead et al. 2005; Dyer et al. 2001).

A modified informant design approach was adopted for the development of each module whereby ‘expert’ informants (researchers, students and teachers) were involved in early co-designing and later tested prototypes in development. For example, with *Burning Issues*, a small group of educators formed the expert informant group to develop the overarching performance task and continued as key co-designers throughout the module’s development. Once a draft prototype was developed, a teacher focus group informed the early design phase. Students were key informants and user-tested an early prototype as well as provided constructive feedback by talking aloud during semi-structured interviews. The development and production were participatory and iterative and at times, messy when numerous iterations were involved particularly during the user-testing and corrections phases. However, these phases were essential in order to ensure that each module’s interface was usable and engaging as well as to maintain the scientific rigour of the content.

Scaffolding, as illustrated in Fig. 17.3, is offered throughout each module using different strategies. Scaffolding includes controlling the focus whereby tutors or experts guide students through explicit questioning or emphasising key ideas or concepts (Bruner 1986). Another form of scaffolding is offered through the student guide in *Burning Issues* (see Fig. 17.3). The guide is accessible throughout the module and helps students formulate their ideas and plan their public awareness campaign. In the guide, a briefing template referred to as ‘My Notes’ acts as part of an online portfolio for students’ ideas and learning so that it can be continually annotated and saved.

Table 17.2 Summary of integrated enquiry, essential questions and learning outcomes for savanna walkabout

		Learning outcomes
Section (enquiry)	Essential questions	Learners
Living savannas (tuning in)	What do we know about tropical savannas?	Reflect on their existing knowledge and understandings of what re tropical savannas Develop understandings of the key characteristics of the tropical savannas biome Understand that unsustainable land use threatens biodiversity in savannas throughout the world
Termite trails	What is the social structure of termite colonies?	Understand that termites (as decomposers and herbivores) play a key role in Australia's savannas
Meet the termites (finding out)	Why are termites the lifeblood of savannas?	Understand that communities of plants, animals and people live and interact in Australia's tropical savanna ecosystems
Interdependence (finding out)	What threatens savannas and people?	Develop skills and understandings to build simple food chains and food webs with real world examples
Impacts (finding out)		Understand some of the key factors – weeds, feral animals and changed fire regimes – that threaten Australia's tropical savanna ecosystems
Research tracks	Who are some of the researchers addressing biodiversity issues in Australia's tropical savannas?	Understand some of the processes as well as the challenges that researchers face as part of working scientifically
Meet the researchers (going further)	What is happening to the Northern Quoll in Kakadu National Park?	Understand that researchers have a major role to play so that well-informed planning and management for biodiversity conservation occurs
Join the researchers (going further)		Participate (through a guided, virtual environment) in exemplary scientific research to overcome current threats to biodiversity in northern Australia Understand that indigenous knowledge and Western scientific knowledge both play a key role in understanding and conserving biodiversity Understand that they can make a difference towards biodiversity conservation and consider how they could get involved in current issues
Savanna treasures (taking action)	What opportunities exist to conserve our biodiversity?	Understand the challenges for biodiversity conservation in the tropical savannas biome Understand that it takes less energy and fewer resources to conserve ecosystems than it does to restore them after significant modification Act individually or as part of a group to make lifestyle choices and take action to protect biodiversity

Fig. 17.3 Scaffolding is integral to each learning module such as *Burning Issues*

17.2.3.2 Learning Designs

Learning designs represent a planned set of learning activities, with resources and supports designed to bring about the development of specific knowledge, skills and understandings (Oliver and Herrington 2001). The modules use a learner-centred approach (Sims 2005), where knowledge construction is supported (Haughey and Muirhead 2005) and where technologies support an active, constructive, intentional, complex, contextual, conversational and reflective approach (Jonassen 2000).

17.2.3.3 Authentic Learning Tasks

As part of the learning design, authentic learning tasks and activities need to provide the types of multiple roles and perspectives that are available in real-world challenges. *Learn Savannas* – the home for the learning modules – aims to engage students in science that is relevant to their lives but also the content pedagogy that helps make this possible. For example, in *Join the Researchers*, Dr. John Woinarski tutors students not only through the scientific process but also emphasises the considerations and challenges that are involved with such human endeavours.

Herrington et al. (2007) assert that the affordances of the Internet enable alternative perspectives to be readily accessed and can be targeted for specific tasks. In the context of the existing strong connection of indigenous peoples in northern Australia to their land, wherever appropriate, indigenous perspectives regarding issues were embedded in the modules. For example, the *Savanna Walkabout* module investigates the impacts of weeds on an indigenous homeland – the Rak Mak Mak Marranunggu People and how they have addressed their problem. In the *Burning Issues* module, the role of fire from a range of perspectives, including early European explorers and Traditional Owners, is woven into the module.

17.3 Diverging Pathways: Barriers and Enablers for ICT Integration

17.3.1 Overcoming Barriers

Research and experience has demonstrated that common barriers to technology integration includes lack of infrastructure and practical computer access for teachers and students, lack of teachers' confidence and skills, lack of curriculum freedom to integrate technology, social norms in teaching and learning communities that do not support technology integration, and teachers' pedagogical beliefs that do not align with constructivist pedagogy (Becker and Ravitz 1999; Ertmer 2005). Hedberg (2007) identifies the range of obstacles to integrating ICT including the lack of confidence and/or time for teachers to learn how to integrate ICT in their practices, the lack of ICT infrastructure and support, and the lack of compatibility between traditional teaching practices and constructivist pedagogies partnered by ICT.

The online modules and the whole *EnviroNorth* website were developed to align with the Standard Operating Environment in all NT schools and effort was placed on overcoming barriers wherever possible. For other educators whose system might be different, the Flash plug-in option and link is available with the online modules. As much as possible, any potential infrastructure barriers have been addressed and continue to be revised. For example, teachers in remote schools identified the need for a CD version of the modules to overcome Internet bandwidth constraints and unreliable online facilities. This need was confirmed early in the user-testing phase of *Savanna Walkabout* with CDs subsequently produced and disseminated accordingly.

17.3.2 Creating Enablers

Becker and Ravitz (1999) identify key enablers to technology integration as opinion climate, information and social support resources, and appropriate educational resources in sufficient quantity. Wherever possible, enabling strategies were included in the research initiative. Ethnography, user observation and user-testing approaches with middle-year students and teachers were conducted as part of the needs analysis of the *EnviroNorth* project. Feedback was incorporated into the resources by ensuring that users have the opportunity to explore the democratic learning environment and are actively engaging with it to construct their own understandings.

17.3.3 Integrating Computer-Based Simulations

Computer-based simulations can provide students with opportunities to predict-observe-explain by using phenomena that otherwise would not be available.

Hennessey et al. (2007) recognise the affordances of multimedia simulation that offer dynamic and visual representations of physical phenomena that would otherwise be dangerous, costly or not feasible in a school laboratory. Further, Papadouris et al. (Papadouris et al. 2009) identify the value and role of simulations for students as a powerful tool for exploring, investigating and interpreting natural phenomena. In *Burning Issues*, students 'enter' a virtual world and have the opportunity to manipulate the *Flames* model. In order to guide students in manipulating and understanding the model and its implications for real world situations, a key scientist who developed the *Flames* model, Dr. Adam Liedloff scaffolds the learning process. Ongoing support from Dr. Liedloff is offered via email messages that are generated at appropriate times and pose questions, emphasise key points and explain the more complex concepts.

17.3.4 Applying Web 2.0 Tools

The merits of Web 2.0 tools are evident as they provide particular opportunities to personalise learning for various reasons especially as they enable learners to create their own resources, which also potentially enables increased creativity in the curriculum (Becta 2008). The emergence of Web 2.0 over recent years has provided opportunities to embed Web 2.0 tools into the performance and assessment task in the more recent *Burning Issues* module. As previously mentioned, students are provided with a template *Guide* and teachers are provided with more support tools in the application of Web 2.0 for effective learning in the *Teach Savannas* section. The *Guide* is structured in two sections: *My Notes* provides scaffolding about how students might approach their public awareness campaign, while *My Tools* provides support on some of the Web 2.0 tools learners might like to adopt as part of their campaign. These tools were selected to provide a range of options that align with multiple intelligences (Gardner 1999) and their affordance to enhance learning and creativity.

17.3.5 Providing Learning Supports

A comprehensive teaching guide for each module is provided in the *Teach Savannas* section which includes curriculum links, assessment and learning plan suggestions. For example, *Savanna Walkabout* is fully supported on the *EnviroNorth* website by a suggested learning plan based on the Teaching for Understanding framework (Blythe 1998). Overarching understandings or 'big ideas', understanding goals that identify what students should know and do – the concepts, processes, skills and key questions – all help to focus the teaching/learning programme towards the intended outcomes. The learning plan is designed so that students are actively involved in their learning and continually construct/reconstruct understandings in the light of experience as they move from acquisition of facts to the development of deeper understandings. A metacognitive approach helps learners take control of their learning by defining goals and monitoring their progress in achieving them. The culminating performance task gives students a chance to apply and demonstrate their understandings in a purposeful and contextualised way. This section also includes relevant scientific articles and graphic organisers to support scientific literacy.

The democratic learning environment of each module is flexible enough to meet a diversity of learner needs depending on the learning focus taken and the offline teaching and learning. Some students will thrive in such an environment while others will need more support than is provided within the online environment. Teachers, in the role of facilitators of learning, guide their learners with the process of making meaning. By targeting specific assessment for and as learning opportunities within the module and/or offline to gain and give feedback, teachers can be informed as to what focused teaching or support different learners require. Also, the teaching guide is home to a range of further materials including articles (written in accessible language by the scientists), videos, data sets and graphics. The teaching guide offers a range of teaching and learning options for integrating across learning areas.

17.3.6 Implementing Savanna Science: School Snapshots

Savanna science programmes in schools that incorporate *EnviroNorth* resources and other innovative ICT practices have provided engaging, relevant, meaningful and purposeful learning for students. The following snapshots from a primary school and secondary school provide insights into the potential and realised pathways from integrating ICT in science education with a focus on the *EnviroNorth* resources.

17.3.6.1 Primary School Snapshot

Most children who attend a large primary school, located 40 km south of Darwin situated in a rapidly growing rural area, live on 2-ha blocks and small farms. This rural area is undergoing major change and the population has increased significantly over the past 15 years with the once predominantly savanna landscape now undergoing rapid subdivision into small holdings for residences and micro-agriculture. Environmental and sustainability education is a central part of the school's mission and its curriculum plan. The purpose is to encourage learners to examine and interpret the environment, both locally and globally, from a variety of perspectives; encourage learners to participate actively in resolving problems associated with sustainable development in the students' locality and the development of the school as a sustainable community; give learners 'first-hand' experiences within the environment – the school grounds, the immediate locality and other visits within the region and beyond – and involve learners in finding practical ways of ensuring the caring use of the environment and its resources, now and in the future.

At this school, the *EnviroNorth* website has been identified as a preferred primary resource for the teaching of (and for) the savanna environment and related issues both locally and globally. Since 2007, the resources have been used to support teaching and learning programmes targeting science, studies of society and environment, English, mathematics, learning technology and visual arts learning outcomes. The versatility of the website has allowed for flexibility in the delivery of content and supports a variety of teaching strategies. The resources have afforded a range of opportunities from teaching a comprehensive integrated unit of work that spans a whole semester to taking advantage of discrete sections of the site for targeted teaching.

In primary schools, students have used *Savanna Walkabout's Termite Trails* to prepare oral presentations for both students and parents. This has involved students using programmes such as *Kidspiration*, *PowerPoint* and *Photostory* to plan, construct and represent local savanna food webs. Throughout this process, students sourced suitable images, manipulated and presented information and shared understandings and concerns for savanna ecosystems.

Another integrated programme in the upper primary at this school included culminating tasks that created claymations where students scripted their short films and used webcams to produce the footage. This particular performance task enabled students to use educational technologies to represent their knowledge through narrative writing. These cooperative claymation films not only reflected the depth of the students' understanding about, and for, conserving savanna environments but they also provided students with opportunities to embed field work and investigate ecological and historical aspects of the savannas.

In early childhood at this school, *EnviroNorth* has been used to introduce students to scientists, the scientific method and dispel the myth of the white lab-coated scientist. The interviews with the savanna scientists and the great number of images of scientists in the field (in *Meet the Researchers* section of *Savanna Walkabout*) had most students agreeing that being a scientist out in the 'bush' looked like a lot of fun. Use of this section also provided an engaging way to introduce students to the type of questions that scientists use.

Graphs and data from the Cane Toad (*Bufo marinus*) and Northern Quoll (*Dasyurus hallucatus*) research provided an active way to engage students in data that reflected recent environmental changes in their own backyards. This area of the website – *Join the Researchers* – was chosen by teachers to teach focused lessons on enhancing students' visual literacy skills.

17.3.6.2 Secondary School Snapshot

In a nearby secondary school, also located in a rural setting, most students live on 5-ha blocks usually with stands of natural savanna woodland vegetation. Catering for over 1100 students from Year 7 to Year 12, it incorporates a 75-ha working mixed produce farm in the areas of stock, horticulture and aquaculture and a 150-ha reserve of natural open woodland where students undertake research and practical studies in conservation and land management. A savannas-focused integrated unit of work is introduced at Year 7. The unit aims to engage and connect students with their local environment and incorporates science, studies of society and environment, English and mathematics, building on students' prior learning by utilising the mapping skills developed earlier in the year. Students developed their knowledge and understanding of the adjacent savanna woodland reserve which they had visited earlier in the year. Fieldwork was supported by local government weeds officers who supported both students and teachers in the field. Links with both home and community were achieved through the development and implementation of the students own weed management plan. This process enabled students to take direct action in their own environment by knowing and applying effective weed management strategies.

Both the primary and secondary schools are well resourced with many aspects of ICT in the classrooms including Interactive White Boards and individual computers. However, challenges have arisen with the use of individual PCs in student computer labs. Older computers were very slow and several instances of machines freezing hampered students ability to complete set work in the lesson time available.

17.4 Conclusions and Future Directions

This project's participatory framework and research-based design approach has enabled it to embed pedagogical strategies and practices, partnered with educational technologies, to develop accessible online resources for science education. However, overcoming some of the barriers to effective ICT integration in science education has been a challenge since the *EnviroNorth* website was launched in 2007. As Conole and Fill (2005, p. 5) emphasise, 'the key to online education and constructivism is not whether or not the potential exists, but rather, whether or not the potential will be actualised'. Actualising such potential, by overcoming barriers to the implementation of these resources, is a challenge. Unfortunately, due to resource shortages (especially people) within the education department and the priority placed on high-stakes testing of literacy and numeracy at a national level the implementation has not been supported at a systemic level. While some infrastructural barriers still exist, they are relatively minor. Confidence and capability in teaching science is still a considerable barrier in many primary, secondary and remote schools in northern Australia where teachers often do not have any tertiary background or experience in science and so are reluctant to take risks and introduce it to their students.

Despite these barriers, *EnviroNorth* has been widely supported not only in northern Australia but throughout the rest of Australia. Evidence from the website usage statistics also suggests that the resources have been used in other countries throughout the world although to a lesser extent. *EnviroNorth* resources have been incorporated in a range of higher education programmes – such as teacher pre-service undergraduate and post-graduate programmes and Vocational Education and Training (VET) programmes. VET in schools is expanding, particularly in remote schools in northern Australia and will be a consideration especially in future. For many indigenous people whose homelands lie in these remote areas, VET is providing pathways for relevant education programmes while completing their schooling.

Experience has demonstrated that supporting teachers with professional learning can be problematic. In northern Australia, not only are there vast distances to cover for teachers to meet for the Science Teachers Association of the Northern Territory, there is also difficulty finding appropriate times. While face-to-face meetings are usually preferable, Web 2.0 tools such as wikis offer greater flexibility for teachers to exchange ideas, experiences and resources irrespective of time and physical location. Such potential opportunities are currently being explored.

The research initiative and resulting suite of website resources, *EnviroNorth: Living Sustainably in Australia's Savannas*, has been successful in achieving its purpose. It is bridging the gap between how science is conducted in the real world in northern Australia and how students conduct science at school. The web-based medium enables new technologies and other initiatives such as the new Australian Curriculum to be integrated into existing resources. The flexibility of such a medium enables new technologies to be accommodated as well as curriculum links and teacher support materials to be easily updated. The research project continues with the next module providing challenging opportunities: how to develop a 'caring for country' module that targets indigenous learners while integrating science, literacy and numeracy.

Acknowledgements This collaborative science education research project involved many other key people including Viki Kane, Peter Gifford, Dr. Peter Jacklyn, Kate O'Donnell, Barbara White, Dr. Linda Ford, Dr. Penny Wurm, Dr. John Woinarski, Dr. Sam Setterfield, Dr. Michael Douglas, Ian Dixon, Dr. Christine Bach, Dr. Ben Hoffmann, Dr. Lindsay Hutley, Leslee Hills, Stephen Sutton, Dean Yibarbuk, Dr. Adam Liedloff, Andrew Turner, Andrew Edwards, Trudi Oxley, Tom Stockwell, Dr. Darrell Lewis, Dr. Gabriel Crowley, Dr. Gordon Duff and Dr. David Garnett. Bushfires NT provided 50% of funding for the *Burning Issues* module. The Tropical Savannas Management CRC funded the project, in collaboration with its 16 partners, including Charles Darwin University.

References

Aikenhead, G. (2006). *Science education for everyday life*. New York: Teachers' College Press.

Australian Curriculum Assessment and Reporting Authority. (2010). *The shape of the Australian curriculum: Science*. Retrieved August 18, 2010, from http://www.acara.edu.au/verve/_resources/Australian_Curriculum_-_Science.pdf

Australian Government Department of the Environment and Heritage. (2005). *Educating for a sustainable future*. Carlton South: Curriculum Corporation.

Becker, H. J., & Ravitz, J. (1999). The influence of computer and internet use on teacher's pedagogical practices and perceptions. *Journal of Research on Computing in Education, 31*(4), 356–384.

Becta. (2008). *Analysis of emerging trends affecting the use of technology in education*. Retrieved August 25, 2010, from http://emergingtechnologies.becta.org.uk/index.php?section=etr&rid=14522

Blythe, T. (1998). *The teaching for understanding guide*. San Francisco: Jossey-Bass.

Bransford, J., Brown, A., & Cocking, R. R. (Eds.). (2000). *How people learn: Brain, mind, experience, and school committee on developments in the science of learning*. Retrieved October 28, 2007, from http://www.newhorizons.org/neuro/neu_review_bransford.htm

Bruner, J. (1986). *Actual minds, possible worlds*. Cambridge, MA: Harvard University Press.

Conole, G., & Fill, K. (2005). A learning design toolkit to create pedagogically effective learning activities. *Journal of Interactive Media in Education, 8*(8), 1–16.

Department of Education and Training. (2008). *Annual report 2008–2009*. Darwin: Northern Territory Government Printers.

Dyer, R., Jacklyn, P., Partridge, I., Russell-Smith, J., & Williams, D. (2001). *Savanna burning*. Darwin: Tropical Savannas CRC.

Ertmer, P. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development, 53*(4), 25–39.

Fensham, P. (2006). Student interest in science: The problem, possible solutions, and constraints. Plenary address to the ACER Research Conference 2006, "*Boosting science learning – What will it take*?" Canberra.

Futurelab. (2004). *Designing educational technologies with users*. Retrieved September 30, 2009, from http://www.futurelab.org.uk/resources/publications-reports-articles/handbooks/Handbook196

Gardner, H. (1999). *Intelligence reframed: Multiple intelligences for the 21st century*. New York: Basic Books.

Garnett, S., Woinarski, J., Gerritsen, R., & Duff, G. (2008). *Future options for North Australia*. Darwin: Uniprint.

Goodrum, D., & Rennie, L. (2007). *Australian School Science Education: National Action Plan 2008–2012: Vols. 1 & 2. The National Action Plan*. Canberra: Department of Education, Training and Youth Affairs.

Goodrum, D., Hackling, M., & Rennie, L. (2001). *The status and quality of teaching and learning of science in Australian schools: A research report*, Retrieved March 20, 2004, from http://www.detya.gov.au/schools/publications/index.htm

Haughey, M., & Muirhead, B. (2005). The pedagogical and multimedia designs of learning objects for schools. *Australian Journal of Educational Technology, 21*(4), 470–490.

Hedberg, J. G. (2007). Searching for disruptive pedagogies: Matching pedagogies to the technologies. *Curriculum Leadership*, *5*(12). Retrieved August 23, 2010, from http://www.curriculum.edu.au/verve/_resources/Hedberg_Paper.pdf

Hedberg, J., & Harper, B. (1997). *Creating motivating interactive learning environments*. Keynote address at EDMEDIA, Calgary.

Hennessey, S., Wishart, J., Whitelock, D., Deaney, R., Brawn, R., la Velle, L., McFarlane, A., Ruthven, K., & Winterbottom, M. (2007). Pedagogical approaches for technology-integrated science teaching. *Computers in Education, 48*, 137–152.

Herrington, J., Oliver, R., & Reeves, T. C. (2003). Patterns of engagement in authentic learning environments. *Australian Journal of Educational Technology, 19*(1), 59–71.

Herrington, J., Oliver, R., & Herrington, A. (2007). *Authentic learning on the web: Guidelines for course design*. Retrieved October 12, 2009, from http://ro.uow.edu.au/edupapers/48

Hutley, L. B., & Setterfield, S. A. (2007). Savannas. In S. E. Jørgensen (Ed.), *Encyclopaedia of ecology*. Amsterdam: Elsevier.

Jonassen, D. H. (2000). *Computers as Mindtools for schools: Engaging critical thinking*. Columbus: Prentice-Hall.

Ma, Y., & Harmon, S. (2009). A case study of design-based research for creating a vision prototype of a technology-based innovative learning environment. *Journal of Interactive Learning Research, 20*(1), 75–93.

McLoughlin, C., & Oliver, R. (2000). Designing learning environments for cultural inclusivity: A case study of indigenous online learning at tertiary level. *Australian Journal of Educational Technology, 16*(1), 58–72.

Oliver, R., & Herrington, J. (2001). *Teaching and learning online: A beginner's guide to e-learning and e-teaching in higher education*. Perth: Edith Cowan University.

Papadouris, N., Constantinos, P., & Constantinou, T. K. (2009). A methodology for integrating computer-based learning tools in science curricula. *Journal of Curriculum Studies, 41*(4), 521–538.

Ramsey, G., Hill, G., Bin-Sallik, M., Falk, I., Grady, N., Landrigan, M., & Watterston, W. (2003). *Future directions for secondary education in the Northern Territory*. Darwin: Department of Employment, Education and Training. Retrieved October 14, 2009, from http://www.det.nt.gov.au/about-us/publications/secondary-education-review

Rodriguez, A. J., & Zozakiewicz, C. (2010). Facilitating the integration of multiple literacies through science education and learning technologies. In A. J. Rodriguez (Ed.), *Science education as a pathway to teaching language literacy* (pp. 23–45). Rotterdam: Sense Publishers.

Sims, R. (2005). Beyond instructional design: Making learning design a reality. *Journal of Learning Design, 1*(2), 1–8.

Statistics Singapore. (2009). *Statistics Singapore*. Retrieved October 13, 2009, from http://www.singstat.gov.sg/stats/keyind.html

Tytler, R. (2007). *Re-imagining science education: Engaging students in science for Australia's future*. Melbourne: Australian Council for Educational Research.

Whitehead, P., Russell-Smith, J., & Woinarski, J. C. Z. (2005). Fire, landscape heterogeneity and wildlife management in Australia's tropical savannas: Introduction and overview. *Wildlife Research, 32*, 369–375.

Woinarski, J. C. Z., Mackey, B., Nix, B., & Trail, B. (2007). *The nature of Northern Australia: Its natural values, ecological processes and future prospects*. Canberra: Australian National University.