An Innovation Framework based on best practice exemplars from the Australian School Innovation in Science, Technology and Mathematics (ASISTM) Project

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Foreword

I am delighted to be invited, as a member of the study team, to write the foreword for this report. The task has been both challenging and rewarding. The challenges were twofold. First it was no easy task to identify from amongst the many successful ASISTM projects those to be represented here. As will be explained in the text, we tried to define a set which would illustrate a range of significant issues in the way projects were established and managed, in their outcomes, in their potential for sustainability and in their potential to inform others. No doubt there were many others we could have represented to advantage but we do hope that the stories we have chosen to tell here will both inform and inspire readers.

The second challenge was to communicate in written form something of the excitement and achievements generated by these projects. For those of us fortunate enough to be part of the study team it has been a privilege to talk with the participants in these projects and to share in some small way in what has been accomplished. I regret that our skills are not sufficient to fully capture the many subtleties and outstanding achievements of the projects but can only hope that we have conveyed enough to encourage thinking and discussion as to how new alignments of ideas, actors and practices can be used to increase the engagement of students with mathematics, science and technology.

On behalf of the team, can I use this opportunity to thank the project participants who, despite the many calls on their time, were willing to make themselves available so that we could get a sound understanding of their projects. It was a pleasure to be able to work with them and I can assure them that we have been inspired by what we have heard and seen.

David Symington

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Abstract

This report describes research into 16 ASISTM projects selected to be broadly representative of exemplars in innovation. Case studies of each project were constructed from interviews with a range of key participants, and used to develop and refine an innovation framework that is used to make sense of and describe the key features of each project. The major issue binding these projects was found to be that of student interest and engagement, and this was pursued through involving students in contemporary STM practices in authentic settings. The findings point to an enriched set of purposes of science, technology and mathematics (STM) education implicit in these projects, a set of pedagogical practices that are varied and consistent with contemporary educational thinking, and a varied array of 'actors' recruited to these projects. The study argues that the quality, sustainability and transferability of these innovations is linked to the alignment of these ideas, practices and actors. From the analysis a set of recommendations is generated regarding future practice in ASISTM or similar initiatives, and a set of broader implications drawn which argue that these case studies represent a productive future direction for education in STM.

Note About the Authors

Russell Tytler

Russell Tytler, Professor of Science Education at Deakin University, has been involved over many years with system wide curriculum development and professional development initiatives. He has researched and written extensively on student learning in science, and science investigations. His recent research interests include student reasoning in science, teacher and school change, and curriculum policy and development. He is currently significantly associated with a number of teacher and school change initiatives. Russell has been involved in a number of international teacher education and research projects, in Asia and Europe. He has a strong record in research, as evidenced by over 40 published or 'in press' refereed journal articles and conference papers, and book chapters, over the last 5 years, and a number of large projects for which he has been principal researcher.

Craig Smith

Craig Smith, Research Fellow at Deakin University, has spent the last 5 years researching in the area of innovation and education. Prior to his position as coordinator of the Faculty of Education's Research Priority Area, he was a senior researcher with the Victorian Schools Innovation Commission where he was the principal researcher on the *Beyond the Pilot* study. This landmark study involved working closely with schools, philanthropists and government, on the nature of innovation and with effecting sustained change in education. He completed a Doctor of Philosophy from The University of Melbourne, and has held a number of roles in academia, ranging from the teaching of philosophy to building research cultures.

David Symington

David Symington spent 14 years as a teacher in Victorian schools followed by several decades engaged in the education of teachers and in research in science education. He has held a number of leadership roles including a period as the Dean of the Faculty of

Teacher Education at Deakin University. He later worked for 8 years in CSIRO in several positions, where he learned a good deal about contemporary science and the path from the laboratory bench to the marketplace. Presently he is an Adjunct Professor at Deakin University where he is engaged with others in a number of research and development activities.

Susan Rodrigues

Susan Rodrigues has recently been appointed Professor of Science Education at the University of Dundee in Scotland. She began her professional life as a teacher in schools in England and New Zealand then, after completing a Doctor of Philosophy degree at the University of Waikato, she has held a number of academic posts in Australia, England, and Scotland. Professor Rodrigues has been a very active researcher working closely with schools and teachers and has published widely. She participated in this project while a visiting scholar at Deakin University.

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The research team would like to acknowledge the cooperation and generous support of the coordinators and other actors, and students, who provided time and information and materials for the construction of these case studies. We would also like to acknowledge the help of Curriculum Corporation personnel for their provision of information regarding the conduct of ASISTM and for helpful information on the projects. We also wish to acknowledge the help of the DEST team who commissioned this report and worked with us to make it happen in a timely manner.

Executive Summary

Background

This report arose from a need identified by the Department of Education, Science and Training (DEST) for an outsiders' perspective of the $33.7 million Australian School Innovation in Science, Technology and Mathematics (ASISTM) project. ASISTM, which enters its third year of operation, has now funded over 300 projects across Australia, resulting in a varied and interesting array of curriculum innovations and practices, with schools working with a variety of organizations to develop worthwhile learning experiences for students.

Specifically DEST was interested in exploring further the concept of innovation, which is one of the cornerstones of the ASISTM project. Deakin University's research group for Re-imagining Education in Mathematics and the Sciences was asked to identify and interrogate a subset of exemplar ASISTM projects to gain insight into their key characteristics, the factors that frame their success, and how one might better understand the nature of innovation in an educational setting, in the light of these projects.

Hence the purpose of this report is to provide advice to DEST on how best to frame the process of selection of future ASISTM projects and/or similar programs of innovation, explore what these projects may have to say about productive directions for the contemporary science, technology and mathematics curriculum, and share with a wider audience a small cross section of innovative Science, Mathematics and Technology (STM) projects undertaken by Australian schools.

This report frames the ASISTM initiative as part of a response to growing concern within Australia with student interest in and uptake of STM courses and careers, and relates it to a growing set of initiatives linking STM in schools with community, industry and other organizations.

One cornerstone of the ASISTM project is the promotion of innovation, and in particular the propagation of an ongoing 'culture of innovation' in Australian schools, as the means to bring lasting improvements to teaching and learning in STM.

An Innovations Framework for ASISTM

On the basis of the analysis of the history of the idea of innovation in education and elsewhere, the research team developed the following definition:

Innovation is the process of assembling and maintaining a novel alignment of ideas, practices and actors to respond to site-specific issues and/or to pursue a vision.

We developed an 'Innovations Framework' to guide the research methods and analysis. The framework was used to develop the broad themes and a set of questions used in building the case studies, and underpins the analysis. The framework includes six major dimensions:

1. The ideas being explored/promoted;
2. The actors (individuals, organizations, resources, environment) recruited in support of the project;

3. Practices (scientific, technological, pedagogical) to support the new alignment of ideas/actors;
4. Intended and actual outcomes;
5. Sustainability of the innovation in some form; and
6. Transferability of the ideas and practices beyond the local site.

This framework is potentially valuable within ASISTM to support educators in thinking through all the essential elements of any proposed innovation. It provides a lens through which the ongoing effectiveness of the innovation can be monitored, and a structure for ongoing planning. It also offers, at the systems level, a mechanism to go beyond the very local perspective and identify innovations that could be more widely applicable and act as exemplars across the education system.

Research design

The central task for the Deakin research team was to identify and write short case studies of 16 exemplars of innovative ASISTM projects. By doing so, the team also hoped to gain insight into these projects' key characteristics, the factors that framed their success, and how one might better understand the nature of innovation in an educational setting. We used the data collected from multiple participants in the 16 'exemplar' ASISTM projects, to answer the following research questions:

- How can we best describe the key features of exemplar ASISTM projects?
- What can these exemplar projects tell us about the potential outcomes of the ASISTM initiative?
- What is the nature of innovation represented by these projects?
- What are the factors that lead to successful outcomes?
- What are the implications of these projects for future policy directions in education in the sciences?

Selection of sites

16 sites were selected to represent a variety of successful projects, across states and territories, and representing different subject areas. Interviews were held with key players at each site, and material gathered, to construct 16 case studies, which we argue, are broadly representative as 'innovation exemplars'.

Findings

The analysis was framed around the Innovation Framework, and was concerned with generating insights into:

- Issues and/or visions underpinning these projects;
- Ideas, practices and actors that shape and contribute to these projects;
- Outcomes of the projects;
- Sustainability of the projects and the factors affecting this; and
- Potential transferability of the innovations.

Issues and visions underpinning these projects: One issue and vision all these projects had in common was that of student interest and engagement. This was generally linked in the projects to students being exposed to contemporary real world practice, and to expert practitioners of STM. Thus, while knowledge was a very important aim, it was usually very contextual, of a variety of types, and served this broad focus on engagement.

Ideas pursued in the innovation: The knowledge that students were exposed to in these projects was incredibly varied, and represented a broad range of purposes for education in STM including understanding of investigative and design processes, awareness of careers, problem solving, and interest. Engagement with science was largely achieved through involvement of students in authentic practices in local settings. Knowledge was often generated to pursue particular purposes, and often related to community interests. This poses a challenge for system wide curriculum policy.

Practices represented in the innovations: Students were often exposed to cutting edge, contemporary practices in science, technology and mathematics that formed the content focus for activities in these fields. The same was true of pedagogical practices and wider school and cluster practices associated with the innovation. Taken as a set, these projects involved a number of pedagogical practices that differ from traditional classroom practice, at least in science and mathematics:

- Project based or problem based learning;
- A strong skills focus involving scientific and related processes;
- More open pedagogies where students are given increased agency;
- The creation rather than absorption of knowledge by students;
- A wider set of knowledges including knowledge of processes, interdisciplinary links, knowledge about the contemporary and local use of STM, and knowledge of people using STM in employment;
- School programs providing significant in situ learning experiences for teachers;
- A ‘real’ audience for students’ work;
- Field trips and projects in the local environment; and
- Working with scientists and with local community members, as well as involvement of parents and the wider school community.

The practices were in almost all cases as significant for teachers as they were for students. For many teachers in these projects, the interaction with scientists and technologists and other community personnel led to a steep but satisfying learning curve. This was true also of their experience of new pedagogies.

The ideas and the pedagogical practices described above are consistent with the scientific literacy aims that underpin contemporary thinking in science curriculum development in Australia and elsewhere.

Actors recruited in support of the project: The report defines actors as those human or material entities impacting on the shaping and conduct of the project. These can be human (scientists, organizations, industries or the local community) and non-human

(local environmental conditions or resources or organisational circumstances that shape possibilities). The actors recruited to the project performed dual roles. They supported the project and its implementation, but they also were part of the local circumstances that gave rise to the project and shaped its direction. The innovation implicit in ASISTM is the alignment of teachers and outside experts in a partnership around a project that represents contemporary practice. Thus in many projects the actors provided insight for students into contemporary science and professional learning in the discipline for teachers. Teachers themselves were often powerful actors in the initiative.

In some cases, particularly those involving large organizations, the management role was taken over by the non-school partner and this released teachers and associates to focus on the intellectual framing and directing of the project. Community interests were important actors in some projects, particularly in rural areas.

Alignment of ideas, practices and actors: What is important for individual projects, in terms of their success and likely sustainability, is that these elements - ideas, actors and practices - are aligned, and mutually supportive. This is the case for these projects. As a generalisation, access to scientists working on local issues (actors) encouraged the pursuit of wider purposes of school science, technology and mathematics (ideas), and involved contemporary scientific and technological practices, and pedagogies that were varied and generally student centred (practices).

Outcomes of the projects: In these projects there have been significant outcomes for:

- Students – in addition to engendered enthusiasm there was significant knowledge generation and the development of expertise;
- Teachers - there was considerable evidence of professional growth and in some cases professional renewal in their stories. The ASISTM initiative offers a significant model of teacher professional learning;
- Teacher associates – there has been increased understanding of education and the value of support from outside the school system and some have chosen to enter the teaching profession; and
- The community – there has been increased understanding of science in society, science, mathematics and technology education, student interest in science based careers, and contributions to community facilities.

Sustainability of these projects: The form in which these ASISTM innovations are sustained will vary. The case studies indicate that the sustainability of an innovation can be usefully analysed through the lens of the Innovation Framework, and will depend on:

- The strength and relevance of new ideas and perspectives;
- The development of embedded practices; and
- Ongoing relationships between actors.

In addition there are concrete aids, such as units of work and web sites developed and equipment to promote sustainability. A number of these projects are already being rolled out, attracting further funding and/or becoming embedded in wider practices.

Transferability: The concept of transferability applies to local (for example, projects built around a specific environment) as well as to global projects, but in a different sense. Local projects are transferable to diverse situations through the applicability of their ideas, practices and alignment of actors. At the level of principle, the concept of capturing student interest through an appropriate local focus is applicable everywhere.

With regard to effective methods of transferring information and enthusiasm about individual projects the study participants point to the value of dissemination through personal testimony.

Implications for ASISTM

The analysis was used to develop a set of recommendations for the future conduct of ASISTM or any program that similarly supports local innovation.

Recommendation 1: That programs such as ASISTM should encourage a separation of management and educational leadership duties and ensure that project proposals factor the costs of each into their budgets.

Recommendation 2: That programs such as ASISTM encourage proposal writers to explore the antecedents of the proposed project, and indicate whether and how it builds from existing ideas and/or relationships.

Recommendation 3: That programs such as ASISTM should not be unduly influenced by prior notions of which topics will be of interest to students, but should recognise that students' interest in many topics in science and technology can be captivated when explored in a context where they can see their relevance and where those responsible for the instruction show passion for the topic.

Recommendation 4: That programs such as ASISTM give consideration to the extent to which proposals will provide opportunity for students and teachers to be exposed to contemporary practice in the field of study. This includes giving attention to both the selection of appropriate Teacher Associates and how their contribution to the project can be maximised.

Recommendation 5: That programs such as ASISTM require project proposals to give clear indication about how positive features of the program will continue beyond the life of the program.

Recommendation 6: That programs such as ASISTM create timelines and the possibilities for change in response to evolving circumstances which allow for the type of complexity which arises from projects involving multiple partners.

Recommendation 7: That programs such as ASISTM build a requirement that project proposals include a plan for communicating the experiences of the project through personal experience and/or testimony and that the costs of this be built into the budget for the project.

Recommendation 8: That DEST investigate ways in which experiences of, and understandings developed from, innovative approaches can be shared effectively across education systems.

Broader policy implications

Curriculum implications: The case studies illustrate the power of local curriculum innovation based on local expertise, local issues and resources, and individual teachers' passions and expertise.

There was evidence that some aspects of current curricula in Australian states were helpful in encouraging and supporting these innovations, and it is argued that curricula need to encourage innovation of the sort represented by these case studies. A question is raised concerning the preponderance of science projects in ASISTM, and the implications in particular for mathematics and innovation. In terms of local innovation of this sort becoming embedded within mainstream curriculum models, questions are raised concerning the implications for teacher knowledge, and also the possible need to be watchful regarding possible partisan interests of partners.

Particularly for technology projects, it was apparent that cutting edge and, often expensive, equipment was an integral part of the representation of contemporary practice, and this has issues for school resourcing. It was also noted that many of these projects were set in rural areas, where links between school and community is perhaps more readily achieved. This raises questions about how metropolitan schools can access contemporary practice in STM.

Teacher professional development: It was clear from the case studies that many teachers benefited enormously from these innovative projects. ASISTM can therefore be characterised as a significant teacher professional learning initiative that potentially provides a model for teachers to upgrade their knowledge of contemporary practice in their discipline.

Conclusion

- This study has shown the quality of projects which can be generated by programs such as the ASISTM program where students, teachers and community members have become enthused about STM and worked very effectively together;
- Provided useful insights into ways in which schools and community can innovate to create more relevant and interesting learning experiences for students;
- Raised interesting questions about the nature and content of school curricula;
- Pointed to a way in which in situ teacher professional development can be provided which brings teachers face to face with contemporary science; and
- Provided some extremely valuable insights into the lived experience of innovation across a diverse array of Australian schools.

Introduction

This report arose from a need identified by the Department of Education, Science and Training (DEST) for an outsiders' perspective of the $33.7 million Australian School Innovation in Science, Technology and Mathematics (ASISTM) project. ASISTM, which enters its third year of operation, has now funded over 300 projects across Australia, resulting in a varied and interesting array of curriculum innovations and practices, with schools working with a variety of organizations to develop worthwhile learning experiences for students.

Specifically DEST was interested in exploring further the concept of innovation, which is one of the cornerstones of the ASISTM project, as a lens to interrogate the quality of current ASISTM funded projects and provide guidance for future projects.

Deakin University's research group for Re-imagining Education in Mathematics and the Sciences was asked to identify and interrogate a subset of exemplar ASISTM projects to gain insight into their key characteristics, the factors that frame their success, and how, in the light of these projects, one might better understand the nature of innovation in an educational setting.

Hence the purpose of this report is to provide advice to DEST on how best to frame the process of selection of future ASISTM projects and/or similar programs of innovation, explore what these projects may have to say about productive directions for the contemporary science, technology and mathematics curriculum, and share with a wider audience a small cross section of innovative Science, Mathematics and Technology projects undertaken by Australian schools.

The report is thus split into five parts. Part A begins by discussing the core issues facing the teaching and learning of science, mathematics and technology in Australian schools and the significance that a program such as ASISTM has in addressing some of these issues. Underlining this discussion is one of the key elements of ASISTM, innovation, which we address by outlining a robust concept of innovation within an education context, allied with an 'Innovations Framework' (Part B) which guided the research and analysis.

Part C outlines the method, selection of sites and data collection utilized in the course of this study.

Part D is a thematic analysis of the 16 case studies, which unpacks the nature of innovation across the diverse educational settings, significant outcomes of these projects for teachers, students, non-school partners and community and how the various projects can be considered in relation to the issue of sustainability.

Part E discusses the implications for the ongoing support for ASISTM projects, including advice to DEST about effective and cost efficient ways to disseminate exemplars of specific innovative practices and broader examples of how to better manage such projects.

Part F raises broader implications, arising for analyses of these projects, for curriculum policy directions in science, technology and mathematics education.

Part A: Background

Outlining the Problem

The Australian School Innovation in Science, Technology and Mathematics (ASISTM) program is one of the key components of the Australian Government's strategy to address a growing concern with the decreasing level of engagement with the sciences (see, for example, DEST, 2003). The evidence for the latter is shown by the decreasing number of students taking up post compulsory science studies, the growing shortage of teachers of mathematics and science, and evidence of negative attitudes to science by students in the middle years of schooling.

There is abundant evidence that many students in Australia and other developed countries are becoming increasingly disengaged with school science. To a large extent they find school science irrelevant to their interests and concerns, the pedagogies authoritarian, and the content unrelated to contexts they would recognise as significant (Lindahl, 2003; Lyons, 2005, 2006; Osborne & Collins, 2001). There is also evidence that traditional science teaching does not capture the nature of contemporary science practice, being overly focused on the development of canonical abstract ideas and not paying sufficient attention to the multi disciplinary nature of contemporary science, the ethical and social and personal settings of science, or the human aspects of scientists' work and passions (Tytler and Symington, 2006; Tytler 2007). Tytler (2007) argues that the problem with student lack of engagement with school science relates to a failure of the content and practice of school science to reflect significant changes in contemporary society, in students' perspectives, and in the nature of science itself, and the lack of representation of contemporary science practices in the school curriculum.

ASISTM is significant in that it represents an attempt by the Australian Government to open up classrooms and support teachers by introducing teacher associates from community, industrial and scientific organizations to engage teachers and students with contemporary practice and knowledge in these areas.

Science beyond the classroom

There have been various motivations for initiatives that link community organisations and people with school science programs. Many initiatives have come from the science community itself. For example, in Victoria the Landlearn program was launched in 1994 by the Department of Primary Industries to help students appreciate the industry's contribution to the State and encourage them to consider careers in agriculture. There are numerous other examples of such initiatives from outside the education system which recognise that the school science program offers opportunity to address issues which the particular group see as important.

There have also been initiatives from within the education sector to form links with science in the community. For example, education officers have been funded by school systems to operate at sites that offer insight into aspects of science, such as Museums and Zoos. These people are normally school teachers who are able to capitalise on the resources available at the venue to generate interest and understanding in the areas of science relevant to the venue and its resources.

More recently concern with student disengagement has been a driver for an increasing incidence of school science activities that link beyond the classroom to local or global

communities. Such initiatives often explicitly aim to expose students to the practice of science in contemporary and socially engaged settings, in order to make science learning more relevant to them. One can argue that meaningful learning entails situating the learning in contexts that are relevant to the learner. Dewey argues that the real issue for meaningful student learning is the need to link classroom learning to students' lived experience.

The wider significance of the ASISTM project

ASISTM is interesting in that it has accepted project proposals where the initiative clearly comes from a school cluster and others where the initiative comes from a community organisation. The case studies presented in this report include the Wildflowers project whose origins are found in the relevant section of CSIRO, and the Ecotourism project that was conceived by educators.

The ASISTM project is also of significance in that the project leaders define the players and their roles in the project. This enables a range of perspectives to be recognised in the planning and implementation of science programs for school students. This is a quite rare event but is congruent with arguments that have been mounted in recent times for a greater range of voices to be heard in determining the purposes and focus of school science.

> *The (community leaders) bring a perspective that is different in emphasis, and draws on experience that is unlike that of most people within the school/curriculum system, yet very relevant to the sort of life pathways we would hope our students to travel.* (Symington and Tytler, 2004)

Innovation in ASISTM and in Education

One cornerstone of the ASISTM project is the promotion of innovation, and in particular the propagation of an ongoing 'culture of innovation' in Australian schools, as the means to bring lasting improvements to science, technology and mathematics teaching and learning. The ASISTM project, as part of the Australian Government's Boosting Innovation, Science, Technology and Mathematics Teaching (BISTMT) Program defines "innovation in schools" as

> *the practical application of an idea or ideas, new for schools involved in the project, to improve educational experiences and, hence, the learning outcomes of students. (BISTMT Programme Guidelines: DEST, 2005, p.6).*

DEST's definition of innovation is in line with current Government guidelines on how we should be thinking about innovation (i.e., "Innovation is about ideas, and the transformation of those ideas into value creating outcomes", National Innovation Council). While it is a useful place to start, when applied to a schooling context it proves inadequate: It is vague, it does not differentiate an innovation from other types of change undertaken by schools, and it passes too quickly from what innovation is (ideas and their transformation) to its anticipated benefits.

Drawing on both older ways of conceptualising innovation and years of field-based research (Angus, Chadbourne & Olney, 2001; Hargreaves, 1999; Latour, 1996; Smith, Smith, and Ryan, 2004; Smith, 2005; Rogers, 2003) how we propose schools should think of innovation is essentially

> *Innovation is the process of assembling and maintaining a novel alignment of ideas, practices and actors to respond to site specific issues and/or to pursue a vision* (Smith, 2005).

This way of thinking about innovation places an emphasis on the notion of combining or recombining ideas *and* practices *and* actors (people, but also inanimate things such as funding, physical structures and so on) to produce something that is new. This is a concept of innovation that incorporates four key moments:

(1) Innovation is the *process* of combining and recombining. It is not an invention, nor an object per se, even if later it acquires an 'object-like' status;

(2) That this process is *ongoing*, with new actors being enrolled into a network of relationships, ideas being refined etc.;

(3) That it is *relative*. The 'novel alignment of ideas and or practices' is novel only to a specific location, context and time i.e., what is innovative at one school or school cluster is not necessarily innovative at another; and

(4) That innovation is *purposeful*. It aims at responding to a site-specific opportunity and toward formalising a vision. The rationale behind exploring new ideas and practices – the "novel alignment" is conceived to make an improvement in the learning environment or related educational aspects, but the value of these 'novel alignments' can only be known after the fact.

The real value of innovation in education is that it is a particular type of change process that knots together the production of new knowledge, creative solutions, new alliances, relevance and engagement into a multifaceted relationship, literally an interlocking 'network' of innovation. To give one example: The ASISTM program is itself an innovation. It brings together people, institutions, resources and specific ideas (entrepreneurialism, 'real' science etc) in a 'novel alignment', in order to redress *inter alia* the issue of waning interest in science, mathematics and technology teaching and learning in Australian schools, which underpins the broader vision of a hi-tech, scientifically advanced economy.

Part B: An Innovations Framework for ASISTM

Based on the understandings of innovation in education, described above, the research team developed an 'innovations framework' to frame the research methods and analysis. The framework was developed iteratively, drawing initially on previous experience with innovation projects, and sharpened as the ASISTM projects were explored and selected. The framework was used to develop the broad themes and specific questions used in developing the case studies, and serves to underpin the analysis. The framework includes six basic dimensions:

1. The ideas being proposed: How adequate are they in terms of the proposed innovation's aims? What is their scope?
2. The practices being proposed: Do the practices support or impede the ideas being proposed?
3. The proposed actors: Who are the people, organisations, resources to be involved?
4. The outcomes: What is the innovation aspiring to achieve and what are the markers of its success?
5. Sustainability: What is to be sustained and how?
6. Transferability: In what ways is the innovation significant beyond its local site?

The Innovations Framework is described in the table below:

Major dimension	Sub categories	Comment
The ideas being explored/promoted	Change in the purposes of school science Change in teaching and learning — Teachers' practice Changes to students' experiences Changes to course content Different exposure of student to the discipline Bridging the primary/ secondary interface	How commensurable and/or effective are these ideas in helping the site achieve their innovation's aims? What is the educational significance of the ideas?
The actors recruited in support of the project	Teachers Organisations (e.g. CSIRO, RACV, universities) Non-school personnel (e.g. local science professionals) Installations / sites: local eg. marine or other environmental features; concentrations of industries, technologies national eg. telescope international e.g., MOON website	What is the range of teacher associates and significant partners in the innovation? How were they recruited, how committed are they to the innovation? e.g., what time/other resource commitments are offered? Are they 'actively' involved in the innovation?
Practices to support the new alignment of ideas/actors	Siting of projects in prior and/or ongoing activity Teaching and/or learning practices that are commensurable with the new ideas/actors being tried/recruited Adequate management structures for the breadth of the proposed innovation? Adequate communication across the participants e.g., website, meetings? Realistic allocation of tasks and resources?	This category deals with the ways in which the innovation is operationalised, including key elements such as new scientific and technological practices, and teaching and learning practices that support the new alignments of ideas and actors, relations between participants, and the importance of a management structure.
Outcomes	Intended and actual outcomes for: students teachers non-school partners community	What are the patterns of outcomes for the various players and how do these interrelate?
Sustainability	This may occur via: production of resources	What aspect of the innovation is to be

	development of embedded processes ongoing relationships between partners the strength and relevance of new ideas and perspectives	sustained and how? i.e., The project clarifies the various mechanisms which enable this to happen.
Transferability	This might occur directly or indirectly through: direct use of the resources developed transfer of practices and actor networks to other sites extension of the underpinning ideas to other sites	How significant, and in what form, is the innovation relevant for other sites? How best could the transferable features of the innovation be disseminated more widely?

This innovations framework has been central to this research. In the ASISTM context it is potentially valuable for encouraging educators to start thinking through all the essential elements of their proposed innovation, in quite concrete terms, right from the beginning. It also provides a lens through which the ongoing effectiveness of the innovation can be monitored, and as a framework for ongoing planning. The innovations framework also offers, at the systems level, a mechanism to go beyond the very local perspective of each innovation, whereby innovations that could be applicable across the education system could be identified, publicised and promoted to interested parties.

Part C: The Data Gathering for the Case Studies

Research design

Introduction

The central task for the Deakin research team was to identify and write short case studies of 16 exemplars of innovative ASISTM projects. By doing so, the team also hoped to gain insight into these projects key characteristics, the factors that framed their success, and how one might better understand the nature of innovation in an educational setting. We used the data collected from multiple participants in the exemplar ASISTM projects, to answer the following research questions:

- How can we best describe the key features of exemplar ASISTM projects?
- What can these exemplar projects tell us about the potential outcomes of the ASISTM initiative?
- What is the nature of innovation represented by these projects?
- What are the factors that lead to successful outcomes?
- What are the implications of these projects for future policy directions in education in the sciences?

Selection of the 16 case sites

We selected 16 sites from a cohort of 74 ASISTM projects, collated by the Curriculum Corporation and DEST from rounds one and two of the ASISTM program. Projects were suggested as suitable on the grounds that they were either completed or well advanced, and seemed to be on track to fulfilling their aims. From the 74 projects, we short listed 30 sites of interest based on criteria that started with a proportionate spread of sites from across the States and Territories, Government and non-Government schools, metropolitan and regional or rural locations. In addition, we also looked to include:

- At least one example of an innovative project drawn solely from a Maths, Science or Technology discipline;
- Projects that targeted students with special needs;
- Projects with strong links to industry or other strategic partnerships;
- At least 30% of the projects involve Catholic and/or independent schools;
- At least two projects that addressed issues relevant to indigenous students;
- Projects that clearly addressed the central ASISTM aims of engagement; and
- A broad spread of projects from rural, regional towns, regional cities and capital city schools.

From our matrix, we initially identified 30 projects of possible interest – 21 from the round one ASISTM projects and nine projects from round two. Four of these had significant partnerships across State or Territory boundaries. DEST was directly involved in the selection of the 30 projects of interest. All 30 projects were contacted, with the research team conducting telephone interviews with the Project Coordinators

and Critical Friends, plus reviewing projects' interim and final term reports to DEST. Where available, the research team also looked at any additional material the site had produced (websites for example).

16 projects were chosen that best met *our* criteria of exemplary innovative projects, with a representative spread across all States and Territories, disciplines, types of schools and so on. There were no ASISTM projects from the Northern Territory whose projects were either far enough advanced or were agreeable to take participate in our project. The final distribution of the 16 selected projects by State or Territory is presented below.

State or Territory	**Number of Projects**
ACT	1
NSW	3
NT	-
Queensland	3
SA	3
Tasmania	1
Victoria	3
WA	2

Two of these projects involved exemplary practices of the teaching and learning of Maths and of Science to remote and predominantly indigenous students.

The following ASISTM projects were selected as case studies:

ASISTM Project #	ASISTM Title of Project *
1005.	BioTech Units at Serendip Sanctuary
1012.	Designing Quality Project Based Learning and Assessment Tasks for Science, Maths and Technology
1013.	Designing the Teaching of Design and Technology
1016.	Developing Skills to Teach Remote Indigenous Students in the Basic Number Understandings
1017.	Earth and Beyond - Astronomy and Space Science Education in Western Australia
1018.	Emerging Scientists
1020.	Endeavour Towards MaST
1037.	Grow Smart Careers in Science
1049.	Kids' Design Challenge (KDC)
1050.	Leading Edge Marine and Environmental Science Development
1055.	Marine and Environmental Education
1098.	Waste Busters and Wind Gusters: Reality Science in Schools
2012.	Collaborative Interaction Design - 3D Prototyping, Remote Realisation and Manufacture
2055.	MOON Project Australia
2058.	Parks and Wildlife Service Environmental Education Program
2099.	Wildflowers in the Sky - Astronomy for Mid-West Schools

* ASISTM project number and title as found on the ASISTM website (http://www.asistm.edu.au)

Finally, why these 16 sites were chosen, beyond meeting the formal selection criteria or showing a willingness to have their stories documented, is that the research team and DEST collectively judged that they were exciting, *innovative* exemplars of science, maths and/or technology teaching and learning in schools. It is worth mentioning that, the research team could have easily included a number of other projects. These included projects such as *Forensic Investigations* (1032), *Improving Retention of Girls into Year 11 and 12 Physics* (1041), *Investigation of the Marine Chemistry and Ecology of the South Western Victorian Coast* (1047), *The Geoscience Pathways Project* (1090), *Weed*

War Jigsaw - Building Lifelong Learning (1099), and *Bringing Deep Space into the Classroom* (2008). Unfortunately for reasons such as limitations on space, time and resources, balancing the mix of projects i.e., not to over or under-represent one State or discipline etc, we could only include the 16 projects described later in this section.

We would argue that these case studies, while clearly not representative of ASISTM projects generally, are broadly representative of projects that are 'working' and potentially representative of innovation. They are intended to be 'innovation exemplars', and the study was conceived with this in mind; to unpack the nature of innovation and its potential as an educative process for schools. While the study cannot throw direct light on the differences between projects that succeed in their aims and those that falter, by charting the processes by which these exemplars anticipated or resolved challenges we can learn a lot about conceiving and managing innovation in school science, technology and mathematics, that will be useful to schools, community and industry organizations, and government.

Data collection

Alongside the initial interviews with project coordinators and critical friends, the team collected data from each site's initial ASISTM application, their milestone reports, face-to-face interviews with other key actors (teachers, outside partners, students where applicable), other relevant documentation that the site had produced. Where possible interviews were digitally recorded, otherwise the interviewer took notes.

We focused our interviews on the following questions:

The nature of the innovation

- Who had been recruited in support of the project e.g., teachers, students, organisations (e.g. CSIRO, RACV, universities), non-school personnel (e.g. local science professionals), installations/sites (the marine environment, national sites)?
- What ideas were being promoted (e.g., changes in the purposes of school science, changes in teaching and learning)?
- What is the nature of the processes (whether the project is sited in prior and/or ongoing activity, the management structures, communication processes)?

The outcomes

- What are the outcomes for students, teachers, non-school partners and for the community?

Steps taken to sustain the innovation

- What steps are needed to sustain innovation? This may occur via production of resources, the development of embedded processes, the ongoing relationships between partners, the strength and relevance of new ideas and perspectives, or the acquisition of other sources of funding.

These categories guided the emphasis across the 16 case studies, which are presented in the Appendix.

Part D: Findings

The aim of the analysis in this section is to identify the major themes that arise from the case studies, particularly in relation to the concept of innovation, and to come to a broader understanding of the significance of these in educational terms. Specifically, the analysis will attempt to provide insights into the nature of innovation, its potential role in supporting broad educational change, and the way in which innovation can be encouraged and sustained at a system level.

The 16 case studies we have presented in this report are self evidently noteworthy and varied. We argue they are exemplars of innovative practice, as we set out in the Innovations Framework in Part A of this report. All 16 ASISTM projects fit within the definition of innovation we have adopted: *Innovation is the process of assembling and maintaining a novel alignment of ideas, practices and actors to respond to site specific issues and/or to pursue a vision.* Hence our analysis will be concerned with generating insights into the:

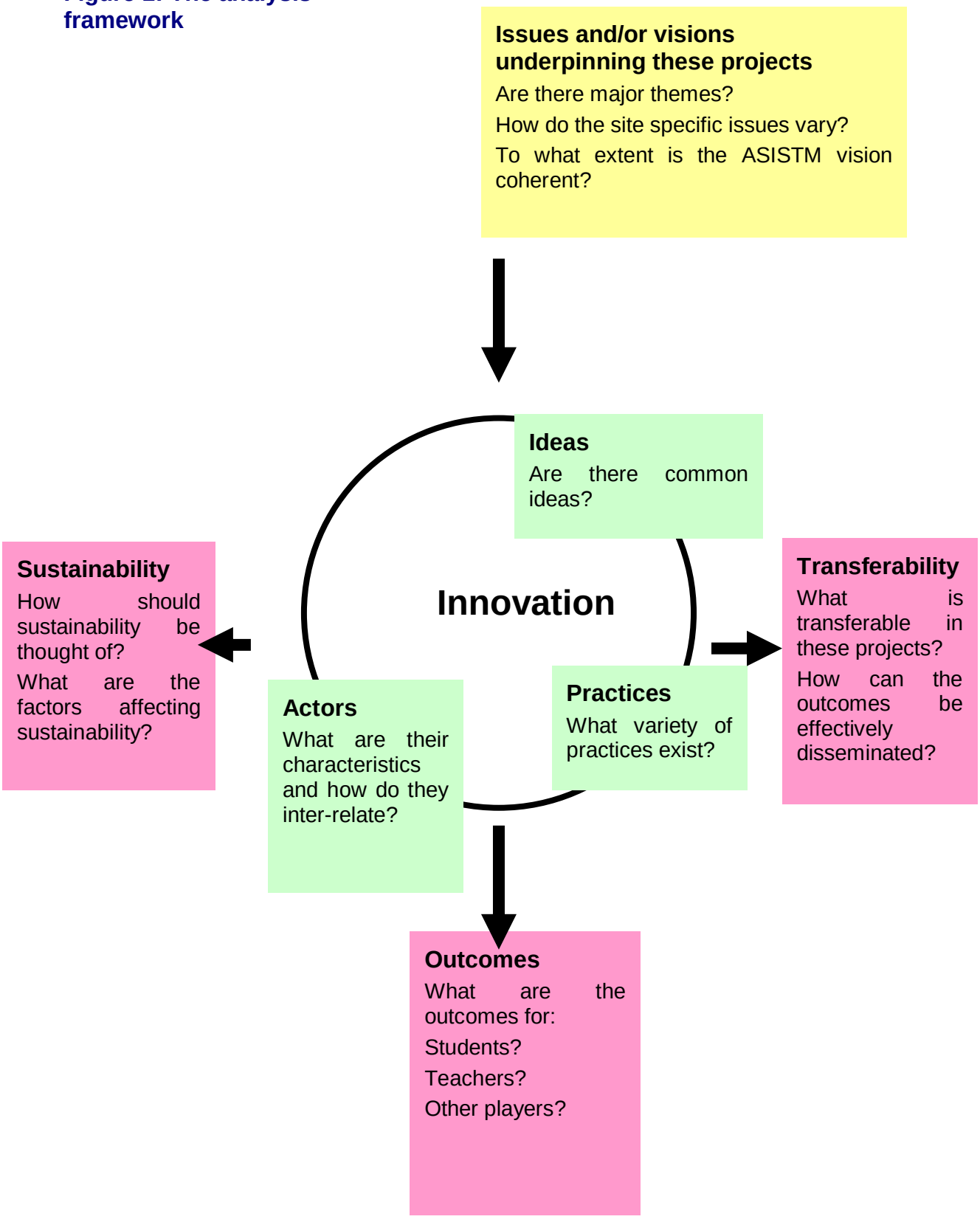
- Issues and/or visions underpinning these projects;
- Ideas, practices and actors that shape and contribute to these projects;
- Outcomes of the projects;
- Sustainability of the projects and the factors affecting this; and
- Potential transferability of the innovations.

The analysis will also concern itself with the processes by which the innovations are established and sustained. This specific issue, which is concerned with the particular ways in which ideas, practices and actors are aligned and interconnected in the innovation, and the practicalities of managing this complex process, will be further discussed in Part E.

An issue, which must be noted before dealing with the interpretation of the data, is that the majority of the projects studied were primarily to do with science. There was only one study dealing specifically with mathematics and three focussed on technology. This occurred despite a genuine attempt to provide a more even spread. It could be argued, therefore, that the generalisations proposed are likely to have greater validity in applying to science based projects than to mathematics and technology projects. However, the research team are confident that a great many of the findings apply to projects across the three discipline areas. The research team did not believe that it had sufficient data to discriminate and it will be left to the reader to bear this qualification in mind whilst reading the remainder of the report.

Figure 1 is a schematic of the analysis.

Figure 1: The analysis framework



The nature of the innovation

The issues and visions underpinning these projects

The vision driving all these projects was that of student interest and engagement. This was directly linked to students being exposed to contemporary real world practice, and to expert practitioners of science, technology and mathematics.

While the individual projects vary considerably in the details of their focus, the partnerships set up, and the specific science, technology and mathematics ideas pursued, a common issue and a common vision underpins all of the projects. The issue is the engagement of students with school science, technology and mathematics; the vision is to capture the interest of students in these subjects. Below we will unpack the varied ways in which this broad vision was pursued by these projects. However, there were certain features of the projects, flowing from this concern, that were common.

All of the projects introduced topics and practices focused on having students actively engaged with exploring environments, communicating with practising scientists and technologists, or with students and teachers from other schools, and designing and /or investigating as part of their practice. While some of the projects had students sitting in normal classrooms, doing 'normal' subject work for some of the time, this was in each case leavened by experiences that introduced different subject matter, and different pedagogies, than is traditional in these subjects. This will be explored further, below.

The pursuit of this vision of engagement in each case involved getting students out of normal classroom practice, and often out of the classroom, and linking student work with wider purposes and practices for science, technology and mathematics. For Glenn in the You Yangs project (1005), the traditional school was a bubble, an artificial world in which teachers and students lived, separate from the 'real' world. Educators involved in this project wanted to burst the bubble, to open schools and communities up to each other, strengthening the whole.

The extent to which this vision of connections outside the classroom involved linking students directly with outside practitioners / teacher associates varied according to the details of the project aims. Some projects had a strong sense that students needed to be connected to real practitioners.

> *Just being around scientists, doing scientist stuff, it's really important… Spend some time with a park ranger – kids love them.* (Glenn, You Yangs cluster, 1005)

Thus, the vision of student interest and engagement was linked to the need to have students exposed to contemporary real world practice, and to expert practitioners of science, technology and mathematics.

The ideas pursued in the innovation

The knowledge that students were exposed to in these projects was incredibly varied, and represented a broad range of purposes for education in STM including developing student interest, understanding of investigative and design processes, awareness of careers, and problem

solving. Engagement with science was largely achieved through involvement of students in authentic practices in local settings. Knowledge was often generated to pursue particular purposes, and often related to community interests. This poses a challenge for system wide curriculum policy.

With respect to ideas pursued, the overwhelming finding from the case studies is that these are incredibly varied and very contextual. Thus, we have an enormous range of topics and knowledge represented, as part of the pursuit of student engagement. To emphasise this point, the knowledge and skills represented in the 16 projects include astronomy knowledge and the use of simulation software and telescopes, fish trapping and identification and monitoring, exploration of science careers in the local area, renewable energy design, 3D design and application, studies of endangered animals in urban settings, indigenous plants, and sustainability studies.

Another point to be made concerns the nature of the knowledge pursued in these projects. Again, this varied considerably not only in content but also in the way it was delivered and the purposes for which it was developed. However, a strong strand running through these projects is that of knowledge pursued for purposes intrinsic to local needs. Thus, at Kangaroo Island (1055) the study of fish and the collection of data related directly to the need to develop a database and understanding of the local environment. In Science in the Aqua Zone (1050) students studied the indigenous plants and hence came to a better understanding of the lives of earlier users of the land. The focus for these projects, taken overall, is less on formal, structured knowledge, and much more on knowledge 'in action' and 'in context'. This is not to say that formal knowledge is not important in these projects, but the projects offer a challenge to the way and the context in which it is developed, and also a challenge to the narrow conception of knowledge that is the traditional focus of many past curricula in these subjects.

One of the key arguments in writing about engaging students in science is the need to situate content in contexts that are relevant to students' lives and interests. This is often interpreted as building on students' hobbies and everyday worlds, for instance by studying force and motion using sports examples such as skateboarding or amusement park rides. It is interesting that engagement of students in these projects did not go down this path, but rather built engagement and interest through interaction with contemporary settings, and with authentic practices and practitioners who were both expert and enthusiastic in representing the subject's ideas and practices. The issue of student interest is not straightforward, since without prior understanding of knowledge and practices in the sciences students are not able to identify what might be interesting. What worked, however, for the students in these projects, was involvement in genuine and contemporary ideas and practices, in a local setting.

The ideas driving these projects were locally determined, dependent on the local context and the enthusiasms of either or both of teachers and industry or community partners. Thus, we can argue through these case studies that a central aspect of student engagement in the sciences is the situating of ideas and practices in local and authentic settings. This poses a challenge for system wide curriculum policy, of which more will be said in the final section.

Another characteristic of a number of these projects concerns the use to which the knowledge is put. In a number of these projects knowledge is linked strongly to community or related purposes. For instance:

- The You Yangs project (1005) involves/d regeneration of the local environment; and
- The Kangaroo Island project (1055) was aimed at producing scientifically valid knowledge and the construction of a data base;

A number of the projects focused explicitly on students' knowledge of the way science, technology and mathematics are practised in the local community. Students in the Riverlands project (1037) expressed considerable surprise at the number of people in the community working in science-technology based employment. The following quote taken from the Kids' Design Challenge case study (1049) makes the point.

> *The process that they go through is real…. …the Council actually accepted the kids' plans, modified them slightly and began work on redesigning the median strips that they had picked as their area. …Real purposeful learning (is) going on. There is a purpose to doing it. Not that tasks in class have no purpose, they do, but when other people are coming in as well, giving them input with the architects that visit and the engineers that visit, they see that it is real world.*

Thus, engagement with science was not seen simply in terms of content knowledge applied to authentic local settings, but also to knowledge about science and technology and its uses in contemporary, and local, settings.

The practices represented in the innovations

Students were often exposed to cutting edge, contemporary practices in science, technology and mathematics. These formed the content focus for activities in these fields. The same was true of pedagogical practices and wider school and cluster practices associated with the innovation. A number of these projects involved a focus on pedagogies that offer more agency to students, and provide contexts that encourage student engagement.

The practices were in almost all cases as significant for teachers as they were for students. For many teachers in these projects the interaction with scientists and technologists and other community personnel lead to a steep but satisfying learning curve. This was true also of their experience of new pedagogies.

These projects involved a varied range of practices also, determined again by local context including the existence of enthusiasts and experts. The practices in this case are of two types:

- First, practices in science, technology and mathematics that form the content focus for activities; and
- Second, the pedagogical practices and wider school and cluster practices associated with the innovation.

In the first case, students were often exposed to cutting edge contemporary practices in these fields. Thus, at Kangaroo Island (1055), some students achieved considerable expertise at trapping and tagging fish, and predicting their distribution. In the Wildflowers in the Sky project (2099), the project coordinator Rob Hollow told of indigenous students who took pride in achieving competence and exercising responsibility for setting up and aligning the telescope. In the 'Waste Busters and Wind Gusters' project (1098), P-Year 6 students became most adept at not only producing

efficient blades for their model wind turbines but also in applying a scientific methodology to explore and verify competing claims i.e., the 'why' of one design was more efficient than another.

In the second case, a number of these projects involved a focus on pedagogies that offer more agency to students, and provide more meaningful contexts that encourage student engagement. In the You Yangs project (1005), primary students were very positive about the sustainability project and its management, because they felt they had planned the unit themselves. In the Emerging Scientists project (1018) a teacher commented, *planning was so thorough the children were freer to explore their own ideas.*

In those cases where the project leads to a community outcome, the relationship between teacher and learner is changed by the shared need. Thus, for the fish-monitoring program at Kangaroo Island some older students became expert at trapping and tagging, and helped other students and teachers.

This presumption of more student centred pedagogies was in some cases a challenge to teachers, sometimes affecting their involvement in the innovation. In other cases it led to significant change and professional satisfaction. For example teachers interviewed with the Designing Quality Project Based Learning and Assessment Tasks project (1012) spoke about how their involvement in the project had led to a more 'hands-off' approach by teaching staff and a deeper sense of confidence to teach 'real' science well.

These circumstances were also evident in the Kangaroo Island project, with some teachers unwilling to take students with discipline problems out in the field, and where the use of more student-centred pedagogies implied by the need of native fish monitoring led to a changed relationship with students.

Taken as a set, these projects involved a number of pedagogical practices that differ from traditional classroom practice, at least in science and mathematics:

- Project based or problem based learning (e.g., Designing the Teaching of Design and Technology (1013), Designing Quality Project Based Learning and Assessment Tasks for Science, Maths and Technology (1012));
- A strong skills focus involving scientific and related processes (e.g., Emerging Scientists (1018), Waste Busters and Wind Gusters (1098));
- More open pedagogies where students are given increased agency (e.g., Marine and Environmental Education (1015));
- The creation of knowledge by students rather than simply knowledge absorption (e.g., Kids Design Challenge (1049), MOON Project Australia (2055));
- A wider set of knowledges including knowledge of processes, interdisciplinary links, knowledge about the contemporary and local use of STM, and knowledge of people using STM in employment (e.g., Endeavour towards MaST (1020), Grow Smart Careers in Science (1037));
- Significant learning experiences for teachers involved (e.g., Developing Skills to Teach Remote Indigenous Students in the Basic Number Understandings (1016), Science in the Aqua Zone (1050), or Earth and Beyond - Astronomy and Space Science Education in Western Australia (1017));

- A 'real' audience for students' work (e.g., Marine and Environmental Education (1015), Biotech units at Serendip Sanctuary(1005));
- Field trips and projects in the local environment (e.g., Science in the Aqua Zone (1050), Parks and Wildlife Service Environmental Education Program (2058));
- Working with scientists and with local community members (e.g., Grow Smart Careers in Science (1037), Wildflowers in the Sky (2099), Endeavour Towards MaST (1020)); and
- Involvement of parents and the wider school community (e.g. Marine and Environmental Education (1015), Emerging Scientists (1018)).

The practices described above were in almost all cases as significant for teachers as they were for students, if not more so. For many teachers in these projects, the interaction with scientists and technologists and other community personnel lead to a steep but satisfying learning curve. Many teachers talked of renewed confidence and interest in their teaching, as a result of the experience. This was true of their experience with the practices of contemporary STM, and the development of expertise (e.g. in fish monitoring, or night viewing with a telescope, or in measuring the velocity of billycarts) and also of their experience of new pedagogies. *I was a teacher who hated science. This project got me and I discovered how much the kids love science*.

The pedagogical practices described above, and the widened set of purposes described in the section describing the ideas underpinning these innovations, are consistent with the scientific literacy aims that underpin contemporary thinking in science curriculum development in Australia and elsewhere (Goodrum, Hackling and Rennie, 2001; Rennie, 2006; Tytler, 2007). A curriculum focused on scientific literacy gives precedence to working and thinking scientifically, student autonomy and interest, and the capacity to engage with science in contemporary social and personal settings. Equivalent principles in technology and mathematics would include a focus on problem solving, on contemporary design principles, and on human aspects of design.

The actors recruited in support of the project

The actors, both human and non-human, who were recruited to the project, performed dual roles. They supported the project and its implementation, but often they also were part of the local circumstances that gave rise to the project and shaped its direction. The innovation implicit in ASISTM is the alignment of teachers and outside experts in a partnership around a project that represents contemporary practice. Thus the actors in many projects provided for students insight into contemporary science, and for teachers professional learning in the discipline. Teachers themselves were often powerful actors in the initiative.

In some cases, particularly involving large organizations, the management role was taken over by the non-school partner and this released teachers and associates to focus on the intellectual framing and directing of the project. Community interests were important actors in some projects, particularly in rural areas.

One requirement of the ASISTM program was for projects to form clusters comprising schools, industry partners, experts and so on. Hence it is unsurprising to find these types

of 'actors' present in one form or another in every case. These include the more obvious human actors:

- Teachers, students, school-based leadership and management groups (Principals);
- State-based officials from the respective departments of Education;
- Local community members (e.g., Parents, local science professionals);
- Industry-based organisations (e.g., SciTech, RACV);
- Knowledge-based organisations (Universities, CSIRO); and
- Critical Friends.

Non human actors also actively shaped and enabled the project, such as:

- Installations such as the Square Kilometre Array, or the Remote Telescope of the ATNF;
- Communication resources such as in the MOON project;
- The concentration of industrial plants and industries in Gladstone;
- Technologies such as the 3D printer in the Interaction Design Project; and
- Particular environmental conditions such as the native fish populations in KI, the clear skies in Western Australia that encouraged a suite of astronomy projects, or the indigenous plants on the Eyre Peninsula.

In these projects, the actors who were recruited to the project performed dual roles – they supported the project and its implementation, but they also were part of the local circumstances that gave rise to the project and shaped its direction. Thus, they were an integral part of the alignment of local circumstances that gave rise to and determined the direction of the project.

The actors represented in these projects were extremely varied, but what perhaps is of more interest than simply who was involved, is the question of how they were involved and the variation between roles, and how this affected the path of the project. The recruitment of a variety of actors enabled complex projects with a wide set of outcomes. For instance, the Designing the Teaching of Design and Technology (1013) which was university-based, brought to schools high levels of expertise and 'real world' industry links. The University could also access a greater range of other types of 'actors' ranging from a ready supply of university-based design students, professional associations and so on, to other actors such as access to further tertiary qualifications.

A number of these projects achieved remarkable outcomes through the recruitment of powerful actors. For example, the Western Australian Department of Science, Technology and Information is involved in both of the astronomy projects (1017) and (2099), and is committed to developing astronomy education in Western Australia. CSIRO has the resources and commitment to support the continuation in some form of the projects it has been involved with. At Kangaroo Island (1055) Tony Bartram had organised a complex web of partnerships with the local council, the University of South Australia, other academics, school clusters, and local fishermen and tour operators. The Gladstone project (1012) was advantaged by the close involvement of locally-based

senior education departmental officers, representatives from the light-metal industries and Central Queensland University.

In some of these cases, particularly involving large organizations, the management role was taken over and this released teachers and associates to focus on the intellectual framing and directing of the project. In other cases where outside actors did not afford management expertise, the teacher initiator was forced to take on this role, sometimes to the detriment of the project because the complexity and time demands of the task had been underestimated.

If the engagement of students involves exposure to contemporary ideas and applications, in local contexts, then this poses a serious challenge to teacher professional learning. How does a teacher keep abreast of new knowledge and practice and views of the subject? The innovation implicit in ASISTM is the alignment of teachers and outside experts in a partnership around a project that represents contemporary practice. This could be seen as a genuinely innovative and productive model of teacher professional learning in an environment where changes to the nature of the science, technology and mathematics curriculum are being canvassed. Teacher learning in these projects involved knowledge of content and practices, and knowledge of the nature of contemporary, authentic application of the sciences in local settings. This was an enriching experience.

Nor were teachers passive players in this process. In many of the projects teachers drove the innovation, and where this was not true they were active partners in the process of planning and implementing the project. In the Wildflowers in the Sky project (2099), the teachers at John Willcock and the School of the Air were active in modifying the project materials and their developed units are now on the website. In the Developing Skills to Teach Remote Indigenous Students in the Basic Number Understandings Teachers project (1016), teachers were involved in contributing to, and modifying, the unit material developed.

Teachers involved in these initiatives sometimes expressed surprise at the interest shown by industry and government and university partners in education, and these projects generally involved genuine collaboration.

Overwhelmingly what motivated actors, including those drawn from industry, was a concern for improving the knowledge, skills and commitment to maths, science, and technology of this younger generation from whom scientists and technologists of the future will be drawn, and a sense of ‘corporate social responsibility’, to put resources into worthwhile education processes as part of a community obligation.

The latter motivation is most evident in the Gladstone case study (1012). In Gladstone local industry has led the way on a number of civic projects leading to improved community resources. This would make sense in terms of an industry maintaining a positive profile in the community. However, questions can be raised about whether offers from industry to contribute to educational programs can always be accepted. For example, is it appropriate to have an industry heavily dependent on coal-fired electricity playing a role in the development of units dealing with energy policy? This issue of the involvement of possibly partisan interests in supporting innovation in schools will be raised again in Section D.

Members of the local school communities were also significant actors in many of these projects. In fact, an assumption underlying a number of these projects was the education

of the community through students. For the You Yangs project (1005) this was a specific outcome driving the sustainability project. Part of the intention of the Wildflowers in the Sky project (2099) was to raise the profile of astronomy in remote regions of Western Australia, and parents in the remote indigenous communities were significantly involved in the night workshops.

In rural areas particularly, these community links seemed important and had a higher profile. In rural towns that are shrinking, it has been said that the school is the last symbol of community. A number of the projects had specific and measurable influence on the local community, and this will be discussed as part of the project outcomes.

A novel alignment

What is important for individual projects, in terms of their success and likely sustainability, is that these elements - ideas, actors and practices - are aligned, and mutually supportive. Because of the way these elements are framed in ASISTM, the initiative as a whole can be seen as a significant innovation.

This section has dealt with the individual aspects of our definition of innovation, and argued that each of these — the issues and/or vision, the ideas, practices, and actors — represent new directions for these clusters of schools, and overall represent a fresh and compelling vision of worthwhile directions for science, technology and mathematics education. However, in terms of innovation, it is the way these elements interact and form a mutually supporting whole, that indicates the strength and quality of the innovation.

From the foregoing analysis, it can be seen that over all these projects there is coherence to what has been achieved, through the mutually supporting nature of these elements. The recruitment of actors who bring fresh and significant knowledge and practice in contemporary science, technology and maths, aligned with a recasting of the nature of knowledge in the curriculum, had implications for the wider purposes of science, technology and maths curricula, and this in turn implied changing practices and in particular changing pedagogical practices. At this meta-level of analysis, it can be seen that the ASISTM initiative in itself represents a significant innovation.

What is important for individual projects, in terms of their success, and the likelihood of their sustainability, is that these elements are mutually supportive.

In each of the 16 projects, the elements were mutually supportive. In fact, when asked to identify what was innovative about their project, informants were quick to point out the new partnerships that had been forged, and the new practices and ideas that this had allowed. In talking about sustainability, again it was the strength of these connections that tended to be emphasised.

To illustrate, the astronomy units developed for the Astronomy WA project (1017) contained many activities that can be found in texts. However, the particular innovation lay in the bringing together of five exemplary teachers of astronomy to share their expertise, and to put them in touch with astronomy installations and a wider network of teachers, to enrich and diversify the approaches; all this in the context of a significant governmental drive towards a premium astronomy research installation. Another example is the Parks and Wildlife Service Environmental Education Program (2058), which put rangers in touch with teachers to develop units on endangered species. The novel alignment involves the support given by these rangers, who formed a network, to

deepen teacher understandings and taking the novel approach of dealing with wildlife in urban areas. Urban spotlighting, and video project work arising out of studies, are examples of the practices that meshed with these ideas and actors.

Thus, in understanding the innovative nature of these projects, and in developing a view of how to select and support projects on the criterion of innovation, we must look to the interactions between these elements, in particular the extent to which they are mutually supporting. It is important, for instance, that there be a mutuality of interest amongst the actors to develop and support coherent ideas and practices. A prior history of interaction is helpful in indicating likely success.

Outcomes of the innovation

A variety of outcomes

In these projects there have been significant outcomes for:

- *Students – in addition to engendered enthusiasm there was significant knowledge generation and the development of expertise;*
- *Teachers - there was considerable evidence of professional growth and in some cases professional renewal in their stories. The ASISTM initiative offers a significant model of teacher professional learning;*
- *Teacher associates – there has been increased understanding of education and the value of support from outside the school system, and some have chosen to enter the teaching profession; and*
- *The community – there has been increased understanding of science in society, science, mathematics and technology education, student interest in science based careers, and contributions to community facilities.*

The major focus for the ASISTM initiative is learning and engagement of students in science, technology and mathematics. However, the complex nature of innovation and the interlocking networks of ideas, practices and actors inevitably meant there were outcomes at all these levels. One could talk of outcomes in terms of the partnerships formed, the development of ideas, the changing cultures in schools in relation to new ideas and practices, or the changing processes in schools and networks, focused on supporting innovation. These issues are very relevant to the question of sustainability, discussed in the next section. In this section we will discuss outcomes for the various types of actors involved; students, teachers, non-school partners and the community.

For students

There were, for the students involved in these projects, examples of significant knowledge generation and the development of expertise, and these have been described in the previous section. These would include the students on Kangaroo Island (1055) developing expertise in monitoring fish, and associated with this a good deal of knowledge about fish and their habitats; students from the cluster at Collector (NSW) (1098) developing a sound understanding of science and the world around them; and students in the ACT and NSW enacting contemporary design processes whilst designing original products such as gripping socks for pets in a zero-gravity environment.

In interview, it was sometimes difficult to ascertain specific student outcomes, even in terms of student engagement. Students are not necessarily the best informants, and the outcomes were not necessarily contained or made explicit by their teachers, and they are sometimes highly contextual. Thus, one group of students involved in the Wildflowers in the Sky project (2099) were, on the surface, neutral about their classroom experience, yet probing revealed their interest in the simulation software they had experienced, and also the podcasts they had produced, new experiences for them. Students at Kangaroo Island (1055) found it hard to talk about their experiences from the previous year but when one in the group pulled out a CD photograph record they were able to talk in detail about the science processes and knowledge in relation to monitoring the native fish population.

For most projects, students were enthusiastic. In interviews, the outcomes were apparent in their stories and expressions of enthusiasm, but it was not always easy to probe actual knowledge gains. As one junior primary student insightfully remarked, *If you have fun you have something that you like to think back on. You remember it better if it was fun. But you don't remember what you put on worksheets. You just remember it at the moment.*

As a team, we have formed the view that evidence of learning could be seen as implicit in the quality of the experiences these students were describing. There was also considerable informal evidence of learning in student work produced as part of these projects. For teachers and schools, the strong focus on student engagement, and on participation of students in contemporary ideas and practices, meant that only rarely was attention given to measuring outcomes in any quantifiable way. Anecdotally, teachers talked of the high quality of student work encouraged by engagement in authentic processes.

For a number of these projects there was a strong focus on future possible careers relating to STM. This was explicit in interactions with some teacher associates and project partners. One student at Yarrawonga, remembering a visit, almost two years ago, from Professor Nick Klomp from Charles Sturt University as part of the Endeavour toward MaST project (1020), recalled learning that *Science is about the ability to research answers. You don't have to know everything but you need to know how to research*. For many projects there was value in students being able to interact with teacher associates who were university students, close to their own age, with science and technology interests, acting as role models and giving them a picture of university life. At Riverland students, by becoming aware through the project of what was available, were successful in getting vacation jobs with industry.

For teachers

For primary teachers, knowledge and confidence were significant in their response to the projects. Renewed confidence was a major theme, however, not only with primary teachers (for whom this might have been expected given the general lack of confidence in science and technology reported in many studies) but also with secondary teachers for whom the particular contemporary knowledge was often new and challenging.

In projects such as Wildflowers in the Sky (2099), teachers have gained content knowledge and confidence with processes of teaching and learning. Arguably, they have also made links between astronomy at the school level and cutting edge astronomy research, and this implies a richer sense of the nature of science as it is practiced at the research level.

In most projects there has been a differential uptake of the innovation by teachers. In some projects, the open way of working with students, and presumptions of negotiation of knowledge and processes, attracted some teachers more than others. The Kangaroo Island project (1055) has examples of such a cross section; teachers who like this way of working, and having the beliefs and pedagogical skills, championed the project, while others expressed scepticism and yet another changed the way of teaching due to involvement in the project.

For these projects, taken as a set, teachers were full partners in the process and there was considerable evidence of professional growth and in some cases professional renewal in their stories. For many teachers the experience has been renewing, if not

transforming. Case studies such as those of the Emerging Scientists project (1018), Waste Busters and Wind Gusters project (1098) and the Designing Quality Project Based Learning and Assessment Tasks project (1012) all point to *the increased confidence of the primary teachers to handle this way of doing science. The context in which they engaged in this activity was important as there was time for detailed collaborative planning, [and they had] the inspiration of highly skilled colleagues (the Teacher Associates), [as well as] the reflection associated with the use of such tools as a reflective journal for example.*

These stories, of teachers working in partnership with practising scientists and technologists, and with peers with enthusiasm and expertise, around projects that deal with local and contemporary applications, raise the possibility that the ASISTM project has generated a very potent and successful form of professional learning for teachers. Researchers working in the field of teacher professional learning and teacher and school change have long argued against the effectiveness of short, one-off professional development in supporting significant learning.

In reality the ASISTM initiative is a new and innovative approach to curriculum development that places considerable demand on teacher learning. Such learning needs to take place in the school context, with the support of peers and of expertise from outside, with the generation of a real sense of ownership. These conditions are in principle fulfilled by these 16 projects. The evidence, provided by teachers of their learning and of the pleasure taken in engaging with new processes, attests to the success of the model in this regard.

What has been generated in many of these projects is a new sense of how both subject knowledge and pedagogies can be developed around authentic science, technology and mathematics curriculum experiences.

For non-school partners

There were a number of examples in the projects of Teacher Associates being attracted to consider teaching, which was one of the hopes of the ASISTM project. Two of the Teacher Associates from the Science in the Aqua Zone project (1050) have gone on to do postgraduate education studies.

Scientists in most cases were enthusiastic about the projects and benefited from them in a number of ways. The astronomers working on Wildflowers in the Sky project (2099), enjoyed working with remote communities and students, and gained a better understanding of the environment in which the Square Kilometre Array will be operating. This was mirrored in a number of projects.

For the community

There is implicit in the project the intention that the ASISTM projects will have an impact on the community through the students' engagement with socio-scientific issues and their exposure to careers with a scientific basis. However, the impact of some of the projects is broader than this. Awareness of the national significance of science education has been brought to the attention of members of the community not only through participation in the projects but also through events and communications about the project. For example, the Endeavour toward MaST project (1020) held a community event attended by 600 people. As the project coordinator commented: *There's such a successful connection between everyone. It's so good. Everyone just loves it. People are buzzed by all the*

things the kids do. You just see that connection between people in the community. It's just amazing. It's really special.

Some projects have contributed to the community in quite direct material ways. For example, Little River Primary School, part of the You Yangs cluster (1005), has been *working with Sam on a biological control project. The school will breed an insect that will eat the cactus that has infested Little River. It is hoped the insects will eradicate the cactus weed.*

Similarly in the Science in the Aquazone project (1050) there has been development of trails for public use. The Garden Island trail has been developed with colleagues from Taoundi. The development of this trail has involved members of the local community working with teachers, teacher associates and pupils to establish a trail explaining plant use by the traditional land owners of the area.

Sustainability of the projects

Relating sustainability to the innovation framework

The form in which these ASISTM innovations are sustained will vary. The case studies indicate that the sustainability of an innovation can be usefully analysed through the lens of the Innovation Framework, and will depend on:

- *The strength and relevance of new ideas and perspectives;*
- *The development of embedded practices; and*
- *Ongoing relationships between actors.*

In addition there are concrete aids, such as units of work developed and equipment to promote sustainability. A number of these projects are already being rolled out, attracting further funding and/or becoming embedded in wider practices.

Whilst in reviewing programs such as ASISTM one must look at the immediate impact of the project on the participants, as was done in the previous section, it is reasonable to ask about the potential for long-term impact of the projects. We have used the title 'sustainability' here but it needs to be made clear that we are not talking about the durability of the particular projects. Rather we draw attention to the original definition of innovation used for this study, that is: *Innovation involves a process of assembling and maintaining a novel alignment of ideas, practices and actors to respond to site specific issues and/or to pursue a vision.* While it may be that the original project does not continue beyond the period of ASISTM funding the influence of the project may continue in a number of ways which will impact on future programs. For example, the central ideas of the project may be taken up in other ways. Or the alignment of actors formed for the ASISTM project continues resulting in other projects. Accordingly in this section we will be considering the durability of the novel alignment of the three elements considered, viz. ideas, practices and actors separately and together.

There is a further point that needs to precede this discussion. Many of the projects reported as exemplary projects did not arise simply in response to the ASISTM initiative. Rather they need to be seen as one step toward achieving a vision. The perfect example to illustrate this point is the Kangaroo Island ASISTM project (1055). This project is one step, although an important one, toward the vision of a group of people

committed to the preservation of the unique qualities of the Kangaroo Island natural environment through community education, including school education.

The strength and relevance of new ideas and perspectives

In a number of projects the study identified how the vision of a single person or group of people became something that was owned by a larger group. That is not to say that everyone involved became as committed to the innovation as the visionary who initiated the idea. But many were convinced by the core ideas, or perspectives that were the basis of the ASISTM project.

In other projects participating teachers indicated that they began the project with a relatively low knowledge base of the relevant science but that through their involvement with experts they believed that they now had the expertise to take a lead in the relevant activity. One example of this is a teacher participating in the *Wildflowers in the Sky* project (2099). She talked about taking a class on camp recently where she ran an astronomy viewing night, *the kids got out the telescope and found Saturn – they were very keen. Prior to this there was no way I'd go out and do a night viewing*.

Development of embedded practices

In conducting interviews for the study there were several words that occurred very frequently. One of these was *confidence*. As indicated above, sometimes this confidence was related to the science being considered. In other cases however it was to do with pedagogical practices. The projects were innovative and so teachers were confronted with new ways of teaching science and technology with which they were not familiar. Yet so often those interviewed indicated the confidence that teachers gained from their participation in new ways of teaching. One teacher spoke *of a hands-on approach to learning as it provides authentic (and therefore relevant) use of new scientific vocabulary as students are using it in the context of the concepts they are investigating, increasing their real understanding of the terms they are using*. One could argue that this comment does not break new ground in teaching science. But for this teacher it was an important step in appreciating the value of such learning strategies.

There is much evidence to suggest that many practices generated by the ASISTM project have become embedded in schools and teachers. *Furthermore the model of teacher professional development promoted within this project is not a short sharp burst of activity, but an ongoing supported and sustained long term engagement that enables teachers to reflect on their practice and reconsider ideas within their given milieu.*

Ongoing relationships between actors

Another finding of the study that has bearing on the issue of sustainability are the relationships that have been developed or strengthened in the course of the ASISTM projects. Several of the criteria for the ASISTM program created the potential for ongoing relationships. The requirement for cluster activity has brought together schools and teachers who had not previously had sufficient incentive to work together but who found great benefit from the interaction when they participated. There are instances where secondary and primary schools have interacted around science for the first time and found it very beneficial. One primary teacher participating in a project said that: *Mostly the teachers appreciated working with other teachers from secondary and primary levels as well as having the expertise of the teacher associates and consultants.*

It wasn't just the primary/secondary boundary that was breached. Interstate boundaries were crossed with benefit in one of the projects where the towns are close to one another but the schools managed by the different state authorities as in the Endeavour toward MaST project: *The barrier between NSW and Victorian schools disappeared and we were a group of schools working together*. This rare occurrence is likely to lead to further cross-boundary interaction.

The ASISTM criteria also required school-community interaction and this brought together school staff with a broad range of community members into relationships that are likely to endure. The Endeavour toward MaST project brought together university staff and representatives of a local industry leading to further interaction between them. *…The linking of industry not only to the local schools but also to Charles Sturt Uni which was part of the project. ADI (a manufacturer operating locally) met CSU people at the workshops and at the science nights with the displays and talks. The latter was totally new to ADI that has subsequently followed up the link with a tour of CSU. I was very disappointed that I was unable to attend the tour but am very keen to do so and maintain that link.* Such data give confidence to make the claim that relationships formed around these projects will be ongoing and will give greater relevance to school science, mathematics and technology programs.

Production/provision of resources

There is a range of concrete resources resulting from the ASISTM projects that will impact on school programs. The equipment which school clusters have purchased for the project will be a great encouragement to schools to continue the type of activity undertaken. In a number of the projects people drew attention to the significance of this equipment. For example, at Yarrawonga Secondary College it was suggested that the equipment purchased was a contrast to the outdated equipment upon which the school normally relies. Further, the requirement that schools operate within clusters was seen positively, as equipment could be shared across schools, thus providing value for money.

*The other really good thing about this project (*Bio-Tech Units at Serendip Sanctuary*) is that schools can share resources. The cluster has been able to buy a water watch kit, whole sets of thermometers, lux meters and all sorts of measuring equipment, and worm bins. So a maximising effect of a cluster approach with good money actually works really well.*

There were a great number of resources developed during the life of the projects. With the use of the internet and other means, these are likely to have an impact beyond the schools participating in their production. For example, in the MOON project the units of work produced by teachers will, after vetting, be mounted on the project website for all to use. A similar story can be told about units arising from the Emerging Scientists project. The existence of units is of course no guarantee that they will be used. However, the units have been most frequently developed and used by teams of teachers and there is hence a greater probability of them being used further.

It needs to be noted also that some of the published resources contain scientific information such as the database of native fish distribution at Kangaroo Island that has scientific value and will also be used as a baseline for subsequent sets of students.

Evidence of further roll out of projects

Beyond a judgement of the strength of the partnerships and processes that have been developed, that might

indicate sustainability, there are a number of projects where the question of sustainability has been answered already. The ASISTM funding can be seen in some case as seed funding that has kick-started a longer-term process of innovation. In other projects the funding has enabled visions to be realised more quickly. In yet others, the funding has enabled more schools to be brought into contact with the vision and to share in its implementation.

In a variety of ways some projects are expanding already into new areas, with new partners and commitments and new sources of funding. Several instances were revealed of clusters finding additional or alternative sources of funding to enable the project to go forward. For example, at Kangaroo Island, each of the five initiatives was only partly funded by ASISTM, and each received funds from elsewhere.

There are plans afoot to broaden the impact of some of the projects. For example, there is discussion about the MOON project becoming part of the formal curriculum in one state. During the course of this study the Chief Scientist of WA, Professor Lyn Beazley, paid a visit to the Graceville State School in Queensland to talk with Sandy Davey about the MOON project. Professor Beazley was quoted in the Courier Mail (24 July) as saying *I've heard about the work Sandy is doing and wanted to see if we could apply it in Western Australia.* Again, it is proposed to use the model developed in the Riverlands project in schools in other agricultural areas of the country.

Transferability

The different senses of transferability

The concept of transferability applies to local projects (for example, projects built around a specific environment) as well as to global projects (for example, the MOON project built around a web resource), but in a different sense. The local projects are transferable through the applicability of their ideas, practices and actors to diverse situations. At the level of principle, the concept of capturing student interest through an appropriate local focus, as illustrated in these ASISTM case studies, is applicable everywhere.

With regard to effective methods of transferring information and enthusiasm the study participants point to the value of dissemination through personal testimony.

The focus of the ASISTM program has been on innovation at the local level, and, as has been discussed, many of the projects strongly reflect the context in which they have been developed and have operated. This has been one of the great virtues of the program in that these projects have been able to capture student interest through presenting science or technology in ways that have local relevance. Further, this has involved capitalising on local actors and has sometimes produced outcomes of significance for the local community. Examples of this type of project, that immediately spring to mind, are the three South Australian projects amongst the sample reported here.

Of course there are others that do not reflect unique features of the context to the same extent. For example the MOON project (2055) was built around a set of web resources originating in the U.S. and one can imagine could be introduced anywhere subject to having the appropriate computer technology. Naturally one could expect that the latter type of project could be picked up by other schools or even by school systems. There is

a core framework to be followed, but beyond that there is a great deal of flexibility so that, as was reported in the case study, a school with a strong gardening focus explored the question of whether, as was once believed, planting at different phases of the moon leads to different outcomes. In fact, as has been mentioned there is a possibility that the MOON project will be adopted by an entire school system. Such an outcome is not unexpected.

In the light of this admittedly rather artificial dichotomy two questions spring to mind: Is it appropriate to think about the issue of transferability in the former projects, that is those which do significantly reflect the context in which they operated? What steps need to be taken to enable transferability where it is appropriate?

With respect to the first of these questions the research team would suggest that the question of transferability is relevant to these projects. The Kangaroo Island native fish study (1055) seems at first sight to be too local to be transferable in any direct form, yet at least one school from the South Australian mainland, and also an international school, has joined in the data collection, and more clusters of schools are now taking up similar projects, utilising scientists and similar monitoring and recording techniques. The broader concept has proved transferable. The whole approach of developing activities which reflect local opportunities, draw upon local resources, and which lead to positive outcomes for the community, is an idea that should be explored more widely. It is to be hoped that the existence of this report with its case studies will stimulate such thinking and that the case studies themselves will provide sufficient clues to enable others to begin the process of creating activities that do the same things within their local context. In fact it is hoped that the definition of innovation used in this research will be a guide to people thinking about such possibilities as it draws attention to three areas in which productive new alignments can be achieved, in actors, in ideas, and in practices.

Another aspect of the question of transferability concerns whether the ideas underpinning the project have sufficient educational potency to be meaningful more generally. Given that each of these projects represented strongly the issue of student engagement and tackled this with a vision of interest and engagement tied to the representation of contemporary practice, we would argue that all these projects are in that sense transferable to other schools.

With respect to the second question raised above, one of the issues the research team was asked to address in this research was that of appropriate dissemination of the experiences and findings of the projects. This represents the practical side of transferability. It seems quite clear from the evidence we have gathered in these case studies, that the most potent form of dissemination involves direct narrative accounts of the projects, and not other more formal dissemination methods such as booklets and reports, or web sites. It is the lived experience of teachers in these projects that represent the most convincing evidence of and insight into the process of innovation and change. This will be discussed in a later section of the report.

Part E: Implications for ASISTM and similar programs

This project was undertaken for both theoretical and practical reasons. First, we have gained insight into the nature of innovation represented by these case studies, and built up an innovation framework that helps understand them. Second, this framework can be used as the basis for ongoing work in ASISTM, helping frame the criteria for selection of projects, helping with selection itself, and providing a basis for advice to potential and actual projects.

Choosing and supporting innovation projects

For a funding body, the selection of projects is a particularly challenging role given one cannot guarantee in advance which projects are going to succeed. In the business community, where the vast majority of innovations do not usher in the benefits hoped for, the definition of success is focussed predominantly on whether or not innovation as a *process* has been appropriately undertaken. Secondly, the question of whether or not the innovation delivered on its promises needs to be open to the possibility that as an experiment, the novel alignment of ideas, practices and actors was not the right combination. And, as we already know from the sciences, a 'negative' result may also be a most productive thing to find out.

With these caveats in mind several factors stood out across the ASISTM case studies, that we suggest can act as indicators of the potential success of an innovation:

- Effective management structures;
- The question of prior alliances and ideas;
- Introducing ideas which will capture student interest;
- Appropriate partners and hence Teacher Associates; and
- Attention to sustainability indicators.

Management of projects

There was significant variation amongst the projects studied in the way the projects were managed. In some projects there was a clear separation of the management of the project and the educational leadership. In several of these the management rested with a community partner, for example with CSIRO, where there was an established management regime in place. This proved to be very beneficial for the project. At Gladstone and in the Riverlands project, day-to-day management of each was overseen by an educator who had only a little, or a restricted, role in the actual direct delivery of the project. In other projects there was insufficient recognition of the management requirements of the project and the educational leader became the de facto manager of the project. In the latter cases this was often seen to place too great a workload on one person that was to the ultimate detriment of the project outcomes.

The consensus amongst the study team is that there are significant benefits arising from a separation of educational leadership and project management and that the funding of projects should recognise this.

Recommendation 1: *That programs such as ASISTM should encourage a separation of management and educational leadership duties and ensure that project proposals factor the costs of each into their budgets.*

Prior alliances and ideas

While there were projects studied in which the network of players and the central concept were built from scratch, many of the exemplary projects built upon existing alliances or communities of interest. The later is illustrated by the Kangaroo Island project where there were existing relationships around concern for the maintenance of the Island's unique environment. At Gladstone the ASISTM project both augmented, and to some degree formalised, the alliances that existed prior to its inception. For the ASISTM project in far Northern Queensland, the ASISTM project levered off ideas and relationships from a concurrent Australian Research Council grant. In each of these cases the existing relationships significantly strengthened the breadth and the depth of the innovation the projects were exploring.

Recommendation 2: *That programs such as ASISTM encourage proposal writers to explore the antecedents of the proposed project, and indicate whether and how it builds from existing ideas and/or relationships.*

Introducing ideas which will capture student interest

The driving force for programs such as ASISTM is to stimulate projects around topics that will capture the interest of students in mathematics, science, and technology. Frequently textbook writers and curriculum planners attempt to capture student interest by illustrating the ideas in ways which are assumed will interest students. So students are introduced to ideas about motion with illustrations involving skateboards.

The lesson from the projects investigated here is that students will be captivated by topics across a wide range of areas, including areas about which they know little if anything, when they have the opportunity to explore the topic in a context where they are able to see its relevance and when they are introduced to the topic by teachers and Teachers Associates who are themselves enthusiastic about the topic. For example, in the 'Teaching Design' project based in the ACT, the Teacher Associates were senior undergraduate design students whose mentoring relationships with high school students were informed by their own passion and experience of learning design. The Teacher Associates, who were only a few years older than the high school students they were mentoring, served as relevant role models.

Recommendation 3: *That programs such as ASISTM should not be unduly influenced by prior notions of which topics will be of interest to students, but should recognise that students' interest in many topics in science and technology can be captivated when explored in a context where they can see their relevance and where those responsible for the instruction show passion for the topic.*

Choice of appropriate partners

One issue that emerged frequently during the study was the way in which the introduction of appropriate partners, often through the position of Teacher Associate, enabled both teachers and students to be introduced to contemporary science and technology knowledge and techniques. In many of the projects the value of appropriate partners providing access to contemporary science was directed toward making science relevant for the students. However, our study has shown the extent to which this was also of value to teachers. Much is made of the fact that primary teachers themselves have quite limited exposure in these fields. However, this study drew attention to the fact that secondary science and technology teachers too are limited in

their experience in some fields of science and technology. Within the normal school program there are relatively few opportunities for teachers to be engaged with scientists involved in contemporary practice. In many of the projects studied here it was made clear to the researchers how important it was for teachers to have the opportunity to gain insight into contemporary practice, often in fields where they have limited expertise.

Recommendation 4: *That programs such as ASISTM give consideration to the extent to which proposals will provide opportunity for students and teachers to be exposed to contemporary practice in the field of study. This includes giving attention to both the selection of appropriate Teacher Associates and how their contribution to the project can be maximised.*

Sustainability indicators

As has been indicated elsewhere the research team warns against an assumption that the project will be simply repeated in succeeding years. However, we believe that it is appropriate for the project planners to think about what it is likely will be carried forward from the project. This study suggests that one of the key sustainability indicators is in the context of the study. If, as was the case in some of the projects studied, such as the Kangaroo Island *Marine and Environmental Education* project, the project arises from previous innovations and is seen as a step toward an ultimate goal then there is every chance that there will be significant carry forward from the project. In a similar way if the project is linked to an ongoing program of an industry partner, such as in the Astronomy WA project for which there are a number of partners with an ongoing commitment to the area of study, there is every possibility that many features of the project will continue.

Recommendation 5: *That programs such as ASISTM require project proposals to give clear indication about how positive features of the program will continue beyond the life of the program.*

Accountability processes

One of the challenges facing a program as large as ASISTM (i.e., upwards of 500 *clusters* of schools, industry partners and others) is how to get the balance right between the necessary accountability mechanisms and the lived experience of innovation at the level of each, individual project. One of the essential lessons this study and previous studies point to is the 'messiness' that accompanies genuine innovation. Things do not often go to plan. Projects not only get behind due to events that may well be beyond their control (e.g., the effects of tropical cyclones isolating schools for months), but also the synchronicity between the various partnerships may be thrown out. For example, schools run on a time cycle that is quite different to that of a university. If one partner is delayed for some reason, it can be most difficult to bring the activities of the two institutions quickly back into alignment. Several project coordinators commented how important it was that there was provision for a flexible approach to timelines and 're-jigging' elements of the project, if they weren't working as initially planned. For example, in the 'Developing Skills to Teach Remote Indigenous Students' project serving schools in Far Northern Queensland, it was envisaged that all the schools involved would produce mathematical resources. The reality was that for staff in a two-teacher school in remote, isolated communities, this task was simply too much. The project responded by sending in experts from the associated universities, who interviewed and collected data, from which they then wrote these materials.

Recommendation 6: *That programs such as ASISTM create timelines and the possibilities for change in response to evolving circumstances which allow for the type of complexity which arises from projects involving multiple partners.*

Dissemination

One of the issues which the researchers raised with project participants during the data gathering was the most effective way of disseminating information about such projects so as to encourage other educators to think about its relevance to their own situation. Many of the projects have developed websites as a means of communication both within the project, and with a wider community. The websites have frequently been used to share the curriculum resources developed.

However, teachers are quite clear that, while recognising the value of material produced and the use of the internet, they believed that personal experience or testimony was the method most likely to have impact. Personal experience can take several forms. The projects reported here frequently illustrated one of these, that of engaging teachers in the project. Various interviewees pointed to examples of teachers who through (albeit a sometimes reluctant) engagement in the project, had grown in confidence and enthusiasm for a different approach to teaching and learning in mathematics, science and technology. Another way in which teachers can experience an innovative approach to teaching these subjects is through visits to sites where the innovation is in operation. Teachers also spoke of the value of personal testimony. They referred to the use of professional development programs, curriculum days and subject conferences as opportunities for teachers to communicate their experiences with an innovative program.

Recommendation 7: *That programs such as ASISTM build a requirement that project proposals include a plan for communicating the experiences of the project through personal experience and/or testimony and that the costs of this be built into the budget for the project.*

Having had the privilege of learning about these exemplary projects the research team is conscious of how much there is to be learned from the experience of others. Accordingly, it would seem wise for bodies such as DEST to investigate ways in which these understandings can be communicated to and utilised by others. We would argue that such dissemination should pay attention to the need to provide rich narrative descriptions of the projects and the experience of participants.

Recommendation 8: *That DEST investigate ways in which experiences of, and understandings developed from, innovative approaches can be shared effectively across education systems.*

Critical friends

One element of the ASISTM program that could be better deployed to help with the accountability processes is the use of critical friends. Since the study was focussed on the projects themselves and not on specific roles such as that of ‘critical friend’ the team did not ask questions about these roles. However, a number of the study participants raised the issue of critical friends. From the data reported to us there would appear to be significant variability in the effectiveness with which this role was played out. This appeared to depend on a number of factors such as the communication processes adopted within the project and the commitment and abilities of the individual appointed as critical friend. The study

team are in no position to make specific comments on this matter but raise the issue because the study participants themselves brought it up. We are aware however that the induction of critical friends has been refined in later ASISTM rounds in response to similar feedback.

Part F: Broader implications for policy direction

In this final section of the report the research team point to some implications they believe can be drawn from the data gathered in the study in the light of current scholarly discussion within the field.

Curriculum implications

There are many ways in which the nature of the ASISTM program raises questions about the school curriculum in STM. In this section we will point to some of these and ask whether the program has given any pointers to future directions in curriculum.

The rewards of local innovation

The case studies illustrate the power of local curriculum innovation based on local expertise, local issues and resources, and individual teacher's passions and expertise. There was evidence that aspects of current curricula in some Australian states were helpful in encouraging and supporting these innovations. It is argued that curricula need to encourage innovation of the sort represented by these case studies. A question is raised concerning the preponderance of science projects in ASISTM, and the implications in particular for mathematics and innovation. In terms of local innovation of this sort becoming embedded within mainstream curriculum models, questions are raised concerning the implications for teacher knowledge, and also the possible need to be watchful regarding possible partisan interests of partners.

Firstly, the program has allowed people not normally involved to influence what is being learned in school programs. Whereas normally it is teachers and textbook writers who determine the experienced curriculum, the ASISTM program has encouraged schools to bring in other perspectives. Through the involvement of a broad range of community members, students have been exposed to activities and ideas not normally encountered in the school program. For example, in the Kangaroo Island project there was a strong input from marine scientists that brought into the school program an understanding of how scientists go about the work of measuring aspects of a marine environment and the opportunity for students to experience these activities first hand. Or the Kids Design Challenge, which brought architects and engineers into the classroom activity as students grappled with real world issues.

Again, the ASISTM program has drawn attention to the importance of enabling projects that address local issues or take advantage of local opportunities. The case studies contained in this report present some excellent examples. For instance there are two projects in which there is a focus on drawing attention to employment opportunities in science based careers in the local (rural) areas. These are the Riverlands project, which enabled students to come to an understanding of the science-based career opportunities available in the local agricultural industries and the Yarrawonga project, which provided students with the chance to learn about careers in a local manufacturing company.

The ASISTM projects also allowed the specific interests of teachers to impact on the curriculum experienced by the students. For instance, the You Yangs project enabled the project co-ordinator to share her passion for sustainable development with her colleagues in the cluster, and hence to tap into a multitude of community resources to

assist students to develop an understanding and commitment to sustainable development.

In a range of cases the ASISTM program gave permission to teachers to draw on their personal expertise and passions in designing activities for their students. It is difficult to over-estimate the potential impact of having students working together with teachers in areas about which they are personally committed. After all it is the failure of many school programs to capture the interest of students that is a driver of initiatives such as ASISTM. In some sense these ASISTM projects can be seen as providing the opportunity and support to unlock the potential of local teacher expertise and enthusiasm. These case studies provide a compelling argument that system wide curricula need to allow for, and indeed explicitly encourage local innovation of this sort.

The shaping of the projects by the current curriculum

It would be wrong to suggest, however, that currently school programs do not facilitate the type of activity that has been generated by ASISTM. In a number of projects participants talked about the enabling nature of the current curriculum, to support what they were doing. In some of the Victorian projects, for example the You Yangs cluster, teachers talked of the impetus received from the Victorian Essential Learnings (VELS). They believed that there is encouragement in VELS for approaching science from a wider, more problem-based and integrated perspective than is traditionally the case. A similar situation exists in Queensland where the MOON team indicated that the curriculum encouraged a multi-disciplinary approach to the topic.

While it might be thought that these locally driven and contextualised projects could only be possible in the relative curriculum freedom of the compulsory years of schooling, a number of projects involved year 11 and 12 students within external examination environment. Through the NSW technology and Riverlands projects, for example, industry partners were keen to establish links with students to increase their awareness of employment opportunities, and there were cases where students were recruited through the project. The ACT project actively sought the involvement of Year 11 and 12 students, to both improve the quality of these students' approach to design, and to offer perhaps a more meaningful experience of design as it is taught in a tertiary context.

In the Gladstone project, the innovation was boosted by the fact that schools in that region are able to negotiate assessment that supports their innovations, whereas a more centralised examination system would have made the project more difficult to achieve and manage.

There is a question prompted by the processes of this project which should be raised but to which the data gathering cannot give an answer. Although the ASISTM program was designed to encourage school-community linkages within the three areas, mathematics, science and technology, it will be noted that the number of mathematics projects is smaller than might be expected. In selecting exemplary projects for this study only one mathematics project, *Developing Skills to Teach Remote Indigenous Students in the Basic Number Understandings*, met the criteria. This suggests two questions which the present study cannot attempt to answer: Are the curricula in mathematics such as to encourage schools to look beyond the resources of the schools to adequately represent mathematics endeavour? Should curricula in mathematics encourage schools to look beyond the resources of the schools to adequately represent mathematics endeavour?

Some implications of local curriculum innovation

ASISTM, at least for these 16 projects, has done what was intended – it has opened up schools to the possibilities of innovation in accessing cutting edge technologies, grappling with contemporary science and technology processes and applications, seeing how scientists work and generate new knowledge, and considering contemporary issues. In many cases this has been exciting and engaging for students. In many cases it has been exciting, challenging and energising for teachers and has led to improved classroom processes for students even if the knowledge is not contemporary. Questions are bound to arise concerning the implications and limits that might be considered if this opening up of the curriculum and of schools was to become an established model.

This type of curriculum innovation introduces complexities in knowledge and its applications beyond those attendant on more managed curriculum models. Community issues, industry imperatives and technological choices are potentially all part of the mix for innovation in school practice. This raises interesting questions for education systems and the community more broadly. The projects covered in this report reflect the fact that science and technology are not conducted in the community within a value neutral environment and the choices of projects by teachers suggest the value stance that they hold. For example, a number of projects reflect values around conservation. This was made much more explicit in some projects than in others. In the You Yangs project 'Sustainability' was the centre of the project. While, at Kangaroo Island, the focus for the primary and lower secondary school students was on the catching and tagging of native fish with associated data collection, some enthusiastic students did see this in the wider context of sustainability issues, and for older students this wider context assumed greater importance.

One can imagine cases where industries might welcome an opportunity to develop curriculum materials that represent cutting edge technological processes but which reflect a more contentious value set. Technologies, and scientific ideas, are not value neutral. Partners may represent strongly partisan interests. If innovation of the type promoted by ASISTM, where schools link with community organisations to energise school curricula, is to be promoted more widely, is it necessary to give consideration to the directions that this could potentially take? For example, given the current concern with climate change under what conditions would it be appropriate for schools to accept as partners industry groups with a strong commitment to the on-going use of current technology for conversion of brown coal to electricity or to the introduction of nuclear energy technology?

Equipment

Cutting edge equipment is inevitably a critical component of contemporary practice, and this has implications for the resourcing of SMT education across the system.

The ASISTM project brought new equipment into schools in a number of ways. The project funds allowed schools to purchase equipment. In other cases the partnerships brought new equipment into the school program. Although not raised directly by the study team many teachers referred to this issue as an important enabler and outcome of the project. And, not surprisingly, amongst the projects where this issue was most apparent were the technology-orientated projects. Reference to this issue will be found in the case studies. For example, one teacher suggested that the equipment purchased

was the only equipment in the school that was not obtained in the 1970s. And clearly, one of the benefits of schools working with partner organizations, such as The University of Canberra, was that it gave the schools involved access to both current technology and the practices by which the technology is employed. That is to say, the issue of equipment is more complex than simply supplying, for example, newer computers or printers: Rather it is access to both adequate equipment and the up-to-date methods by which such technology is used in the 'real world'.

This issue raises the question of whether it is possible for schools to adequately present science and technology as relevant and contemporary activities with the present resource base.

Location — an advantage for rural schools?

The fact that many of the exemplary projects are in rural settings raises issues about the relative ease of links between rural schools and communities, and the viability of this model to introduce metropolitan students to contemporary practice.

The present study raises interesting questions about the impact of location on the type of innovative project developed. It will be noted that amongst the case studies there is a significant number in rural and regional areas in which the project is closely tied to local issues. For example, both the Riverlands and the Yarrawonga projects reflected both a local opportunity, access to a range of scientific activity in the region, and a local issue, the recruitment of scientifically trained personnel to serve local industry. Both the Kangaroo Island and You Yangs projects reflect concerns for the sustainability of the local environment. For the cluster schools involved in the Waste Busters and Wind Gusters project based at Collector (NSW), the project became a site for the local farming communities to engage and become more informed about the science underpinning alternative energy proposals, such as the proposed (and contentious) building of wind farms in the area. The case studies do not reveal any comparable projects in the large metropolitan areas with a local focus.

These observations lead to questions about whether it is simpler in country areas to identify local activities with scientific and technological bases than in the cities. If so, this is a serious issue for those who wish to see all students (and teachers) having access to contemporary practice in these subjects. In the view of the research team this is a subject that warrants further exploration.

Teacher professional development

It was clear from the case studies that many teachers benefited enormously from these innovative projects. ASISTM can therefore be characterised as a significant teacher professional learning initiative that potentially provides a model for teachers to upgrade their knowledge of contemporary practice in their discipline and to explore alternative pedagogy.

One of the most striking outcomes of so many of the ASISTM projects studied was the way in which the projects operated as teacher professional development activities. In some of the projects, for example Science in the Aqua Zone project, the provision of teacher professional development was a key aspect of the planning. However, there were many others in which there was no initial expectation that teacher professional

development would occur yet where comments indicated that this had been a major outcome of the project. The development has been both in terms of the science or technology and also in terms of pedagogy. This experience points to the value of in situ teacher professional development.

There is no argument that teachers are the key to capturing the interest of students in these critical school studies. Whilst these projects show that Teacher Associates are able to make a valuable contribution, the hope of programs such as ASISTM must be that teachers are able to take what has been learned from the project and to incorporate this into the ongoing program in the subject. This places teacher professional development at the very centre of what it can be hoped will be gained from such programs.

Conclusion

This study, by examining in some depth a number of ASISTM projects, has in the view of the research team done several things. First, it has shown the quality of projects that can be generated by programs such as the ASISTM program where students, teachers and community members have become enthused about mathematics, science or technology and worked very effectively together. Second, it has provided useful insights into ways in which schools and community can innovate to create more relevant and interesting learning experiences for students. Third, it has raised interesting questions about the nature and content of school curricula. Finally, it has pointed to a way in which in situ teacher professional development can be provided which brings teachers face to face with contemporary science This study has provided the research team with some extremely valuable insights into the lived experience of innovation across a diverse array of Australian schools, which they hope have been communicated effectively through this report.

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Appendix: The Case Studies

Case Study: Education for a Sustainable Future in the You Yangs

1005. BioTech Units at Serendip Sanctuary

The BioTech project in this Geelong satellite area was devised in response to a felt need to strengthen the community engagement of youth in the local schools. The cluster of schools agreed to develop a four year plan with sustainability as the theme whilst allowing diversity amongst the schools in their curriculum development within this agreed theme. Meg, the coordinator, manages a complex web of initiatives involving visiting scientists and other community members, environmental projects, excursion programs and project based learning initiatives. In the secondary school Connections is a one day a week program focused on connecting students with themselves, the community and the environment. In the primary schools the theme of sustainability is reflected in a range of activities involving local science-based services. The projects lead to public outcomes such as a reclaimed piece of river, or reduced water use at the school

Context

The You Yangs Learning Community in Victoria is made up of Lara Secondary College and neighbouring primary schools. The locals in Lara like to think of it as a rural town, identifying with it as a 'gateway' to the mountain ranges to the north-west, the farming plains to the north-east, the coastal estuaries to the south. Historically it was a rural town. Now it is part of the Greater City of Geelong, and many of its people commute to Geelong or Melbourne to work.

Lara has more young people, fewer old people, fewer unemployed people and greatly fewer non-English speaking people than the state of Victoria generally. The town continues to grow, having recently passed 10,000.

Lara Secondary College was formed only a few years ago, and has been welcomed by the locals, so that its enrolments far exceed the projections made when the school was planned. The Cluster of schools engaged in the ASISTM project centres on the Secondary College, with five primary schools – two in Lara, three in surrounding small towns. These towns are more 'rural' than Lara, but share characteristics with it.

The project

The decision that each school would adapt the program to its own situation means that in a report such as this it is not possible to describe in detail the activities arising from the ASISTM project in the different schools. What will be done is to describe briefly the program operating at Lara Secondary College and to indicate the type of approach being adopted across the primary schools.

Connections, the program at the Lara Secondary College, involves some 14 teachers and all the Year 9 students in the Secondary College, one day a week. The first term in *Connections* is geared to 'connecting to self' through personal and physical challenges; second and third terms are 'connecting to community' and community action (with the physical environment part of 'community'), and fourth term seeks integration through studies of Geelong and Melbourne and their relationships to Lara. *Connections* operates

on Wednesdays, all day, with groups of 15-17 students and two teachers engaging in excursions, community work, field work, library work or class work. The projects spread naturally across subject areas. So too the projects naturally promote cooperation, and fitting pieces together into 'big pictures' or big projects. One such big project is to study fish and fishing in a nearby bay. In *Connections* projects are supported by visiting speakers, library/ internet research, etc., as appropriate. The projects lead to public outcomes such as a reclaimed piece of river, reduced water-use at school, and to public productions such as Science Nights, newsletters and displays. For formal assessment, students present their projects (and stories of their projects) to three-person panels comprising a teacher, a student and a community representative. Public and private, individual and community, theory and action come together.

The primary schools started with the critical action question, 'How can we make our world be a better place?' Schools then sub-themed the critical question with 'water', 'energy', 'biodiversity' or 'waste' depending on the school's individual focus, setting and priorities. Teachers in teams developed inquiry based curriculum units relevant for their students. Units of work were planned across semesters. For example, a unit of work developed in one of the primary schools focused on water, around questions such as: Where, what and how do we use water? How do we affect water quality? Do we waste water? What can we do to reduce water use? How can we convince others to reduce water use? What will our future be? Have we reduced the use of water at school/home?

This unit was framed using curriculum tools currently recommended in Victoria such as the Victorian Essential Learnings (VELS) and Principles of Learning and Teaching (POLT). For example, under POLT 3: *Students Needs and Backgrounds, perspectives & interests are reflected in the learning process,* the unit plan identified the following:

- Linking to local and broader community e.g. Little River, Melbourne Camp, Easter Beach excursion;
- Home auditing;
- Variety of independent, dependant, group, pair, cross-age activities to suit different learning styles;
- Open-ended tasks;
- The use of a real theme – water; and
- Integrated use of computers, digital camera and video camera.

Outcomes

There have been outcomes for the range of people engaged in the project. For example, one teacher pointed to what she had learned about science from the excursions and the school's interaction with the Teacher Associates: *We (in the Connections program in the secondary school) also used ASISTM money to go to Queenscliff to the Marine Study Centre (QMSC) where there is a fabulous guy. Harry was brilliant…They (the students) investigated things that were in the water in Swan Bay. …We then went back to the QMSC where they had a touch tank….. The touch tank is one of the most amazing things I've ever seen……*

There is evidence too from the primary schools that the program has impacted on the teachers: *Yes, our teachers are learning from my kids. Probably the kids aren't aware the effect they're having. It [would be a good way to end the year] letting them know how they've motivated some adults. Yes that is definitely one of the outcomes for the school community. Overall it has been a fabulous program.*

Glenn Davidson also pointed to the impact beyond the You Yangs cluster: *The other interesting thing too is that this little cluster is having enormous effect on the other clusters within Geelong. You know all of a sudden it's become, while not necessarily a case study, but certainly a leading cluster for exploration. It is having an impact not just on surrounding clusters but right along the Bellarine Peninsula there, and then you slip off towards Ballarat and back into Brisbane Ranges clusters. We've done a bit of work with those other clusters as well so the ASISTM grant has also allowed us to interface.*

Success factors

What are the factors that have made the project such a success? One is that the project sits within an existing and successful school cluster. As Glenn Davidson, from CERES, pointed out: *The cluster, the Learning Community, includes 3 small schools. These schools wouldn't get the opportunity to play the game without the cluster approach, and having the secondary school as a hub it worked really well.*

Another of the keys to the success of the project has been the connection made with the community. The project utilised the services of Teacher Associates sourced from twenty organisations: some from local service providers, for example Barwon Water, some from local community groups, for example Anakie Tree group, some from professional associations, for example Victorian Association of Environmental Education, and some from government departments, for example Department of Sustainability and the Environment.

To achieve this level of involvement required a huge amount of effort but has paid enormous dividends. As Glenn Davidson commented: *The third element is the wider school engagement….. The great thing is that you've got a very strong catchment management authority in Barwon; (including) a very strong water utility…. And all these people have great people doing really good things. Parks Victoria has field rangers doing scientific work. Kids can go along and actually be out in the middle of a paddock, or the middle of a lake, or whatever, and actually doing the real science in situ, just as it happens in real life. …That's what really makes the difference.*

The ASISTM project needs to be seen in the wider context of a cluster operating well. The success is in part due to the enthusiasm and expertise of the cluster educator, Meg Parker, whose job is to promote and support the cluster. She recently completed an overseas tour, as the Westfield Premier's Scholarship Recipient, studying ways schools and communities connect. She is also committed to environmental education, and is a past president of the Victorian Association for Environmental Education.

All of the participating schools are active in the cluster, and seek to integrate cluster initiatives with school initiatives – a feat that is not straightforward, because of the 'rolling plans', priorities and personnel of individual schools. The ASISTM project is a part of the life of this on-going cluster and the schools have all agreed to the development of a four year plan built on the theme of 'Education for a sustainable future'. Whilst initially it was envisaged that the ASISTM project would be more

uniform across the cluster the schools agreed to work together around the theme of sustainability but with each school developing its own curriculum.

For innovation on the scope and scale of this project leadership is critical. The drive comes especially from Meg Parker, who is deeply committed, on the ball and 'out there' in the cluster. Further the principals of the schools believe in the project and support it. Outside assistance (with curriculum design, teacher development, and networks in environmental education) has been possible through the ASISTM grant, and used to advantage. Even so, the programmes depend on distribution of leadership, all the way to classrooms, and this has enabled them to bite deeply into school life. The commitment that binds the programmes, for the people we talked to, is a belief that children should learn and learn enjoyably, through rich, 'real life' situations. As Glenn Davidson, the current president of the Victorian Association for Environmental Education and one of the Teacher Associates, put it: *Just being around scientists, doing scientist stuff, it's really important… Spend some time with a park ranger – kids love them.*

Sustainability

What can be said about the sustainability of the programs arising from this project? There are some strong pointers to continuity. First, there is the commitment of the schools to the four year program. Second, there is the professional development that has been shared across the cluster. Third, there is the equipment that has been purchased using the ASISTM funds. As Glenn Davidson indicated: *The other really good thing about this project is that schools can share resources. The cluster has been able to buy a water watch kit, whole sets of thermometers, lux meters and all sorts of measuring equipment, and worm bins. So a maximising effect of a cluster approach with good money actually works really well.* Finally, there are the links that have been made with individuals and groups operating within the community. Although it is time consuming to establish these linkages the benefits will last beyond the life of the ASISTM Project. As one teacher said, pointing to the cultural changes which have been happening: *I think that this program can lead to the development of some fairly significant cultural changes both within the school and within the community.*

Case Study: Gladstone Industry Partnership

1012. Building Alliances for Authentic Middle School Learning and Assessment

'Building Alliances for Authentic Middle School Learning and Assessment' was an opportunity for a group of local educators to bring together under the one banner a number of recent state government initiatives such as the Queensland Curriculum, Assessment and Reporting (QCAR) Framework, previous relationships with industry groups and teacher initiated activities, such as the Teacher Generated Tasks.

What we saw with the ASISTM process fitted in with the strategic directions around curriculum reform, authentic learning and tasks that were meaningful to students here.

Involving over 900 students in Years 4, 6 and 9 from 12 schools, the project focused on exploring innovative approaches to the teaching of science, maths and technology through 'project-based learning tasks'. These tasks were developed primarily by teachers, in partnership with industry mentors, and would over time form the basis of a bank of 'authentic tasks', which align with the assessment, standards and descriptors of the Queensland mathematics, science and technology curricula. Other key actors who supported the development and implementation of these new tasks included university mentors, and critically, the Assessment and New Basics Branch of Education Queensland.

Context

Gladstone, a small city on the central Queensland coast, is perhaps best known for its alumina plant, its deep-water port, and its emergence as one of Australia's busiest export hubs. Raw materials such as coal and bauxite are shipped in to support the near continuous smelting operations, which in turn produce the aluminium used in so many commercial applications.

These industries and the port are a central feature of the city, so perhaps it is unsurprising to find that the ASISTM project undertaken by a cluster of Gladstone educators, looked to its local environment to find the experts and 'real world' applications in science, maths and technology, to assist them in enriching and enhancing the learning opportunities for their students.

Overview and background

The core idea of the Gladstone project was that, through talking and working with local industry players, teachers and others could identify links between local 'real world activities and products' and key concepts from the maths, science and technology curricula. These links formed the basis of the 'authentic tasks' mentioned above, and were developed by teachers and mentors during the second half of 2005. A crucial part of the development of these tasks involved them being reviewed and accredited by an internal process managed by the project's 'Cluster Team'. In 2006 the accredited tasks were implemented by over a hundred teachers and teacher aides, with additional support from 40 industry and university-based mentors. The tasks were then published as part of a 'bank of tasks', and included things such as the making of circuit boards as part of a bigger unit on exploring energy, the designing and modelling of bridges, and a

collaborative project between a primary school and a high school based on fashioning energy-efficient billycarts.

The Cluster team also appointed external experts from Central Queensland University (CQU) to evaluate the project's outcomes, in keeping with its emphasis on promoting educationally rigorous activities. CQU also contributed to the project by placing their students in classes where teachers were implementing the new tasks, both to expose the students to innovative teaching practices and to assist teachers in refining and delivering their tasks.

'Building Alliances for Authentic Middle School Learning' was, however, more than simply a coalition of 'small projects' and teacher-based professional development. At its broadest, the Gladstone ASISTM project resembled something more akin to a reflexive 'meta-project', where the Gladstone educators not only wove together a number of related ideas, initiatives and practices, but also applied recently acquired insights into how to improve outcomes in the teaching and learning of maths, science and technology, in a rigorous and systematic fashion.

The local region had recently undertaken a pilot project encouraging 'teacher generated tasks' (TGT), to counter a prevailing sense among teachers of an overly prescriptive curriculum. Instead, through TGT, curricula would be orientated around teacher tasks, foregrounding teachers' perspectives. Core elements of the TGT were retained in the ASISTM project, but after planning meetings and other exchanges with experts from local industry, these tasks where extended to include both industry and community perspectives.

The ASISTM project also grew out of a series of identified needs, based on earlier research from a range of studies. What the research studies collectively identified included the need to:

- Increase and improve both the number and quality of students attending university-based science and technology courses and industry job-seekers in the Gladstone region;
- Positively influence student attitudes to related careers and further study by the provision of industry based teaching associates within the context of real world problem solving; and
- Engage teachers at a deep level in professional learning about curriculum intent, pedagogy and assessment in mathematics, science and technology.

Why the 'middle years' became a focal point for the project was that, previously, industry had tended to focus more on the school leaving years (i.e., years 10-12), whereas both the research data and the local educators' experience indicated a need to engage with students much earlier in their schooling experience.

The project

Gladstone's ASISTM project started with the leading educators (including some from the regional office of the Department of Education) inviting representatives from local industry to discuss their overlapping concerns and how they could usefully work together in addressing some of the identified needs. Prior to this meeting, many of the players had worked together in a series of loose alliances, dating back to the early 1990's. The educators bought to the meeting a planning framework, a notion of 'real

world' engagement and authenticity, and the desire to sustain a change in their pedagogy. For the teachers, the promise of input from industry was seen as critical in shaping learning tasks. From the point of view of industry, they wanted to engage with the education of their potential workforce in the areas of science, maths and technology whilst exploring new ways of being 'good corporate citizens'. And for some from industry there was a deep interest to explore the question of how best to educate students in the sciences: *The question from industry was how to get involved...(and) about influencing kids in some way.* The meeting culminated with industry representatives suggesting the formation of a network that would bring together these alliances and ideas under the one ASISTM project banner.

What held this group together was: *one central theme: that is to move forward the one core business that we have in our classrooms which is to engage the learners and provide better opportunities to learn.*

With such a large and diverse array of mini-projects being run across 12 different schools, the importance of a dedicated project officer was paramount. Terry Rudder was appointed to this position and was asked to take the various elements from the network and 'hammer' out the points of contact between teachers' who were writing tasks and industry mentors, overview the process by which critical friends reviewed and commented on the teaching plans teachers were constructing, and to address administrative issues as they arose.

> *A key component of this ASISTM project was 2 days of intensive training called Teacher Generated Task Training. Teachers of participating schools created tasks, working in consultation with industry and community mentors that were subsequently implemented back in their classrooms. Critical friends supplied both a mentoring and critical role, ensuring that the tasks could be independently verified as quality tasks.*

The guiding principle was to ensure quality at each stage of the process. Terry's experience was that teachers were widely supportive of this process: *When you give teachers the opportunity to get better at their core business they are totally into it, totally engaged.*

Speaking to the students, it became obvious how much they had enjoyed participating in the ASISTM related projects and the content knowledge they wished to share. One task this particular cohort of students had undertaken was structured around energy and its use in the local community. The students undertook a field trip to the power station, heard presentations by workers from the local power company on working safely with electricity, and constructed their own electrical circuit boards. As one year 6 put it: *It made learning at school more funner*. Students worked in small groups, and several commented that they weren't only *learning about stuff* but that they also were *learning to learn together.*

From the teachers' perspectives, what came across most strongly was the increase in their confidence to teach science and technology to a particular age cohort, the advancement of their own discipline understandings, and the importance of appropriate, timely and expert external advice in developing and implementing the authentic tasks. For example, one task involved teachers and students from neighbouring primary and secondary schools, working together to fabricate energy efficient billycarts. Year 7 students from the primary school worked closely with students from Year 10, to design, construct, test and evaluative their products. And what took this task beyond simply

being just another, albeit enjoyable, metal work type project, was the thorough and rigorous planning undertaken prior to the first lesson commencing, which looked to integrate task activities with the learning framework, standards and assessments from the Queensland curriculum. The students didn't simply build and race billycarts, they also utilised learning, drawing on maths and physics understandings to first predict and then make sense of how their billycarts behaved in the 'real world'. And, consistent with all the tasks undertaken in the Gladstone project, the teachers had access to outside mentors to assist them in developing these tasks, assistance in the actual construction of the billycarts, and documented their task so it could be added to the grow 'bank' of tasks for other teachers.

As mentioned earlier, input from the teacher's critical friend was an essential part of the process of developing and accrediting these tasks. Some teachers expressed their initial difficulty with the notion of developing tasks with a critical friend, both at the level of opening up the teacher's work to outside scrutiny and in the context of tight time constraints. In the end, this iterative process used to develop authentic tasks was described as *hugely worthwhile*, because it was felt to have been a process that promoted science and technology content that actively engaged students, drew on relevant examples from the local community, and was educationally rigorous.

Innovation

When asked why they considered their project to be innovative, Mark Collis, the project's coordinator, drew a distinction between innovation as context dependent i.e., an activity that is new to a particular site, and innovation as something that breaks new ground. In regard to the first part of Mark's distinction, the 'Building Alliances for Authentic Middle School Learning' project was innovative because it enabled a new alignment between industry, teachers and other mentors to co-construct teacher generated learning tasks. What is groundbreaking are the close and 'authentic' relationships that formed and deepened over the lifetime of the project, between industry and teachers. These relationships allowed industry to position itself as a partner interested in a range of issues beyond that of securing tomorrow's labour market. To the (delighted) surprise of the educators their ASISTM project facilitated the formation of ongoing and meaningful relationships between industry, schools and others, based on the actual learning processes of maths, science and technology.

Challenges

Two of the challenges that were mentioned by several actors concerned the need to negotiate between different systems and the pervading sense of a lack of time to properly get through all the various demands that came with the tasks.

Negotiating between different systems included the need to manage effectively things like the requirements of the Department of Education for police checks on adults working with children being sensitively balanced with working with volunteers, finding commonality between primary and secondary school timetables and between school and university timetables, and finding solutions to logistical issues of transporting cohorts of students between schools.

One aspect everybody, teachers, industry representatives, and the regional office all emphasised was the central importance of the role of the project coordinator to ensure timelines were met, to be an 'operational' point of contact for all concerned, and to actively maintain the link between scientists and schools.

Sustainability

Sustainability is where teachers value what they did. I won't say every project will run again this year. They won't. But I know a lot of what has been achieved will continue.

By the time of visiting this site, the ASISTM project had formally stopped six months earlier, yet a number of schools had already run a second year of maths, science and technology 'tasks'. The teachers all indicated the way the project had changed how they taught science, maths and technology and this was the change that they carried forward. Secondly, a large bank of tasks had been created, with more being added as they are signed-off through the accrediting process. Thirdly, the steering committee that effectively drove this project is still active and engaged in continuing the project, including the links with industry partners and an expanding input from the local university (CQU). The only real question regarding sustainability concerned the role of the Project Coordinator, who was funded to *work on the business not in the business* and whose role was strongly seen as essential in *taking charge of the bigger picture*, ensuring standards and other forms of accountability were maintained, and perhaps most crucially of all, tying together the feedback from all the different groups, whilst maintaining a critical overview.

Outcomes

The project identified four major, quantifiable outcomes:

- Through the provision of real world problem based tasks, students engaged deeply in key concepts underpinning maths, science and technology curricula as evidenced by their core learning outcomes;
- Teachers internalised an action-based method of incorporating science, mathematics and technology into their day to day teaching;
- Teachers become more skilled in curriculum intent, and designing and assessing quality innovative science, maths and technology tasks; and
- An ongoing bank of tasks with accompanying standards and descriptors has been published.

Recognition of the quality of the project's outcomes has also lead to the Gladstone educators being invited to form the hub of one of the six new Innovation and Professional Practice Hubs, funded by the Queensland State Government, as an exemplary hub for sustainable curriculum leadership in the areas of maths, science and technology.

Reflection

What the ASISTM initiative enabled for this cohort of educators was the resources they needed to plan, and implement with partners, ways to extend, formalise and document relevant, engaging and educationally rigorous ways to teach maths, science and technology. What stood out was the unity of purpose, the professionalism of the various actors involved, the scale of the project and the enthusiasm, from students and teachers alike, for thinking about science, maths and technology, in their local environment.

Case Study: Designing a Weightless Life in Canberra

1013. Designing the Teaching of Design and Technology

How appropriate that this project, which is orientated around the importance of good design and its processes, was set in Canberra, Australia's own unique exemplar of good design. Year 11 and 12 design students at four public schools in Canberra were given an open-ended design brief by one of Australia's leading tertiary institutes, the School of Design and Architecture at the University of Canberra: If gravity did not exist but all the other dimensions of life were exactly the same, how would designers respond? And whilst the task set was interesting of-itself, what was exemplary, from an innovations perspective, was that this design task was as much about the processes involved in good design 'in the real world' as the final product. In addition the value of this project is not merely confined to others interested in promoting contemporary design processes. The 'Designing the Teaching of Design and Technology' project also has much to share with interested parties on how to manage effective and mutually beneficial relationships, especially those innovations looking to forge new alignments between the university sector and schools.

Context

The 'Designing the Teaching of Design and Technology' project formally began in early March 2006, with a planning meeting hosted by Prof. Craig Bremner and Stephen Trathen, respectively the Head and Deputy Head of the School of Design and Architecture, University of Canberra. This meeting brought together interested principals and teachers from four ACT schools (Dickson College, Hawker College, Lake Ginninderra College, Narrabundah College), Tim Grace from the Technology Educators Association of the ACT (TEAACT) and the ASISTM appointed Critical Friend, Noel Gough.

The purpose of the meeting was to plan a project that would explore and address several issues that involved, to varying degrees, all who attended. These included:

- A shared desire to raise the possibilities of design and its related technologies as an exciting, relevant and legitimate vocational path for high school students;
- Trialling ways to address the gap between how contemporary design is thought of and taught within schools and at university;
- Exploring how best to bring exemplars of design practice into the classroom; and
- The University of Canberra's desire to raise its profile among the high schools in its local community, and especially with Year 11 and 12 students.

What was central to all these issues was the core idea that the University could work in partnership with schools, professional associations and others, as a hub for a 'design-centred community of practice'. Such a hub would facilitate and support an extended notion of 'teachers of technology', in their practices of teaching contemporary design and its related processes.

One prominent element that the project embraced as a means to meet these ends, was the appointment of nine senior tertiary design students as Teacher Associates, to act as mentors to Year 11 and 12 students. For teachers, alongside practical support (workshops, design materials etc) from the University to assist in running the project, there was the offer of further professional studies in design, with options leading to postgraduate studies if teachers so desired.

From this initial planning session, two design teachers and their Year 11 and 12 classes from each of the four schools were recruited into the next phase of the project, to undertake a design brief under more 'authentic industry' conditions, culminating in a combined schools public exhibition.

The Project

The participants had approximately seven weeks to respond to and complete the open-ended design brief. The students' task was to start from the context of a 'No Gravity' situation where *all other dimensions of life on earth are exactly as they are today, just minus gravity* and to design a way to live in such an environment.

The No Gravity design task was organised into seven stages:

1. Project briefing for participating teachers, teacher associates, and students;
2. Research/enquiry;
3. Evaluation and feedback;
4. Evaluate against research enquiry;
5. Design proposals selected and developed;
6. Production of final result; and
7. Combined exhibition

The project brief introduced both the design task and the teacher associates to the Year 11 and 12 students. The briefing also served to introduce students to the aims of the project, set the design tasks parameters and to field student queries. Central to the project brief was the project aim of *exposing students to a contemporary design process* and this was reflected in the design task's short time frame and open-ended brief. When I interviewed a cohort of Year 11 students a year later, several still remembered their initial dislike for both the short timeframes and what they described as a vague task. Indeed some were still worried about how an environment would or could function without gravity i.e., *wouldn't the oxygen escape without gravity*?

After a briefing, students were asked to brainstorm responses to designing for a zero gravity world and with assistance from teachers and teacher associates, produce a design proposal within three weeks. Students were then invited to present and speak to their design proposals to the group (fellow students, teachers and teacher associates) for evaluation and feedback. A key part of the presentation was the facilitation of the discussion by the Teacher Associates, who attempted to replicate the type of pedagogical processes employed by the Design School at the University. In particular the group was asked to consider and reflect on how well did the proposal engage with *the core design task and did it address the technical and/or skill requirements* to achieve its intended outcome (Trathen, 2007). Again, some students later commented that they found this type of group scrutiny of their work initially difficult but all agreed that it was beneficial in deepening their thinking about their respective proposals. For example, students needed to think through what was meant by gravity and hence what

ideas would work in a non-gravity environment prior to designing anything. Several students commented that the open-ended brief meant that *one thing led to a new set of problems* i.e., one designs a zero gravity living quarters but then the next question arises re how to deal with the implied elements such as plumbing and so on. Students commented that the *design process forced us to stay focussed and not get mislead onto other tangents.*

The selected proposals were developed further, again with input from teachers and teacher associates but with the students very much 'in-charge' of their design task: *We were in charge of everything including time management. The task was sooo big, we needed guidelines [from teachers and TAs] with tight timelines* (Year 11students). The teacher associates assisted directly with technical elements of design such as *the use of new model making methods, higher design order animation methods, three dimensional computer modelling and other computer aided design*, as well the more traditional mediums of design such as sketching and rendering. The University of Canberra also provided 'blue foam', which is the basic industry standard for industrial design (Trathen, 2007). The students produced a diverse array of design-based responses that ranged from potential fashion products such as form-fitting anti-gravity suits; practical products such as compression suits to off-set the effects of a lack of gravity; whimsical designs such as dog-bootees that assist the family pet to stick to a surface; to the more abstract (imagining ways to produce art in zero-gravity) and the mediative (a home bio-sphere that serves as an archive to store memories of life in a gravity zone).

One important element, supporting the aims of the ASISTM project (the transference of design expertise into schools), was weekly meetings with the Teacher Associates run by Stephen Trathen, the project deputy coordinator. At these meetings Teacher Associates were given the opportunity to both debrief on their various experiences and reflect back to the project coordinator progress regarding the design task.

The final element of the design task was to mount a public exhibition in mid-September 2006, which was held at the University of Canberra's Design Gallery, opened by the Pro Vice-Chancellor Academic of the University and on display to the general public for a fortnight. Following the exhibition, the deputy project coordinator facilitated separate evaluations with teachers and teacher associates. In addition the teacher associates kept weekly journals of their experience, which also helped form the basis of the project's evaluation and final report.

Outcomes

After surveying some of the final products and collecting personal testimony from teachers, teacher associates, students and others directly involved in the 'Designing the Teaching of Design and Technology' project, the overwhelming impression one has is that the project was a resounding success. It met or exceeded all its proposed objectives, and the enthusiasm among the Year 11 students for design was still evident a year later. Perhaps the only area where the response wasn't as fulsome as it had been hoped was the lack of uptake among the teachers to undertake further units of study at the University (possible reasons for this are suggested in the next section).

For students it was evident that the project had changed and broadened their sense of what is involved in contemporary design and the role of a university-based design school. For example some students commented that because of last year's project, they were now viewing their career options differently and thought that the project had

increased their chances of being admitted into the School of Design and Architecture. At the level of their work students readily offered their opinion that this project had *definitely made final product better and more purposeful; Going to Uni (to watch a design class) gave me more of an idea what Uni was really like;* and, *I knew what design was but it (the project) opened our minds more, to think not so literally.* (group discussion, Year 11 students).

For teachers, one opinion regarding the value of being involved in the project was that it helped to reposition the teaching of design: *When you teach design, there is a struggle within, a split within subject, that it is about a narrow idea of technology. The link of this project with Canberra (University) was important to us to promote the subject – (its) relevance, credibility, (and the consideration of) design as a serious option (for students).*

For the Teacher Associates, the project offered them the opportunity to exercise their knowledge and expertise, to undertaken some assessment tasks toward their degree in a different mode (the work the TAs did with the project was counted toward one of their units of study), and a chance for some to test out their desire to teach in a secondary school setting. At least two of the participating teacher associates are proceeding to a Graduate Diploma in Education, Design and Technology.

Challenges

One of the most difficult challenges was the difficulty of two institutions, school and the university to find ways to make the different timetables line up. Another challenge was overcoming some of the cultural differences of importing design pedagogies from university setting into school setting. And whilst these issues where neither unexpected nor that difficult to overcome, one external factor that hadn't been envisaged, an industrial dispute between teachers and their employer did add another layer of tension to the innovation. *There were certainly some issues regarding this long dispute discussed in the evaluation workshop, where the thought of having to engage in the extra-curricular activities involved in further study was too much for that time.*

No teachers took up the offer of the postgraduate professional development study option provided by the project. The reasons for this varied (the lack of time/wrong time to study) but clearly, as it stood, this option was not seen as attractive nor as particularly relevant to teachers.

Sustainability

Overall the project was deemed a success in that it served to better prepare high school students for design orientated tertiary studies, whilst raising the profile of the Design and Architecture School within the four local high schools and in the community generally. In addition, the project was not excessively expense to run, with most of the costs absorbed into the day-to-day running costs of the respective institutions e.g., the teacher associates do their mentoring work as part of their degree studies. In 2007, a second (non-ASISTM funded) version of the project was run, with the University of Canberra and School of Design and Architecture absorbing the administrative costs involved with running such a project. This project again was based around a design competition run with schools, culminating in a public exhibition (for media reports, please see http://www.canberra.edu.au/monitor-archive/reports/20060926_gravity.htm and http://www.canberra.edu.au/monitor-archive/gallery/2006/gallery40/index.html).

Case Study: Improving Maths in Far Northern Queensland

1016. Developing skills to teach remote Indigenous students in the basic number understandings"

The essence of the "Developing skills to teach remote Indigenous students in the basic number understandings" project concerned the need to improve Teachers' and Teacher Aides' maths skills (content and delivery) and to support schools in developing innovative programs to teach whole and rational number and operations across Years 3, 5 and 7. This, it was envisaged, would lead to improving learning outcomes in maths for indigenous students. In addition, the QUT team also committed itself to a series of ongoing support services for these programs across the life of the project.

Context

"Developing skills to teach remote Indigenous students" was aimed at addressing indigenous students' underperformance in mathematics in eight remote primary schools. The team comprised Professor Tom Cooper, Queensland University of Technology (QUT), colleagues Dr Annette Baturo, QUT, and Associate Professor Elizabeth Warren, Australian Catholic University (ACU), and a team of researchers based at QUT and ACU in Brisbane. The cluster schools they worked with stretched out across the vast distances of the Queensland hinterlands to the Gulf of Carpentaria. It is important to stress not only the distance between these sites (e.g. Doomadgee lies over 2200km away from Brisbane) but the remoteness, the lack of essential services and infrastructure that the rest of Australia take for granted, coupled with an environment that encompasses both desert and tropical climes. These are some of the conditions under which education is delivered in the far North, and which to various degrees impacted on aspects of the project.

The ASISTM project grew out of a larger Australian Research Council (ARC) grant, led by Annette Baturo with Tom Cooper and Elizabeth Warren as Chief Investigators, that sought to find effective ways to intervene in the area of mathematical knowledge and the underperformance of indigenous students in remote schools. On the basis of the ARC project, working relationships had been established with key school-based educators, which was significant at both the level of recruiting schools to the ASISTM-funded project and in gaining insights into their and other teachers' and teacher-aides' professional learning needs.

The Project

In late 2005, interested principals and educational officers from the Mt Isa district met with the QUT team, to work through how best to deliver the teaching resources QUT had developed specifically to engage indigenous students in early number and whole-number numeration. One outcome of this meeting was agreement for the research team to undertake a series of out-reach visits to the participating schools, where they would deliver professional learning (PL) seminars on-site to teachers and crucially teacher-aides, as well as overseeing the classroom trials of the new materials. Furthermore, the initial project plan envisaged that the teachers on-site would complement the QUT materials by developing additional teaching materials, drawing on their enhanced knowledge and local experiences.

Splitting the schools into 'Gulf' schools (i.e., schools close to or in the Gulf of Carpentaria) and 'Border' schools (schools abutting the Northern Territory border), the research team proceeded to implement the project in 8 schools, including the three schools visited by the researcher (Urandangi, Dajarra, and Doomadgee). Given the QUT team was predominantly based in Brisbane, the role of the Deputy Project Coordinator, Doomadgee State School principal Michael Hansen, proved to be essential in coordinating the project across such a large area. Having settled on a schedule of visits, the project was partially delayed by the impact of cyclones and extended periods of flooding, where some of the schools involved were inaccessible by road.

The professional learning seminars initially covered information on the new mathematics syllabus, 'hands-on' experiences for teachers and teacher-aides with materials effective in teaching counting, place value, rank and multiplicative structure for 2- and 3-digit numbers, and possible activities that the schools could trial focussing on new practices to address performance in maths. Examples of these included Urandangi State School (SS) trialling teacher/aide-developed computer activities focusing on counting and 2-digit numeration activities, and Dajarra SS trialling computer-based learning activities to enhance mathematical learning in whole numbers.

Initial visits by the research team were backed up by further series of *tinkering visits*, which aimed to further support teachers and teacher-aides in their classroom activities as well as revising the teaching and learning materials. One major shift in the direction of the project was recognising that the project's initial aim of incorporating materials developed onsite by teachers was beyond the capacity of the schools to deliver.

Urandangi SS, a two-teacher school that serves the community of Urandangi was visited as part of this study. This school is at the end of a 100km dirt track, which was reached after already having covered 90km out of Mt Isa on a single lane road. There is a 'pub', some buildings and little else. Power to the school is supplied by its own generator, and the two young teachers run this as well as the school. They start their very busy day early, by ferrying students from the local community to school and providing breakfast. As Selina, the head teacher explained, their role is one that is greatly expanded from what one typically associates with teaching. Their responsibilities range from school-based activities, such as teaching across all the discipline areas, to providing services to their local community. So while these teachers were excited and willingly participants in the ASISTM project, and found it of enormous benefit, the expectation of producing material on top of these demands was too much. The QUT project team responded by interviewing the principals and teachers of the schools struggling to develop their own, local materials. Through this process additional teaching materials were developed with the help of Tom Cooper, Annette Baturo, Elizabeth Warren and others. Later these were incorporated into the full suite of resources the QUT team and the other participating schools had created. These materials are due to be released on CD and also on the project's website.

Outcomes

All the teachers and principals were overwhelmingly positive about their experiences, with some of the larger schools such as Doomadgee pointing confidently to measurable improvements in students' outcomes in the areas of numeracy targeted. Other benefits reported included increased knowledge of the new maths syllabus, teaching materials better suited to the local conditions, higher levels of enjoyment by the students and a

deeper sense of confidence in the teachers' ability to teach maths to indigenous students.

Innovation

The ASISTM project "Developing skills to teach remote Indigenous students in the basic number understandings" was innovative because it really did facilitate a "novel alignment of actors, ideas and practices" aimed at overcoming issues unique to these sites. That is, this project wished to tackle both the stated issue of addressing the relatively poor understanding of aspects of basic numeracy among indigenous students, and the issue of how to deliver effective mathematical teaching to remote, indigenous communities.

The key to the success of the innovation was the idea of relevant and engaging modes of delivery, the need to develop the suite of teacher resources through a process of consultations and iterations, and the need to recruit teacher-aides (who are often locals) alongside teachers, to ensue the innovation is sustained. Central to all of this was the commitment of the QUT team to get out and visit sites regularly. And whilst site visits per se may not be perceived to be either especially innovative or difficult, in the context of far Northern Queensland, the impact of a *full professor* (as one teacher put it) *coming all the way out here* to share new ways of teaching maths, was profound for both parties. Obviously teachers and teacher-aides benefited from this support, but also by being *in situ*, it provided for the QUT team the opportunity to *tinker* and fine tune their original teaching resources, garner support from representatives of the local community, and boost teachers' and teacher-aides' ability and confidence in delivering effective mathematic pedagogy.

In addition, by the QUT team opting to come to sites, the project directly addressed two of the structural impediments for remote schools trialling innovative practices; the difficulty of finding relief teachers in the remote schools' regions and the reluctance of teachers to spend even more time away from their class, given the prior demands of Education Queensland directed training.

Challenges

The overwhelming challenge for this project was simply the lived, everyday experience of schooling in far Northern Queensland. Aside from the cyclonic weather and distances between sites, the underlying problems to schooling in far Northern Queensland are a mixture of poverty and the ongoing impact of a clash of cultures. Schooling is undertaken against a social backdrop lacking in everyday resources such as adequate housing, roads, and transport. However, the principal of Doomadgee was very straightforward. His overarching vision is that schools need to provide the *best* education for all students, regardless of their location, evidenced when Doomadgee students achieve the same educational benchmarks as their city counterparts.

Amongst these very real and large 'challenges' are ones closer to the longer-term impact of the ASISTM project: retaining experienced and effective maths teachers in remote locations. Simply, there are very high rates of turn over of staff at these locations. The "Developing skills" project chose to overcome this challenge by including teacher-aides alongside teachers in the professional learning programs, to ensure some of the professional learning remained onsite, as well that of an 'institutional memory' and a point of connection for future programs with the QUT team.

Reflection

Without wishing to gloss over the very real limits, difficulties and issues facing education in remote sites such as those involved in this ASISTM project, there was much to admire and value about the work of all those involved. Firstly, a university team had demonstrated both an effective model and mode of delivery of how to address an area of need among one cohort of Australian students. Secondly, the level of dedication and professionalism of all the educational staff is extraordinary. These locations 'stretched' the received notion of teacher identity, and given the relatively young age of staff, their maturity and positive energy is also extraordinary. As Clarence Walden, a former mayor and elder from Doomadgee, remarked in the school's promotional DVD, outsiders are entrusted with formal education of their children and hence need to come prepared to be part of their community.

Case Study: Star Gazing in WA

1017. Earth and Beyond - Astronomy and Space Science Education in Western Australia

The Astronomy in WA project, formerly known as 'Earth and Beyond - Astronomy and Space Science Education in Western Australia', involved the collaboration of a small number of experienced astronomy teachers and astronomy related science centres, to produce a set of materials to support the teaching of astronomy in Western Australia. It did not involve students directly (with the exception of an Astronomy Challenge Day), but is an example of an innovative project largely focused on collaborative curriculum resource design. Important to the project, were the networks of astronomy facilities and teacher enthusiasts that were set up, and which are ongoing.

Context

The large Australian bid to establish a radio astronomy facility in WA, the 'Square Kilometre Array', brings with it a government interest in developing astronomy expertise and infrastructure to the State, and the possibility of this science context achieving a high profile in school science education. On the back of this bid, for which Australia is one of a shortlist of two countries, Scitech, the Perth science centre which includes a well regarded planetarium, had been talking to the WA Department of Industry and Resources about a funded project to increase the profile of Astronomy in WA schools driven through a website (www.astronomywa.net.au). ASISTM came at the right time, to inject funds to expand the original concept. The WA Department has also contributed funds.

As Rob Gates, from the Department of Industry and Resources, explained, while the state provides a wonderful facility for the SKA because of its quiet skies and reasonable access, it does not have a history of radio astronomy, nor the infrastructure and technical personnel to make best use of a successful bid and the job opportunities it will bring. The government has been therefore working to provide such support, with the appointment of two radio astronomers through a Premier's Prize fellowship, the encouragement of university astronomy studies, and a number of scholarships and awards for teachers of astronomy. The aim is to have astronomy more strongly represented in the school science curriculum, and the recruitment of expert teachers passionate about astronomy to support this, was a natural step to take. The ASISTM funding opportunity arrived at a time, therefore, when a significant vision and a plan of action were already in place.

The project

The project is built around the expertise of five enthusiastic teachers of astronomy, value adding by putting them in touch with astronomers and facilities with a view to setting up a network of people with astronomy interests. The project involved visits by these expert teachers to the various sites, and also regular meetings of the 'Astronomy WA' committee that oversaw the project and created a network. Thus, the Astronomy WA concept provides a coordination role to bring together organizations, teachers and schools, and to set up curriculum and infrastructure resources to support the teaching and learning of astronomy.

The informants for this case study identified this bringing together of different interests around a common theme, and the putting of schools and other organizations in touch with each other for a common purpose as innovative. The other innovative aspect was the way in which these expert teachers were recruited and managed to develop quality resources, and the way they were also connected to contemporary astronomy through workshops at a number of facilities. For these facilities, which run programs for schools and the public, it was an opportunity to learn about practice in schools, and to be put in contact with schools and with committed teachers. On both counts, Astronomy WA is about networking. The resources that were developed, created out of these teachers' experience, were both held to be of high quality and innovative.

The first step in the project was to identify five 'teachers of excellence' in astronomy, to pool their expertise and resources to produce a web based curriculum resource. These teachers were self-selected in some ways, in terms of their profile and their enthusiasm. The original idea had been to have these teachers shadow astronomers, to pick up new developments in astronomy. This proved impractical because of timetable and coordination difficulties, and what actually happened was that these teachers arranged, at suitable times, to visit each of the astronomy facilities to learn about their work and the latest ideas and research, and also to develop ideas about how to incorporate such facilities into the curriculum. The facilities were:

- The Gravity Discovery Centre;
- The University of Western Australia, Australian International Gravitational Research Centre;
- The Perth Observatory;
- Horizon Planetarium; and
- Scitech science centre.

Following these visits, in which these astronomy experts explored astronomy ideas and the potential of the facilities to support worthwhile student learning, a three day weekend workshop was held, with these five experts and a number of less knowledgeable colleagues who had responded to the call – 17 teachers altogether. These five expert teachers took the lead in planning and delivering PD sessions, interspersed with lectures given by astronomers. The teacher associates from the astronomy facilities both pre and post-planned with the teachers.

There was general consensus as to the success of these workshops. Pete Wheeler made the point that an important part of this process is the synergies that inevitably occur when you get expert, enthusiastic teachers together. The informants made two points concerning the value of this. Firstly, the energy that comes from putting enthusiasts together, and secondly the strength of a professional development experience led by teachers. Paul Nicholls (Scitech) made the point that teachers are generally under valued, but that this project, by looking after these expert and other teachers, had made them feel valued and generated enthusiasm. Teachers had gained a lot of energy from each other.

At the same time, work proceeded on the production of a CD with hands on astronomy activities for the middle years of schooling. A recently retired teacher, Ray Priskich, was identified to develop a CD resource that consisted of activities gleaned from the

experience of all five teachers, and any further input given by astronomers. There were three modules written: two are ten week modules, and one is a project based module. That work has resulted in an online resource (at http://www.astronomywa.net.au/). The site has proved popular, with 4000 hits over the first few months, and a rising profile. It has the resources described above, an event calendar, news, events and local photos.

In June, Astronomy WA ran a Challenge for 15 schools each with a teacher and three students as a team. There were a variety of activities, including workshops with these astronomy-passionate teachers, and a quiz in the evening. The event seemed to have tapped into a real demand, and it *exposed kids to astronomy knowledge*. It is also expected that this will assist in ensuring the project becomes sustainable in the long term.

Partners

The project was overseen by Paul Nicholls of Scitech, and managed on the ground by Pete Wheeler, who runs the Horizon Planetarium. Pete was a very hands-on coordinator and was praised by others for his support and for his attention to detail: *Peter was a major player – the team leader. He did a lot of ringing around, organising meetings, bookings and speakers. We were treated with respect*. (Teacher)

Paul made the point that the project was in fact quite substantially subsidised by Scitech, given the amount of management time required. The Scitech role was that of a hub institution, and therefore quite critical to the success of the project.

The astronomy facilities were very positive about the project. The Gravity Discovery Centre for instance, appreciated the addition to its programs made possible by funding. Carol Redford from the Centre talked of using some of the grant money to purchase 'Sky Scout' equipment that enables identification of stars and the plotting of movement.

Andrew from the Perth observatory was very positive about the project. He claimed that previously the program did not represent a clear view of what schools might want, but that through the project and its committees he now has a better idea about how students respond to topics. He was of the opinion they would continue to meet without funding, with the following benefits:

- Better promotion of events;
- Cross funding of opportunities; and
- More grant applications.

Andrew argued that the biggest success has been getting people to talk together.

For the five astronomy-passionate teachers the benefits of the project seemed to have been being put in touch with other astronomy enthusiasts, and to have had a chance to develop and influence policy approaches. Murray Thomas is a biology teacher who runs astronomy evenings for his school and class, and has a history of interest in astronomy. He mentors and supports year 8 teachers of science. He contributed a number of activities to the CD for primary schools. He was enthusiastic about the workshops: *They were all an eye opener to find what goes on behind the scenes. We found out what's happening, used the telescope, found the Gravitational Discovery Centre exciting and were impressed by the planetarium*.

Sustainability

There are a number of circumstances in this project that point to the likelihood of sustainability:

- Continuing policy drive of the WA Department of Industry and Resources;
- Ongoing and generally enthusiastic links implied by the Astronomy WA group;
- Networking that has gone on with cross collaboration common;
- Existence of an active website;
- On-going commitment, supported by resources, of Scitech as managers;
- Existence of the resource bank of activities (the critical friend had visited two schools who had trialled materials after the workshop. The teacher rewrote the materials to make them more appropriate. There was a very positive feeling about the residential workshop.); and
- Take-up in schools – the group had penetrated quite a few schools.

What is clear from this study, and was clear when talking to the participants is their enthusiasm. The Challenge Day was sufficiently successful that it will continue for a few years at least.

There were also other initiatives that were broadly supportive of this push. A round 4 ASISTM project had been short-listed, featuring members of this group, and focusing on astronomy hardware. There was also close links between this project and another ASISTM project 'Wildflowers in the Sky'.

Outcomes

The critical friend, Coral Pepper, was enthusiastic about the organization and the outcomes of the project. She saw benefit in the resources (although there was some indication they were generally at too high a level), in the astronomy viewing nights, the guest speakers, and the professional development for the teachers: *The project provided an avenue for dedicated astronomers to spread their message. They gave a continuous involvement, despite changed circumstances. People were passionate. It's good to have expertise and dedication rewarded!* (Critical friend)

There was no direct evidence of student outcomes, and this was not the immediate focus. However, informally, the project has been judged a success.

The existence now of Astronomy WA, a body with a purpose in terms of the website and greater school contact, is a major outcome. So also is the enthusiasm and commitment of these teachers.

For the teacher associates from the astronomy facilities, the project has provided access to schools and greater understanding of the needs of schools. In the case of the Gravity Discover Centre, it also developed a new program featuring new Celestron technology.

Case study: Scientists in the Community

1018. Emerging Scientists

This project involved teacher educators and scientists working with secondary and primary teachers to enhance the teaching and learning of science in a number of primary schools, The project shows how the ASISTM funding enabled schools to participate in joint planning of science units and to engage Teacher Associates with the expertise to contribute to this process, with an emphasis on evaluating and using students' understanding of ideas. The project illustrates also benefits which can flow from crossing the primary/secondary school interface.

Context

The genesis of this project was at a meeting of primary school principals in a cluster in south eastern suburbs of Melbourne. They were looking at ways of working together in science. Further they wanted the science programs in their schools to have a greater emphasis on scientific investigation and the development of scientific processes. This is reflected in the goals of the project as stated in the application:

- To motivate students' interest in Science through challenging scientific exploration; and
- To enhance students' skills in observation, investigation, prediction, forming hypothesis, analysis and recording.

Further, a parent in one of the participating schools was an eminent scientist, Dr. Rossjohn, 2004 Prime Minister's Prize for Life Scientist of the year and winner of the 2003 Australian Society of Biochemistry & Molecular Biology Roche Medal, who agreed to be a Teacher Associate with the aim of acting as a role model for the students.

The project

The evolving Emerging Scientists project was focussed firmly on the ongoing curriculum in the primary schools. The central activity of the project was joint planning of the science units to be undertaken by the children in the participating primary schools. One teacher from each school was designated as the link with the project and it was their responsibility to participate in the planning meetings and to convey both the developed units and the enthusiasm to the staff in their school. The latter task was certainly a challenge to these key players in the limited time normally available for such activity within schools.

The planning involved not just the teachers from the primary schools but also colleagues from the secondary school in the cluster. The participation of the secondary school teachers served several purposes. Firstly, the primary teachers found it helpful to understand the treatment of the chosen topics that the students would experience in secondary school. Further, the secondary teachers, generally having a more extensive background in science, were able to assist their primary colleagues with the science concepts. Thirdly, the secondary teachers were responsible for preparing their students for peer tutoring activity that was another important element of the project.

How were the units developed different from those that preceded the project? Interestingly, the primary school pupils interviewed were able to clearly identify one difference – it was much more hands-on. Gone were the old work sheets and students were engaged in hands-on activity. When asked about this, one of the students interviewed pointed out that: *If you have fun you have something that you like to think back on. You remember it better if it was fun. But you don't remember what you put on worksheets. You just remember it at the moment.*

In some of the activities secondary students, acting as peer tutors, assisted primary pupils. This was a voluntary rather than compulsory activity for the secondary students. Feedback from the secondary students revealed that some enjoyed the role greatly whilst others found the primary students *made too much mess.*

Some of the activities were conducted in the laboratories of the secondary school and at other venues. The use of the human and material resources of the secondary school was not without its difficulties as secondary schools run on different patterns and the secondary school was some distance from the primary schools. However, there was an appreciation within the primary sector of the benefits of crossing the primary/secondary school interface.

Partners

The focus of the project on the science curriculum also led to the cluster using two educators as their Teacher Associates and consultants. They engaged a former teacher who had worked on science development projects and was able to provide inspiring leadership in curriculum planning. The other Teacher Associate was a teacher educator who contributed significantly in the curriculum planning and in the development of tests to identify children's thinking. These were used at the beginning and end of each topic. The choice of these people with strong backgrounds in science education as Teaching Associates reflects the fact that this project was focussed on curriculum planning based on specific ideas about the value of allowing the children to engage in hands–on activity to explore ideas about the natural world.

As mentioned earlier another Teacher Associate was scientist Dr Rossjohn of Monash University who was seen as providing a role model for students to show that there are *career and further education opportunities in science, including research, training, travel to international laboratories, diagnostics, and biotechnology companies.*

Outcomes

To describe the outcome of this project is no simple task. At the very obvious end there are the curriculum units which have been collaboratively developed and which are there for the participating schools to reuse and for others to use as appropriate. There are other quite concrete outcomes as well, such as the water carrier proposed by students in one school during the work on Water and Sustainability. One of the teachers drew attention to this to illustrate the positive impact on the children when their ideas had practical application.

There are other visible pointers to the success of the project. At one of the participating primary schools the development of a Living Science Centre is well underway reflecting the school's decision to bring lots of the things they were doing related to animals, plants and sustainability together within the science curriculum.

There are many less obvious but nevertheless important outcomes of the project. One is the increased confidence of the primary teachers to handle this way of doing science. The context in which they engaged in this activity was important as there was time for detailed collaborative planning, the inspiration of highly skilled colleagues (the Teacher Associates), and reflection associated with the use of a reflective journal. It is of interest to note the comment of a teacher who claimed that because their *planning was so thorough the children were freer to explore their own ideas.* It would seem that this teacher at least was pleased by her ability to plan in such a way as to enable the students to be 'emerging scientists'.

Whilst recognising the difficulties created by staff changes and other factors, there are on-going linkages across the schools in the cluster. For example, the primary schools are able to access the laboratories and equipment available for science at the secondary school and there are student cross-school visits.

Of course, the whole exercise is aimed at ultimately improving students' understanding of and attitude to science. In this project attention was paid to exploring the students' ideas both before and after participating in the units. It is of interest to note that this activity provided not just evidence of the development in students' thinking but also provided teachers with new insights: *We were surprised to learn what students did and did not know prior to our unit of work.* On the other hand a teacher commented that *some schools thought there was a lot of pressure on them because of the student assessment.*

It is not just the teachers and students who benefited from the activity. One of the Teacher Associates, the teacher educator, indicated that for him it was a worthwhile experience as he was able to have endorsement of a model that he believed would be successful.

Success factors

In summary there is a great deal of evidence pointing to the success of the program. What has contributed to that success? It would appear that one important factor was the choice of Teacher Associates who had the expertise to be able to play substantial roles in the type of development that the cluster sought to achieve. There appears to be an excellent match between what they had to offer and what the schools wanted. The co-ordinator pointed to the fact that Teacher Associates also provided continuity to the project that helped at times of staff change.

A large proportion of the money available for the project was used to release teachers for joint planning and to visit one another's classrooms. This appears to have borne fruit not just for the life of the project but also for the future as the teachers have gained a great deal and they have the units produced for future use. One of the schools in the cluster has taken up the idea of freeing teachers for planning time and is freeing teachers for an afternoon each term to enable joint planning to occur.

Challenges

It would be wrong to suggest that there were no problems in the implementation of the project. As with all projects that take some time, there were teacher changes that impacted on the project and this will be an ongoing issue for the schools of the cluster to address if they wish to continue to use the model developed.

While there was appreciation of the benefits gained from the co-operation between the primary schools and the secondary school, inevitably there were difficulties that arose because of the different ways in which these two levels of schooling traditionally operate.

Arising from the way that the cluster decided to allocate the funds, the management of the project became a significant task for the co-ordinator. This is an issue across many school projects where there is a tendency to allocate all of the money to things which appear to be directly for the benefit of the students.

Development of the website has not been simple. However, it now exists and will be utilised in the future as a means of teachers sharing their units of work. The project has demonstrated the value of sharing successful units.

Sustainability

It is clear that many elements of the program will continue without the ASISTM project. Most significantly there are the units of work that have been developed and will be used again. Further, there is ongoing interaction between the primary schools and the secondary school in the area of science. It should be noted also that one of the primary schools has appointed a leading teacher with extensive experience in science teaching to lead the science activity within the school.

Case Study: Crossing the Divide between School Science and Industry

1020. Endeavour toward MaST

This ASISTM project created the opportunity for the development of a number of significant relationships within a rural community that did and will generate a greater understanding of science and the part that science and technology play in contemporary society. The project facilitated the crossing of state boundaries that tend to inhibit educational opportunities for individuals.

Context

The town of Yarrawonga sits on the Victorian side of the Murray River and has a somewhat smaller sister town, Mulwala, on the New South Wales side of the river. The sister towns are a popular destination for holiday-makers, particularly those who like golf and water sports. The town is also the centre of a farming district and has a significant industrial company, Australian Defence Industries (ADI), located nearby. Charles Sturt University (CSU) has a presence in the area with campuses at Wagga Wagga and Albury.

The project

The project to be reported here reflects the enthusiasm, energy and vision of a teacher at the Yarrawonga Secondary College, Roberta Williams. A local resident, married to a farmer and the mother of four children, Roberta recognised the need to lift the profile of science in the minds of students and the local community.

The most striking thing about the project is the relationships that have been formed and which will continue to influence school science within the area. The project consisted of a number of apparently disparate activities and so drew upon the expertise of a range of people. While their contributions to the current project have been important it is the links that have been formed between people that can be anticipated to provide the greatest benefit beyond the life of the current project.

Building bridges, however, was not the only objective of the project. Rather, the project was developed to increase understanding and abilities in several areas. The project set out to enable students and adults in the community to recognise the significance that science and its applications play in our lives. It was also designed to make people aware of the range of careers available even in the local community that built upon scientific understandings. Further, the activities were all designed with a view to increasing student higher order thinking skills. Through all of these it was hoped that the numbers of students taking science subjects at school beyond the compulsory years would increase.

What were the activities conducted to achieve these objectives? There were a number of workshops where students from various schools, crossing the primary/secondary school divide, and sometimes with the aid of students from Charles Sturt University, were engaged in hands on activities. The label ‘workshop’ clearly applied to these events as the focus of the day was on students hands-on problem solving. The following extracts from the final report of the project indicate the type of activities undertaken.

This workshop was a highlight in the project for all the students and staff involved. It brought together CSU Professor, CSU Students, ADI staff, teachers from all cluster schools and students. Students where given hands on challenges (ranging) from making a burglar alarm to a wind powered winch.

One of the activities involved students working in groups to create vehicles driven by various forms of energy - including Solar, Wind, motors and other forms of mechanical energy eg rubber bands.

A major activity of the project was a family science night. Over 600 people, including students, parents and community and industry members attended. Students from year 5 to 11 worked on creating curriculum based projects/displays/stalls focusing on 'Energy and Environment'. There were also displays arranged by and talks given by science and maths based professionals including Australian Defence Industries - A greener future, Australian Defence Forces, and Water Dynamics-energy efficient sprinklers.

There were also visits for Year 10 students to the local science-based industry Australian Defence Industries. Prior to the excursion students were surveyed to gauge their interest area based on personal career aspirations. There were two activities at the site. One was a set of career talks where professionals from ADI spoke of the scope of the organisation and Science and Technology career options available to students. The second was tours available to the students: Light and Optics, Mechanical Workshop, Nitric Acid Plant, Chemistry Laboratory, Effluent Treatment Plant. The response to this activity was such that it was suggested that: *This was an outstanding event and should be made into an annual event due to its result in promoting the Science subjects.*

Another feature of the ASISTM program was the emphasis on cluster activity. In the case of this project this has special significance as the cluster crosses state boundaries. This has been a very positive in enabling teachers and students to interact. Jan Hamson, a teacher at the Mulwala Public School commented that:

This was a new venture to link the schools with the secondary school where most of the pupils go. The barrier between NSW and Vic schools disappeared and we were a group of schools working together. Most of our interactions are within the respective states and this is limiting. It was innovative for the primary kids and their parents to go to the secondary school for our big science night.

For Jan the opportunity to talk with colleagues, including those in the secondary school, about teaching science has been much appreciated.

Outcomes

Clearly much of the activity was focussed on long-term objectives. However, there are some clear indicators of the impact of the program on students. In response to the question on how the excursion to ADI improved your knowledge of available careers in Science at ADI, the majority of the students responded 4 or 5, on a scale of 1 to 5. On the question relating to student's now considering studying a Science / Maths elective in VCE, 15 out of 28 responded "Yes". In fact the number of students selecting year 11 Physics has increased from 6 in 2006 to 11 in 2007.

In terms of student development one of the key features of the project has been the stress on higher order thinking skills. This has been facilitated by the engagement of students in problem solving activity throughout the project: *Development of student's*

higher order thinking skills was definitely a key feature of this workshop. Students planned designs, asked questions to the CSU students on each of the workstations, students developed models and working protocols in a variety of 'Electricity' areas.

Partners

One of the key features of the ASISTM program has been the involvement of teacher Associates in the projects mounted by schools. In this project one of the Teacher Associates was Professor Nick Klomp of Charles Sturt University. His contribution to the project has clearly been significant. He has interacted in a number of contexts with a range of people. He has given a formal presentation about 'Science in a Challenging world', with parents being able to ask questions: *Judging by the comments made on the surveys - students and staff were amazed and engaged with the high level of teaching presented by Prof. Nick.* One of the students who heard him speak two years ago when in Year 7 can clearly remember the impact of his talk: *Science is not just about knowing facts. Science is about researching answers*. Professor Klomp also engaged with students during workshop sessions:

Links with our University partner CSU and our Teacher Associate, Professor Nick Klomp, has not only been formed over the last year, but also strongly embedded into our curriculum and student's learning. Prof. Nick and some of his undergraduate students came out to the 'Electricity and Environment' workshop where they assisted in the running of table activities and answering student's questions -it was a very relaxed and engaged scene as students became totally engaged in their learning and Prof. Nick socially interacted with the students.

The other Teacher Associate was Mr Neil Walker of ADI. Neil and other ADI personnel have been engaged throughout the project in both the events held at the schools, parent night and workshops, and have hosted visits to the ADI complex by student groups. While clearly this has been of great benefit to the project's success there have been benefits for ADI. Neil believes that the involvement has lifted ADI's profile in the community and could contribute to better recruitment of staff in the future. He also noted the links made with CSU through the project:

ADI met CSU people at the workshops and at the science nights with the displays and talks. The latter was totally new to ADI that has subsequently followed up the link with a tour of CSU. I was very disappointed that I was unable to attend the tour but I am very keen to do so and maintain that link.

Sustainability

A key issue for all such projects is that of sustainability. In this case there are a number of factors to be considered. There is little doubt that Roberta Williams' enthusiasm and dedication are central to the activity in this centre. She has been the driver of the project and has carried much of the administrative burden. This would suggest some uncertainty about the level of future activity without her. On the other hand there is the strength of the relationships that have been developed within the cluster of schools and between the schools, CSU and ADI. There is clearly a great deal of goodwill that has been generated by this project that suggests that some of the possibilities generated by this project will continue. As Neil Walker said: *It has been a really great experience working with the schools and it created a fantastic feeling. ADI hopes to continue on. The staff who volunteered to be involved want it to continue*.

Case study: The Riverland Story

1037. The GrowSmart Project

The Riverland area in South Australia has an agriculture and horticulture base. Many of us, like the many able pupils who live in the region, probably do not perceive the horticulture and agriculture industry as an environment that requires skilled, highly qualified, science based professionals. The GrowSmart project provides an opportunity for pupils to learn about local horticulture and agriculture industries where innovative, highly skilled science and technology concepts and processes are crucial to the longevity of the local industry.

Context

The GrowSmart project is based on a programme advocated by David Russell in Tasmania, and it is a model that is currently deployed in three States (South Australia, Tasmania and West Australia). The key aim of the project is to rebuild and rebadge agriculture and horticulture, so as to attract able students to local science related careers in these industries. By raising the profile of the Riverland agriculture and horticulture industries and by providing pupils with practical experience, the project hopes to encourage them to consider the range of science based career opportunities. There is significant evidence to suggest that the project is well and truly meeting its goals and reaching its target audience.

The Project

A key purpose of the GrowSmart project is to enthuse pupils and encourage them to study horticulture and agriculture science based subjects, at a tertiary level, and to encourage them to return to the local horticulture/agriculture industry to fill various positions that remain unfilled. These shortages, identified by industry representatives, include the areas of "on farm" researchers and managers, consultancy positions, positions in research organisations, food processing and packing industry and qualified teachers.

One 'retired' science teacher Peter Haines, was designated as the link project coordinator and he worked closely with a University representative and a steering committee to determine the programme to be offered. Peter is from Waikerie in the Riverland area and he was appointed, on a 0.6 workload, as the Science Education Officer in charge of coordinating the project in early 2006. Peter visited schools and through a power point presentation to Year 9 and 10 students in all of the High and Area Schools in the Riverland and Mallee areas, he advertised the June science camps, related to the sheep industry.

The program included a camp and an industry placement in a local horticulture/agriculture industry. For example, during the three day science 'sheep industry' camp for twenty three Year 9 and 10 pupils from six different schools, the pupils visited a sheep property at Karoonda to look at cell grazing and innovative management of sheep. They then visited Yookamurra wildlife sanctuary. On Day Two they went to Adelaide and worked with the Australian Science and Maths School located at the Flinders University Campus and took part in a data logging activity. They then worked with Flinders University students and lecturers, conducting experiments

related to wool, including separation of wool proteins and gel electrophoresis. On the third day, they visited the wool stores at Port Adelaide and then visited the Turrettfield Research Centre to look at research into sheep reproduction, pastures and electronic tagging of sheep.

He also visited Year 11 and 12 senior science classes to advertise a science camp for them. The power point presentation was designed to show the cutting-edge science career opportunities in the horticulture and agricultural industries.

Outcomes

To describe the outcome of this project is no simple task. At the very obvious end there are the participating schools using the available resources, and the participating pupils learning about local industries. There are other visible pointers to the success of the project, such as the pupils changing their ideas about career pathways, in order to pursue careers they learnt about while on placement or camp. But there are also many less obvious project outcomes. The project increased pupil confidence, as was seen when the pupils presented an overview of work experiences to an audience in an auditorium. They paid tribute to the industry partners who shared their working lives with them, and they shared their understanding of the science and technology they encountered while on camp and work experience. Of course, the whole exercise was aimed at ultimately improving students' understanding of, and attitude to, science within a specific industry.

> *We just went on a GrowSmart camp that introduced us to the horticulture industries, not just in the local Riverland areas but in the Adelaide area and it sort of told us what opportunities we have, where we can go after the university, and I didn't realize that there were lots of jobs here in the Riverland area itself that you can come back and do, after if you choose to go to University.* (Luke, pupil, 2007)

Innovation

While outdoor education and physical education camps are probably common, a science camp is unusual. In addition to the camp for the year 9 and10 pupils, Peter also organised a five day horticulture camp for ten Year 11 and 12 students. On the first day they visited the Fruit Doctors (who explore biological control), they visited Almondco (almond processing), and they visited Yandilla Park (consultancy services and citrus packing). After lunch they visited Kangara (citrus) then headed for the camp site at Calperum to look at a native plant orchard and have a tour of Calperum Station. Claire Treilibs and Tracey Steggles from Department of Environment and Heritage spoke to them before bedtime, and then the pupils spent part of the night monitoring Stone Curlews and frogs. The next day they visited Gurra Downs, visited the Loxton research centre for a tour of Research Centre Orchard. They visited Century Orchards and listened to a presentation by two working scientists (Amanda Feldmayer and Sarah Kuchel). They then travelled to Yookamurra – for another talk and night spotlighting activity. The following day they visited Turrettfield Research Centre, then the Virginia Horticulture Centre to look at tomato production in the afternoon, before travelling to the Marion Holiday Village. The next day was spent at Flinders University, mingling with students. The following day they visited the Genomics Centre at the Waite Institute.

The students also worked with university and industry people to observe scientific research related to the horticulture industry. Peter organised a sponsored industry placement programme where students spent five days working with scientists in a business work place or research organisation in the local environment.

The pupils interviewed suggested that their work placement was both enjoyable and informative. They were fascinated to find that, though they had lived in the vicinity, they were not aware of the various 'high challenge', science careers that were located within industries in the Riverland locale.

Peter also organised a two day teacher professional development session where teachers were shown science at work in the horticulture industry to help them introduce these industries and science processes into science lessons. The GrowSmart team are also producing a CD ROM teaching resource for teachers and students to use in the classroom, and a website has been developed.

Success factors

Though the project was aimed at the more able pupils, they believed the project would be of interest to all pupils.

> *I think in applying for the actual programme only the students who are really motivated would really do it, but once you are there you find that its good for pretty much anyone because it just shows you what your options are more than anything, and especially for people who don't really know what they want to do. It is like a really good opportunity.* (Gabby, pupil, 2007)

Some of the pupils believed that the camps allowed like minded people to demonstrate their interest in science without the peer prejudices they encounter in school should they draw attention to their interest in science. The pupils appreciated the variety of experiences. Furthermore their comments suggest that prior to their engagement with the project they had a lack of awareness of science within the local industry: *I didn't realize how scientific, say grape growing for example, is. I didn't know the research centre up in Loxton existed. Going there was just amazing. It does happen here!* (Luke, pupil, 2007*)*

Clearly providing such a rich experience requires significant planning and cooperation. The steering group membership included industry and school partners in senior positions. This meant that the project was high profile. The planning involved not just the teachers from the schools but also contacts from Flinders University and industry. Kathy Schuller, a Flinders University academic, was a key in ensuring that the project received due prominence within the academic community. The University found it helpful to understand the way in which schools operated. In addition, tertiary students, working as Teacher Associates, also learnt about career opportunities in secondary schools.

Senior industry executives signalled the importance of the project to the local wider community. The schools found it useful to identify local industry and it helped pupils interested in studying at tertiary level.

Probably one of the key factors in the success of this project lay in the appointment of Peter Haines. Peter's passion for teaching science, combined with his history of working with teachers around the region and his strong links with the schools in the

area, provided a solid basis from which to develop GrowSmart. With Peter employed to coordinate the activity, there was no duplication of effort and the schools were not forced to dedicate significant amount of teacher and time resource to planning and organising these events, nor were the industries inundated with requests to tailor programmes for individual school visits.

The cluster team has established good working relationships that enable them to address challenges and make progress. A large proportion of the money available for the project was used to fund the coordinator for joint planning and to visit the various industries and participating institutions. This appears to have borne fruit not just for the life of the project but also for the future as the various participants have gained a great deal. Perhaps a key indicator of the level of success is the fact that this project model is to be replicated in other states in Australia.

Sustainability

The formalisation of existing and developing partnerships and the clustering of multiple school sites focussing on local horticulture issues resulted in relevant, engaging local activities for teachers and pupils. The project is sustainable, and growing (involving other Australian States) because it involves a local focus. The ASISTM funding provided a seed grant for local schools, to work with scientists and to learn about local scientific opportunities for highly qualified individuals. The status afforded to the project through tangible support at high levels within the participating schools and with the industry involved, helped advance the project. School engagement is at a senior level in terms of involving senior members of staff (principals, assistant principals and coordinators). Likewise engagement with industry and Flinders University involves senior members of those industries.

Organising the events was a challenge as there were nine schools from the Riverland and Mallee district. (Loxton High School, Renmark High School, Glossop High School, Waikerie High School, Lameroo District Community School, Browns Well Area School, Karoonda Area School, Swan Reach Area School, East Murray Area School). This centrally coordinated activity is in itself unusual, it also ensures that costs associated with planning for events were kept low. Costs would have been high if schools planned similar programmes on an individual basis, and of course there would be a duplication of effort. For a teacher at each of these schools to put together a similar sequence of activity for their school camp would have required significant resource (in terms of teacher/administrative) time. This may also have put some pressure on the local industries in trying to cater and plan individual programmes for each and every school. Having a central person to coordinate activity limits duplication of effort and cost, but there was some discussion with respect to school staff representation on the camps. This far one teacher has accompanied Peter on camp. Staffing of the camp was an issue not just in terms of resource, but also in terms of establishing long-term relationships with the pupils that would carry on from the camps. Whilst recognising the difficulties created by factors such as coordinating activity across the schools and securing staff to accompany the pupils on the camps, the benefits of the cross-school camps were immense, and these were recognised by the pupils.

The Year 12 pupils interviewed suggested that the talk and recruitment to camps might be better placed at Year 11, in order to attract more pupils, as most Year 12 pupils had already made their career choices. Indeed, with hindsight most participants, organisers and pupils suggested that pupils' work commitments (and resulting financial security

for tertiary education) affect recruitment numbers of Year 12 pupils. Many of the Year 12 pupils would normally be using their vacation time to accumulate funds to support their prospective university studies.

Case study: Kids Design Challenge NSW

1049. The Kids' Design Challenge (KDC) Project

This project was about more outward looking conceptions of science education, in effect seeing science as a living activity rather than a sharing of historical information. The central activity of the project was combined planning of science and technology units with a particular focus on two design challenges involving, respectively, go-karts and the local environment. The children in the participating primary schools undertook these challenges with the assistance of professionals in the field – architects and engineers.

The project built on an existing network, where a group of teachers were actively promoting hands on-science activity. The ASISTM funding provided the means to support and develop this activity. Teachers from various schools met at the planning meetings and developed resource materials that enabled them to return to their schools to deploy the two challenges.

"It began with a group of teachers keen to promote hands-on science and technology activities. The year before ASISTM funding it operated on a shoestring budget. ASISTM has enabled the formation of further links". (Susan, Coordinator, June 2007)

The project

In essence this project involved the deployment of two key challenges in primary schools. One challenge involved the designing and building of a go-kart, the other redesigning a local environment. The time and sequence of these activities within the participating classrooms was governed by the learning cycle and program within each of the participating schools. So, while some schools were busy preparing to race go-karts designed by pupils (and their grandparents) others were applying for planning permission to modify playgrounds or median strips, based on the work undertaken by the pupils.

This project was about more outward looking conceptions of science education, in effect seeing science as a living activity rather than a sharing of historical information. It involved an active engagement with ideas rather than a rehearsal of science knowledge.

> *Both tasks have been successful because they are real tasks. The audience that the kids are designing and making for is real. The process that they go through is real…. …the Council actually accepted the kids' plans, modified them slightly and began work on redesigning the median strips that they had picked as their area. …Real, purposeful learning (is) going on. There is a purpose to doing it. Not that tasks in class have no purpose, they do, but when other people are coming in as well, giving them input with the architects that visit and the engineers that visit, they see that it is real world.* (Teacher 2, June 2007*)*

Outcomes

The outcomes were numerous and varied. They ranged from building pupil and teacher understanding of relevant science, to establishing working networks with local industry

to producing resource materials that can be used by other schools. The outcomes for pupils also include science learning and pupils seeing that they can make a difference in their community. The challenges have also raised the profile of science in the school and community.

> *I had a very interesting class, 4,5,6, G and T, gifted and talented. I only had 16 originally for the first challenge…. It was very successful. They got a lot out of it. They enjoyed putting it into effect. We actually got funding we modified the bush area, that we set out to do, it is still on going and valued and is high profile in the school and the community.* (Teacher 3, June 2007*)*

Apart from establishing and strengthening partnerships at state and local levels between students, teachers and industry personnel, the project also strengthened home-school links and engagement.

> *Some of the kids are really enthusiastic… we had only started working on it for a week, they went home and told their grandparents, and grandparents started working and I have got these beautiful carts that have come in…and mum saying things like the child has always been so busy watching TV and playing video games and everything else that they don't spend time with their grandparents, and yet now they are spending time with their grandparents wanting to know about these carts that they used to ride years ago.* (Teacher 1, June 2007)

This project had as much to do with teacher professional development, as it had to do with pupils' activities. Most of the teachers indicated that the model of active, sustained, supported teacher professional development was a fundamental aspect of this project. But not all teachers embraced it as some found it quite daunting. However, it was a model of teacher professional development that brought about considerable and notable change in classroom practice. Some of the teachers involved suggested that to work with their colleagues to bring about change is the best way to provide teacher professional development.

> *When I went back to school I had to work closely with teachers who hadn't been to the course. I did certain sections of the work and they did other sections. It all came together very well on both occasions. Even now I am doing the pushcart with two other teachers. We are working together very well as a team. We have involved a lot of the teachers in the school. I feel that I have trained a lot of the other teachers along the way.* (Teacher 1, June 2007)

Another key aspect of the project was the involvement of senior members of staff (principals, assistant principals and coordinators). These key personnel in schools were key to the development of the challenges, and key to establishing a high profile for the activities. They were, and continue to be, core to sustaining this project.

Partners

The Kids' Design Challenge has involved Teacher Associates from the Royal Australian Institute of Architects, the Young Engineers Australia and the NRMA Motoring Services. These groups helped to support teacher professional development and pupils' learning in situ. These industry partners provided expertise and experience, in both the designing phases and in the engineering and model making phases.

> *The pushcart, that's involved getting design lecturers from University to come out. B Jacobs from NSW came to our school and she coordinated a fair amount of people and materials for the pushcarts as well…. A number of architects have come out to schools to discuss the design process, so the kids actually see that the design process we are teaching is what the architects go through when they are designing…. The NRMA have also provided their retired road service people to come out to schools to scrutinise the children's carts and give them a roadworthy certificate.* (Teacher 2, June 2007*)*

Working with professionals assisted in demystifying the work of architects and engineers and helped to promote practical messages about the role of technology professions in society and specific issues around sustainability, the built environment, building and construction and safety. Furthermore, working with experts provided a degree of legitimacy and made the pupils feel special.

Innovation

Coincidence of interest was visible throughout this project, from its conception to its completion. There is also an element of distributed organization to be found in the project in terms of the task it set the pupils and of the way the project collective worked toward addressing the challenges the teachers and pupils faced.

> *In the pushcarts, the tasks are divided into four teams; the building team is responsible for the actual building of the pushcart, the construction…. the fitness team who are obviously going to be your fastest runners, and your athletes who will be the riders and the pushers on the day. And you have your speakers, who will be your media team to do all the presentations, and the compute savvy people who are going to do the PowerPoint and take that role on and take responsibility for the multimedia, the marketing team, who are responsible for team identity, so they might come up with the jingles, or colours or design.* (Teacher 2, June 2007)

This jigsaw activity models practice often encountered in industry, where people collaborate on a project taking responsibility for a particular aspect while having an overview of the task.

Another innovative element of this project was the hands-on aspect that enabled pupils with a range of abilities and capacities to demonstrate their skills and build their self esteem.

> *Some of the girls who are very sort of low profile, lets say…a lot of them went on to the marketing team where they had to design t-shirts, and they made badges and they had to go on the computer, they designed the logos, they rang and emailed and looked around for the cheapest … and made decisions with one another, their self esteem was on the roof.* (Teacher 3, June 2007)

In this project, the pupils were involved in relevant and authentic investigations. Often in science classrooms the activity is a rehearsal of what is deemed to be scientific practice. In contrast, this project was real. The consequences of the pupils' activity had tangible outcomes for their everyday world.

> *It is a project with real consequences such as the implementation by councils of some of the ideas generated in the built environment project. The kids are amazed that they can make a difference.* (Susan, Coordinator, June 2007)

Sustainability

The Kids' Design Challenge's model of curriculum/professional learning was not instantly uniformly successful.

> *Initially, the first year we relied on word of mouth, and it was a bit like preaching to the converted already. ...But we hoped, we didn't want it to fall flat, we did hope that the kids' enthusiasm would make other teachers want to know... but in my school that hasn't happened. The kids really loved it, but the teacher didn't necessarily love it. She still felt it was a lot of work. I'm not sure if she would pick it up again or not.* (Teacher 2, June 2007)

However, other teachers reported that the model encourages teacher professional development if the right circumstances are developed to help support teachers.

> *I think it is the style of teaching, because I'm finding that if you put it all on them too quickly, I share the work. So sometimes there are teachers who aren't prepared to take it all on. I tend to spend a lot of time coordinating and they are getting a taste gradually.* (Teacher 1, June 2007)

The team continues to work collaboratively and they continue to support each other. It would appear that leadership was an important factor. Key personnel played substantial roles in promoting and supporting the activity within the cluster. The showcasing of previous solutions has also been useful. However, technical constraints (access and reliability) and time available to locate and utilise resources continue to be difficulties identified by teachers. In each challenge, online collaboration environments were established for teachers to share their experiences but teachers' feedback suggests that finding the time to make use of this facility is a challenge. Time was identified as an issue. As with most school-based activity finding the time to make use of the online sharing facility was problematic. Nevertheless revised materials have been developed for the 2006 Challenges and support materials are available from the Kids' Design Challenge web site, which is updated periodically.

Reflection

Overall this project has a feel of bringing the curriculum into the new century, bringing in authenticity, bringing science into the schools, involving local industry and raising self esteem.

The model of teacher professional development saw teachers talking about renewed confidence in dealing with science, and feeling a sense of being able to talk and mix with people in industry.

Case Study: Science in the Aqua Zone

1050. Leading Edge Marine and Environmental Science Development

This project is impressive in a number of ways. First there is the size of the project. It brought together a very large number of institutions and people in a collaborative venture: in the project, 34 teachers, numerous scientists and educators from Flinders University and local industry involved in ecotourism, created links between16 schools in three clusters across South Australia. The effective operation of such a large project points to very well developed arrangements for planning and communication. Central to this organisation was the leadership of the Australian Science and Mathematics School (ASMS).

Second is the way in which the project used the local environment and resources to engage students with relevant science and mathematics. While the schools in three clusters worked collegially they also acted independently to address the issues and opportunities pertinent to their locale. The Eyre Peninsula Cluster focussed on Marine science and Aquaculture, the Ocean View Cluster focussed on Marine ecology and ecotourism, and the Aberfoyle Cluster focussed on Bio-remediation.

Third, while the schools were individually responsible for various components, the project leadership, built around the ASMS, facilitated these schools working as a cooperative in both teacher professional development and resource development. Each cluster had a project manager, an action research facilitator, and teacher associates. The schools within each cluster used an action research model of teacher professional development to support the development of curriculum materials and resources that were relevant to their particular environment. The action learning process was an essential part of the project in that it encouraged reflection on and in action.

The project

While the project had a common aim of improving students' understanding of, and attitude toward, science and mathematics, given the decision to create activities relevant to the locale it is impossible to describe the activities undertaken in a brief report such as this. There were many, and they were impressive. For example, the Ocean View cluster, which involved 7 schools, 9 teachers, and links to various industries and Flinders University, developed activities based around varying natural environments such as flora and tidal pools, sand dunes and mangroves, on the Le Fevre Peninsula.

The Aberfoyle cluster included 3 schools and 5 teachers. Through the contribution of the Teacher Associates both teachers and pupils had opportunities to develop a greater understanding of scientific techniques and how these were used in environmental monitoring. This cluster has also produced mathematics materials related to student directed projects.

The Eyre Peninsular cluster included 6 schools, the Education Department District Office and 9 teachers. Focusing on students in their early years of schooling, this cluster adopted a scientific inquiry based approach that was student centred and authentic.

Teacher Associates, from the Lincoln Marine Science Centre made an important contribution to the program by sharing their professional expertise with both students and teachers.

Outcomes

It is really difficult to capture the outcomes of this project in simple terms because they are considerable and complex. There is evidence of significant impacts being made on all participants; students, teachers and teacher associates.

A diversity of outcomes for students was noted. Interviewing primary students who had been part of the project was an eye opener, especially when young pupils start telling you about classification, using scientific terms and relating them to their everyday knowledge.

> *We've been learning about phylums... the Chordata, a creature with a backbone. Fishes for example, and seahorses, they have backbones, like us. We also have backbones which are also called vertebrates….*

However, the learning was not restricted to being inducted into the formal structures of scientific knowledge. The approach adopted also helped facilitate the development of thinking skills, which, as one teacher commented, led to *the development of the project branch into higher order innovative thinking.* For example, by learning about how science operates in the world, Michael McGlinchey and his Year 9 Sailing class investigated the effectiveness of antifouling products on special panels supplied by a local paint company. The students and teachers gained a great deal of insight into "real" science experiments by developing this investigation. Students also developed insight into the links between science and community issues.

The project set out to include Aboriginal perspectives alongside research scientists' views on approaches to environmental science and management. This was not always simple. However, the North Haven Schools worked with a local native nursery supplier to plant and maintain flora that is indigenous to the Le Fevre Peninsula. Students learnt the value of planting natives for water conservation and as a means of encouraging native birds and animals to return. Input from local Aboriginal people and research has allowed students to develop an understanding of the ways the indigenous people used the different plants. The students are now able to guide visitors through the gardens passing on the information and telling the stories of life on the Le Fevre Peninsula.

The pupils interviewed were confident, articulate and impressive, both in terms of their knowledge of locally relevant science and in their ability to convey their enthusiasm for the subject.

For teachers, their growth occurred in a number of areas. There was evidence of increased confidence of the primary teachers to handle science topics. One teacher remarked that their involvement with the project *increased our personal levels of confidence with the scientific process.* And across the board teachers claimed that the project had increased their understanding of areas of modern science where they had limited knowledge. For example, teachers in the Ocean View Cluster reported *a growing awareness of leading edge science and technology applications in aspects such as data gathering for monitoring of marine populations, water quality and flow rates.*

A further outcome of the project is the curriculum units and resources which were developed collaboratively and which are available online. As was indicated earlier, from its inception the sharing of curriculum resources was a key element of the project. Those produced and shared have been quite varied, for example one class made a digital computer game about their project, a scientific literacy big book for junior primary children, and Power Point presentations which have been posted onto the website. Interestingly there were side benefits from the decision to put the developed resources on the website. It was reported that: *the requirement to post materials on the web-site provided motivation for several teachers to develop the skills resulting in their developing confidence in working in an on-line environment*.

Apart from pupils and teachers, other project participants have also benefited from the activity. Two Teacher Associates have taken up options for post-graduate study in education. One of these is undertaking a PhD in science education and is being supported by the school.

Success factors

The success achieved by this project has not occurred simply due to good fortune. Rather it is the result of inspiring leadership, and insightful, careful planning and management.

Clear roles were established for the project under a Governance Group led by Jim Davies, Principal of the Australian Science and Mathematics School (ASMS) and the ASISTM Project Coordinator, Jayne Heath, Assistant Principal of ASMS and ASISTM Project Manager, a Project Management Group and Cluster School Teams from each of the three districts. These groups, which met regularly, ensured a common vision and the ability to respond to issues as they arose. As a member of the Governance Group put it:

> *The project involved schools and various partners from around the state and meeting common timelines proved difficult. It was necessary to make alterations to various aspects of the action plan to meet needs of individual school cluster groups as their work evolved over the life of the project. Having an action plan to base these adaptations on proved critical to the successful outcomes of the project, particularly given we were trying to coordinate 16 schools across the state.*

Another key contributor to the success of the project was the decision, while maintaining a strong focus on student outcomes, to incorporate an Action Learning model of teacher professional development. Members of the staff of the Australian Science and Mathematics School (ASMS) were allocated as action-learning facilitators to each school cluster team, to provide support in implementing this approach to professional development. Their role was to maintain regular contact with the teachers in the cluster team and to support the teachers reflecting on their practice and during specific professional development activities, such as data logging workshops. The evidence is that this process was extremely successful.

> *When I went to the big expo, where we had the project celebration it was that element of teacher engagement with the project that they were most articulate about.... Here were teachers talking about the pride they had in their own teaching. ... So there was this sense of breakthrough ... in terms of their professional growth.* (Principal, ASMS)

A third success factor was the strength of the linkages formed between clusters and the community, principally the scientific community. The university student Teacher Associates were able to contribute to both student and teacher development. Further, there were numerous other linkages with community bodies that contributed to the success of the project. For example, the local 'Fish Watch' group also provided information and active support for the Catch & Release activities and have offered further assistance whenever it is required.

Sustainability

There is evidence that much of what has resulted from this project will continue and influence education within these school clusters. The evidence revolves around the relationships that have been formed, the teacher skills and confidence that have been enhanced by the project, the curriculum activities and resources that have been developed, and the fact that the project had status within the schools and the community.

The project formalised both some existing partnerships and the clustering of multiple school sites focussing on local issues. In the past these schools worked with certain groups, individuals and organisations on an informal basis, but this project enabled them to formalise these relationships and recognise the value placed on these partnerships by schools. This formalisation constituted a real strength of the project.

> *Oceanview cluster have already engaged in discussions with the Eco-Tourism Faculty from Flinders University regarding the future of our collaboration. Both the schools and the University personnel are very keen to continue the project into next year. We envisage that another group of 3rd Year students will be given a similar brief i.e., to develop a range of Science/Environmental interpretive experiences suitable for school students focussing on the Le Fever Peninsula area*. (Extract from Final Project Report)

As discussed earlier in the case study, the teachers who participated in this project have grown in competence and confidence as a result of their participation. As a consequence it can be expected that their future teaching will benefit.

> *The professional learning of many teachers involved in the project has also been noteworthy. Andrew Morris, as one example, has become an "expert" in the teaching of Marine Science… as a result of this project. Not only has he developed a comprehensive knowledge base regarding Marine Ecology and Environmental Education but he has also refined a methodology for engaging students in exciting Science investigations.* (Extract from Final Project Report)

The third factor, which suggests the sustainability of the project, is the production of learning activities that have been developed during the project, and the resources developed to sustain them. The teachers themselves have been involved in the development and trial of these activities and resources and this increases the likelihood of their continuing use.

> *The final point to be made on sustainability is that the project has had a high profile within the school clusters with strong leadership from within the ASMS and the schools, and within the community. This will maintain pressure for continuation of what has begun, whilst also generating future opportunities to grow. Given that the recently elected Mayor of the Port Adelaide/ Enfield area*

has been an active supporter of this project up until now we may be well placed, with his support, to form a consortium of local businesses that would provide financial support to this initiative. (Extract from Final Project Report)

Reflection

This is a fascinating project that is exemplary on a number of levels, ranging from the mentoring of new and effective science-based pedagogical practices to the enrolment of a wide range of partners to support these practices. Its future looks especially promising, for not only is the enthusiasm of the partners (pupils, teachers, teacher associates, and industry) infectious, but also the materials generated and the community that has evolved around the project will ensure that it is sustained in some form. As it currently stands however, there is still much that can be learned and is of direct relevance to schools wishing to undertake such innovation.

Case Study: Marine and Environmental Education on Kangaroo Island

1055. Marine and Environmental Education

The Kangaroo Island marine and environmental education project is a complex project involving three schools and a number of initiatives built around the marine and aquatic waterways of the island. The key aspects of the innovation are the use of scientists to work with teachers and students in monitoring fish and other animal populations and environmental conditions, to build up a substantial data base of scientific interest, the involvement of community in these projects, and the interlocking and expanding funding base that has seen these projects grow.

Context

As you fly in over Kangaroo Island (KI) in the small Regional Express plane, you are first greeted by the site of Kingscote jutting out on a small promontory, a small town in a sea of green farmland. To the west of the town lies the large bay of shoals which presents a translucent kaleidoscope of greens and blues and browns, and is the centre for some of the marine studies involved in the ASISTM project. The island gives all the appearance of a rural haven but Bluegum forests are now replacing small farm holdings. These forests bring with them a very different commercial sense, and different environmental challenges. Much further to the east, out of sight, lie the expanses of the Flinders Chase National Park, with its seals, sea lions, lighthouses, wildlife, wilderness areas and beaches. The island is renowned as a premier wildlife habitat, which brings with it both a responsibility and commitment to maintaining its nature.

The Kangaroo Island (KI) Community Education Marine and Coastal Education project is a continuation and a scaling up of activities centred around the school and the community that have been in operation for some years. It builds on the back of a considerable interest and activity by environmental scientists and environmental organizations, attracted by the natural and relatively unspoilt environment of the island, and fuelled by a growing ecotourism industry that, together with Bluegum forestry, is gradually replacing farming as the major economic base for the island. Tony Bartram, the coordinator, is a teacher at Kingscote Campus of Kangaroo Island Community Education and has been a member of a community Marine and Environmental Education group since 2003.

One feature of this ASISTM project that stands out is that it sits alongside a number of other funded projects focusing on environmental awareness and action, and has spawned further, substantial project activity. As such, the ASISTM support has operated as a seed grant that came at the right time for local teachers and scientists concerned about the environment, supported by a growing taste in the community for such a focus. At the centre of these developments is Tony Bartram, the coordinator of the project that runs across the three school campuses on the island. The shape of the project was largely determined by Tony and Judith Wingate, a consultant marine biologist, working with his Community Marine and Environmental Committee, driven by a broad vision that encompasses the quality of the environment, the education of children based in community action, and the longer term awareness and action of the community.

The project involves scientists, especially two environmental scientists, Judith Wingate and Michael Hammer, from the University of Adelaide, working with teachers and students on a number of interlinked environmental projects: Beach and Waterways Monitoring, 'The Pelican Brief', Native Fish, 'Being Black Bream', and Islandmind.com.au database development. All of these projects have separate funding sources, so that it is difficult at times to know which are ASISTM funded and which are shared. This complex of interlinked projects is substantially the vision of Tony Bartram, who has enlisted the support of an array of environmental scientists and activists and community members, and put together bids for funding from a range of sources. Tony either manages, or is otherwise involved in, most of these projects, and is currently in the process of retiring to act as a freelance consultant, in order to focus his time more substantially on them. His one day a week off teaching commitments has not freed much time for the complex task of management across three school sites.

The project

Tony Bartram is a physical education/primary teacher who has a background in science and a longstanding commitment to the environment. Tony's vision has two main components. The first involves the education of students where he believes in active involvement with a local focus, and an approach to teaching through activity that opens up possibilities for all students, but particularly those who are not advantaged by traditional classrooms and delivered knowledge. The second involves a concern for the environment of KI and the need to maintain the waterways and marine environment as a baseline measure that is not eroded by human activity.

Each initiative can be seen as establishing a baseline, and data that can be used to monitor the effect of human action at each point in this system. The study of the animals and plants are in a sense designed to provide a marker for the health of the system. To this end, we see in the project an interesting and articulated vision of links between the KI aquatic and marine environment, the community through its support and also its raised awareness through student activity, students who are actively involved in learning both scientific processes and becoming aware of their natural environment and their role in protecting it, and scientists who provide expertise but are themselves served by students who help them build databases, and are energised by their contact with students and the community.

The project involves the three campuses of KI Community Education; Kingscote, Parndana, and Penneshaw. The project activity was different at each site, but in each case teachers volunteered and were supported through professional development by Tony, Judith and scientists, and with field work by Judith, Michael or others that Tony helped organise. Each teacher sat down with members of the project team to plan what they wanted to do.

Parndana

Mainly two teachers were involved at Parndana. Tamara Markopoulos is a Year 3/4 teacher whose students during 2005 and 2006 went on a 3 day camp, among other activities. She planned this with Tony and Michael, and it included catching and mapping black bream, and water quality testing. Students learnt how to fish and set traps, and how to handle fish, measure length and weight of the fish, water temperature and quality, and make records. Parents helped in this by providing local knowledge and fishing equipment. The term's work was focused on native fish, using local information

and the internet, and further topics arose from the camp such as the effect of introduced marron on the native fish population following the catching of marron in different locations. The science that arose from this involved the effects of introduced species and the different environments to which fish are suited. Tamara made the point strongly that her knowledge was built from a low base, but she had gained confidence to the point where she could manage the monitoring activities herself and she is taking over as manager of the ongoing project during 2007. As time went on she introduced more mathematics into the program, through mapping, data recording and display, and analysis.

She spoke of the enthusiasm of the students and that they were themselves taking responsibility for doing the work, posing and investigating questions. She emphasised the power of hands-on work, supported by scientists, in generating new knowledge for themselves. She could see the change in students' awareness of science, and of native fish and the need to preserve their habitat. They had learnt scientific methods such as measurement processes and careful recording.

Students spoke positively of the camp they attended one or two years ago. William's class caught a rare eel: *We were all pretty excited about it. People ran from everywhere*. He described how *Galaxia have no scales so you can see right through them. See their veins.*

In fact, students had captured and identified a number of rare species whose presence was unexpected.

> *We learnt that native fish are not all the same, and how native fish live. We learnt about threats and other species that affect habitat. We learnt how to handle fish. I may be a scientist – to help the world … There are less bream in Hanson Bay because the mouth of the river is closed off.*

Kingscote

Kenita Williamson is a SOSE and humanities teacher. She and the science teacher volunteered to be involved. Other teachers from the Middle School, Primary and Junior Primary sections became involved in other aspects including Beach Monitoring. Kenita looked at the South Australia frameworks and decided to focus on water quality, and was supported at a training camp involving the Teacher Associate scientists. The focus of her unit was on the water quality of the Cygnet River and threats to this. She also focused on scientific methods; how to gather, research and document information. Supported by Judith she took excursions to the river locally. Her work was structured for the different grade levels. Year 8 chose to do a profile of native fish involving their capture, examination and identification, measurement of water quality and temperature. They got some surprising and hitherto unknown results concerning distribution of marron and fish.

Year 9 looked at bio-regions and constructed a profile of native species, working with scientists from the national park. Year 10 assisted Tom Nelson, Water Scientist at the KI Natural Resources Management Board, who was surveying the waterways of KI, who *was fantastic*, working with students to take video records, do GPS positioning, talking about the effect of development such as fertilisers, grape growing, and erosion of banks by cows etc.

Kenita talked of student enthusiasm, and the value of hands-on experience in the company of scientists. Students were aware they were generating useful data. She talked of the fact that science at this level does not have definitive answers, and there is a lot of speculation and investigation going on. She espoused the need to support students to link their knowledge to make it more robust, and talked of the promotion of a SOSE – science - art – mathematics - language connection in the various activities in the project. She talked of the literacies involved in doing this science, and ensured her students presented material that they could use to teach younger students. She had worked with local artists to produce marine-related sculptures that were positioned round the school, some of which had gone touring and were exhibited in the Adelaide Museum.

Kenita, along with all the teachers, emphasised that students who were disruptive in normal classes were quite focused during excursions and other activities and often took leadership roles. She told the story of a particularly difficult student taking significant leadership in conceptualising the design of a major sculpture, linking it with his outdoor experience. Another student raised questions and wrote on native fish and achieved a significant measure of self worth through these activities. The interviews with teachers and scientists were peppered with such stories.

She was very clear, however, in her views of the factors that encourage this type of activity. Teachers are generally reluctant to expose themselves to the risk of taking difficult classes into the aquatic environment, and tend to be locked into traditional, teacher-centred pedagogies. The support of extra people with expertise is a great help, and some funding for buses is essential. She herself is primary trained, and spoke of the greater commitment to teaching life skills and self confidence that primary teachers have, and the more flexible curriculum, that made it easier for primary teachers to adopt this type of approach.

Penneshaw

Maria Sexton is the science and mathematics teacher at the smaller Penneshaw campus. She had worked on black bream monitoring with her Year 8-9 class, having them catch, measure and tag these to be released back into the river. Judith helped her with field work, which was invaluable since she has a physics background and was not familiar with environmental monitoring techniques. She described how her teaching approach had changed because of the project, in that she now tends to work to introduce science that is relevant to students and gives them hands-on experience and choice in what they do. Tony observed that it had transformed her work as a teacher, and she was very clear that she had enjoyed the project. Like Kenita, she espoused the value of linking knowledges. Her students had been trained by a local artist in how to do annotated botanical drawings and had drawn fish. They had designed nets in technology class, and used statistics in data analysis. She talked of the need to include social issues, and of the support and interest of the community in monitoring the native fish.

Students from Penneshaw talked of their enjoyment about being outside, and displayed considerable confidence in knowing about fishing, claiming they knew more about fish catching and handling than the scientists who were training them.

Partners

Judith Wingate is a marine biologist from Adelaide who is employed by the school part time to support teachers and students. Judith has been central to the project from the beginning, and spoke of the *fantastic* experience of working with students and teachers

in the field. She is a committed marine educator, and on the basis of her reputation from the KI project is now working with other school clusters. She contrasted this field-based, data collection and analysis work with normal classroom experience of *following instructions*, and emphasised the relevance for all students:

> *If you do science in the outside environment, use scientific methods, collect data and use this for conservation, we have in education a completely different point of view of how to teach and learn science. It's a fantastic outcome.*

Michael Hammer is a PhD student from Adelaide University. Michael was doing research on native fish on KI, and involvement in the project has enabled him to do broader sampling, and to develop new ways of collecting data. He was enthusiastic about the involvement of the students.

> *They have their own ideas. They get involved in planning and try out ideas. They understand what they are trying to catch and why we are monitoring. There is increasing understanding, especially for a core group, but even new classes seem to start now from a higher level.*
>
> *We learn scientific methods – how to develop a rigorous sampling method that they can get long term data from, for instance repeating traps, planning where to put them, designing experiments for instance one we did on colours….*
>
> *We caught a short finned eel that hadn't been seen for 25 years. We found a gobi that hadn't been described for 10 years. I gave a specimen to the museum for a DNA project and that's now the basis of a paper.*

Michael talked about the strategic sense used in picking the monitoring approach that would attract students and give them a deeper sense of the purpose and design of monitoring methods. The science expanded with the various surprising finds. He was also very positive about the role of the teachers, who did background research work, developed identification keys, and increased their confidence to the point they can run the monitoring themselves: *The only things we are really helping them with are the specific techniques like Fyfe nets.* However, he acknowledged that it would be hard for teachers to drive the monitoring program by themselves.

Jon Lark is a scientist with an aquaculture background and runs an aquatic skills centre at Parndana. He has become involved in the project to help investigate breeding native fish (unsuccessfully as yet).

Jon has helped in various ways with fish handling at the school. He spoke of students' growing awareness of aquatic issues and the need to monitor, and to follow scientific procedures. He also emphasised that so called problem students are not a problem when working on authentic tasks, and described two boys becoming lost in a statistics aspect of a measurement task without realising they were doing mathematics. For Jon, who has a long-standing commitment to community education, this applied way of learning is significant because it puts students in touch with authentic scientific activity, and also exposes scientists to students and their enthusiasms and to the wider relevance of their research. Jon was clearly energised by his contact with the project, and he has been successful in the 3rd ASISTM round with a project on aquaponics.

Innovation

Tony tells of a history of environmental projects dating back to the 1970s, with an emphasis on community action and active student involvement. He came to KI in 1984, and quickly established a camp program at Kingscote around aquatic issues, particularly focusing on seagrass, that involved student exploration. That program had been stable for more than a decade, when in 2003 the KI Marine Centre and the school hosted a national marine education conference. Following this, a school-community committee decided that marine education should be a major focus for the school, and Judith Wingate, a marine scientist, was employed part-time as part of this. In late 2004 the school established the position of marine and aquatic education coordinator that Tony applied for and won. In 2005, as part of a need to answer critics of this commitment, he approached the KI Natural Resources Management Board for support for marine and aquatic projects. He received a grant, and in-kind support from scientists who worked with students and teachers on marine and aquatic projects. This was the background to the application for ASISTM funding, which in essence allowed this developing activity and collaboration between the school, scientists and the community to be developed to a new level.

What changed with the ASISTM funding is that scientists with research expertise were identified and approached for support, and the newly amalgamated trio of schools on KI committed to a marine and aquatic focus confident of support for teacher professional development, resource provision, and linking with serious scientific study of the KI marine and aquatic environment. Judith Wingate's involvement was increased and Michael Hammer, who was involved in studies of native fish on the island, was engaged to work on this with students and teachers.

Each of the initiatives comprising the project have attracted additional support from various organizations, and as the project has achieved a reputation through a variety of public profile events, awards, and word of mouth, each has attracted the support of volunteer scientists to work with students and teachers. Thus Jon Lark, who runs an aquaculture skills centre at Parndana, became involved in supporting the project. His work explored the possibility of breeding native fish, while other scientists were attracted to work with students on a range of marine and aquatic studies. Over the life of the project and those subsequent, a range of local citizens have become involved, from parents providing advice and equipment for fishing in local streams, a boat charter owner who helped students construct an artificial reef, and more recently support for the KI Dolphin Watch program from locals. The establishment of the possibility of students being engaged in serious scientific measurement and survey work has attracted approaches from other scientists, and students have been involved in a census of the Western Whipbird, and also Pipefish studies involving snorkelling.

Tony Bartram's, and the scientists', vision is that the project will continue on to develop a long term data base of measurements concerning, among other things, the number and location of native fish and dolphin and water quality. These then can act as a resource for scientists and schools alike. There have been requests from schools for the data to work on, and at least one mainland school has visited to collect more data of their own. 14 years of penguin research data is to be added by the Department of Environmental Health and Safety. Student groups from Japan and U.S.A have spent time on the island involved with project activities. Expertise from the project, in the form of teachers and

scientists, has been used by schools on the mainland as part of setting up their own projects.

The project has also spawned involvement in two further ASISTM projects – a mathematics based Round 2 project in which local caves were mapped using GPS positioning, and a Round 3 aquaculture and aquaponics project managed by Jon Lark.

Thus, the KI ASISTM project built on ideas, activities and relationships that had already been established, and has opened up opportunities in a number of directions.

Outcomes

The project has delivered very effectively on its intentions. Teachers, students and scientists alike talk of the quality of the learning that is happening, and the enthusiasm and engagement of students. Not all students are equally engaged, but a strong outcome has been the decrease in disruptive incidents when students are working on this project, in or out of class, and the engagement and increased sense of self worth felt by otherwise disengaged students. This is verified by a number of anecdotes.

However, while many of the KI students have been involved in the project, not all have, and teachers have been involved at different levels. Perhaps that will always be the case, but time will tell if the commitment of school administration, and the support of teachers, will continue to increase or whether it will continue to operate with only part of the school population.

That the community is significantly involved is clear from evidence of parental support, from student testimony, the growth of the project into other areas, and from surveys conducted by teachers. The project is strongly based on the principle of a school-community partnership, and in this case the school has become a significant focus for the expression of community awareness of the marine and aquatic environment of KI.

The project has seen the collection of a significant data set, charting previously unknown information on the diversity and spread of native fish, and the effect of introduced species and land management practices. The science has been thorough, and the data set itself is intended to be made available through a website currently being developed. However, this is being held up due to problems of staffing and software development.

Sustainability

That the project has spawned so many offshoots and has attracted partnerships with other scientists and links with other school networks, speaks to its potential sustainability. It has acted somewhat as a beacon for other school networks, and the ASISTM funding has allowed the consolidation of a vision that has developed over time. The drive to sustainability is substantial, with a network of people committed to continuing with this longitudinal monitoring program, having put in place community partnerships and separate funding agreements around all of the initiatives. Much, however, hinges around the vision and organizational capacities of the coordinator.

It was generally acknowledged that the support of the scientists, funding for buses and management, and teacher professional development are all essential parts of making this exciting project happen. Funding is there for specific purposes, but to continue to bring this together the school would need to continue its commitment to both the coordinator position, and to funding Judith's time. There is always the danger, when school

administrations see funding flowing from other sources, that they turn their fiscal attention elsewhere. Tamara, as the coordinator-designate, is committed and experienced, but is a contract teacher and well aware of the challenge this brings. Tony will continue to be involved in many of these initiatives on a voluntary basis. There is a core of teachers who are committed and excited to be working on marine and aquatic education in partnership with scientists.

The commitment of the school leadership will be a critical factor.

Case Study: Doing Real Science in Collector

1098. Waste Busters and Wind Gusters: Reality Science in Schools

This project illustrates a number of important points. First, it shows what can be done in a cluster of very small rural schools. Second, it capitalises on local science based developments the proposal for a wind farm and the existence of a bio-reactor. Using the big ideas behind these, the Collector cluster decided to design and implement a series of integrated studies (which still sat within the curriculum framework), to investigate with their students the science behind biodegradable waste and the harnessing of wind-generated power. Third, it enabled teacher professional development both in the science and in the use of IT knowledge in pedagogically effective ways.

Context

Collector Public School is a single principal/teacher, P-Year 6 primary school that serves the educational needs of its small, mostly farming community. As a single principal school, the challenges of delivering a quality education are large and start with the obvious issue that it is usually one teacher teaching across all the curriculum areas and across a range of differently aged children. Perhaps less obvious is the sense of isolation that comes with both the rural and professional context and the difficulty of finding replacement staff to free up the teacher(s) so they can attend professional learning opportunities and the like. To address some of these issues, Collector Public and five other similar schools (the largest of which having up to three full-time teachers), decided they wanted to offer "reality" science education in their schools which would excite the local students, overcome their sense of isolation and engage students with science-based learning which drew on cutting-edge technological projects in their local district. At the same time, the teachers who conceived of and managed this project also wished to exercise some newly learnt ICT skills, but perhaps most importantly, learn for themselves how to deliver a more hands-on approach to the teaching of science. As one of the teachers put it: *This project was also about increasing our [the teachers] confidence in teaching science.*

The cluster already had experience of working collectively on a number of different projects over the last five years. These included projects that explored on-line pedagogies, 'Quality Teaching', and the 'Primary Connections Science Literacies' project. The significance of all these to the 'Waste Busters and Wind Gusters' project was that these other projects had already raised the standard of professional learning among the teachers, especially in the writing of science units. Additionally, each school now had the prerequisite ICT hardware and on-line skills to utilize their new knowledge in pedagogically effective ways.

What the ASISTM program offered the cluster was the chance to come together again and trial new approaches. These relied on engaging experts, 'real scientists' as it were, who, it was hoped, would help to support and extend the teaching of science and technology in the cluster schools. Central to the 'Waste Busters and Wind Gusters' project were two new and contentious enterprises. The first was the opening of the new Woodlawn 'bio-reactor' at a recently decommissioned mine site, to process biodegradable waste from Sydney into methane gas, which is then used to generate

electricity. The second and perhaps more contentious enterprise was a proposal for a wind farm at the same site (which carries with it possible effects of encouraging more wind farms, with resultant impacts on the price of land, on the environment and so on). Using the big ideas behind the bio-reactor and the potential wind farm, the Collector cluster decided to design and implement a series of integrated studies (staying within the curriculum framework), to investigate with their students the science behind biodegradable waste and the harnessing of wind generated power.

The project

Alongside Collector Public, the other small rural schools involved were Breadalbane Public School, Tarago Public School, Tirranna Public School, Windellama Public School, and Gunning Public School. Also involved were the Minerals Council of Australia, Questacon, the NSW Department of Education and Training's Centre for Learning Innovation and The National Science and Technology Centre.

Through their partners, the cluster schools visited the Woodlawn bioreactor and wind farm site at Tarago. Teacher Associates were recruited from young scientists at Questacon and university students from the Centre for Promotion of Awareness in Science at ANU, and the Environmental Science Dept at University of Canberra. These university-based scientists visited the schools and conducted workshops that culminated in hands-on experiments into the biodegradation of waste, and in students designing and making their own wind turbines. In conversation with Year 4-Year 6 students nearly a year later, the knowledge these students retain about the design principles behind an efficient turbine design was most impressive.

To support the teachers in their professional learning, the Teacher Associates offered expert advice in regard to the science behind the experiments/projects, provided access to some of the key materials required and importantly, they offered an infectious sense of enthusiasm and fun to the use of science as the means to understand and explore the world around. One of the industry partners, The Minerals Council of Australia, brought to the cluster's project both advice and a framework for the cluster schools to implement their own waste reduction schemes (part of one The Minerals Council's initiatives called 'The Envirosmart project'). Facilitated by The National Science Museum in Canberra, students went on a 'Science Immersion Excursion'/camp which included an overnight stay.

Lastly, the cluster received support from the Education Department's Centre for Learning Innovation to produce online research tasks, facilitating students' interactions across the cluster via email and discussion forums. This last element is significant in that it goes to the heart of the issue of isolation which affects not only rural teachers isolated in their practices but also students who have limited opportunities to share and exchange their work with others. The use of the newly established on-line links by the Wind Busters project gave students and staff timely, 'real' material to share between schools and via media such as collaborative websites. This provided the opportunity to bring the project to a wider audience such as local government and farming bodies.

Outcomes

Whilst it isn't hard to provide evidence of improvements in the learning and teaching of science and technology across the cluster schools, what was most evident in visiting and talking with students and teachers was their sheer excitement coupled with a desire to pursue a science-based interest in their local environment. As mentioned earlier,

students were impressive in their knowledge and passion not only for efficient blades for a wind turbine or the scientific method they had used to measure the rate of decomposition of buried organic material but more widely for *the science in things around us* (Year 5 student).

According to the teachers, the major impact of the 'Waste Busters and Wind Gusters' project professionally, concerned their increased sense of competence and confidence as science teachers. One teacher recalled: *The scientists [the teacher associates] were very strict when it came to the teaching of the scientific methods.* i.e., teachers were well grounded in both the scientific method of hypothesising, testing, observing and interpreting data, as well as the necessity of taking good notes, identifying variables and plotting their results in appropriate graphs.

For the local community, where the school plays a very real and significant role in its life and well being, the expanded and relevant science education the children were participating in had the unexpected impact of contributing to the debate on the potentially divisive issue of wind farms. A point stressed to me by one of the teachers involved in the project was that their role was not to promote one form of energy production over another but rather to raise the level of the debate by educating themselves and their charges in the science (and its limits) that underpins proposals such as wind farms. As the project coordinator put it:

> *We want our students to have the opportunity to engage in, explore, experiment with and explain the concepts behind these projects to each other and to the wider community. We have cutting edge science happening on our doorstep - what an opportunity to immerse staff, students and our community in these exciting projects and to be able to educate them for an informed role in the wide and growing debate about these issues.*

Sustainability

At the conclusion of the project it was evident what elements had been sustained. Starting with elements directly connected to the project, the wind turbines built at the schools still existed, with ongoing plans to use them as experimental sources of electricity generation. The experience and knowledge gained through the waste reduction and recycling aspects of the project have been put to work to meet the NSW education department's environmental audits for all state-based public schools. The staff members at the schools carry forward their knowledge and expertise in teaching science and technology in innovative and relevant ways, into their every day lessons and into future projects. As a cluster, the project has further reinforced their capacity to work collectively and assisted in the recruitment of new players such as Questacon, into any future strategy to develop links with outside expert partners. While all these elements are important and worthy, the most valuable thing the project has initiated (and a year later this was still strong) was a deep sense of curiosity among the children to see 'the science' in the world around them.

Case study: Collaborative Design in NSW

2012. Collaborative Interaction Design - 3D Prototyping, Remote Realisation and Manufacture

This project modelled exemplary practice in terms of fostering teacher professional development and 21st Century pupils learning in technology classrooms. The support for the participating teachers in the delivery of technology education and the co-operation between teachers across systems and between States has resulted in some innovative practice being modified to suit the particular needs of different State syllabi. This has served to strengthen the quality of technology education being delivered across various States in Australia. Through limited funds this project provided students and staff with an opportunity to work collaboratively when using rapid prototyping technology that is not usually available in technology education classes in Australia.

"Initiated by a discussion Ruth and I had: What could we do next with the students? When kids can design things from scratch in high school, what's the next step? What would technology education be like in ten years? And the thing that came to mind was the collaboration issue. It was the collaborative thing rather than the particular technology. I mean that has been great, but it's the collaborative thing, they do what people do in the real world and they collaborate internationally on projects. And that is really what this is about." (Peter, Head of Faculty/ Teacher, June 2007)

In essence the project modelled industrial work practice within and across school settings. Simply introducing new rapid prototyping technology into classrooms into one school would have been a challenge in itself. However, to adopt this technology while trying to model work practice in terms of team-work and collaboration across schools, with industry and the professional association, illustrates the work ethic of those concerned, as well as their insight into the role of technology education in the 21st Century workplace.

The project

The project introduced rapid prototyping technology to schools. A printer was delivered to Bossley Park High School that enabled the School to set itself up as a 'manufacturing centre' to which partner schools could send emails with attached stereo lithography (.stl) files for 3D printing, and developing protocols for students at the Bossley Park High School manufacturing centre. Teachers and Teacher Associates received information on exporting .stl files from 3D parametric modelling software, 3D printer use and management of files, and setting up the WEBEX telecommunications portal. Initially the project involved working within the one school, but as familiarity with the technology and teacher interest (state-wide and beyond) has grown the nature of the collaboration has evolved.

The first challenge was to draw a carriage for a 1gauge track and the carriages produced by the various schools would be piloted around the track at the Luddenham Model Train site. This was within-class collaboration. The second challenge was to design an optical pointing device for someone with a disability. Schools were paired up and had to collaborate on the design and drawing of the device, which, it was hoped would

function. The third challenge was a multi-part mechanical toy, schools were grouped and each school designed and drew a part for the toy and collaborated with the others in their group as to fit, how the toy works, and so on.

> *We started with this project (carriage), it was an in-class collaboration, most teachers got all the kids to do one then they voted and decided which one was to be printed, and the next stage was between 2 schools with the input device for a person with a disability, and the next stage with one team of five school, involves designing a mechanical toy, where each piece is designed by a school and then passed on to the next school to design another piece of the toy.* (Ruth, Head Teacher, June 2007)

In most classrooms the existing technology education resources date back to the mid-20th Century. The schools involved in this project have enhanced their technology education resource base through the introduction of 21st Century, rapid prototyping technology more commonly found in the workplace.

Ruth Thompson's (Head teacher) skills in encouraging and promoting engagement between schools and industry, dealing with changing goalposts tied to the funding and reporting associated with this project, managing unanticipated challenges associated with technology dilemmas, and fostering a climate of change that encouraged teachers and students to take risks in a supportive environment have produced a framework that enabled both students and staff to demonstrate their skills, knowledge, understanding and interests in technology education.

> *Without patronising Ruth, I think she has done a terrific job, and certainly Peter as well. I think Ruth has got this terrific personality. I think her stamp on this project is something that ought to be reviewed. And again not so much to say this is Ruth and she's terrific and all the rest of it, but to say all right here we have a successful project, and one of the aspects of the success is the personnel. What characteristics does she bring to the project? I think she is very supportive, very energetic, keen, (and) enthusiastic. … She's good to work with. I don't find her judgemental. She's that kind of a manager. I think a good manager is someone who can kind of cajole their staff into doing things they don't want to do and everyone still feels good about it.* (John, Critical Friend, June 2007)

Ruth Thompson established a support network that ensured the project did not grind to a halt when the initial technology purchase failed to live up to expectations. In addition, industry input was instrumental in helping the project get started. The teachers involved have been actively seeking support from, and to work, with national industries. In some cases the industry participants have gone above and beyond the call of duty and this has been valued and recognized by the school participants.

> *The links to industry have been really good too. The first person we dealt with Adam at S and I in Melbourne, he flew himself up to talk with all the teachers. Sitting in the room there, on a Sunday afternoon, talking to the teachers, and he went away so excited because the teachers were excited. He was really supportive. We haven't broken the link. Concentric in Sydney, they do 3D prototyping, ...they were an expert group for us.* (Peter, Head of Faculty/ Teacher, June 2007)

The belief in the underlying principles, and the potential for this project to significantly affect teacher professional development and student learning, encouraged those involved to persevere.

Innovation

A common feature, identified by several of the participants interviewed, would suggest that the project provided an opportunity to mimic within secondary schools an aspect of industrial practice. This was an excellent aspect of the ASISTM vision. It allowed for different participants to work together, building relevant industry links and producing a more authentic curriculum. In particular the acquisition of a piece of technology that is found in industry but not in schools, was an acknowledgement of the common misalignment of what goes on in technology classrooms in schools, where old technology is used, and what is happening in the real world, where modern technology is being used. This was a key feature of the project identified by those interviewed - teachers, students and critical friend.

> *It is new in the country, the concept of rapid prototyping in high schools, where students can do 3 D, CAD (computer assisted design) models out of it, without going into a workshop and making it by hand. With this they can design anything crazy and still have an output that is the really amazing thing… It is innovative because it is new, so it is leading edge. It is innovative, because it is a creative way to use the technology. My definition (of innovative) is a degree of difference and this is certainly different, because it challenges them with new technology. It is unique… If we are going to move technology education into the 21st century, … and if we are going to encourage students and teachers you've got to have this sort of gear. The technology has to be available to them.* (Peter, Head of Faculty/ Teacher, June 2007)

> *As a student looking to get into engineering, the project has given me an inside scope of like what CAD can do in the engineering field.* (Student 4, June 2007)

> *I really hope - I would like to see the collaborative learning side of it continue. I think, certainly from the design perspective that is how a lot of design is done this day. So if we are in the business of producing graduates from high school who are going into the real world, we have to try to give them some realistic skill base. If they go into the design area some of them will have experienced this.* (John, Critical Friend, June 2007)

> *The fact that we have a 3D printer in our school…. It is amazing that it can just be printed out in 3D. It makes prototyping easier.* (Student 1, June 2007)

> *You don't have to carve it out of wood.* (Student 4, June 2007)

> *We are one of a few schools. We are one of about 5 or 6 in the State to actually have a printer.* (Student 2, June 2007)

However, not only was the technology innovative, the working practices in using these tools became innovative.

> *Because we are now collaborating over distances we can set up a project using industry standard collaborative software called Windchill Project link, which has been donated to the project by PTC, to set working folders up. So the kids, if they are going to pair up, can just have a folder for the pair of them so they can upload*

> *their work to a website which is accessible to all the people in the project, which is what happens in industry. One person uploads files, others can log in and work on the file from a totally different place, if someone has got the folder open no-one else can get in, all the iterations of work are saved. So it is really starting to look at what happens in industry even at our simple level, with one or two folders.* (Ruth, Head teacher, June 2007)

It gives students an opportunity to demonstrate their skills and understanding while being creative. Furthermore students with a range of abilities can use it. Students themselves realised the potential of the technology:

> *Imagination, let that run wild, you can pretty much do anything with that software.* (Student 1, June 2007)

> *It is kind of nice to see the sort of work that other students are turning in*. (Student 3, June 2007)

Sustainability

Many of the participants identified teacher professional development as a key element to sustainability.

> *I also think if you are going to try to sustain it you are going to have to train staff. If you want to expand it you have to get people in to train them up. That certainly happened in this project…. Invest in resources.* (John, Critical Friend, June 2007)

However, the reality of classroom practice is probably going to be a great motivator in encouraging sustainability. Not only was the new technology seen to be important in providing pupils with an opportunity to use current tools, the technology was also seen in terms of encouraging pupils who would otherwise have difficulty in visualising their output, to produce objects that give them some degree of pride in their work.

> *I had a class that needed to do technology, and because over the mandatory classes we run the same program, so I needed to have something that they could do. And while they might not be able to do it practically with their hands, they could go a step before that and do it practically by getting their idea into a 3 dimensional object.* (Pete, teacher, June 2007)

Unfortunately one of the challenges that the project still faces is that of time. Finding the time to learn to find cutting edge technology that falls within the school affordability price range, then learning how to use this technology so the students get the most out of it, is a considerable challenge. Time is often a limited commodity in schools. Not surprisingly, some of the teachers involved have had to use their own personal time to both find and learn to use the technology before deploying it in school.

> *We have spent a lot of hours at home investigating. Just looking at the industry standard software, and without training, which you can't really get, you have to suss it out yourself, which takes time.* (Ruth, Head teacher, June 2007)

Outcomes

This project had many outcomes. Teachers across a variety of sites learnt new things and learnt to use current technology. The nature of the tasks enabled them to gain

some measure of confidence in promoting technology education with up-to-date technology.

The outcomes in terms of product varied. This was seen by some of the project participants to be a consequence of differences in curriculum across states with respect to the encouragement of creativity.

> *They (Queensland) seem to be more creative in what they do because they have more freedom in their curriculum framework. There are pros and cons, for that, I'm not making a comment either way. Once people in NSW see this and know that it is available to them, I expect to see that it will be built into their curriculum, so once they start doing their CAD module they will be thinking about what project can the kids draw even it is something small to send off to get back, to look at the interaction between CAD and CAM.* (Ruth, Head teacher, June 2007)

Another clear outcome was teacher professional development. The project has tried to maintain a sense of continuity in terms of the ideas and practices that have been successful, and to keep in contact with a network of people who will sustain this continuity.

> *I think it excites the teachers too, you can see them working it out in their head, "what can I use this to do?". Firing them to move them outside what they traditionally do. As Industrial Arts teachers we have got to be looking at new technology and this provides them with an opportunity to do that and apply it in ways that they might not have done. They are often surprised by what the kids can do. (Ruth, Head teacher, June 2007)*

The collaboration across schools and between schools and industry was a significant outcome. For many schools the technology available at Bossley Park would be out of their financial reach. To have access to this technology and work in cooperation with Bossley Park enables them to use cutting edge technology in their technology education classes.

In addition, overall this project is helping students to develop skills that will be useful beyond the classroom.

> *So in their workplace twenty years from now that is the learning that they will still have. It doesn't matter if they are in engineering or not.* (Peter, Head of Faculty/ Teacher, June 2007)

> *Giving us a good scope of the profession, what engineers and designers do together as a team. It is a team thing. Engineers would do one thing, designers another.* (Student 4, June 2007)

Case Study: Toward an Australian Moon

2055. The MOON (More Observations Of Nature) Project

With the MOON project, the ASISTM funding enabled a group of enthusiastic educators to take an existing program, designed in the USA and available on the Web, adapt it to the Australian context, and broaden the number of teachers and schools using sustained observation of the Moon and consequent analysis and thinking by students as a starting point for studies at the upper primary level.

Context

The ASISTM MOON Project is an adaptation of a project operating in the United States of America under the direction of Professor Walter Smith. Some Queensland teachers have been participating in the US based project for several years and the ASISTM project has enabled them to adapt the concept to the Australian context. The adaptation to the Australian context and development of the Australian website is quite significant in a number of ways. First, it deals with the issue of the students in the two hemispheres making different observations. Second, the Australian project operates on a more collegial basis with teachers putting materials they have developed on the website to be used by others.

Dr Judith Mulholland, of the Australian Catholic University led the Australian project. Primary teacher Sandy Davey serves as Deputy Director. Both of these people had utilised the American based program via the internet in the past, had contact with Walter Smith, and had been impressed with the enthusiasm and learning of students who engaged in the activities. At this stage the ASISTM project is focussed on Queensland schools whilst retaining the opportunity to link classes and students across countries, a key feature of the US program.

The project

The word, or its synonyms, most used by students, teachers and Teacher Associates alike to describe the MOON Project is 'engaging'. As one student said, when asked whether the activities appealed to all students: *Some kids weren't interested at the start but toward the end everyone got into it.*

It is not just the students who have engaged with science through the MOON project. Sandra Davey, the Deputy Director of the project, is also enthusiastic. *I was a teacher who hated science. This project got me and I discovered how much the kids love science*. Because of this project, she is now a very enthusiastic and committed science teacher, a co-ordinator for Primary Connections, and has won awards: the CESI Exemplary Elementary Science Teaching Award, 2006, and a Peter Doherty Award for Excellence in Science and Science Education, 2006.

The project is built initially around observations of the Moon that students make over a period of two lunar cycles. The students are then required to construct ideas to explain the observations they have made and how these differ from observations made by students in other parts of the world. Further, teachers have developed a range of options that build on these observations and on cultural and historic facts about the Moon. For example, in one school the class investigated an ancient idea that growing crops at different phases of the Moon made a difference to the plant growth. This particular

school had the facilities to do this effectively. The children were required to make a number of decisions about the investigation such as deciding how to do the test, what plants would be tested and how the growth would be measured. As the teacher said: *It is an excellent example of enquiry-based learning. The teachers are not telling the students but are guiding them. It sparks something in the children.*

Another feature of the project is that it can become a 'whole family' learning experience. Observations of the Moon and the recording of these are done at home and so there is every opportunity for other members of the family to become involved. The extent of family participation obviously varies from family to family, but clearly the project does facilitate the involvement of parents should schools wish to grasp this potential. One teacher said: *It is truly a family thing because the observations are made at home. Lots of parents get very excited about it. They commented that they will never take the Moon for granted again. I hadn't predicted the extent of the family involvement.*

Partners

The Website (http://e-learn.acu.edu.au/moon) will include the units developed by teachers and so teachers who wish to pursue the topic will be able to choose and adapt the particular options that appear most suitable to their context. As part of the ASISTM project the material being put onto the website is being vetted by Teacher Associates at the Sir Thomas Brisbane Planetarium who check on the scientific accuracy of the material submitted. It was suggested that: *The greater the number of teachers who participate in the project, the greater will be the range of options available to schools and teachers.*

Attention has been paid to ensuring that the activities being provided for students match the curriculum outcomes required of Queensland schools. This is not just in science but also in mathematics, language and technology. Those already engaged in the project find it a valuable way to integrate studies.

As an aid to using the Moon as the focus of either science or integrated studies a documentation of resources for teaching about the Moon was carried out. These resources included web sites and children's books. An annotated bibliography of such resources has been compiled and is included on the MOON Project Australia web site. The non-fiction literature is organised under three topic headings; *Other Moons and Ours, Moon Exploration* and *The Moon in Culture, Myth and Legend.* A separate list of fiction for children has also been compiled.

The links with students in the USA provides Australian students with significant insights into issues of communication. This is reflected in the comments of one of the students: *It was hard to communicate with the kids in the USA and we learned a lot about how to communicate successfully. There were three problems – they saw different things, they used different names for things, and the differences in the language.*

The internet is being used as a way to introduce teachers to the potential of the project and ways of introducing studies of the Moon into the curriculum. Also, it is a means to enable students to link with others in different locations, to communicate and compare their observations. The project has revealed the variation in teachers' and schools' ability to use the technology effectively. As one participant commented: *Some teachers use the technology well and others don't.*

Innovation

In what way is this program innovative? It is a novel way of taking an existing idea, the USA-based MOON project, and adapting it to meet local conditions. Whilst there were teachers participating through the American website, the ASISTM funding has allowed interested people in Australia to get together and adapt the concept to more suitably reflect local conditions and operations. In 2007 there are both more schools and more teachers in Queensland involved in the MOON project, and there are schools in Western Australia trialling the approach. It is possible that there will be widespread adoption of the project in Western Australia in 2008.

In addition to the development and trialling of units and the construction of the local website, ASISTM has enabled materials to be developed to enable participating teachers to provide professional development for their colleagues. As one of the participating teachers interviewed reported*: For example, we are having a pupil free day soon and I will be presenting to the teachers in the Gympie region about the project. I'll introduce the website. The funding allowed us to develop professional development material for those of us who can spread the word*.

Sustainability

The key to the sustainability of this project appears to depend on two factors. The first is the enthusiasm of the teachers already engaged. At this stage the level of enthusiasm suggests that there will be no problem in this regard. As one of the Teacher Associates (a teacher education student who is now herself a teacher) indicated: *I have got the other two Year 5 teachers here to do the project with their classes when I do it. I see it as an interesting topic, engaging for the students and hands-on.*

The second sustainability indicator is the website. This will be a key means of communicating possibilities for teachers. The decision to include a diverse range of units, developed by teachers with appropriate checks and clearly linked to the curriculum, should encourage teachers to utilise the possibilities offered.

Case Study: Environmental Education in Tasmania

2058. Parks and Wildlife Service Environmental Education Program

Tasmania has been a state associated with being at the forefront of environmental issues, so perhaps it's no surprise that the Parks and Wildlife Service Environmental Education Program was an ASISTM project that looked to deepen, systematise and extend the educational relationship between Tasmania's Parks and Wildlife Service and schools across the 'Apple Isle'. At the heart of this extended relationship would be a teacher directed environmental education program, aimed at assisting future Tasmanians to be better equipped to understand some of the conservation challenges that inevitably lie ahead.

Context

The ASISTM funded 'Environmental Education Program' was a project initiated by rangers from the Tasmanian Parks and Wildlife Service. The Parks and Wildlife Service (PWS) had identified a number of issues and opportunities in regard to trialling a new 'Environmental Education Program' for schools". These included:

- The Tasmanian government was implementing a new curriculum requiring educational materials and inspiration for the 'World Futures' Essential Learning;
- Schools cited lack of curriculum materials as reasons for not visiting National Parks or not participating in educational activities while there;
- Schools that do visit National Parks were tending to go only once due to cost restraints. Hence multiple visits, which would have reinforced students' and teachers' understandings and appreciation for the environment were not being widely undertaken; and
- Survey data that suggested a lack of Tasmania-specific environmental knowledge throughout the Tasmanian community.

The 'Environmental Education Program' aimed to respond to these needs and opportunities. It grew out of an earlier program run by the Parks and Wildlife Service, which had been going for over twenty years. The Summer Interpretation Ranger Program was aimed at giving visitors to the state's parks and reserves meaningful experiences and deeper understandings and appreciation for the environment. While the Parks and Wildlife Service had been keen to be involved in education there had been few opportunities to work with teachers in a systematic way to develop appropriate educational materials. The program's overall aim was to foster collaboration and understanding between schools and the Parks and Wildlife Service. Through a systematic and purposeful engagement, it was envisaged that teachers and students working with rangers would be inspired to start thinking in a scientific way about the environment around them and its conservation.

The role that was envisaged for the Discovery Rangers was that of Teacher Associate, with one 'TA' being assigned to a specific school. The Teacher Associate would take a leading role in one of the school's environmental education projects, including bringing

park ranger 'real life' experiences into the classroom, as well as providing expert support for the classroom teacher.

For teachers, the program would offer new approaches and techniques on how to use the natural environment. An essential element of this would be the development and distribution of resource kits (which would be available for future use in other schools) designed to support the improvement of science teaching into the future.

For students, it was hoped that through a 'hands-on approach' plus exposure to the experience and expertise of the Discovery Rangers, students would foster an interest and link with the natural environment, which for some would continue on into later science-based studies.

The project

Managed by the Project Coordinator, Jen Fry, the 'Environmental Education Program' initially met for a day with interested Parks and Wildlife Service's staff, in mid-June 2006, to familiarise them with the aims of the program. This included an outline of the wider DEST-run ASISTM program, classroom management strategies and practical advice on how to prepare lesson plans, blogs and the various administrative requirements.

Parks and Wildlife Service staff were matched to their nearest interested local school, where the rangers (teacher associates) held planning meetings with school leaders, project coordinator and others to brainstorm topics chosen by the school, plan for all aspects of the proposed activities and prepare pedagogical materials such as project lesson plans and activities for each session that linked back to the new curriculum. Some of the topics that were chosen included: Why have National Parks? The Wonder of Waterways; The Value of our Rainforest; Wildlife Survivor; Using Wetlands; The Roles of Rangers and The Future of Foreshores.

The planning meetings enabled both the teachers to choose topics appropriate to their own situation and the teacher associates to match their expertise and professional preferences with the topics. In addition, materials were produced that were relevant to each school's local environment. For example, if the local environment was an urban setting, the program would focus on the wildlife found in these areas through using investigative techniques such as administering surveys of wildlife including measurement strategies, as well as covering the scientific understandings about animals and the ecology found there.

Educational resources of most relevance to the topic and age group of the classroom were gathered by the TAs for use in the classroom and during the field site visits. These included materials such as slides and equipment for slideshows, books, display posters, wildlife specimens, magnifying glasses, water scopes, bush food items, spotlights, and personal ranger field equipment.

Most of the associated schools' field trip sites were within protected areas such as Mt Field National Park, Moulting Lagoon Ramsar Site, Strahan Rainforest Discovery Centre, and Freycinet National Park. Students participated in activities such as tasting bush foods, water quality testing, ranger duties, spotlight walks, and rubbish collection.

What one teacher thought his students had learnt from being involved in the program included *the sustainability of ecosystems, how scientists really work in the world, how to collect and interpret data, and the scientific method underpinning their inquiry.*

Post field excursion visits teachers worked with students on the chosen topics to produce displays using posters, photographs and videos to present to others at their school a report of what they had learnt.

The field trips were all very successful, setting a great precedent for teachers in the future to follow this environmental education program model. The project continued with students working in class and in the field with the Discovery Ranger, and teachers finishing the unit of work in the classroom.

Teacher resource kits were created, known as PWS e-sets (i.e., Environmental, Educational and Electronic set of notes for teachers) with input from teachers on-site, Teacher Associates and the education consultant of PWS. The e-sets will be used state-wide by teachers in the future to provide a comprehensive environmental education unit of study, complete with a field trip visit to a reserve with an education ranger.

Challenges

A key challenge for the 'Environmental Education Program' was overcoming a mismatch between the scope of the program (seven classrooms across six schools) and the timeframe envisaged in the ASISTM guidelines. This issue was intensified by the part-time status of the project coordinator and the need to meet post-project surveys required by DEST.

An additional challenge was that some teachers were wary of having conservation messages prevailing in their classrooms; especially if the students had already done a few projects with a conservation theme. These concerns were addressed and overcome by working closely with the teacher in question and renegotiating aspects of the project. For example, one class took a broader view, focusing on the users in their area rather than simply on conservation.

Outcomes

One evident success was the enjoyment and enthusiasm of students reported by teachers, the critical friend and others in the project. As one teacher put it: *students still talk about this (the Environmental Education Program) and it took place last year!*

But perhaps the most significant marker of success has been the uptake of the resources produced by the TAs working with teachers, with 16 school groups lined up to use them. When schools contact the Parks and Wildlife Service for an environmental education session, the PWS can respond by giving them relevant and appropriate materials that best match their educational needs.

In addition, the teachers we talked to commented that *the collaboration with Parks and Wildlife was excellent… an effective relationship was established... a partnership between schools and Government sectors is a great idea.*

Case Study WA: Stars and Remote Schools

2099. Wildflowers in the sky

In this project, scientists and educators from the CSIRO Australia Telescope, inspired by Australia's bid for a major international radio astronomy facility, worked to link remote schools in North Western Australia with the astronomy research community to support the teaching and learning of astronomy.

The Square Kilometre Array (SKA) is a huge scientific bid, and it has the potential to transform areas of Western Australia (WA) with the infrastructure needs and employment opportunities it offers. However, WA has not had a history of research in radio astronomy, and astronomy tends not to be taught much at school level, neither appearing in senior science curricula, nor represented adequately in junior secondary or primary school science. Wildflowers in the sky is a project, conceived and coordinated by the CSIRO Australia Telescope National Facility (ATNF), and aimed at raising the profile of astronomy and helping teachers in schools in north western WA.

The project aims to use the expertise of professional astronomers, and the education resources of ATNF, to inspire and support teachers in a range of schools in Geraldton, and the remote north west of the state around Meekathara. The project was the initiative of Rob Hollows, the Education Officer at the Parkes facility in NSW, who saw an opportunity to use some established facilities, including a remote telescope at Charles Sturt University capable of being driven remotely by schools, and CSIRO-developed activities and professional learning resources, to kick-start interest in astronomy in communities adjacent to the SKA.

The project was supported by the WA Office of Science and Innovation, which is managing the SKA bid and anxious to establish infrastructure in WA communities that will maximise opportunities in the region, including knowledge of science and astronomy. SciTech, the science centre in Perth, also supported it. The project involved workshops and visits to schools by Rob, who has an education background, and scientists undertaking doctoral research. This team offered viewing nights and solar spotting activities by day, and worked with teachers and students, including sessions run through the school of the air, to develop astronomy teaching and learning sequences. Schools were given telescopes and other equipment, including software packages, to support their work.

The schools involved were very different in their location, and social context, and the associated opportunities and challenges. The story of the project played out differently in each, and both Rob and the teachers attested to the way that processes and expectations changed in response to local conditions and needs of the teachers. The schools involved were John Willcock College in Geraldton, Meekathara District High School, Pia Wadjarri remote community school, Cue primary school, and the School of the Air which was originally located in Meekathara but has shifted to Geraldton following a fire that destroyed their facility, including a telescope and other project equipment. The project involved a substantial number of indigenous students, particularly at the remote schools.

The first workshop held at Cue and running for 3 days, was judged very successful by participants, and the project team. Dorit Maer, the critical friend, described the

excitement that was generated with the astronomy activities held in conjunction with the professional learning work, with parents and students keen to participate. The team operating the other WA astronomy project, Astronomy WA, incorporated the workshop design into its own project. In the workshop the visiting scientist gave talks about the nature of research astronomers' work and about the research itself. The team worked with teachers to introduce activities and provide support for understanding astronomy concepts. As Rob Hollows pointed out, it was clear at this first visit that the focus had to change and more emphasis needed to be put on teacher professional learning support. The teachers themselves concurred with this view, talking about the steep learning curve, and the fact they did not at that stage know enough to ask the right questions about astronomy concepts. That would come later. The activities themselves were explicitly constructivist in nature, including probes of student conceptions and allowing room for students to construct their understandings.

John Willcock

John Willcock is a large Year 8/9 school with a mixed and sometimes challenging population of students. Damon, the science coordinator, had embarked on a plan to reform the science curriculum along constructivist/conceptual change lines and the astronomy project was *a case of fantastic timing.*

None of the science teachers had a background in physical science and Damon was enthusiastic about the support they had been given, the good ideas and the inspiration of the astronomer who made links with current astronomy practice, *even though it was a bit over our heads*. Other teachers endorsed this view. For instance Susie talked of the three workshop days as *very useful, but a lot was above my head*. She referred to the quality of the practical ideas, and talked about taking a class on camp recently where she ran an astronomy viewing night where *the kids got out the telescope and found Saturn – they were very keen. Prior to this there was no way I'd go out and do a night viewing*. During the visits Rob and the team had taken her class outside for activities on sunspots, and planetary distances.

Christie referred to being *blown away* by the *high-end* nature of the workshops, and pointed out that the SKA could not really be used to inspire classes since radio astronomy was beyond their level of understanding. Damon talked of the scientists inspiring students, and showing teachers *what is being done at the cutting edge*. All the teachers talked appreciatively of the repeated visits and the chance to ask questions once they were in planning mode. Erin talked enthusiastically about the hands-on approach and the use of laptops, and the support *if we were stuck*. She and other teachers also talked about the prior probing of student ideas, and the focus on big ideas and processes rather than facts. During the latter visits Rob included Ilana, a science educator, in the team, as well as a research scientist. Her presence was much valued and all the teachers appreciated the advice she gave them. Ilana was managing the evaluation of student learning using pre- and post-tests that gave *really relevant information on misconceptions.*

One of the issues for the project, then, was working out how to match the materials and processes to the needs of the teachers and students, and to the local context. Christie in particular (she has enrolled in a PhD through contacts from the project) emphasised the difficulty of giving the supplied materials to students because of the literacy levels. She also talked of the difficulty of applying constructivist approaches in classes in which there were behaviour management problems. Consequently, the team modified the

materials for their purposes, and these were sent back to Rob to be put on the website for more general use.

Damon, as science co-ordinator, used the project to push his curriculum vision forward. The team used a 5Es conceptual change structure and Susie and Erin talked about coming to a group consensus of activities to include in the 'engage', 'explore' and 'explain' stages. The school has been supplied with laptops for every student, and so the staff thought that the timing of the project was good because of the software they accessed through it. This included 'stellarium', a virtual environment (the students were impressed at how it allowed you to go forward and backward in time) and a moon journal program. Damon was keen that the laptop program was not restricted to web browsing, and aside from the commercial software, they devised an assessment for students as a podcast in which students presented their version of an astronomy topic. Damon had hoped that some students might take the opportunity to present some traditional stories that might be useful as resources, but this seemed not to have happened. However, Susie talked about getting all the podcasts on a day when they often have trouble, and said: *It was impressive seeing them all so engaged.*

School of the Air

John McHale, principal of the School of the Air, was very enthusiastic about the project. Rob and his team had visited the school in Meekathara and run a session for students. They had planned the professional development specifically for School of the Air teachers. The School was delighted to have some physical science in its program that was *real life* and showed an unfamiliar aspect of science. They had made the program voluntary – more like a club – and had so much success attracting upper primary students (*the response was huge – 100% of students*) they had opened it up. John explained how fathers did not normally get involved with their children's education because of the demands of their properties during the day, but that many fathers were now quite involved in night viewings, or models. This was a welcome shift. The school has *set up a website from which students can download photos and upload observations, thoughts and so on, and chat online*. John saw the value of the program in representing scientists' voices, and described how they *had lots of requests about the work of scientists – What do they do? Is there a career in it? A lot of our parents are saying 'he or she is really interested in becoming involved in science' ... For some teachers also it has rekindled an interest*. Rob had made the point that for them Astronomy was a context with which to *get some excitement for science.*

Other schools

Damon had pointed out that the timing of their astronomy unit was a year too late for them to be able to act as a network resource for the other schools, which had been hoped. In fact the video conferencing and control of the remote telescope did not happen because of firewall problems, but there are plans for solving this.

Maintaining the project had been difficult at the other schools for a variety of reasons, not the least of which was teacher turnover. As Rob described:

> *Meekathara had four out of the original twenty when we returned a year later ... we need to be understanding. At Pia Wadjarri the principal was supportive and enthusiastic and sent a colleague to the workshops. But she'd left. The new principal found it overwhelming and didn't provide follow up. The current principal is keen but has no science background. But Yalgoo Primary ... 40 kids*

in a minibus came up to the workshop and it was really good. Now the two schools are communicating and its going well. ... Having teachers passionate on the ground ... for instance the school of the air ... but the fire changed arrangements. The plan was for an itinerant teacher to take a telescope out on rounds. It didn't happen because they lost the telescope in the fire. But it will happen.

Nevertheless, Rob was enthusiastic about some of the good things that have happened and are happening:

The real success story is Glen… who has got upper primary and his class is really into it. They've linked up with a Canadian school ... he'll link up with the remote telescope. A teacher ... came down to Perth and went to the planetarium – he talked to us about it.

The mayor of Meekathara was really welcoming. The district high school had 100 kids turned up and families to the viewing ... people you'd not expect were enthusiastic.

Innovation

Different actors identified a range of features of the project which are innovative. The bringing together of a range of scientists, science educators, teachers and community schools in this remote region is different to previous experience. The combination of pedagogical innovation (constructivist approaches), a range of resources including software and telescopes, computer technologies and communication software (although this did not work very well) were some of the features identified. With the context came a range of problems, but the team was flexible in its response and there were some notable success stories also.

For the science team, the experience had been rewarding. They had got a much greater appreciation of the issues facing teachers and had learnt a lot. Rob saw it as valuable professional development for them. He argued that bringing scientists was important for students to see them as normal people.

Sustainability

This project is supported by CSIRO which will maintain its commitment in some form. This is needed particularly by the remote schools, given the problems of turnover. The promise of getting a videoconferencing system working may help with sustainability, since Damon at John Willcock sees the school as providing advice and resources, particularly now they have been through a full unit. The School of the Air should maintain its program given the enthusiasm shown by all parties, and the existence of developed materials. For John Willcock, sustainability is reasonably assured given the enthusiasm of all the science staff and the existence now of curriculum materials and resources.

The existence of the SKA bid ensures that the WA Department of Science and Innovation remains interested in the project and the teaching of astronomy in the region.