Report on the P.R.I.S.M. Project to inform National Collaboration

Version 2.0

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Contents

Executive Summary

P.R.I.S.M. (Practical Resources & Interactive Science Materials) is a strategic response to the needs of a national online initiative aimed at providing exemplary online learning materials, effective and economical development and management models, and a flexible and accessible delivery mechanism. The ‘operating proof of concept’, funded by the Department of Education, Employment and Training (DEET) Victoria and project managed by Curriculum Corporation, was developed to address the goals of the Victorian Science Online for the Middle Years Project and functions as both a test bed for the generic requirements and as a valuable learning resource in itself.

The P.R.I.S.M. ‘operating proof of concept’ has been evaluated by teachers, students and education systems nationally and including New Zealand. Research findings show that participants were enthusiastic about the role of P.R.I.S.M. in enhancing learning and teaching. In particular, participants acknowledged:

- the flexibility of the system to address context-dependent learning needs;
- the advantages of the customisable nature of the system and content; and
- the benefits of the communication and work-flow tools in enhancing learning interactions and aiding effective tracking.

The P.R.I.S.M. project has proved invaluable in assisting with the identification and resolution of relevant issues associated with the establishment of a national collaborative initiative to develop and deliver online content to Australian schools. The project has effectively developed and trialled management methodologies, content development strategies, an effective and flexible delivery mechanism, quality assurance processes and intellectual property management.

1 Overview of the Project

1.1 What is P.R.I.S.M.?

P.R.I.S.M. (Practical Resources & Interactive Science Materials) is a strategic response to the needs of a national online initiative aimed at providing exemplary online learning materials, effective and economical development and management models, and a flexible and accessible delivery mechanism. The project was funded by the Department of Education, Employment and Training (DEET) Victoria and project managed by Curriculum Corporation and was developed to address the goals of the Victorian Science Online for the Middle Years Project. It functions as both a test bed for the generic requirements and as a valuable learning resource in itself.

P.R.I.S.M. integrates fully developed, highly interactive online content into a learning and content management system. Whilst the functionality of this system is developed to a level sufficient to ascertain its efficacy in meeting the project goals of providing a flexible delivery and management system, refinement of its user-interface design is outside the scope of the project. Its status as an 'operating proof of concept' is derived from its agenda of 'proving' its system design. It is important to note that the science content delivered by the system was developed to the highest levels of pedagogical design and usability.

The P.R.I.S.M. system is built on an object-oriented model that treats content as discrete objects, tagged with metadata and configurable by the end users. The system allows users to create spaces, communicate with others, upload files, link to online content outside the system and to download content for their own purposes. P.R.I.S.M. is accessed over the World Wide Web to ensure maximum penetration into target user contexts, but at the same time addresses the current data flow limitations of this medium through the use of chunkable downloads and the local execution of content.

The current 'operating proof of concept' implementation of P.R.I.S.M. has been evaluated by students and teachers and education systems personnel in diverse learning contexts around Australia. Key findings to date (reported in section 4.3) point to its viability as a system, as a development and management methodology, and as an effective and engaging assemblage of online science materials.

1.2 Who is it for?

P.R.I.S.M. has been developed with an initial focus on providing exemplary content for years 7 and 8 science students in Victorian Schools. Students in these middle years of schooling have well documented issues with engagement in formal education (see section 2.1) and in response, the content in P.R.I.S.M. has been designed to maximise relevance, authenticity and learner control.

P.R.I.S.M. has been developed to inform a national collaborative effort in the areas of development and delivery of online content into Australian Schools. The need for a coordinated response in this area is well recognised and P.R.I.S.M., as an 'operating proof of concept', has been created with the intention of initiating dialogue and action at a national level. Accordingly, the project has significant relevance to national and state policy makers.

In addition, P.R.I.S.M. has been developed to support the diverse needs of teachers in a wide range of contexts and allows them to integrate online material into their existing practices and teaching/learning contexts. By supporting educators in enriching their own effective practice, rather than dictating contextualised and possibly inappropriate pedagogues, P.R.I.S.M. offers a strategic approach to professional development and the fostering of best practice. P.R.I.S.M. supports such contextualised enrichment by providing teachers with effective content access mechanisms, flexible delivery and extensible, adaptable resources. P.R.I.S.M. reflects the way teachers prepare, plan and re-purpose materials for use in their classrooms.

1.3 Why is it needed?

It has long been recognised that uncoordinated development initiatives have resulted in a dearth of quality online content in Australian schools. Typically, little attention has been placed on the unique and diverse contexts and needs of Australian students and teachers and the importance of adaptive, rather than inflexible, online learning experiences. This flexibility should enable online learning materials to be effectively contextualised to suit the needs of individuals, specific student groups and class and curriculum frameworks across Australia's states and territories.

For this reason a national collaborative framework is needed, that embodies effective delivery and access mechanisms, sound and economical development methodologies and contextually adaptive content.

P.R.I.S.M. addresses this need by supporting and facilitating practices that:

- exploit technology to enhance learning;
- challenge traditional classroom practice;
- engage students in motivating, authentic, culturally relevant and challenging experiences;
- provide the flexibility to ensure that integration of technology is relevant and controllable by the user (both teachers and students);
- enable materials to be flexibly adopted across diverse learning contexts; and
- acknowledge that online experiences gain by situating them interactively with the offline activities of a classroom.

1.4 Why is it different?

P.R.I.S.M. distinguishes itself from other online educational projects through its national focus and its emphasis on developing methodologies for the effective and economical generation and management of online content. The project has successfully trialled a tiered management model that ensures all participants in the development process are informed and guided by curriculum-based needs. The P.R.I.S.M. model provides effective mechanisms for education bodies and commercial organisations to work collaboratively on the development of content (see section 2.4.8).

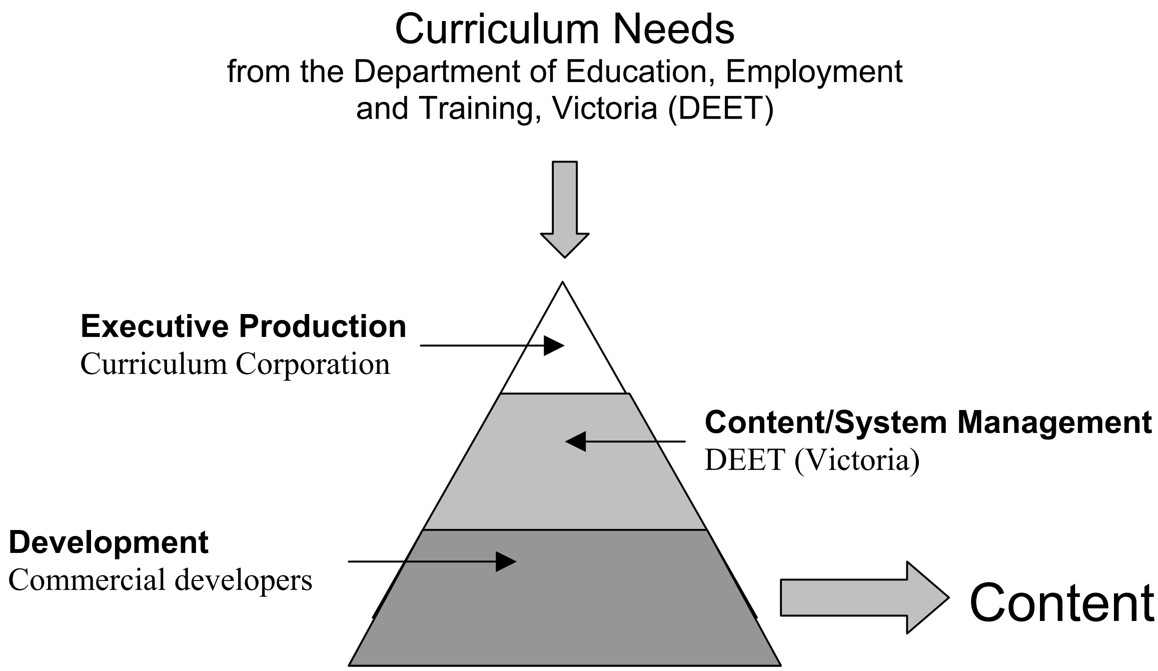

Figure 1. P.R.I.S.M. Management and Development Model

Figure 1 depicts the tiered management model employed in the project. Curriculum needs, as determined by DEET, were passed to Curriculum Corporation who collaborated with DEET in the articulation and refinement of those needs. Production tasks were then passed to commercial developers who created the interactive learning content. Curriculum Corporation maintained a high-level management and quality assurance role throughout the process.

In addition, P.R.I.S.M. provides mechanisms and methodologies that support contextual diversity rather than inappropriate uniformity. The P.R.I.S.M. model diverges markedly from existing approaches, in the flexibility of both its content and the degree of control it affords its end users (both teachers and students) in the manner in which that content is used. The P.R.I.S.M. object-oriented model (see section 2.4.2) allows content to be accessed in concept chunks, sequenced and extended to suit contextually determined needs.

1.5 Where is it up to?

The P.R.I.S.M. 'operating proof of concept' has been developed with users as a central component of both the systems architecture development and the content development. Teachers, students and education systems have evaluated it nationally, as well as in New Zealand. Research findings (reported in section 4) show that participants were enthusiastic about the role of P.R.I.S.M. in enhancing learning and teaching. Initial research has supported the propositions on which the 'operating proof of concept' and the initiative were based and the project is now in a position to make recommendations about its future directions and its contributions to the development of a national online initiative.

2 Theoretical Framework

This section outlines the theoretical underpinnings of the P.R.I.S.M. 'operating proof of concept' developed as a strategic response to the goals of the Victorian Science Online for the Middle Years Project. Whilst some of the theoretical foundation is therefore specific to the development target, the discussion offers widely applicable thinking to the use of technologies and, in particular, interactive online content to enhance teaching and learning.

2.1 Middle Years of Schooling

The middle years of schooling, years 6-9, have long been recognised as a particular challenge for formal education. These years are transitional for students as they move from primary to secondary education, from integrated knowledge domains to more discipline-based learning, and from childhood to young adulthood. The dissonance that results from such overlapping transformations, brings with it varying degrees of instability, uncertainty and self-questioning. It is not surprising then that the middle years are a period of high student disengagement (EQ Australia, 1997) where the purpose and relevance of formal education are challenged against changing individual frameworks.

Developmentally, the middle years period is seen as being a highly formative time when young people establish important learning and cognitive strategies (Brainerd, 1997). Engaging learners in experiences which foster problem solving skills, strategic thinking and learning skills is a priority for this period. In addition, school learning at this time should provide experiences that build self-efficacy, self worth, intentional and self-guided learning strategies as well as social responsibility (Middle Years of Schooling Research Report, 1999).

Traditional approaches to schooling and, in particular, traditional approaches to curriculum, have failed to adequately address the needs of students in the middle years, leaving a legacy of skills deficit and global disengagement. This has led to a large number of students leaving the middle years under-prepared for more advanced learning and with a poor sense of self esteem. Reshaping the school experience to address these problems has been the focus of national projects such as the National Middle Schooling project (www.acsa.edu.au/projects/middle/), and the Middle Years Research and Development Project (www.sofweb.vic.edu.au/mys/research/). Such projects, throughout Australia and overseas, have focused on issues of engaging students with school learning by providing experiences that are relevant to the learner.

One of the approaches which has proved to be successful is the effective integration of learning technologies into middle years schooling. The Report on the Effectiveness of Technology in Schools (Bialo & Sivin-Kachala, 1996), has found that 'students felt more successful in school, were more motivated to learn and had increased self-confidence and self esteem when using computer based instruction'. Similarly Kimber & Deighton (1998), note that introducing learning technologies into the learning environment enhances interest in learning, making it more student centred, collaborative and encouraging cooperative, creative problem solving.

The P.R.I.S.M. 'operating proof of concept' acknowledges the powerful contributions that learning technologies can make in engaging students in the middle years. The online science content developed through the P.R.I.S.M. project has been designed to be engaging, relevant and authentic, actively involving students in decision-making and knowledge construction. Initial research has shown that the project has been successful in these aims.

While the potential of engaging students in the middle years with effectively designed and integrated technologies is well recognised, it is also true that Information and Communication Technologies (ICT) can enhance teaching/learning contexts throughout schooling and across curriculum areas. The following section looks more generally at the contribution that such technologies can make to Australian Schools.

2.2 Learning with Information & Communication Technologies

We are long past the point of questioning whether ICTs *should* be integrated into schools. Three decades of research has shown that effectively utilised technologies can enhance learning, foster critical literacies and aid the development of cognitive and metacognitive strategies. This aside, ICTs are so pervasive in the activities of society that their absence in education can only point to a chronic disconnectedness in our schools. Effectively integrated ICTs provide experiences and resources consistent with the social and educational demands of the global technological society (Suleiman 1997).

2.2.1 Motivation

Motivation is an important drive for all learning and a key issue for particular cohorts of students; interactions that increase student motivation will produce higher levels of student engagement. Woolnough (1997) notes that motivational factors that stimulate the imagination and commitment of students will reap rewards in student engagement, and here technology can play an important role. For example, Tobin (1999) reports research that shows students typically expressing a desire to use technology within science activities, with a resulting increase in motivation and time on task.

However, it is also recognised that many classroom-based science activities motivate students through practical engagement in hands-on activities. The key to the effective use of ICTs is not wide-scale replacement of such activities with computer interactives and simulations, but the strategic blending of these approaches. This position is echoed in teacher responses made during the evaluation of the P.R.I.S.M operating proof of concept. For example:

> "I especially would not replace hands on work that [students] do in class, rather [P.R.I.S.M.] is used to reinforce, or help explain this work."
> Secondary Science Teacher, NSW.

ICTs have the potential to bring to the classroom many experiences that would normally be prohibitive. Science activities that are too dangerous, or require expensive equipment can be simulated using ICTs to provide students with experiences otherwise unavailable. It is this widening of experiential opportunity, rather than the replacement of effective hands-on activities, that increases the educational valency of the science classroom. Through strategic integration, ICTs have the potential to heighten students' engagement with the domain and to increase active involvement across the science curriculum.

2.2.2 Authenticity

Traditional education is often criticised for its lack of relevance to learners' real needs (Lave, 1988; Collins, Brown and Newman, 1989). In such contexts knowledge is often decontextualised and abstract, with little relevance beyond purely educational applications (Säljö & Wynham, 1993). Science education has faced a particular challenge in this area, as much practical science cannot be effectively practiced in the classroom. A significant body of science, particularly in the higher grades, involves activities that are too dangerous, or too expensive to situate in the classroom. In such cases there is little recourse but to explore these activities through more theoretical and abstract approaches.

ICTs have provided the opportunity to broaden students' experiential learning by modelling or simulating challenging concepts and activities. The best of these provide authentic virtual contexts in which the learner can anchor their learning to a better understanding of real-world applications and relationships. In doing this, ICTs extend the physical limitations of the science classroom into the virtual and situate students in experiences normally only available to small numbers of privileged science practitioners.

In the evaluation of the P.R.I.S.M. 'operating proof of concept', many educators acknowledged this role of the project:

> "You could see and do things that are not possible to do in the classroom. It is a stimulating way to present learning activities."
> Secondary Science Teacher, Victoria.

2.2.3 Catering for individual differences

Learners vary in their approaches to learning and classroom-based education is often constrained in the degree that it can be attentive to the learning needs of the individual. The potential to represent information in multiple ways and to support individual interactions with that information is a powerful attribute of ICTs. Computer software allows the learner flexible and individually controlled interaction, exploration and discovery in semantically rich terrain (Cognition and Technology Group, 1993; Jonassen, 1992).

In addition, educators are becoming increasingly aware that students vary in the type of learning experience that provides maximum individual benefit. Gardner (1993) responds to this awareness with a notion he refers to as 'Multiple Intelligences', which supports the proposition that while some students may learn well from text-based, academic style resources, others may be more responsive to other modes, for example practical hands-on learning. Similarly, some students may adopt an exploratory learning style and be comfortable with this approach, others may require much higher levels of support and guidance.

P.R.I.S.M. has adopted a sound instructional and educational design in the development of its 'operating proof of concept' materials to ensure that flexibility is inherent in its learning materials. Many teachers noted this achievement during the evaluation phase.

> "Differing student needs are catered for."
> "Appears to include a variety of approaches to cater for different needs."

2.3 An Integrated Pedagogical Approach: Content and System

While the potential of ICTs to enhance student learning is well supported by research into areas such as motivation, authenticity and learning styles, the successful adoption of technologies requires more than just principled content. The success of any mediated learning is as dependent on the mediating agent as it is on the learning content. ICTs are powerful mediating tools and their role in learning interactions must be addressed in parallel with content-based developments. The symbiotic relationship between the tools of human activity and the activities for which they are used is fundamental to the socio-historical philosophy initiated by Lev Vygotsky (1978) and developed by educational researchers such as Cole (1993), Lave & Wenger (1989), Wertch (1995), Brown(1994) and many others. Hunter (1994) notes the essential relationship between tools and activity in her statement,

> "In shaping the evolution of the information infrastructure, we are at the same time shaping the future educational system and opportunities for learning."

The acknowledgement that successful development in the area of ICTs and learning requires attention to the infrastructure, the content and the use-in-context of that content, is fundamental to the P.R.I.S.M. project. This initiative has focused systemically on the interrelated aspects of effective technology use within learning contexts and has therefore been as concerned with the development of enabling technologies and effective access to these technologies, as it has on exemplary content and methodologies of development and use. The inter-relatedness between these interactive aspects of P.R.I.S.M. is discussed briefly below.

2.3.1 User Centred (teacher & student)

For too long, learners have been required to adapt to inflexible and contextually insensitive learning materials and technologies. The failure of this authoritative approach to design is well documented and is exemplified by the large body of under-used educational software that has been developed over the past two decades. It is clear that to break this cycle of 'develop and discard', an approach is required that is more attentive to the actual needs of diverse users. This user-centred approach has been adopted in the development of the P.R.I.S.M. 'operating proof of concept'.

Mackenzie (1998) notes that ICTs 'can dramatically modify student performance provided the choice of tool fits the situation and the individual student'. The user-centred approach adopted in P.R.I.S.M. is an integration of curriculum driven learning outcomes, content modules with multiple representations and flexible sequencing, and a system that facilitates context dependent structuring and integration of content. This approach affords both teachers and students a high degree of control of the selection and ordering of content, as well as the ability to embed and extend the content in uniquely appropriate ways.

2.3.2 Collaborative

Socially oriented approaches to learning are recognised in contemporary learning theory as basic to mastery of a knowledge domain. Collaborating with peers and others (including experts in the field), helps students move beyond their current knowledge and into their 'zone of proximal development' where new learning can occur. Brown (1994) notes that ICTs can enhance classroom activities by allowing online social interaction that extends the classroom into real world domains and enhances student understanding through interaction with more knowledgeable people.

The P.R.I.S.M. system provides tools designed to specifically support collaborative learning activities. These have been designed to work in concert with materials delivered over the system and provide students with potential access to other learners, teachers, organisations and domain experts.

2.4 Content Fundamentals

2.4.1 Teaching and Learning Concept

The P.R.I.S.M. 'operating proof of concept' is designed to provide exemplary learning experiences that both challenge and enhance traditional classroom practice and exploit current technologies to engage students in learning experiences that are interactive, authentic, engaging, relevant and accessible. This section outlines the key characteristics of this learning and teaching concept.

2.4.2 Knowledge Objects

P.R.I.S.M. adopts an object-oriented approach to content, designed to support diverse teaching and learning activities rather than dictate modes of usage. Knowledge Objects are content kernels, consisting of one or more files designed to stand alone, or to contribute to a learning sequence created by the developers or constructed by the end user to suit their specific requirements. Objects have relevance to specific curriculum areas but can be re-purposed to suit diverse user contexts.

A learning sequence is an assemblage of knowledge objects and the P.R.I.S.M. 'operating proof of concept' has default learning sequences available for all its content. In the Physics module, for example, the learning sequence immerses learners in a narrative where they need to assemble the stage lighting for a band. The sequence consists of objects dealing with wiring a parallel circuit, wiring a series circuit, putting together a spotlight and selecting appropriate coloured filters and thus covers curriculum content related to electricity and light.

The objects in this sequence are also designed to stand alone so that a teacher, wishing to deal with just one aspect of the Physics module, could select, for example, the object dealing with simple circuits, and either use it alone or sequence it with another object from within the P.R.I.S.M. system (or which they upload to the system for their use). This approach to content affords a high level of flexibility and control for the end user and helps ensure that materials in the system can be effectively integrated into diverse learning contexts.

2.4.3 Flexibility

The flexibility of the P.R.I.S.M. approach to content extends beyond the ability to select, sequence and extend the online materials. An additional design consideration ensures that the online experiences can integrate into offline classroom activities. Experiments, investigations, assessment tasks and assignments, as well as research, presentations and communications have been created to be used in a variety of contexts, both onscreen and offscreen, and to be used across domain areas. This approach helps to maximise the value of expensive computer interactive materials.

2.4.4 Integration

Maximising the usability of online materials is also supported through P.R.I.S.M.'s ability to allow its content to be linked with other online learning materials outside the system. This means that existing valuable online resources can be integrated with those in P.R.I.S.M., maximising re-use of teaching and learning resources. Teachers and students can use the P.R.I.S.M. system to incorporate the best of what they already have with the exemplary materials that reside on the P.R.I.S.M. database.

2.4.5 Authenticity

The science materials developed for the P.R.I.S.M. 'operating proof of concept' have been designed, not to reproduce activities that can easily be carried out in the classroom, but to provide virtual experiences that would be dangerous, costly, difficult or impossible to reproduce. The experiences have been situated in 'real-world' activities to provide an authentic context for the learning. For example, in the geology module students travel down a mineshaft, re-tracing the footsteps of a previous geologist explorer. Whilst searching for treasure, students learn about sedimentary rocks and the formation of fossils. Similarly, in the biology module, students take on the role of a field biologist undertaking research in the Australian rainforest, and are invited to replicate online and offline investigative techniques required.

Providing authenticity has direct benefits in terms of perceptions of relevance and students are much more likely to be motivated to engage in learning experiences that they see as relevant.

2.4.6 Neutrality of learning/teaching paradigm

The P.R.I.S.M. system embodies no particular learning/teaching paradigm and this is an intentional effort to ensure that learning models can be widely represented. For example, knowledge objects in the 'operating proof of concept' vary considerably in their adoption of pedagogical approaches and embody paradigms ranging from behaviourism to information processing, constructivism and social constructivism. This neutrality ensures that learning experiences do not conform to restrictive models and teachers and students are able to choose materials that are relevant to their needs.

Similarly, P.R.I.S.M. does not embody an overarching assessment system, instead allowing integration of materials into assessment processes derived from the specific learning outcomes required in diverse learning contexts. The knowledge-object model supports this process by enabling teachers to construct and integrate learning sequences related to specific learning outcomes.

2.4.7 Scaffolded

As noted above, students vary considerably in the amount of support and guidance they need when interacting with new learning experiences. The materials in P.R.I.S.M. have been designed with integrated supports for self-guided learning, but are equally designed to integrate with a classroom context. The user-centred principles of the system facilitate a high level of teacher control, affording opportunities to employ the resources within a support-context appropriate to the needs of students. Accordingly P.R.I.S.M. materials can be integrated into highly teacher-supported activities, self-supporting peer groups, or can be used by individual students with little or no additional support.

2.4.8 Relationship between developers and producers

Ensuring the veracity and relevance of content during a distributed development process involving collaborating teams requires a sound management and quality assurance model.

The basis for the relationship between developers and producers is on the understanding that pedagogy needs to drive technology, not the inverse, as is so often the case. The methodology requires that content experts work in collaboration with the developer/s to ensure the accuracy of materials and approach.

A methodology to enable this collaboration was developed as part of the P.R.I.S.M. project and has, as its foundation, a central management authority that directs the development (see Figure 1). This executive role entails direction of the content development, adherence to the technological requirements, as well as quality assurance, testing and support. Curriculum Corporation, on behalf of DEET, undertook this role during the development of the P.R.I.S.M. 'operating proof of concept' and was also responsible for the production of guidelines, standards and supporting documentation.

2.4.9 Relationships between key project groups

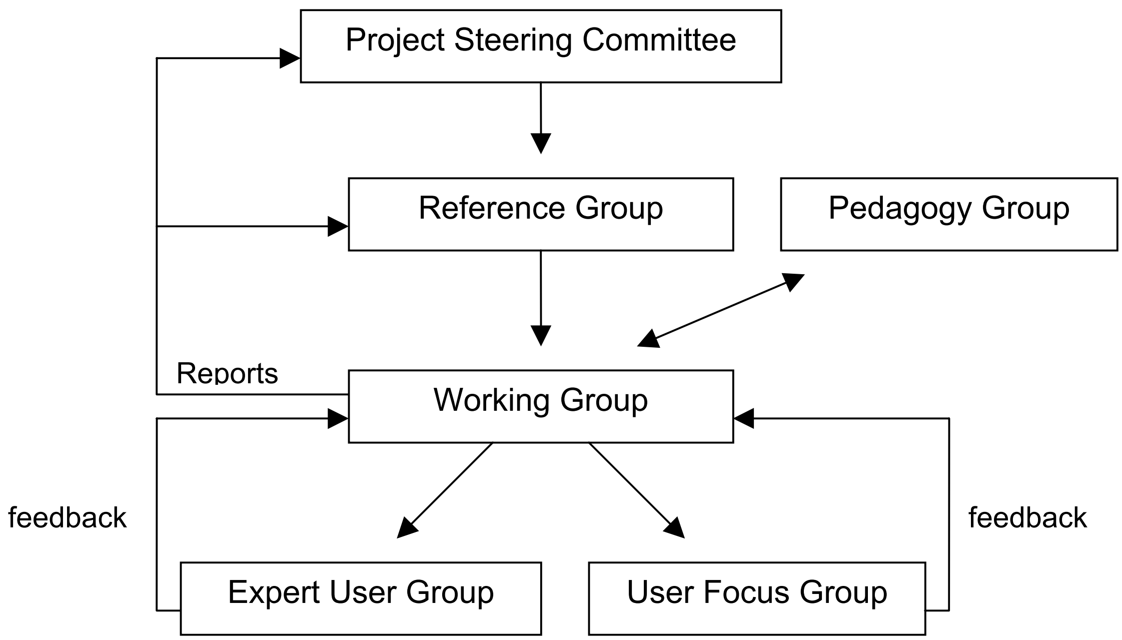

Figure 2. Project Participant Group Relationships

Figure 2 depicts the relationships between the key groups in the P.R.I.S.M. project. A Project Steering Committee, comprised of representatives of Victoria and other participating states, provided overview responses, decisions and advice concerning issues of national applicability. The project Reference Group included representatives from participating organisations, units and sectors with expertise critical to the project. This group reviewed outcomes, and provided advice about project directions. A Pedagogy Focus group investigated, monitored and evaluated the quality of the pedagogical approaches associated with the use of learning and communications technologies. The working group was responsible for the day-to-day management and progress of the project. This group reported progress and findings back to higher-level groups. Expert and target user groups were used to trial materials and feedback to the working group was integrated into the design and development process.

2.4.10 Quality Assurance

P.R.I.S.M. can integrate content from diverse sources and while this is an intentional design aspect of the system it has implications for quality assurance issues. For the development of the 'operating proof of concept' the QA processes that were applied to newly developed content were, in most cases, also utilised for extant content. For example, in the P.R.I.S.M. 'operating proof of concept', the New Zealand Department of Education employed the development specifications to create content for P.R.I.S.M., but also for its own curriculum and delivery needs. It was thus subject to meeting the standards and QA processes and checks.

At the same time, other existing content was modified to meet the requirements of P.R.I.S.M. but wasn't subjected to the same QA processes and therefore didn't necessarily comply to all pedagogically based criteria and guidelines. A recommendation would be that content that is to be contributed to a national initiative must meet technical functional and pedagogically based standard and guidelines and compliance reported within the metadata and or an endorsement rating or system applied.

2.5 System Fundamentals

2.5.1 Integration into Server Environments

The system has been designed using robust, flexible and extensible technologies to integrate with DEETs web server environment. The adoption of pervasive architectures enables the potential migration of the system to other server environments both in the department and across states and territories. This ensures that P.R.I.S.M. content is not wedded to a particular sever environment within a particular organisation and can be re-implemented as required (see section 2.5.6). Content can be downloaded and uploaded into other systems as long as content objects can retain integrity in the relationships between the associated files. The metadata will not move with the objects into another system. This is an area requiring further investigation.

2.5.2 Integration into User Environments

The design of P.R.I.S.M. pays particular attention to the diverse levels of technology available for the end user. Client-side accessibility is assured through an architecture that is platform and browser independent and through content that can be assembled according to educational requirements. A further level of accessibility is attained through the adoption of server-side processing that relieves user sites from the demands of stringent hardware and software compliance.

2.5.3 Support of Knowledge Objects

The object-oriented content model outlined in section 2.4.2 is supported by the P.R.I.S.M. system that integrates a backend database with a robust data-tagging protocol and effective mechanisms for finding and assembling content. The files that constitute an object are associated by the system in three ways:

- a database reference in the user space;
- a zip file that can be downloaded; and
- a unique folder in the public domain.

Knowledge Objects can be uploaded or downloaded into other systems, providing a compatible file structure exists. To ensure maximum interoperability, the content within P.R.I.S.M. has been constructed with a flat file structure. This provides the most flexible approach to system content organisation and is compatible with most wide-scale learning technology implementations (e.g. WebCT). Further considerations will determine if this approach continues to be the most effective and a major consideration for a nationally distributed system.

2.5.4 Neutrality

The P.R.I.S.M. system is independent from the materials it delivers in terms of pedagogy and teaching and learning methodologies. Materials embodying diverse pedagogical approaches can be equally included in the system, which does not discriminate between them.

2.5.5 Flexibility

The centralised database structure of P.R.I.S.M. ensures effective management of content at a high level. However, the system also provides for on-site management of content once downloaded, enabling educational organisations to make effective use of their local area networks. Once content is downloaded, the system tracks and manages its use to the client and protects IP and copyright via a robust rights management system (see section 2.5.7).

2.5.6 Discoverability

The P.R.I.S.M. 'operating proof of concept' has incorporated a metadata tagging methodology to ensure that materials can be effectively discovered. The system stores metadata within database fields associated with knowledge objects and sequences of objects. Whilst this is a robust system, it has limitations with regards to the accessibility of this metadata to outside search engines, and the binding of this metadata to objects once removed from the system. These and other issues related to metadata tagging will need to be explored in subsequent implementations of the system.

2.5.7 Metadata

P.R.I.S.M. adopted the preferred metadata standard for the Department of Education, Employment and Training, Victoria. This was a draft standard at the time of development but incorporated EdNA and Dublin Core elements. Metadata was applied to objects as they were created within the P.R.I.S.M. environment. Controlled vocabularies were provided for the following elements:

- Type
- Format
- Size
- User level/Audience
- Learning Area
- *Substrand
- *CSF level
- *CSF code

*These sub elements are specific to DEET, Victoria.

Other elements in P.R.I.S.M. included:

- Resource types: e.g. assignment, experiment
- Pedagogical approaches: e.g. cognitive, modelling
- Skills & processes: e.g. techniques

These were included in the 'operating proof of concept' to extend the metadata, enabling discoverability of content in relation to pedagogical processes applied to learning sequences and activities, and ultimately for the purpose of providing some intuitive professional development. These elements were not described for learning objects without an explicit learning context within their instructional design. For example, a standalone image file or interactive exploring scientific concepts such as the process of photosynthesis. Thus, the teaching and learning strategy and or methodology applied to the instructional design are highlighted, rather than the actual content within the resource. It is intended that content objects could be used within a professional development activity to demonstrate approaches and strategies to enhance teaching and learning. Users could potentially apply this to the construction of their own learning sequences and activities.

2.5.8 IP Tracking

Intellectual property rights for content specifically commissioned for the P.R.I.S.M. 'operating proof of concept' were contractually assigned to DEET. However, extant content included in the system was sourced from a wide range of organisations and was thus bound by the specific intellectual property arrangements struck with those organisations. The flexibility of the system to share content with other state and territory systems, provides unique flexibility but raises issues of ensuring intellectual property rights and economic responsibility to the owners of content.

In response to this, the P.R.I.S.M. system has implemented the following to address this important issue:

- system users are authorised on the basis of registration with EduMail domain or similar authentication system;
- the system tracks content usage by counting object placement in a specific user download area;
- content is tagged with intellectual property metadata; and
- the system ensures the integrity of content objects and object sequences.

While these measures help to guard property rights at a high level, other issues are raised by the flexibility of the system to be contextually responsive and an effective teaching/learning resource. For example, the system allows content to be downloaded to local area networks and also allows the enhancement and extension of content through the integrated publishing tools. Similarly, users of the system may upload their own learning content and may, within that content, embed links to websites outside the P.R.I.S.M. system. These and other issues raise longer-term considerations of effective controls in the area of intellectual property rights.

3 Project Management Model

In addition to developing responses to the content and system requirements for exemplary science learning materials, the project trialled methodologies for effective project management for the development of such materials. The project employed a tiered management model (see Figure 1) designed to ensure an effective production flow, as well as directing content development and ensuring the quality and integrity of that content.

During the P.R.I.S.M. 'operating proof of concept' development, Curriculum Corporation occupied the position of high-level management and in this role was responsible for the following:

Identification of priority development areas

To ensure the maximum return on investment, production was intentionally focused on priority content areas.

Curriculum fit

Within the priority content areas, the managing body ensured that content was appropriately designed to address learning needs dictated by the curriculum framework of Victoria, but also relevant to curriculum frameworks nationally.

Selection of appropriate developers

Content developers were selected through a competitive tender process and commissions were awarded based on demonstrable expertise, prior experience, ability to deliver within the timeframe and, importantly, ability to work with education specialists and users.

Provision of effective development guidelines and educational principles

To support commissioned providers, Curriculum Corporation produced development documentation that outlined content as well as technical guidelines. Guiding educational principles were also articulated through documentation as well as during face to face sessions.

Iterative development feedback

During production, an iterative feedback loop was established between providers, the management authority and users, to ensure continuing adherence to guidelines and to ensure content remained focused on curriculum-determined needs.

QA and version control

Quality assurance procedures were implemented and carried out by Curriculum Corporation throughout development to ensure that end of cycle products required no time-consuming and costly re-development to meet compliance.

Focus group testing

Prior to release, all commissioned products were subject to testing by expert and user focus groups, to confirm the validity of content and its adherence to curriculum-driven goals.

User testing and reporting

Final phase production involved broad-spectrum user testing, data collection and analysis. Testing was carried out in representative user contexts and involved structured and unstructured feedback procedures. Results of the user testing informed necessary modifications to products and generated knowledge to guide further development. The results of this process were published in a series of reports.

Post-production management of materials is controlled by integrated functionalities within the system that track use of materials for IP compliance. The management methodology adopted through the P.R.I.S.M. 'operating proof of concept' has shown potential in providing sustainable mechanisms to ensure quality content is delivered into Australian schools.

4 Evaluation

A national consultation and evaluation process followed the implementation of the P.R.I.S.M. system, involving all states and territories in Australia, as well as the New Zealand Department of Education. The aim of the research was to determine the applicability of the content in the 'operating proof of concept' to curriculum frameworks, as well as to evaluate the integration of the P.R.I.S.M. system with existing state and territory online systems. More specific data was also collected on teachers' and students' responses to the system and the content, including such factors as instructional design, ease of use, appeal and flexibility of the content.

The evaluation process involved participants in an introductory presentation of the 'operating proof of concept' followed by a workshop session. Workshops focused either on an evaluation of the online science content, or an evaluation of the P.R.I.S.M. system. Data was collected formally, through the use of structured questionnaire instruments, and informally, through discussions and observations.

The evaluation revealed a high level of teacher and student enthusiasm for the project, with responses being thoughtful, critical, but overwhelmingly positive. In particular, participants acknowledged:

- the flexibility of the system to address context-dependent learning needs;
- the advantages of the customisable nature of the system and content; and
- the benefits of the communication and work-flow tools in enhancing learning interactions and aiding effective tracking.

The majority of participants also responded positively to the design and content of the integrated learning sequences.

4.1 Distance Education Evaluation

As part of the evaluation process, the P.R.I.S.M. 'operating proof of concept' was also trialled in distance education settings. All teachers involved in the trials could appreciate the applicability of the system to the challenges of distance education and found the learning materials to be highly useful. Teacher comments are exemplified by the following:

> "This site has tremendous potential for distance educators."
> "This is a very valuable resource. I think it is great."
> "The idea of P.R.I.S.M. is excellent."

Some difficulties were also noted with the use of the system, and these will be further investigated. For example:

> "Download times were slow for images and animations."
> "I found the search and browse facilities unhelpful."

4.2 Issues for Further Consideration

Following the trialling and evaluation, a number of issues raised by participants warrant further exploration in the pursuit of providing an exemplary online teaching and learning resource. In particular, many participants indicated that a program of professional development would enhance their ability to exploit the system to its full potential.

> "This has great application for teaching and would need intensive in-service for staff to get the most out of it."
> (Teacher, South Australia)

Some teachers also had concerns over the suitability of specific content modules to target users, the depth of content in those modules, and the veracity of assumptions about students' prior knowledge to cope with learning interactions.

> "There are assumptions made about the level of my students' background knowledge that does not reflect my students' experiences." (Teacher, Victoria)

Some issues were also raised about the technology itself, with teachers being concerned about bandwidth constraints, the need for additional software plugins to view aspects of the content, access to the internet for distance education students and the difficulty less-technically-literate users have in understanding the functionality and navigation of the system.

> "The use of software such as Acrobat required students to have a level of technology expertise that many of them did not have."
> (Teacher, Victoria)

4.3 Key Findings

The overwhelmingly supportive response to the P.R.I.S.M. 'operating proof of concept' has clearly demonstrated that:

- effective and accessible technologies delivering principled content can enhance the learning and teaching experience;
- educators welcome the inclusion of such technologies into their educational contexts;
- content can be developed and delivered in flexible ways to allow effective integration into diverse learning contexts;
- an object-oriented approach to content supports and enables this flexibility to occur;
- a tiered management model, with an executive role performed by an educational organisation such as Curriculum Corporation, can ensure high quality, targeted content, cost-effective processes, adherence to time lines and sound educational design; and
- user-centred design provides control over the use of the content in diverse ways to suit student learning needs.

5 Conclusion

The P.R.I.S.M. 'operating proof of concept' has proved invaluable in assisting with the identification and resolution of relevant issues associated with the establishment of a national collaborative initiative to develop and deliver online content into Australian schools. The project has effectively developed and trialled management methodologies, content development strategies, an effective and flexible delivery mechanism, quality assurance processes and intellectual property rights management.

The P.R.I.S.M. project firmly anchored its development on the needs of its end users. It has exploited technology to enhance students' learning while affording teachers high levels of control over both the content and the manner in which it is integrated into their classrooms. Such a user-centred approach is essential if the key people involved in education, the teachers and the students, are to be empowered to enhance their knowledge-building endeavours.

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