Field Review of the Schools Online Curriculum Content Initiative

Report of Stage 1

The Le@rning Federation Pilot Field Review

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Introduction

The goal of The Le@rning Federation Schools Online Curriculum Content Initiative is to ensure students from Australia and New Zealand maximise the educational opportunities made possible by online technology. The Le@rning Federation has adopted a ‘learning objects model’ approach to the development of interactive multimedia computer-based resources. The potential economic advantage of learning objects is that they can be disaggregated and re-sequenced for different educational purposes.

The Le@rning Federation was initially commissioned to develop, over five years, learning objects in the following priority curriculum areas:

- Science from K–P to year 6 and for years 9–10
- Mathematics and numeracy from K–P to year 9
- Literacy for students at risk in years 5–8
- Studies of Australia from K–P to year 10
- Innovation, enterprise and creativity from K–P to year 10
- Languages other than English (Chinese, Japanese and Indonesian) from K–P to year 10.

Terms of reference

A Field Review project was initiated by The Le@rning Federation as one of a number of research studies to evaluate the impact, application and effectiveness of the online digital content developed for classroom teaching and learning. This report concerns Stage 1 of the Field Review – a pilot research study to:

- evaluate the pedagogical application of the learning object model and the online digital content developed by The Le@rning Federation at systemic, school and teacher levels
- identify the key components that impact on the application and effectiveness of the learning object model and online digital content, including:
  - curriculum provision
  - pedagogy
  - resourcing
  - professional development
- design the specifications for a longer-term research study.

The Centre for Learning, Change and Development at Murdoch University was contracted to carry out the pilot Field Review. This report concentrates on the first two terms of reference. A further report will focus on the longer-term research study.

Data collection

A case study methodology was adopted for the study. A pre-pilot study was conducted in four schools in Perth to explore the most effective data collection methods for the full pilot study and to validate the evaluation instruments. The full pilot Field Review involved case studies of 20 classrooms in 14 schools in Australia and New Zealand. The Le@rning Federation planned to select schools in order to provide researchers with access to a desirable age, geographic, socio-economic, educational and cultural demographic according to the needs of the study. In practice, the demographic mix was relatively broad, but student numbers in some groups were small. Some teachers were not sufficiently familiar with learning objects to be able to fully integrate them into lessons. In the next phase it is likely that, with appropriate professional development, this problem will be overcome.

The four main data collection activities were student observation, student interviews, student surveys and teacher interviews and observation. Data were analysed using three different methods: the production of field notes generated by individual researchers, a NUD*IST qualitative data analysis of field notes and student and teacher interview transcripts, and a Rasch analysis of student surveys.

Results

Usefulness to teachers

Overall, teachers were very enthusiastic about the potential of learning objects to introduce a wider variety of learning activities into the classroom. Among other reasons, they believed that learning objects allowed them to conduct lessons that would otherwise be dangerous or beyond the scope of existing school infrastructure or budgets. Teachers gave examples of Science experiments needing chemicals or materials they would be reluctant to use with students. Teachers also felt that the simulation aspect of many learning objects increased the viability of time-dependent activities such as science experiments requiring a number of days or weeks to complete.

Teachers also appreciated the variety of geographical locations learning objects made available. This allowed them to introduce students to environments they would be unable to experience in the local area. Teachers were able to frame lessons innovatively, using the learning objects as a springboard from which to engage students in other program activities.

Learning objects that demonstrate sensory experiences outside the range of normal activities were very popular among teachers. These included objects that enabled students to investigate plant systems or functions of the human body.

Impact on teaching

The study reconfirms previous findings that suggest that teachers' beliefs about teaching and learning influence their choice and use of learning objects. In practice, researchers found that while teachers were eager to exploit learning opportunities offered by learning objects, some teachers replicated acceptable, inexpensive classroom activities.

Teachers believed their teaching benefited from the introduction of learning objects. Some teachers found that learning objects presented new ways for them to view the curriculum or led them to appreciate a wider variety of learning perspectives. Often the use of learning objects prompted them to reconsider their assumptions about teaching and learning.

Learning objects were intellectually stimulating for teachers. They reinvigorated teachers and introduced challenges. In some cases teachers overcame initial fears of using information and communications technology when they were exposed to learning objects and realised the positive impact objects could have on their teaching. There was evidence of a 'trickle down' effect as enthusiasm was passed from teachers to students, and to other teachers.

In keeping with this, teachers indicated they wanted more learning objects from which to choose. They expressed a need for reliable online resources that were easy to sort through, select and download. They expressed a need for resources that extended and supported their knowledge of curriculum areas, and would in turn bolster their confidence in the classroom.

Teachers were quick to identify the strengths of learning objects, and they developed teaching strategies to capitalise on these. Teachers recognised that learning objects had the potential to:

- cater for a range of cognitive abilities
- allow for individual progression
- provide new opportunities for collaborative learning
- match students' cognitive capabilities
- assist in providing links between concepts and contexts
- provide scaffolding and reinforcement.

Further development

It is important that learning objects continue to be developed and used with these strengths in mind. Some teachers used learning objects whose concepts or graphics were ill-suited for the cognitive abilities of their students. This led to learning objects failing to meet the learning needs of students.

Because the study found evidence that some teachers were choosing to use learning objects as pivotal teaching resources, content accuracy and integrity are very important. Some factual inaccuracies were detected in a small number of learning objects in the first round of Science development carried out by The Le@rning Federation. Researchers also found instances where learning objects failed to provide timely and meaningful performance feedback to students, thus reducing their effectiveness in supporting learning, also primarily observed in the first round of development. Details about these issues have been communicated to The Le@rning Federation.

Support

Teachers felt more professional support was needed to maximise their use of learning objects for effective student learning. This need was confirmed in the case studies, where the researchers observed instances of learning objects not being used adequately.

Usefulness to students

Engagement

Learning objects were found to have a variety of benefits for students. Students in general appreciated the different approach to learning offered by the learning objects and found them engaging and motivating. Teachers reported increased levels of concentration, enthusiasm and successful learning when students used the learning objects.

Learning objects engaged students resistant to traditional classroom approaches or those with low levels of academic performance. In the case studies, disruptive students were observed participating actively in learning object lessons and withdrawn students were observed purposefully investigating activities. Students were motivated in their use of learning objects when the learning objects

- were challenging
- allowed them to explore
- gave them control
- allowed them to collaborate with each other.

Student choice and control

Researchers observed students interacting with learning objects in a non-sequential manner. Many students preferred learning objects that facilitated this approach and enjoyed the levels of choice and control they provided.

Students enjoyed being able to regulate the pace of their learning. They were able to take time to investigate concepts they found difficult in class or to repeat activities as they chose. They also enjoyed selecting their own multiplication problems or setting the variables in Science experiments.

The study found that students were able to use learning objects appropriately. Students found most interfaces easy to navigate and pleasing to look at. Factors that diminished student engagement, thereby reducing learning impact, were also identified.

Use of text

Students did not like reading large sections of text and were less inclined to make appropriate use of learning objects containing text-heavy instruction pages. Students generally preferred to skip instructions and experiment with the learning object. Some were unable to read the instructions or became confused by them, struggling with the text rather than the concepts. Students with weak literacy skills were sometimes better able to engage in learning because some learning objects gave them non-textual ways of interacting with the concepts.

Game format

Students liked to see immediate feedback on their input and appreciated learning objects that gauged their success or progress. Learning objects designed as games with a clear goal or reward were found to maintain high levels of interest.

In some cases student strategies circumvented the work intended to lead to the learning and students were inappropriately rewarded by accelerated completion of the learning object. It is important that learning objects are designed so that students can succeed in games only by applying the intended learning.

Addressing student diversity

The case study approach enabled the investigation of ways that students of different abilities and backgrounds used learning objects. Teachers in the study were interested in providing learning objects to gifted or talented students because they considered the learning objects would effectively challenge the students' ability and extend the scope of their lessons.

Learning objects were also found to benefit lower achieving students for a number of reasons. They provided these students with motivation to engage in activities and anonymity when providing answers or input. Students who might be too embarrassed to participate frequently in class for fear of ridicule or failure were observed to persist when attempting learning objects. The learning objects created an opportunity for students to attempt learning activities in a non-judgemental environment.

Learning objects also provided lower-achieving students with alternative ways to succeed. Students could tackle activities involving experiment and strategy despite being unable to engage with the text or fact-based aspects of the learning object. They were also able to produce high-quality work in cases where writing or drawing on paper proved time-consuming and difficult.

Students were comfortable using the 'help' or 'hint' features of the learning objects. These provided timely advice without the student having to wait for the teacher's attention. The ability of learning objects to respond individually and patiently to student needs was found to have a significant impact on student enjoyment of curriculum areas.

Students from non-English-speaking backgrounds were found to use the learning objects as easily as did other students, although they tended to avoid reading lengthy sections of text. They were able to navigate around learning objects using visual clues and intuitive logic. Teachers felt that learning objects with more audio content would particularly benefit these students, and others with weak literacy skills.

For many of the above reasons, teachers were enthusiastic about the ability of learning objects to cater for different cultural modes of learning or individual styles of learning. Visual learners were provided with new and stimulating ways to learn. Graphics and animation contributed to this and enabled the demonstration of abstract concepts generally found difficult to teach.

Exploiting the potential of learning objects

Learning objects can exploit the entertainment potential of computer or arcade games and provide structured learning activities that offer different levels of difficulty and enable manipulation of variables to accommodate students with a variety of skills, knowledge and learning styles. They can also provide complexity and surprise. Elements of the unexpected were found to motivate students to engage with the learning object more thoroughly and for a longer period of time.

Both students and teachers preferred to perform activities using real materials rather than computer simulations. Learning objects, therefore, need to exploit the ability to provide students with novel content and learning situations beyond the scope of the classroom.

Multimedia elements

Comfort and familiarity with multimedia elements and conventions influenced how well learning objects were used. Not all students understood how to follow links to 'help' areas. Students were more likely to follow graphical cues and avoid reading. Students, especially the literacy-challenged, particularly liked the use of sound to alert, add effect and provide assistance. They responded with varied success to visual complexity. This meant that some helpful features of learning objects were overlooked by students until they were pointed out by the teacher.

Students were particularly receptive to animation and cartoons, preferring them to photographs or video clips shown in small windows. Animation and cartoons were also useful from an educator's point of view as they allow simple, pertinent graphics and can provide a focus for learning. Accuracy and clarity of graphics and animations are critical. Researchers found students had difficulty providing appropriate input when they were confused about what the graphics were demonstrating. This significantly undermines the value of a learning object.

The ability of multimedia to accept student input and provide feedback is a key benefit of learning objects. Input and feedback must be meaningful and function well. Students experienced difficulties using the 'Predict–Observe–Explain' (POE) model in some learning objects. This was due to the way the model was structured, the level of preparation of the students by the teacher and the content of the particular learning objects.

The highly structured nature of the POE learning objects suggests they can be used as stand-alone resources. However, observation in the case-study schools indicated that they were unlikely to be used effectively without being contextualised, explained and monitored by the teacher.

Student learning outcomes

The study uncovered preliminary evidence regarding student learning outcomes. A future study at a time when teachers are at ease with the use of learning objects as key resources should be undertaken to investigate this issue further.

Evidence of learning, specifically student perceptions of learning, was obtained. Researchers observed instances of students expressing satisfaction with a lesson or concept after using a learning object. Students felt in some cases that learning objects had successfully demonstrated concepts they had difficulty with, or helped them relate generalised knowledge to their concrete experiences of the world.

Researchers found many instances of students using learning objects to reinforce classroom learning and consolidate their knowledge. Evidence was also found suggesting knowledge learnt through learning objects initiated positive behaviour changes in some students (in terms of nutrition choices, for example).

School and system-level issues

The ability of the teacher and student to access the objects depends on the technical infrastructure and the skills of the individual teacher or student. The pilot study found a wide variety in terms of computing facilities, technical support and policies for using technology within schools. There was also a wide range of levels of teacher competence and confidence with using the available technology and the learning objects. Without appropriate facilities and both technical and operational support, uptake of the learning object model is uncertain, and is likely to be limited.

Teachers are aware that they must plan learning experiences that match the differing competencies of their students. Many teachers, however, are not familiar with how learning objects can make demands on students' literacy, memory and cognitive abilities. A mismatch in any area will result in a less successful learning experience for the student. Teachers need to understand this for both selection and use of learning objects.

Professional development of teachers in selecting, structuring, implementing and monitoring the use of learning objects must be a priority if the full potential of learning objects in the classroom is to be achieved. Teachers have expressed a preference for ongoing support rather than one-off sessions. The development of communities of practice is one means to achieve this. Coupled with this is the need for others within schools to be familiar with the requirements for successful use of learning objects. This includes both technical support and administrators. Professional development is appropriate for these groups as well.

Conclusions and key recommendations

The design of learning objects and their introduction into the classroom is an initiative in its early stages of development. The evidence obtained in this study has led to the identification of several areas where some improvement is required. The Le@rning Federation has indicated that it has addressed the areas that were identified in draft versions of this report, and those identified through its own quality assurance procedures.

Despite some teething problems, this pilot Field Review has demonstrated that learning objects have a valuable role to play in the classroom. Both students and teachers find learning objects useful and effective for learning. Students are enthusiastic about the motivational and educational potential of learning objects. Given the right conditions, learning objects can lead to improved and different learning outcomes.

Students

Students are open to, and interested in, computer-based learning, and there is evidence that students with a range of abilities can achieve success through this medium.

The Le@rning Federation should continue to realise the potential of learning through multimedia.

Teachers

In most cases, learning objects need to be incorporated into meaningful classroom learning activities to be effective. Teachers also need encouragement to adopt learning objects.

When introducing learning objects into classroom lessons, teachers need guidance to optimise the impact on student learning outcomes. This integral aspect of the initiative is necessary to ensure long-term, effective use of learning objects.

Schools and systems

The Le@rning Federation should develop learning objects and infrastructure to support central storage, retrieval and distribution of learning objects to the school systems and sectors.

Appropriate technical and system infrastructure should be identified and established at system and school levels to expedite the uptake of learning objects in schools.

A substantial and sustained support program should be provided for teachers, school administrators and support staff to develop awareness of learning objects, to encourage and facilitate uptake and to support development of skills and strategies in their use.

The Le@rning Federation

The Le@rning Federation should continue to build a resource bank of learning objects in the targeted curriculum areas at a range of levels.

The Le@rning Federation should continue to improve its educational design, content procurement and quality assurance processes, informed by the results of this pilot Field Review.

The Le@rning Federation should proceed with research to investigate the educational soundness of learning objects embedded in classroom practice.

Government	**The Le@rning Federation Schools Online Curriculum Content Initiative should continue to be funded and evaluated.**

Chapter 1 Introduction

In January 2001, the Prime Minister of Australia announced, as part of the Backing Australia's Ability package, $34.1 million over five years to:

- develop a body of high-quality curriculum content, suitable for each State and Territory
- develop a framework that supports distributed access
- over the long term, use the framework and content to stimulate further contribution to the pool of material.

In July 2001, all Australian States and Territories agreed to match Australian Government funds and establish The Le@rning Federation. New Zealand has subsequently joined the initiative. The Le@rning Federation is owned and funded by these stakeholders and managed as a joint venture by Curriculum Corporation and education.au limited (more detail about The Le@rning Federation's organisation and goals is available at http://www.thelearningfederation.edu.au). The goal of the Le@rning Federation Schools Online Curriculum Content Initiative is to collaboratively develop, and provide Australian and New Zealand schools with, a continuing supply of high-quality digital resources through a series of projects.

The Le@rning Federation has adopted a 'learning objects model' approach to design and construct digital content. A learning object:

- is one or more files or 'chunks' of material, which might consist of graphics, text, audio, animation, calculator or interactive notebook, designed to be used as a stand-alone learning experience
- is reusable – a single learning object may be used in multiple contexts for multiple purposes such as across curriculum areas, year levels, different locales and cultures
- can be used as a component of a topic or unit of work alongside other digital and non-digital resources and tools
- is accessible from the World Wide Web and is referenced, located and accessed by its metadata descriptors
- can be identified, stored and tracked using a content or learning management system.

The Le@rning Federation initiated a Field Review project as the start of a long-term research study to evaluate the impact, application and effectiveness of the online digital content developed according to the learning object model. Stage 1 was a pilot research study intended to:

- evaluate the pedagogical application of the learning object model and the online digital content developed by the Le@rning Federation at systemic, school and teacher levels
- identify the key components that impact on the application and effectiveness of the learning object model and online digital content, including:
  - curriculum provision
  - pedagogy
  - resourcing
  - professional development
- inform the design and specifications for a longer-term research study.

The pilot Field Review was contracted to the Centre for Learning, Change and Development at Murdoch University, commencing in March 2003 and finishing in February 2004. This document is the final report of the pilot Field Review.

The report is divided into five chapters. An overview of the Schools Online Curriculum Content Initiative is provided in Chapter 2. Chapter 3 describes the planning of the pilot Field Review, its rationale, program logic and key research questions, as well as the methodology employed.

Chapter 4 provides a description of the context of the first year of the pilot Field Review and an analysis of the classrooms and learning objects investigated in the pilot study. The findings of the pilot study are presented in Chapter 5 under four research themes, distinguished where possible by more specific research questions.

Chapter 6 provides a discussion of results of the broad research questions, including an overview of learning objects as pedagogical tools. The final chapter of the report draws conclusions, and makes recommendations for future directions for the Schools Online Curriculum Content Initiative. Background information is provided in three appendices.

Chapter 2 Description of the Schools Online Curriculum Content Initiative

The Le@rning Federation commissioned learning object content development in each of the following priority curriculum areas:

- Science from K–P to year 6 and for years 9–10
- Mathematics and numeracy from K–P to year 9
- Literacy for students at risk in years 5–9
- Studies of Australia from K–P to year 10
- Innovation, enterprise and creativity from K–P to year 10
- Languages other than English (Chinese, Japanese and Indonesian) from K–P to year 10.

At the time of writing, 66 Science learning objects, 46 Literacy-at-risk learning objects and 20 Mathematics and numeracy learning objects had been 'released' for general use by The Le@rning Federation. Many more learning objects are in various stages of development.

The Le@rning Federation developed an 'educational soundness specification' to inform the design and quality assurance of learning objects. This specification encompassed four guiding principles: Learner focus; Integrity; Usability; and Accessibility. Development specifications regarding content, technical requirements, accessibility, rights management and metadata are published on The Le@rning Federation website. Comprehensive project management and quality assurance frameworks are in place.

The development process is informed by *curriculum area reference groups* and *expert focus groups*. The first of these groups consists of representatives from education systems who are expert in their area. They oversee the development of a broad scoping brief for each content area.

Expert focus groups assist the development process on a more detailed level. These groups are made up of practising teachers who provide feedback on specific learning object content. This informs the work done by design teams, which include education experts, multimedia developers, instructional designers and technical experts.

The pilot Field Review process was overseen by a Field Review Reference Group consisting of:

Claire Murray, Manager, Strategy & Policy, The Le@rning Federation
Di Kerr, Curriculum Advisor, The Le@rning Federation
Margery Hornibrook, (Chair) Manager, Communications, The Le@rning Federation
Susan Atkins, Manager, Educational Design & Quality Assurance, The Le@rning Federation
Bridie Raban, Professor of Early Childhood, University of Melbourne

Once released, online digital content in the form of learning objects is posted to the Schools Online Curriculum Content Initiative's Exchange website. It is then deployed to the education systems in each country who decide how it will be used.

The Exchange is a system specifically designed as a repository of quality-assured learning content for the Australian education sector. This system supports the full digital life cycle of learning objects, from creation to use and reuse. The Exchange is designed to provide solutions to the following:

- Content creation and procurement: streamlining and creating efficiencies in content creation and processes. This includes supporting various types of learning content and descriptive metadata schemes, reusing and extending existing content, and quality assured workflow of the content.

- Content distribution management: managing and enabling the distribution of content. This includes interfacing with the education jurisdictions, enabling content discovery and trading, and managing and tracking the digital rights of traded content.
- Content usage: managing the usage of content distributed from the Exchange, including importing learning objects into downstream learning content management systems. These are operated by school sector agencies and assist teachers in generating tailored learning experiences for students.

A core principle of the Exchange is to adhere to and support open industry standards throughout the life cycle phases of the resources. The Exchange will therefore provide 'back-end' services to education jurisdictions in obtaining, managing and distributing learning content. A demonstration product, the Basic E-Learning Tool Set (BELTS), has been developed to assist education jurisdictions to understand the services they need to provide.

BELTS is an open-source demonstrator application. The main objective of the application is to provide early access to digital learning objects. This enables education jurisdictions to gain knowledge in the management and use of digital learning objects early in the development process. BELTS has been developed to demonstrate two major functions: content management and distribution, and content use. Content management and distribution includes the ability to receive, store, update and distribute learning objects. The usage functions include the ability to find and sequence learning objects into an activity, to control access to that activity and to download learning objects to a user's desktop. The open-source nature of BELTS will enable jurisdictions to develop the product to suit their own needs.

The technical specifications and quality assurance framework established by The Le@rning Federation were designed to ensure that learning objects function as intended. This pilot Field Review is primarily concerned with the way in which teachers and students use the learning objects. The emphasis in this report, therefore, is on the educational use of learning objects as a resource in the classroom, how teachers are using them and could use them to improve their teaching.

The overall purpose of the Field Review is to conduct a long-term research study to evaluate the impact, application and effectiveness of the learning object model and of the on-line digital content developed by The Le@rning Federation, in a range of classroom environments over time.
The study will

- evaluate the pedagogical application of the learning object model and the on-line digital content developed by The Le@rning Federation at systemic, school and teacher levels
- identify the key components that impact on the application and effectiveness of the learning objects model and of the on-line digital content developed by The Le@rning Federation. These may include
  - curriculum provision
  - pedagogy
  - resourcing
  - professional development.

It is intended that the research will be carried out in several stages. The first stage involves designing and carrying out a pilot research study. Subsequent stages in the project will be undertaken if the pilot demonstrates the feasibility and usefulness of doing so.

Chapter 3 The pilot Field Review

3.1 Background to the evaluation

The managers of a program such as the Schools Online Curriculum Content Initiative have a range of decisions or judgements to make at different stages in the development and implementation of the program. Evaluation can therefore have different purposes. Owen and Rogers (1999) have provided a framework for understanding these purposes by identifying five categories or forms or evaluation:

- Proactive
- Clarificative
- Interactive
- Monitoring
- Impact.

Proactive evaluation is conducted before a program is designed, to assist planners to make decisions about what type of program is needed.

Clarificative evaluation concentrates on clarifying the internal structure and functioning of a program or policy. The need for this type of evaluation arises when a program has not been fully specified or described, even though it may be in operation, or where there is confusion about how the program should be implemented.

Interactive evaluation provides information about the delivery or implementation of a program or about selected components of the program. This type of evaluation is usually directed to middle-level managers and program implementers and is concerned with helping staff understand how and why the program operates the way it does and how it could be improved.

Monitoring evaluation is appropriate for well-established and ongoing programs and may involve the development of a system of regular monitoring. This type of evaluation provides managers with a picture of the actual operation of the program, including expenditure. It often addresses issues of efficiency rather than effectiveness.

Impact evaluation is used to assess the impact of a settled program. Impact evaluations focus on the attainment of specified objectives and may determine the level of performance according to outcome indicators, or by examining intended and unintended outcomes. This information assists with decisions about whether to terminate a program, extend it or adopt the initiative in another area. In essence, these evaluations look at whether the stated goals of the program have been achieved and the needs of the client group addressed.

The value of Owen and Rogers's categories is that proper identification of the purpose and form of evaluation enables the most appropriate focus and design to be developed, thus improving the likelihood that the study will address the most important issues and provide the most useful information.

The Le@rning Federation is a new initiative. Thus, using Owen and Rogers's categories of evaluation, it is clear that the evaluation study is predominantly an interactive evaluation that looks at the implementation of the initiative to inform decision makers about the efficacy of the learning object model (and the associated content).

Further, the evaluation considers the question of *how* the processes are applied, by addressing whether factors such as different learning areas, phases of schooling and school contexts

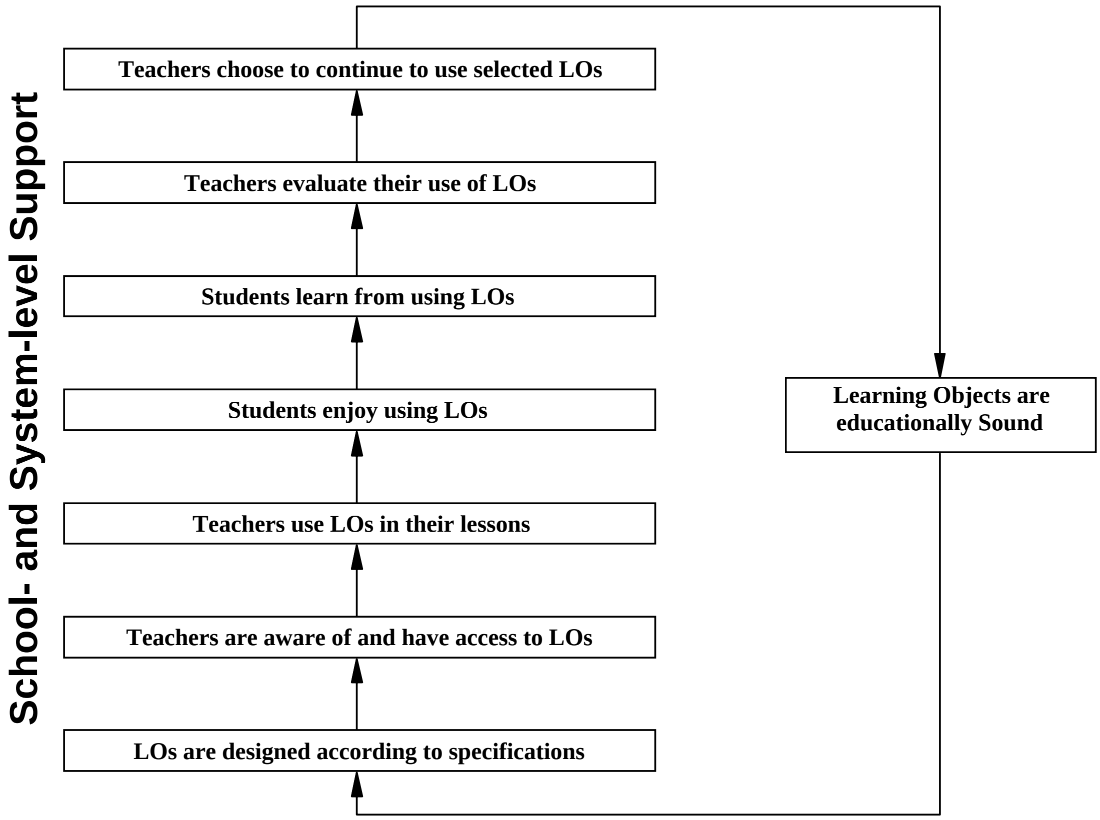


Figure 3.1. Program Logic for the Field Review

impact on the effectiveness of learning objects. As The Le@rning Federation initiative progresses, the evaluation focus will change to monitoring and impact evaluation.

3.2 Context and purposes of the pilot Field Review

It is critical that, when a new program is implemented, stakeholders share an understanding of how the program is intended to operate and what it is trying to achieve. Most programs, including The Le@rning Federation Schools Online Curriculum Content Initiative, produce formal documents describing the program. However, current evaluation practice indicates that many stakeholders and evaluators benefit from a process of developing a clear and agreed understanding of the program. The process of achieving consensus about the actual nature of the program informs stakeholders about the underlying rationale of the initiative. This increases the likelihood of successful program implementation. It is also critical to stakeholders, enabling them to make the best use of the information produced by an evaluation study.

A number of tools have been developed to help evaluators and stakeholders to arrive at a program description. One of the most useful is a Program Logic analysis (a diagrammatic explanation of the program logic approach can be found at http://www1.uwex.edu/ces/pubs/pdf/G3658_1.PDF). An explanation of program logic is provided by Funnell:

> In simple terms, a program logic is a program's theory of action. It is a theory about the causal links among the various components of a program: its resources and activities, its outputs, its short-term impacts and long-term outcomes. Like any other theory, it is testable and should be tested. Making a program's theory of action explicit is the first step towards testing its validity. Program analysis is the process of identifying and making explicit the logic of a program. (Funnell 1997).

A program logic analysis was conducted with the Field Review Reference Group to explore understandings and assumptions about the nature of the learning object model and the pilot Field Review. This included:

- clarifying the evaluation aims
- providing the evaluation team with background information
- identifying documents and data sources
- identifying underlying assumptions
- identifying who should be involved in the evaluation
- assisting the evaluation team in selecting the best opportunities for data collection within the time and budget constraints.

There were two iterations of the Program Logic analysis. In the first iteration the Program Logic and research design explicitly included the four educational soundness criteria (Learner focus, Integrity, Usability and Accessibility). A subsequent review of the Program Logic with two members of the Field Review Reference Group de-emphasised the four criteria.

The Program Logic analysis identified factors required for the success of the Schools Online Curriculum Content Initiative. There are dependencies between factors and these are displayed as a hierarchy in Figure 3.1. Each element in the hierarchy is a necessary condition for the next element.

The Program Logic analysis led to the development of four broad research questions, listed in Table 3.1. These questions are the primary focus of the pilot Field Review. Questions B1 and B2 look at the usefulness of individual learning objects within the classroom. Questions B3 and B4 investigate the use of learning objects in different contexts. Question B3 investigates factors specific to particular schools, whereas question B4 looks at broader, systemic factors.

Table 3.1. Broad research questions for the Field Review

B1	How useful are the learning objects for teachers?
B2	How useful are the learning objects for students?
B3	How do: learning object design geography structures within the school and classroom socio-economic status student diversity interact to affect the ways in which teachers and students use learning objects?
B4	What factors, including school and system level issues, impact on the wider adoption of learning objects?

Further analysis of the Program Logic indicated that it was appropriate to split question B2 into three sub-themes: usefulness to students, student learning process and student learning outcomes.

3.3 Stakeholders and participants in the evaluation study

There are two primary stakeholders for the pilot study. The Le@rning Federation has funded the study and is charged with implementing the Schools Online Curriculum Content Initiative, while the governmental bodies and education systems will make decisions about the use of learning objects in schools. Secondary stakeholders include teachers, curriculum developers and students who use the learning objects.

The primary participants in the study were students using the learning objects and their teachers. These groups were the major source of data for the Field Review. Secondary participants were the researchers, people with expertise in specific curriculum areas who observed students using the learning objects and made judgements about their appropriateness in the context of those areas. The research team included experts in Science education, Mathematics education, Literacy and early-childhood education.

3.4 Evaluation plan

An evaluation plan was devised once the broad research questions were developed and the participants identified. Table 3.2 summarises the plan in a data collection matrix. Details of the methodology were submitted to The Le@rning Federation in July 2003.

The evaluation questions in Table 3.1 are general and further refinement was necessary to develop research questions that are more readily answerable. Accordingly, the evaluation team developed a set of specific questions with advice from the Field Review Reference Group. These are labelled as generic questions in Table 3.2.

The generic questions have been separated into four themes. One is teacher-oriented and three are student-oriented. In terms of the student-oriented themes, for a learning object to be useful to students, they must enjoy using it, but they must also learn from it. A useful characterisation of learning is to distinguish between learning processes (how people learn) and learning outcomes (what people learn). The four themes are, therefore, usefulness to teachers, usefulness to students, student learning process and student learning outcome. These themes were used to structure the Results section of this report.

The broad evaluation question(s) for each theme are shown in column 2 of Table 3.2.

The remaining columns of Table 3.2 indicate which information is expected to provide the most valuable data. Six primary data sources (methods) were planned:

- Student observation
- Student interviews
- Student surveys
- Student focus groups
- Teacher interviews
- Teacher surveys.

These will be described in more detail in later sections. Where possible, multiple sources of data have been identified. This enabled researchers to employ triangulation techniques to strengthen research findings.

The mapping of questions to data sources was a starting point in the development of interview, survey and observation instruments. These data sources and instruments are described in more detail below.

Table 3.2: Data collection matrix

1 Theme	2 Broad question	3 Generic question	Student Observation	 Interview	 Survey	 Focus group	Teacher Interview	 Survey
Usefulness to teachers	B1	Q1. How do teachers select learning objects?					X	X
	B1	Q2. How do teachers incorporate the use of learning objects (LOs) into their teaching?					X	X
	B1	Q3. Are the LOs intuitive for teachers to use in their teaching activities?					X	X
	B1	Q4. How can the use of the LOs by teachers be improved?	X					
	B1	Q5. What makes a learning object useful to a teacher?					X	X
	B1	Q6. How can the LOs be made easier to use by teachers?					X	
	(B4), B1	Q7. What factors inhibit or enhance uptake of the LOs by teachers?					X	X
Usefulness to students	B2	Q8. Can students use the LO easily (can they navigate, gain access to materials, perform the requisite tasks, etc.)?	X	X	X		X	X
	B2	Q9. How much do students enjoy using this learning object?	X	X	X		X	X
	B2, B3	Q10. To what extent do target students use the available accessibility features of the LO?	X	X	X		X	X
Student learning process	B2	Q11. How do students (from different backgrounds and contexts) use learning objects in order to learn?	X	X	X	To be determined	X	X
	B2	Q12. In what ways does the use of the LO guide learners to engage with, interact with, organise, represent, interpret and manage the content?	X	X	X		X	X
	B2	Q13. In what ways do students realise the knowledge can be applied in new contexts?	X	X	X		X	X
	B2	Q14. How does the use of the LO enable students to make connections with their prior learning?	X	X	X		X	X
	B2	Q15. How do the multimedia attributes of the LO influence the intended learning processes?	X	X	X		X	X
Student learning outcomes	B1, B2	Q16. What assessment did teachers use to determine the intended student learning?		X	X	To be determined	X	X
	B2	Q17. What evidence is there that learning is occurring as the LO is used?	X	X	X		X	X
	B2	Q18. Which unintended outcomes arise from the use of the LOs?	X	X	X		X	X
	B3	Q19. Are the benefits of the learning objects widespread or limited to some students?	X				X	X

3.5 Data collection

Researchers visited schools in pairs. They spent between one and five hours in each classroom. Students were observed using the learning object and then interviewed. Teachers were also interviewed during or after the lesson. Surveys were administered to students and teachers. Copies of these instruments are included in Appendix 1. The instruments were administered in accordance with Murdoch University's human research ethics policy. Permission forms were provided to students and teachers. Copies of the permission forms are included in Appendix 1.1.

Selection of students within classes was restricted to those who had returned the permission forms. This was normally about 50 per cent of the class. In several cases the teacher selected students according to characteristics they felt made them of special interest (for example, cultural background, non-English-speaking background, ADHD, reading or mathematics difficulties). The researchers made no representations in this area.

A pre-pilot study (see 4.1.1) trialled the instruments in seven classrooms in four Perth metropolitan schools.

Student observation

Researchers planned to observe students using a learning object in the context of a normal lesson. This decision reflects the importance of the learning context and environment.

The researchers observed students working through the learning objects on the computer. During this time the researchers asked students what they were doing and why. Researchers did not provide assistance unless students had significant difficulties getting the learning object to operate and directly requested assistance from the researcher.

All classroom activity was tape-recorded and transcribed for later analysis.

Student focus groups

The original research plan involved organising student focus groups. These were to take place some time after the use of the learning objects in class to investigate longer-term learning issues. As research progressed it became clear that this would not be feasible because of limited resources coupled with the diversity of student ages and learning objects used.

Student interviews

Semi-structured interview questions were developed from the generic evaluation questions in Table 3.2, and reduced in number and refined through use in the classroom during the pre-pilot study. The student interview questions are listed in Appendix 1.2. A second set of student interview questions involving role playing was developed for early years students (see Appendix 1.3).

Students were interviewed at their computer or in an adjacent area. Where two students used the same computer, they were interviewed together. Interviews took between five and 20 minutes. All interviews were recorded and transcribed for later analysis.

Student surveys

A student survey was designed as a two-page questionnaire based on Likert-type statements relating to the generic evaluation questions. It was trialled and refined during the pre-pilot study. The survey instrument is listed in Appendix 1.4. The survey was designed so that it might function as a stand-alone measuring instrument to be used in evaluating future learning objects.

The survey consisted of four parts: a common section about general learning object usability, and three optional sections with questions specific to Science, Literacy and Numeracy respectively. Student questionnaires were given to one teacher in each of the 10 post-pilot schools, for them to distribute to their students.

Teacher interviews

On the same day as the student observations, the class teacher was interviewed for between half an hour and an hour. Semi-structured interview questions were developed from the generic evaluation questions in Table 3.2, and reduced in number and refined through use in the classroom during the pre-pilot study. The refined set of teacher interview questions is listed in Appendix 1.5.

Interviewers probed issues specific to the way in which learning objects augmented accepted pedagogical approaches within the relevant learning area when the issues arose. However, teachers were encouraged to provide any feedback they felt was important. All interviews were recorded and transcribed for later analysis.

Teacher surveys

A teacher survey was designed in a similar way to the student survey, and revised during the pre-pilot study. The refined teacher survey instrument is listed in Appendix 1.6. The survey consisted of four parts: a common section about general learning object usability, and three optional sections with questions specific to Science, Literacy and Numeracy respectively.

The teacher questionnaire was distributed to one teacher in each of the 10 post-pilot schools, but this instrument was used only as an exploratory tool, and as a stimulus for discussion for the subsequent interview.

3.6 Data analysis

3.6.1 Field notes

Each researcher made a set of field notes based on their classroom observations and a review of tape recordings. These recordings were made of:

- the lesson that set the learning objects in context
- the use of the learning object by six to 12 students (usually working in pairs)
- interviews with the students immediately after their experience with the learning object
- interviews with the teacher after the lesson.

A pro-forma template used for consistently recording field notes is included in Appendix 1.8.

3.6.2 Qualitative analysis

Qualitative data was collected from three sources:

- transcripts from student interviews
- transcripts from teacher interviews
- field notes.

These were analysed using the NUD*IST computer program. A node tree of expected response themes was developed from the generic questions and expanded by issues that emerged from the data. A set of additional ‘free’ nodes was created from unrelated themes. A total of 84 documents, consisting of over 55,000 lines of interview transcripts and field notes, were analysed.

Data was coded by two research assistants. Initially each assistant worked in collaboration with a member of the research team to increase reliability. Coding was also reviewed independently by other members of the research team.

3.6.3 Rasch analysis of survey data

The student and teacher surveys collected quantitative data through the use of Likert-type opinion scales. The four schools in Western Australia were used to trial and refine the instruments, and were therefore not appropriate for analysis. Student questionnaires were distributed to one teacher in each of the 10 remaining post-pilot schools, and teachers were asked to return them to the researchers. Responses were not obtained from four classes.

Teachers in six schools administered the questionnaire to their students in the week following the field observations and returned them for analysis. For three out of these six classes, the learning object had been integrated into the teaching program. However, in one instance, the Science learning objects had been used to develop a media-related program rather than a Science program. These six classes included all those who had used Literacy and Mathematics and numeracy learning objects, but some students had also used Science learning objects, and chose to answer the questionnaire by reference to these learning objects. As a result there were comparatively few responses to the questions that targeted disciplinary objectives for Literacy and Numeracy.

Responses were obtained from 134 students in the six participating classrooms, more than the approximately eighty completed responses required for a meaningful analysis.

3.6.3.1 Rasch analysis

Responses from 134 students from the six classes were analysed using the RUMM computer implementation (Andrich, Sheridan & Luo 2002) of the Rasch Extended Logistical Model (Andrich 1988). The RUMM software package uses the Rasch latent trait measurement model, and is suited for cumulative scales. Researchers employed this form of analysis to:

- ascertain the relationship between different features of the learning experience
- determine the relative importance of each factor in creating a useful learning experience.

With this information it was possible to determine whether the constructs were valid and the responses reliable, and what distinguishes high-rating learning objects. Participating teachers were asked to coordinate the distribution and collection of surveys.

Chapter 4 Context of the pilot Field Review

4.1 Design and conduct of the pilot Field Review

4.1.1 Pre-pilot study

It was decided, after discussion with the Field Review Reference Group, to conduct a pre-pilot trial in schools in Western Australia. This was to establish the operability of the main data collection instruments in a manner that was both time- and cost-effective. The pre-pilot enabled field testing, refinement of each instrument and identification of logistical and other issues that might impact on the field work in the pilot study.

The pre-pilot study involved seven classrooms in four Perth metropolitan schools. Only Science learning objects were available for use at the time of the pre-pilot. The researchers liaised closely with the Western Australian Department of Education and Training in planning for the pre-pilot. The department provided professional development that assisted teachers to structure lessons around the learning objects.

While the pre-pilot enabled the instruments to be refined, the general structure of the research was found to be sound.

4.1.2 Pilot Field Review

The design of the pilot Field Review included case studies at a sample of school sites. The Le@rning Federation required investigation of the effect of the learning objects in a range of jurisdictions over a range of circumstances and target groups. These included:

- location – urban, rural, remote
- gender
- language – NESB (non-English-speaking background), ESB (English-speaking background)
- indigeneity – Aboriginal, non-Aboriginal, Maori
- socio-economic status
- age range from K–P to year 10.

The research team planned to include the following types of schools:

- One independent school and one Catholic School
- One rural school with a high Aboriginal population
- One urban school with a high Maori population
- One school with a high proportion of students from non-English-speaking backgrounds
- One urban school drawing on a population of low socio-economic status.

In practice, schools were selected from those responding to an expression of interest from The Le@rning Federation. Fourteen case studies were conducted across New Zealand and five Australian States and Territories. The schools visited are summarised in Table 4.1. Twenty classes in the 14 schools were visited between August and November 2003.

School selection was assisted by The Le@rning Federation in collaboration with The Le@rning Federation's contact liaison officers in States and Territories. Actual research included the following school types:

- Four schools with low socio-economic status
- One school with a high Aboriginal population

- One school with a high Maori population
- Two schools with high proportions of students from non-English-speaking backgrounds (NESB)
- Two schools with high proportions of students with learning difficulties
- Three rural schools
- One regional school
- Six urban schools with no special characteristics
- No independent or Catholic schools.

Most of the school characteristics of interest were included in this sample. Nevertheless, no Aboriginal students took part in the study.

Less coverage was obtained in terms of years of schooling. Table 4.1 indicates that the majority of classrooms in the case study were in the middle to upper primary years. Only one early years class was observed. No material on the early years was available other than in the Science area.

While it was intended that teachers would integrate learning objects into their teaching program, this only occurred in 11 of the 20 classes. To make arrangements with individual teachers it was necessary to work through The Le@rning Federation, the State or Territory

Table 4.1 Schools and classes visited in the pilot Field Review

School	Location	Characteristics	Participating Classes / Learning Areas			
School 1†	WA	Urban	P Sci			
School 2†	WA	Lower socio-economic High Aboriginal population	yr 5 Sci	yr 5 Sci	yr 4-5 Sci	yr 6-7 Sci
School 3†	WA	Urban	yr 8 Sci			
School 4†	WA	High NESB population	yr 7 Sci			
School 5	Tas	Rural Lower socio-economic	yr 3-7 Sci			
School 6	Tas	Urban	yr 10 Sci			
School 7	Qld	High proportion with learning difficulties	yr 7 Sci			
School 8	Qld	Regional High proportion with learning difficulties	yr 8 Sci			
School 9	NZ	Rural	yr 5-6 Sci	yr 3-4 Maths	yr 1-2 Lit	
School 10	NZ	High NESB, Maori and Pacifica Lower socio-economic	yr 8 Maths			
School 11	NSW	Urban	yr 6 Lit			
School 12	NSW	Rural Lower socio-economic	yr 7-9 Lit, Sci			
School 13	NT	Urban	yr 6-7 Maths	yr 5-7 Sci		
School14	NT	Urban	yr 6-7 Lit	yr 6-7 Sci		

† school taking part in the pre-pilot

contact liaison officer and then the school.

A variety of teachers took part in the study. While only four teachers were male, that number is representative of the gender mix among teachers at primary and lower secondary levels. Teachers, including the secondary teachers, were not generally specialists, although half had an interest in the use of computers in the classroom.

The nature of both the research and the learning objects initiative made securing a representative sample of teachers difficult. As with many studies of this nature, it was largely experienced, confident teachers who were prepared to take part in the initiative and were comfortable with observation. This may have important implications when attempting to extrapolate the results from this study to the wider teaching population.

The pilot Field Review methodology document submitted to The Le@rning Federation in July 2003 outlined a number of potential risks:

- The targeted population of teachers may not be sufficient in number to enable statistically significant instrument testing.
- There is a limited number of learning objects and potential delays in the availability of further Mathematics and numeracy and Literacy learning objects
- It may not be possible to effectively visit schools within the available time frame.
- Because learning objects need to be evaluated in a realistic teaching setting, rather than in isolation, teachers need to have information about how to use learning objects, and time to select them.

4.2 Summary of the classes studied

Some schools participating in the Field Review were provided with professional development. This varied from a half-day, centrally delivered, structured workshop through school based in-services, to individual tutorial sessions with the contact liaison officers for the jurisdiction.

A brief summary of the participating schools and classes is provided below. More detail on each school is provided in Appendix 2.

School 1, Western Australia

School 1 is situated on the outskirts of Perth, Western Australia. Two researchers observed learning object use in one early years class. The learning object was associated with a number of activities throughout the week. Some students used the learning object while others engaged in parallel activities.

School 2, Western Australia

School 2 is situated in outer suburban Perth, where teachers cope with significant behavioural and family problems. Researchers visited four classrooms ranging from years 4 to 7.

Few students had returned permission slips allowing them to participate in the study. Teachers in this school also had difficulty accessing the array of learning objects. Eventually, teachers chose learning objects that tied in with their current Science lessons, allowing the students to investigate abstract concepts or conduct simulated experiments.

School 3, Western Australia

School 3 is located in suburban Perth. It is a large school with over 1,000 students currently enrolled. One year 8 classroom was visited.

The class appeared to be motivated and the teacher had embedded the learning object in a well-planned lesson. However, students were unable to run the selected learning object on the day of observation for technical reasons.

School 4, Western Australia

School 4 is located in suburban Perth. It is a new school with a high proportion of students from non-English-speaking backgrounds.

The researchers visited a year 7 classroom. Students each had access to a wireless laptop computer and the teacher was confident using ICT resources. On the morning of the learning object activity, the students went on an excursion that was connected with the selected learning object.

School 5, Tasmania

School 5 is a small school situated in rural Tasmania. It is relatively isolated and surrounded by bushland. The school has two teachers and two classrooms.

Two researchers visited School 5. The teacher was new to the school and had participated in an expert focus group to guide learning object content. She had prepared a series of activities relating to each learning object and students worked on these over a number of weeks.

School 6, Tasmania

School 6 is a boys' school in Hobart, Tasmania. It is located in an inner-city suburb and caters for years 7 to 10. The teacher was experienced in incorporating ICT resources into her lessons and had participated in the development of learning objects. The lesson was well planned and took place in a computer laboratory.

School 7, Queensland

School 7 is located in an established suburb undergoing redevelopment. The school caters for a wide range of academic abilities.

Researchers visited one class of year 6 students. The teacher was confident and the lesson had been well planned. However, students were asked to review learning objects for their design characteristics as a precursor to designing their own. The learning objects were not used according to the learning purpose intended. The teacher was able to provide researchers with worksheets that indicated how she had integrated the use of learning objects into her lessons.

School 8, Queensland

School 8 is a regional, agricultural school with a high proportion of rural students, serving the Darling Downs area in Queensland.

Two researchers visited one classroom. The lesson took place in a computer laboratory containing 30 machines. The teacher selected two learning objects that he believed would capture student attention. An attempt was made to embed the learning object in a lesson plan despite the lesson taking place in the computer laboratory.

School 9, New Zealand

School 9 is a small rural school with 130 students from years 1 to 6. Teachers in this school were relatively comfortable with the use of ICT resources in the classroom and a number of ICT activities had been initiated.

Three classrooms were visited, of year levels 1–2, 3–4 and 5–6. Students selected by the teacher were 'those most likely to cope'. Only one teacher was observed attempting to tie the learning object into a wider classroom lesson. Other teachers were absent from the area entirely and students turned to researchers for help.

School 10, New Zealand

School 10 is located in an area of low socio-economic status in Auckland. The school has a high proportion of Maori and Pacifica students. In this class all students were of a Maori or Pacifica background. One classroom of year 7 students was visited. The lesson was held by an experienced ICT teacher and took place in the computer lab. The teacher had received professional development and was familiar with learning objects.

School 11, New South Wales

School 11 is located in an area of fairly high socio-economic status in Sydney. Researchers visited one classroom of students. The lesson began in the classroom and continued in the computer laboratory where the teacher was joined by an experienced ICT teacher.

The teacher being observed incorporated the use of computers into a classroom lesson plan. This was in spite of the difficulties involved in relocating the students mid-lesson in order to access machines.

School 12, New South Wales

School 12 is located in rural NSW and serves a small country community. One class was visited, which contained students in years 7 and 8. The students were deemed to have below-average literacy levels. The teacher was familiar with the use of ICT resources in the classroom.

The lesson took place in a computer laboratory. The learning objects were treated as self-contained computer exercises and were not linked to current lesson activities.

School 13, Northern Territory

School 13 is located in an inner suburb of Darwin. It is a well-equipped school and has received grant money to upgrade ICT resources. Researchers visited three classrooms containing students from years 5 to 7.

Use of learning objects was embedded into the lesson in one class only. In other classes teachers expected learning objects to work as stand-alone teaching resources. The lack of guidance undermined the success of the learning objects, and some students were confused by the instructions.

School 14, Northern Territory

School 14 is situated on the outskirts of Darwin, in a new and expanding suburb. Researchers visited two classrooms containing year 6 and 7 students. Both lessons took place in a computer laboratory.

Learning objects were embedded into the lesson in one of the classrooms visited. The teacher viewed the learning objects as stand-alone resources in the second class and looked upon their use as a ‘treat’ for the students.

4.3 Summary of the learning objects encountered in classes

Forty learning objects were used in classrooms in Australia and New Zealand as part of the pilot Field Review. Some learning objects were observed only once while others were viewed in more than one classroom. In some cases student usage was brief, especially when students had been given learning objects to ‘play with’. In other cases, student usage was extensive. Teachers used learning objects in a wide variety of ways, and usage by students varied according to the number of classroom computers available.

A detailed analysis of the learning objects and how they were used in classrooms is presented in Appendix 3 (One literacy learning object, ‘Letters to the Editor’, has not been included because very little evidence of its use was obtained) where each learning object has been analysed based on evidence from students, teachers and observers, and summarised in tabular form. The initial section of each table provides The Le@rning Federation’s description of the learning object. This is followed by a description of the context of use of each learning object. The analysis concludes with a summary of the strengths of the learning objects, any issues that may require resolution, and a summary of the effectiveness of that learning object.

Six forms of learning objects were identified during the review, ranging from least to most interactive:

- Talking books. A talking book learning object provides information to students in a set sequence of pages in the same way as a conventional book. The information may be supplemented by sound, video or other multimedia inclusions. User control is limited to controlling access to specific parts of the learning object or the display characteristics.
- Drills. A drill learning object is used to practise a specific skill or pattern of actions. It requires the user to be presented with, or select, various versions of a problem situation that can be solved using the action. Thus, the possible inputs are restricted, the desired pathway to solve the problem is fixed and the output for any of the possible variations is predetermined.
- Tools. A tool learning object is an instrument used to perform a mechanical task with greater efficiency. The inputs are determined by the user, but are restricted to the parameters required by the algorithm. The strategies are determined by the algorithm of the learning object, and the outputs are fixed.
- Activities. An activity is an exercise where the students investigate some particular context-linked issue, making decisions to solve a problem or to produce a tangible product. The learning object provides a ‘story line’ that dictates the desired outcome. Users devise their own means to achieve that outcome. The user has the ability to choose the inputs from a range available, and it is possible to achieve the desired outcome in a number of different ways.
- Simulations. A simulation is an algorithm-driven learning object that attempts to mimic processes in the real world. The user sets the variables required to run the algorithm, either as initial settings, or in real time as the simulation is running. The desired outcome is often clear, but it may be possible to select different outcomes before commencement. The user must develop and use a strategy to achieve the desired outcome.
- Interpretative activities. An interpretative activity allows the user to select not just the content of variables, but also the type of variables that they input. They also determine the type of output that will be produced and the appropriate strategy to achieve that output.

Chapter 5 Results

5.1 Introduction

The development of the methodology of the pilot Field Review was discussed in Chapter 3. The evolution of the evaluation plan led to the development of four main themes which underpinned the data collection: one teacher-oriented theme and three student-oriented themes.

The four themes are:

- usefulness to teachers
- usefulness to students
- student learning process
- student learning outcome.

These themes have been used to organise the presentation of results in this chapter. In each section, the generic questions listed in Table 3.2 have been used as general guides to structure. The nature of the evidence obtained did not directly match the questions derived as part of the evaluation plan.

The complex and dynamic nature of learning means that several issues identified in the research cut across the four themes (above) and the questions (in Table 3.2). These issues included professional development, ICT, the classroom environment, the school's technology environment and student–teacher interactions. These issues arise repeatedly throughout the results and provide a useful springboard for the general discussion and conclusions that appear in Chapter 6.

5.2 Usefulness to teachers

5.2.1 How do teachers select learning objects?

The teacher is responsible for developing the teaching–learning program, using resources to create learning situations. Learning objects are just one of the possible resources that a busy teacher can use to structure those situations. Not all teachers are alike, and not all teachers are trying to achieve the same outcome. Therefore, there needs to be a mechanism or mechanisms to help teachers make decisions about how they can, or should, use learning objects.

The themes and sub-themes explored in this section are guided by the following generic research questions:

Usefulness to teachers	Q1 – How do teachers select learning objects?
	Q2 – How do teachers incorporate the use of learning objects into their teaching?
	Q3 – Are the learning objects intuitive for teachers to use in their teaching activities?
	Q4 – How can the use of learning objects by teachers be improved?
	Q5 – What makes a learning object useful to a teacher?
	Q6 – How can the learning objects be made easier to use by teachers?
	Q7 – What factors inhibit or enhance uptake of the learning objects by teachers?

A metadata ‘application profile’ was developed by The Le@rning Federation to provide background information about the purpose of each learning object. However, to make wise decisions teachers need to consider not only the learning object, but also the nature of the class that will use it, and how the students will be asked to interact with it. A number of factors influence how teachers select appropriate learning objects to use in the classroom. These are examined in this section.

5.2.1.1 Reasons for choosing learning objects

Teachers were largely positive about the potential of learning objects, seeing their advantage over linear media such as books and video:

> T: they can really capture an audience because ... it is not something kids can pick up [in] a book … well maybe they could see it on a video but learning objects can actually do more than what a video can in some respects. The video can give information whereas a learning object can make it interactive.

In general, teachers felt that learning objects were most useful when they displayed or simulated situations that could not easily be experienced in the classroom. Examples given were:

- experimenting with the braking distance of cars
- showing the inside of a volcano
- demonstrating what the heart looks like and how it works
- simulating field excursions
- exposing students to a variety of landscapes that were unlike those that they could experience near their schools
- demonstrating sensory experiences that would not otherwise be possible, such as the dual view inside and outside the body in the ‘In digestion’ learning object
- simulating astronomy experiments.

> T: I found most of the learning objects to be really good like that, in that they do allow you to start from a place that previously you haven’t been able to start from before, because we haven’t had access to the resources.

> T: … and I looked at some of the metal ones and if you were looking at properties in metal – I mean – the children can examine things and look at them but they can’t melt them and bend a lot of them and look at them that way … things that you couldn’t do in class.

Teachers preferred learning objects that were relevant – that linked learning materials to real-life contexts. They looked for opportunities for students to obtain live data to process, or for simulations of real data to compare to real-life situations.

> T: I think it is useful that it is something that all the kids that are doing something relevant can have a go at it, and it is a real life possible problem to solve and it is a lot of lateral thinking as well.

One area where teachers recognised the benefits of learning objects was in situations where learning activities involved danger or unacceptable risks. Science experiments involving radioactive isotopes, heat, and chemicals – particularly acids – were mentioned most.

> T: So if it involves dangerous sorts of goods which is not practical then … you couldn’t actually do [it] in a class.

Processes that take a long time in real life were also areas where learning objects were found to be useful by teachers. Teachers believed it was difficult to maintain student interest in time-delayed activities, such as observing plants grow.

> T: … things that take a long time to have an effect in the real world. So in real time, if it takes too long to get a result, they would be the sorts of things that would be good on simulation because you can say: ‘This is equal to a weeks worth, or a fortnight’s worth of time’.
>
> T: … these shells had an immediate effect almost. It was bad enough making them wait overnight but the next morning they were very curious. If nothing had happened for two weeks or three weeks, forget it. They wouldn’t have been with it. So things that take a long time in real life would be good to be simulated.

One teacher felt strongly that learning objects should not be used to replicate teaching that is readily accomplished in the classroom:

> T: … but if there was anything on that computer that I could do just as well in the lab, I’d choose the lab ten times over. You know, if there was a simulation on timing a swinging pendulum by changing the length of the string, there is no way I’d use the computer for that, because we can do it just as easily in class.

One way in which teachers strive to make their teaching relevant is by using examples that are familiar to their students. However, a lower secondary and an early years teacher avoided using the ‘Nuclear Power’ and ‘Volcano’ learning objects respectively, because the content was not familiar.

Some teachers cited the time needed to collect materials, arrange them before the lesson and dispose of them after the lesson as reasons for using learning objects rather than ‘the real thing’. For example, it takes considerable amounts of time to collect a series of radioactive isotopes, Geiger counters and other materials to demonstrate the inverse square law for radioactive emissions, as one secondary teacher did.

Teachers applauded learning objects as a time-saving device, and used the time saved by the learning object to extend and consolidate learning. For example, one teacher planned to maximise the impact of a lesson by using real isotopes as a demonstration, and then have the students repeat this as a simulation using the computer. Similarly, another teacher involved his class in constructing model aeroplanes to test the effect of blade size and angle, and then used the learning object that demonstrated the same content to reinforce the real-world experience. Both these teachers enhanced their students’ learning experiences.

Some teachers found that time was an important limitation on what they could achieve. Many reported spending three or four hours looking through the learning objects to select materials appropriate for the content they were focusing on in class. They requested various forms of professional support (see 5.2.6) to assist them.

Furthermore, some teachers look for resources that comfortably fit their existing levels of subject knowledge. This is an issue for primary teachers particularly, as they are not discipline specialists yet are required to teach many sections of the curriculum. Research (Goodrum, Hackling, & Rennie 2001) has repeatedly found that many primary teachers lack confidence in teaching Science. Some primary teachers in this study reported that the learning objects provided them with support for their teaching in an area where they lacked confidence.

> T: It was the only one I could basically understand and apply fairly quickly from my own time frame.

5.2.1.2 Metadata issues

During The Le@rning Federation production process, learning objects were identified by a range of relevant descriptors stored as metadata within the learning object. This was intended to facilitate searching for learning objects and choosing those appropriate to student learning needs.

The accuracy of searching using the prototypical BELTS system was an issue for one teacher, who did not locate a learning object when she typed in its name. However, the accuracy of the metadata descriptions of the learning objects was a larger issue for a number of teachers. Several queried the attribution of age classifications to particular learning objects. One suggested that for her students, some of the P–2 learning objects were too hard. Other teachers did not like the age classifications at all.

> T: And one of the biggest problems is that we can’t easily identify what level this is actually pitched at, at the moment.

Following from these experiences, one teacher decided to make an independent judgement about which learning objects to choose.

> T: OK I am not going to be relying too much on what the descriptor says. I am going to have a look at the learning object myself and say, ‘OK, will my children be engaged in using this? Does it look like it is appropriate? … So I haven’t relied on what the descriptor has said because I don’t think that it is right.

This approach underlines a need for teachers’ views about the usefulness of learning objects to be recorded and made available to other teachers seeking to choose learning objects appropriate to their needs.

5.2.2 Use of learning objects in classrooms

Teachers incorporated learning objects into their lessons in a variety of ways. Some teachers provided ‘lessons’ that were simply a series of learning objects and associated instructions, while others embedded learning objects coherently into a unit of work. This section is mainly concerned with the variety of ways in which teachers used learning objects in structured learning activities.

Teachers in the pilot Field Review generally had access to up to three computers in their classroom whenever required, or to a laboratory of computers for one or two lessons each week. A few classes had computers continuously available for all students. Teachers saw the ‘laboratory lesson’ (except where additional time had been allotted for our visit) as the least satisfactory alternative, largely because it limited the ability of students to progress through work at their own rate. In almost all cases, the teachers were able to give students sufficient time to complete the task at their own speed.

Researchers observed that teachers generally structured computer work using pairs of students, or larger groups when the task was part of a larger research project. There was considerable collaborative interplay between students in cases where each student had a computer. In one classroom the students were provided with wheeled chairs allowing them to push themselves across the room – an opportunity they took advantage of frequently.

> T: I have the students working in groups of two or three for these learning object things and I felt that that was a really good size because it was enough for them both to sort of get, or three of them to get, a fair go with the mouse. They all like to have a go with the mouse and at the same time they could discuss what they were learning.

5.2.2.1 Matching use to needs

An important factor for teachers who used learning objects purposefully was matching use to student learning needs. These teachers wanted to either incorporate a learning object into a unit of work, or to build a unit of work around a learning object:

> T: I don't believe in giving 40–60 learning objects that cover a whole range of broad spectrums and just letting them play. I want it to be actually structured and actually have some sort of bearing on what we are trying to teach and I'd use it that way.

> T: To have a look at the learning object first and … see … what science is the student actually learning from it and then, 'Well what else can I do to try and get them to reflect on this knowledge and to apply it in other situations?'

> T: OK so there is some chemistry in here. That is great for them to know about chemistry. And then what is the overall goal of that then? How could that go to further thinking about futures and things and investigating the natural structure of the world? That sort of thing. So … that was there as well that this has got to fit into a meaningful context in their little lives ... essential learning type curriculum.

> T: To have a look at the learning object first and have a look and see, well, what science is the student actually learning from it and then, well, what else can I do to try and get them to reflect on this knowledge and to apply it in other situations? And then come back to it again somehow at the end … there needs to be a match with what the resource is trying to achieve and what I am trying to achieve with my program goals.

Evidence of matching use to needs was obtained in a number of cases, where content material from learning objects in various disciplines was used innovatively to create literacy activities. Both the 'Ecology' and the 'Letters to the Editor' learning objects have been used to develop content and techniques for a 'classroom newspaper' project. In another school, the 'Old Bernie's story' Science learning object was integrated into an 'interviewing' project. One teacher had her class develop an 'ecological newspaper' called 'Earth alert' using the 'Earth alert' learning object as the springboard.

> T: … even though they were Science learning objects, they had the vocabulary, they had the language that I wanted the children to [learn].

5.2.2.2 Stand-alone versus contextual use

There was a mixture of views among teachers as to whether learning objects should be used in isolation by students, or whether they should be placed in a classroom learning context. A minority of teachers saw learning objects as something students could use in isolation, to teach mundane concepts and for practice and reinforcement:

> T: I think the kids pretty much worked through it by themselves anyway. It was pretty self-explanatory I think. They didn't seem to have any problem with it. So I think if you are developing anything it needs to be something that kids can just pick up and go straight into it. As a teacher you don't have time to sit down and spend twenty minutes explaining stuff all the time … so if they can just pick it up and work through it themselves, then that is ideal.

However, the majority view of teachers was that learning objects should be integrated into the classroom context:

> T: So some of it seems to me to be set up in a way that is sort of trying to get the students to go through those things independently and some teachers will probably use it that way but I don't think it is the best way of using it. I think it is better to actually have the teacher there.

> T: It is not a stand-alone from the point of view that kids having literacy problems are not going to be able to cope with it without some input from someone else. It wasn't [as if] they could sit down and go from the start to the end and be able to achieve and manage the whole lot. So I think there is very, very little in the way the resources are stand-alone. I think it is the input and people that gives it meaning and relevance.

> T: So I would rather use it as a teaching thing and actually guide them through it and I will make sure that they get more out of it than they would if they were just left to their own devices. Some of the kids will want to try everything and try and want to work through the whole thing and won't want to move on until they have done every possible combination of events but some will just go, 'Nah. Too much. I am bored with that now'.

Teachers felt that learning objects were resources, to be used as a preliminary to work to be done in the classroom, or as a support or catch-up. They wanted learning objects to expose learners' beliefs and understandings about content, and possibly use this for assessment. Some teachers wanted to encourage metacognitive activity in students so that they looked at the learning focus and began to ask 'What have I learnt?' and 'What do I need to learn?'

However, one teacher recognised that teachers needed to find a match between their teaching style and the available learning objects, and adapt learning object use to meet the needs of their class. Teachers noted that some learning objects have purposes built in, while others are context-free. In both cases, teachers need to use creativity and add value to ensure learning is taking place. As one teacher vehemently claimed:

> T: You don't need the program to be the teacher. I'll tell the kids, 'Put up your hands if you have got a prediction as to what might happen'. So they have done that … It is [similar to] aircraft circles … the more they actually take control off the pilot and decide to make the computer do everything, the more the pilots hate it. I look at that and I think, 'Let me do that part. Trust me to do that part'.

5.2.2.3 Teaching methods

Teachers integrated learning objects into their units of work in different ways. One teacher used a learning object as the starting point, and built learning activities around it, to add context to the learning:

> T: I went with what was in the learning object and I went with the knowledge that came out of that … the activities that I built up around it so that it was all backing up – starting from the learning object and all backing up. Not adding any extra knowledge on, but just all experiences to back up … the knowledge in here.

Another teacher used learning objects in a contrasting way, to engage students to review material already covered in class:

> T: With that learning object there was more to actually engage them in, and to get some feedback on how they had been going with what we had been doing with changes within the class … but it is just to get them thinking and as an engagement activity for that, but at the same time to tap into what they already know and to build upon that and also to see what they have picked up about changes and how things change.

A third teacher designed a lesson so that students could make connections between the learning object and the content of previous lessons in a different area of study:

> T: To use the knowledge that they had learnt within the classroom because during a health unit of work we had learnt about body systems … and then to use that knowledge to extend ourselves … and say, 'OK. Here is a learning object that tells us all about plants, so how could we make a comparison?' And it was a very challenging task I might add, and was probably above the level of some of the kids in that class, but when I use the learning objects I feel that you need to add.

An observer reported that in one school, an early years teacher had prepared worksheets to accompany the 'Who's for dinner?' learning object that included a great deal of ecological terminology together with some familiar activities. She had paired 'strong' and 'weak' students for the activity. However, she found that the 'strong' students completed most of the written work while the 'weak' students had returned to the 'game' (finding a strategy to enable the animals to survive) at every available opportunity. These students rarely took part in classroom lessons, and generally disturbed others. While the teacher was concerned that theses students were not participating in the verbalisation activities, they were learning, and enjoying the experience. Other teachers report similar stories with their lower-achieving students later in this report (see 5.4.2.2).

> T: … it doesn't rely exclusively on being able to write a good essay or being a good speller. He can go in and play 'Who's for dinner?' and he doesn't need to be able to have a lot of background knowledge to be able to play that and then be able to have a reflective discussion at the end and say, 'Well what is actually happening here? Oh, maybe this could be happening.' So he is quite capable of doing that sort of philosophical-type thinking and talking about things and learning through talking and hands on … So there is more opportunity for success …

5.2.2.4 Constructivist approaches

The Le@rning Federation's Educational Soundness Specification (The Le@rning Federation 2002) supports a constructivist learning model, where the role of the teacher is to provide the environment for students to construct a framework with which to understand the world. The teacher uses resources such as learning objects to help the student in this process. Teachers approached this task in a range of ways.

One teacher set students a task with a learning object and provided a brief overview before letting the students attempt the task on their own. However, instead of letting them work in isolation, he made occasional suggestions about things to try. An observer noted: 'By "casually" asking if anyone had managed to have the character successfully digest the food, he created a challenge for them.'

The nature of the learning objects themselves was also used to create challenges for students. In one school, the teacher chose 'It's a drag' as a hook to get the students from her low-achieving year 10 class learn how to create graphs from tables in Excel™. The teacher had previously experienced problems motivating students with abstract computing problems. Several of the students reported they had recently experienced unstimulating lessons in similar Mathematics lessons also using road safety data. However, the concrete, visual example in the learning object was complimented by a student as being 'really freaky'.

In another example, a teacher of a physics class asked students to make a prediction, in the expectation that most of them would be wrong. This was used as a challenge to make students think harder:

> T: So they have got to think harder because, you know often … they think, 'Oh yeah this is straightforward.' And when they are surprised that they are not right that they are going to delve a little bit deeper.

Simulations and the ability of students to control and manipulate variables also support a constructivist approach to learning:

> T: It was good in that it went through the variables and they could change a number of variables. So I encouraged them to just change one set of variables at a time and to not go through and change everything because obviously they are not going to find that. So I was sort of linking that into the basic premise of science – just change one thing at a time and see what the effect is. Keep the speed the

> same, keep the road the same but maybe change the tyres. And then try increase the speed again, or just check all those variables and go through that. S o I encouraged them to do a bit of that.

5.2.2.5 Impact on teachers

The use of learning objects can provide challenges that stimulate interest and reinvigorate teachers. One primary teacher with little ICT experience explained how she believed the learning objects 'had to happen' to provide her with new ways to innovate in her classroom. Similar comments were common, and there is evidence of a trickle-down approach, in terms of teachers passing their enthusiasm on to students. Another primary teacher who was designated to provide ICT mentoring for other teachers reported how one early years teacher, initially reluctant even to switch on a computer, had realised the potential for her teaching after using several of the 'Gecko' suite of learning objects.

> T: As a teacher, to this day, technology is so new to me and I am learning all the time with the kids but I wasn't doing that in my program so it was a self-assessment of me, evaluation of mine. I needed BELTS to come along, basically for me, not just for the kids.
>
> T: By recommendation – I saw, I heard, 'Oh this is really great,' – is honestly the way most of us choose our resources.
>
> T: … it is having something different to start that springboard of learning from. A different perspective. It is something new and innovative and so exciting.

Learning objects can provide valuable professional development for teachers. On two occasions, 'The multiplier' was cited by teachers as making them reconsider how they thought about multiplication, and made them aware for the first time that there were many ways of knowing mathematics.

> T: … I sometimes even introduce a concept depending on what I am doing at the time. I could put it up onto a projector in the classroom and go through it and say 'look what happens when I drag down the top number and you can see the numbers breaking up,' and then I could leave that and go and ask the kids 'OK, what could we break up if we had a sum like 25 times eight? How could we make that easier?' and so use that as an introduction and then get the kids to think of other things.
>
> T: And things like 'The multiplier' I had never even thought of. Wow! that is how you can explain that concept. It is still abstract but some kids pick up on it and if it works for a few of them, great.

5.2.3 Assessment issues

Teachers had varying requirements regarding learning objects providing assessment. Some teachers were keen to have formal internal assessment within the learning object. One user of 'Dynamic Fractions' would have liked a printout of the correct answers. Another user of 'The multiplier' would have liked a record of which multiplications had been attempted.

Other teachers felt that assessment was more appropriate to the unit of work rather than to the learning object. However, a number of teachers reported that they were considering using some specific learning object as an assessment tool for their unit of work. In one case a teacher, planning to use 'Intergalactic cook-off' (chemical change) and 'Grumpy in the Desert' (physical change) as part of a chemistry program for year 5 students, was intending to use 'Treasure puzzle' (properties of acids) as an assessment tool, although the content was only superficially similar to that of the other learning objects.

Other teachers did not accept the need for assessment tools within the learning objects. Close contact with students during the task provided formative feedback, and summative feedback was not relevant to the learning object, but rather to the unit of work.

> T: … important to 'do the writing' with the worksheet approach – converting the game to a worksheet generator.
>
> T: … with a lot of the learning objects … when you get to the end … it means that you have mastered it, you have to have obtained this Science knowledge … That is how a lot of them are set up. So you sort of assume that by the time they get to the end that they do know these things – but not necessarily because with 'River journey', for example, they can go through that and it is just if they don't click and drag it onto the right one then they can sort of guess and maybe get a lucky guess and maybe get there without stopping to read a lot of the stuff. Especially because it is for early childhood. They avoid some of those reading tasks so they can kind of bluff/luck their way to the end if you like. So I think that to really assess it you do have to have some of these other activities.
>
> T: I say, 'Do you understand?' Because I am unfamiliar with the content of a lot of them, it is going to have to take me time and I learn with the kids and usually you ask them what they have got from it and they all [give] feedback to you and that is how I operate.

5.2.4 Benefits of learning objects to teachers

Teachers identified a range of benefits arising from The Le@rning Federation Schools Online Curriculum Content Initiative. These ranged from the pedagogical to the practical.

From a pedagogical point of view, teachers found that learning objects assisted students with:

- literacy difficulties:

  > Liked the audio support option with 'Plant scan' – this assisted those for whom the text was otherwise inaccessible.

- visualising abstract concepts:

  > Having to explain those concepts – that is really great … because abstract concepts are so difficult to grasp and we can do hands-on activities, this can build onto them because if a child can see something as simple as when you do a section of a 3D shape and to have something that turns that around and *actually shows the kids and allows them to do it.*

- connecting concrete understandings to abstract concepts:

  > … the reason I liked this particular one was because lungs and things, as I discussed earlier … are something that the children can't see in everyday life. So already you are in an abstract phase, and in all reality the children can't put their hands on those sorts of things. So if you are working in the abstract I find that … anything that can be done practically, where you can actually have the kids doing it, making it, hands on at this particular level, I am more inclined to use those sorts of things … more than asking them to go straight to abstract and that is what I looked for.

- thinking:

  > … It requires them to think and that is probably one of the best assets. It is an interactive thing.

From a practical point of view, teachers liked learning objects because they:

- offered creative opportunities to weave learning objects from different areas together, and to work in a cross-curricular manner, for example:

> … using Venn diagrams to compare and contrast [in Maths] and to interpret a range of texts for gaining information, analysis and synthesis [in reading, viewing, writingand speaking], encouraging more challenging kinds of thinking, providing meaningful contexts in which learners needing enhancement of confidence and skills in reading can develop and practise these skills.

- enabled teachers to segment the class for teaching purposes:

> … to break some kids off, [who] need to do a little bit extra or maybe a little bit of extension, depending on what the object is, while I work with other kids.

One teacher was positive about The Le@rning Federation initiative despite having experienced technical difficulties:

> T: I know that there is a lot of negatives about it all but I want to reinforce the fact that it is a good initiative and it is something that is convenient for teachers and I want to make sure that that message is reinforced.
> O: … Why convenient?
> T: You go to the one place and here is a bank of resources for teachers that is relatively easy to sort through and to find what you are looking for and then to integrate that back into your program and I think that that is fantastic. So, if you can sort through all the technical messes, that will be great.

Another teacher had initial misgivings about the effectiveness of the learning objects, but subsequently changed their mind:

> … at the end of just having them involved in the learning objects I didn't feel that they had learnt much of the content that was there at all but then after we had gone through this learning sequence and we came back and I asked them questions about this they understood all the things that were within it.

This evidence reinforces previous assertions that learning objects need to be incorporated into meaningful lessons to be useful.

5.2.5 Effect of the ICT environment

Almost every classroom visited had difficulties accessing learning objects. It is likely that the majority of these difficulties can be considered 'teething' problems. These are unlikely to impact upon the success of the initiative over the long term.

5.2.5.1 School infrastructure

Schools are not generally state-of-the-art where ICT is concerned. Schools reported that constant demands for new and updated hardware, regular upgrades of software, and human costs of maintenance were a considerable drain on the budget. The learning objects need to be flexible enough to cope with actual conditions in schools to win acceptance during the introductory phase.

Platform

Design specifications require that learning objects function under Windows 2000™ and Mac OS X™ and only with certain web browsers. There were relatively few computers with the required specifications in a number of case-study schools. In many cases, teachers were unaware of the hardware and operating system requirements for running learning objects, and tried to execute the learning objects under Windows 98™ and Windows XP™.

> T: Froze it again …
> O: What are these machines? Are they Windows 2000?
> T: No they are Windows 98 … These are the best computers in the school.

Many teachers had to experiment with computers throughout the school to find those able to run the learning objects. ‘I have got one of the few computers in the classroom that it can actually come through onto. There are about three in the school.’ In one school, the only computer that could do this was the Principal’s laptop, and the student observations were carried out in the Principal’s office. This was unlikely to have been a relaxed learning environment for the students.

It was noted that simulation learning objects and those learning objects using Shockwave can perform slowly and crash machines with limited memory. Over time, it can be expected that the number of Windows 98 machines, some with slow processors and low memory, will decrease. However, during the early periods of learning object release, teachers and support staff need to be aware of the operating requirements.

While Windows XP is not one of The Le@rning Federation’s supported operating systems, instructions are provided about how some learning objects may be made to work. As time goes by, increasing numbers of computers will use Windows XP and newer operating systems. For learning objects to continue to be useful, they will need to be periodically updated to work with future operating systems.

Plug-ins

Several cases of computer failure were due to the machines not having the free software installed, or, in the case of one Shockwave ‘failure’, the latest software version.

> T: … that was one that I didn’t have to upload Shockwave on and yet that was one of the older machines in this room. A couple of the newer ones I had to upload with that. So I just think that sometimes the technology goes faster than what people actually can. We could have 2000 except that half of our computers are not up to 2000. We’d prefer to have the same throughout the whole school … [for fewer problems].

School intranet issues

An intranet creates a resource issue for many schools, and sometimes it is not managed optimally. The intranet is beyond the control of most classroom teachers and decisions about its use may not be made by teachers or communicated to them. In one school the observed lesson failed to eventuate because, unknown to the teacher, the IT manager had stopped classroom (but not staff room) access to swf Flash downloads.

> T: I don’t understand why it cut off the last five kids that tried to log on … yesterday I went through and I made them all a folder, the ‘Save the lake’ folder because we can access all their folders in here and when I got to [student’s name] it wouldn’t let me modify anything in there or add anything, so that is a rights issue on the server.

Those concerned with all areas of the school infrastructure need to be aware of, and support, the initiative if learning objects are to function properly in classrooms.

Access to learning objects

The schools observed accessed the learning objects centrally through versions of BELTS, through intranets within the school, or from disks in the drives of individual computers. Each had its own advantages and weaknesses, but BELTS use elicited strong responses from teachers.

> T: I mean the BELTS has created lots of problems just trying to get into it. For someone that isn’t computer literate it is quite frustrating.

> T: You get all very enthusiastic when you put the lesson together and, when it comes to the day, you type in the password and it doesn’t come up.

While it is accepted that the BELTS delivery system is in developmental stages, it caused a number of problems that will affect its use in the classroom. A number of improvements were suggested (work on some of whcih may already be underway):

- Login persistence needs to be longer than ten minutes.
- Lesson names and passwords need to be easier for early years students and for low achievers in literacy. One teacher reported spending 40 minutes of a 50-minute lesson 'teaching these kids how to do "l:user name" to log onto the BELTS lesson'.
- As students can use BELTS to access their lessons, user screens need to be easy to understand. A teacher should be able to create visually stimulating lesson directions incorporating graphic (and oral) elements, with varying fonts.
- Wording on the BELTS pages needs to be clear and unambiguous, for example, when outlining the various download alternatives.

Despite these difficulties some teachers saw the potential of BELTS:

> T: … what I loved about BELTS is that we had our learning objects there that we could utilise straightaway but we were able to put our URLs in and we were able to put our own lessons in as a part of the sequence so that the kids saw a sequenced lesson.
>
> T: They were engaged all the time and it is something that they can go back to. There can be follow-on from this. And that is what I have found all along with BELTS.

Internet access

One teacher wanted the opportunity to load learning objects onto the school intranet, so that difficulties making each student a user through BELTS could be avoided. Accessing learning objects through BELTS was an issue for several schools for different reasons.

Several schools believed that they needed to download the same files over the Internet for every student. One school has a 'megabyte bank' in which each student has a credit each month to be used for in-class resources. With students needing to download learning objects to participate in normal classroom activities, the megabyte bank concept may need to be revisited.

Internet access is a component of the behaviour management policies in many schools. This may mean that some students are prevented from completing class work because their Internet access has been suspended. These policy approaches may need to be reconsidered within schools.

At an infrastructure level, bandwidth may be a limiting factor in some schools. The normal situation would be to have all machines accessing the same website simultaneously when the teacher gives the instruction. One school found that limited bandwidth made it impossible to have all computers access the BELTS site at the same time.

Two teachers reported that they had difficulty accessing the system through their Internet service provider on weekends when they were planning their program.

Support and expertise

Only one school reported they had no problems accessing the learning objects. The degree of difficulty experienced seemed to correlate with the amount of IT expertise available within the school. Schools with dedicated IT professionals experienced fewest difficulties, those with an enthusiastic teacher with some release time to manage IT systems experienced more problems, and those with no technical backup experienced the most problems.

> T: We have a wonderful teacher in [teacher's name] who is very, very technologically capable and can solve those problems and we have kids who, for the most part are, 'Oh look, that one doesn't work. We will just go to the next one.' Or 'We will try this.' Or 'Heck, it is not working all right. So we can still figure our way around it.' They have sort of become immune to that because we do try and push technology a lot.

5.2.6 Professional development

A strong theme for teachers was the need for professional support and development so that they could use learning objects appropriately and effectively.

> T: … you can't give teachers learning objects without teaching them the good practices that really make it an effective learning process.

Teachers felt that professional development needs to be tied to training in how to integrate technologies into units of work, otherwise learning objects run the risk of being used superficially:

> T: How do we integrate … learning technologies and information technologies effectively into our units and programs so that they are not just one-off lessons? Because I think the danger is that by just putting them out on the market people will go, 'Oh yeah, that links pretty well and I'll just use that,' and they really don't know whether or not children are learning anything.

5.2.6.1 Professional development needs

Teachers need to be informed about The Le@rning Federation initiative, and technical and infrastructural issues relating to learning objects. However, they also need other information including:

- Guidance about learning objects, with appropriate content and factual material around which to structure programs
- Advice on class management techniques suitable for lessons incorporating learning objects
- Advice on techniques for presenting the learning object – in particular, suitable introductions and conclusions to the session
- Advice on how and where specific learning objects fit into the local syllabus
- Advice on the integration of new learning strategies used in the learning objects into their own curriculum development
- Advice on techniques for presenting the learning object as an example of general principles, with particular reference to its strengths and limitations.

The Le@rning Federation is a new initiative. As more content is released, greater attention will be focused on professional development. Professional development needs should be identified by jurisdictions trialling content in a range of different contexts.

Professional development is also a mechanism to promote the use of learning objects and enthuse teachers to use them:

> T: I mean they need to be in-serviced and shown these kinds of things because if they see it they think, 'Wow. This is great. We can use it'. They will use it but if they are not shown and it is just landed on their desk they probably won't …

> T: that will actually spark off other teachers' ideas so I just think [there] has to be … those demonstrations out there.

In general, the teachers involved in this pilot Field Review were enthusiastic about the use of ICT in the classroom and keen to try new approaches. Many spent considerable amounts of their own time experimenting with learning objects. However, not all teachers are like this. Adoption of learning objects needs encouragement through professional development:

> T: … I sat down there and had a look and a play with it – but once again I spent close to two or three hours just going through that. A lot of teachers won't do that.

5.2.6.2 Preferred type of professional development

Teachers almost universally felt that professional development should be brief and focused. Preferably it should be offered by a trusted classroom practitioner, and be 'hands on':

> T: … and demonstrate some of the better ones and say, 'You can do this and you can do this.' And then it would probably be a case of working in the different curriculum areas like Science and get the core teachers to actually identify which ones specifically meet the needs of the outcomes of year 8 Science or whatever they are doing. So it would be a matter of going through and identifying those and then give a list to the teachers and maybe instruction, 'Go here. Go here. Go here and you are in.'

> T: I think we usually like to see it performed in front of us and if it is performed then we are going to go and get it. Or if our best buddy who we respect in the classroom, if they say, 'Oh have you tried?' 'Oh OK. If such and such is trying it, then I'm going to try it.

> T: I think if somebody had had nothing to do with [learning objects], I'd get a computer lab like that and have some opened up and just let them go and use them and then go and show how to set it up but I think just to immerse people in them – various types of them for twenty minutes or half an hour – you would get a really good feel for what they are all about. Then go and show people how to set them up.

5.2.6.3 Ongoing professional support

Teachers who were experienced with using ICT in the classroom identified a need for teachers to engage with their peers about appropriate use of learning objects, in an electronic 'community of practice':

> T: I wonder if there is a need for a dynamic 'learning exchange' of teachers' ideas saying HOW they used specific objects … probably run at the systemic level in some way … useful PD for all teachers as a discussion group with threads linked to each object through the metadata/search page.

According to teachers, an electronic community of practice should enable:

- conversations with peers about techniques to adapt generic learning objects for specific themes
- debates with peers and the wider academic community about the role of the curriculum, and the part that ICT can play in its development
- conversations with peers evaluating forms and quality of student learning, particularly relating to satisfying the specific needs of different students
- sharing worksheets and other teaching materials to be used by students while they are interacting with the learning objects
- information about how learning through the assistance of learning objects can be assessed.

> T: I'd like to see the learning objects put out there as models of how this can be used so that other teachers would exemplify the best way of using it. I would like to see it utilised within a lesson that shows teachers how to use it ...

Some expert teachers requested a platform to share their own learning objects with other teachers.

5.2.7 Further suggestions from teachers

A range of areas in which learning objects could be improved were suggested by teachers. Many suggestions are included with feedback in 5.3, but some issues are specific to usefulness to teachers:

> T: There needs to be the quality processes built in to make sure that we are getting the bugs out of the system and the basic design features are [right] from the start.
>
> T: What is going to change within that learning object that is going to force my kids to engage with that text rather than to engage in the game?
>
> T: 'Would it work for everyone?' No. I don't think it would and a lot of people aren't as computer literate as others in any case.
>
> T: A lot would just look at that and say, 'Well it doesn't fit into anything that I'm doing so I am not going to even try it … and I can't modify it and you can't save and you can't …' so they'd probably pick out all the negative things about it.
>
> O: Would that work for your standard kids?
> T: No. No.
> O: Why not?
> T: They get frustrated because they just wouldn't have a clue what is going on … A lot of kids would see 'Radiation Inverse Square' [and react with] 'Forget it, it is too hard for me' … I mean it is a complicated concept.

5.3 Usefulness to students

The second major theme in the report is usefulness of the learning objects to students. Learning objects must be useful and usable to impact on learning. This section presents results using three sub-themes, each aligned with one of the generic questions in the study.

Ease of use	Q8 – Can students use the learning object easily (can they navigate, gain access to materials and perform the requisite tasks, among other things)?
Enjoyment	Q9 – How much do students enjoy using this learning object?
Accessibility features	Q10 – To what extent do target students use the available accessibility features of the learning object?

5.3.1 Ease of use

Students need to be able to use each learning object easily if they are to undertake the learning activity and stay motivated in the face of difficulties with the process or subject matter. Students, particularly those who are less familiar with computers, will give up if they face difficulty using the object. This section explores what was learnt from the field visits about ease of use of learning objects.

5.3.1.1 Learning object usability

A focus of the research was whether students could use the learning objects appropriately. The results show that, overwhelmingly, students were able to use the learning objects without difficulty. The user interfaces were easy to navigate and pleasing to look at, with bright, clear and sharp colours.

> S: It didn't take long and I could understand easy.

Although in many classes the teachers explained how to access the learning object to each student or pair of students, in one class the teacher successfully demonstrated the learning object to all the students at once to save class time.

> T: I think the majority would have worked it out within a few minutes. Within ten or fifteen minutes I would think. It is just that I thought with the compressed time scale that we were looking at that it would be better rather than have ten million hands up … I thought, 'No. It would be easier if I go through all that part of it first.'

Many teachers and students found it easy to get started with the learning objects. However, several had problems finding an 'exit' strategy. This became an issue in several schools where students completed a task and handed over the computer to the next student. In many cases, it was necessary to re-launch the learning object. This also happened to students who made errors using some learning objects.

Interface improvements were suggested for a number of learning objects (see Appendix 3 for a more comprehensive list). Although some of these impede the efficacy of the learning objects, they are relatively easily implemented. The following issues in specific learning objects were identified:

- The factor extension facility was not obvious to students in 'The multiplier'.
- Students did not notice the 'challenge' and 'try' buttons in 'It's a drag'.
- Students did not notice the active buttons for specialised vocabulary and aural support in 'Plant scan', leading to mispronunciation of unfamiliar words.
- In 'Park Fractions', some students did not notice the 'use the times tables' option for difficult calculations and were resorting to pencil and paper methods and getting stuck.

- In ‘Compound Shapes’, original shapes created by the learning object ‘disappeared’ as they were cut up. This discouraged students experimenting to find the best ways of cutting the original, since a ‘picture’ of how the original had been cut was not shown, making it difficult to compare various solutions for their efficacy. The observer noted that ‘this would suggest that the learning object is reinforcing practising a formulaic procedure rather than encouraging the development of mathematical processes such as using logic and reasoning’.
- With ‘Intergalactic cook-off’, students engaged with the chemistry, but didn’t realise they could move further, until their teacher encouraged them to enter some more competitions.

The students did not appear to have difficulties with download times where technical and infrastructure issues did not intervene.

Students were able to navigate easily between screens in most learning objects. However, the following section will demonstrate that they had more difficulty in carrying out the tasks expected of them.

One aspect of the user interface that was problematic for some students was the use of underlining to highlight a link – to a glossary for example. This was not intuitive for some students, particularly younger ones. The use of rollover pop-up hints to explain these features would be valuable. On the other hand, some students discovered the facility of clicking on underlined words, and found the underlying explanations valuable.

> S: I like it the way it is because they have got it big enough so you can see, and if you click on the words if you don’t understand, it will tell you what everything means.

5.3.1.2 Instructions

Students were strong advocates of multimedia alternatives to reading. The teachers using literacy learning objects and several using other learning objects commented on the difficulty of getting students to read the text. Even those students who claimed that they liked reading were also clear that this did not extend to reading lengthy text from the screen. Very small fonts, like those used in ‘Dynamic Fractions’, created additional impediments to reading.

The majority of students did not read on-screen instructions, particularly when they were presented in one block at the beginning of a learning object.

> S: Oh there is a bit too much writing like ‘Come follow me down the creek.’ … they should just have what you have to do in there.
>
> S: Well you wouldn’t want too much because you wouldn’t want to be sitting there reading all that stuff. You would want to get on with the activity, not just read, read, read. Just simple instructions that you can read straight away.
>
> S: I always skip instructions … the less reading you can do the better.

Students did not read the instructions for a number of reasons:

- Many students preferred to experiment rather than work sequentially. An observer noted that young learners’ tendency to ‘follow their noses’ when using the learning objects is sometimes in conflict with the designers’ intentions (and assumptions) that the learning objects be used systematically.
- Some students lacked the literacy skills to read the instructions (see also below).
- Students could find the instructions confusing.

> S1: … sometimes I don't understand it. I just keep reading through and then I think I actually get what it means.
>
> S2: They weren't all that easy to follow.
> S1:I don't really understand that bit.

- Students wanted to use their time efficiently.

> S: You don't want to spend all your time reading and miss out on doing the rest.

- They felt that the font sizes of instructions were too small.

For those students who read the extensive text materials in some learning objects, some were unable to retain the information because of the demands it placed on memory. For example, in 'Treasure puzzle', students without the worksheet did not remember the information presented at the start of the learning object about how to identify an acid and what litmus paper does.

'Intergalactic cook-off', 'Treasure puzzle' and 'Save the lake' contained large quantities of text-rich information in the introduction. This information was essential to the completion of activities within the object and yet was not available throughout the object. In contrast, 'Dynamic Fractions' has over three screens of instructions, but these load in a different window, making them accessible during the use of the learning object.

Students repeatedly expressed the view that they needed instructions not only at the 'beginning' of a learning object but 'when you are doing it, not just before'. They wanted instructions 'in little bits all over the place,' that is, context-sensitive help placed as hints or as pop-up screens attached to hotspots. The context-sensitive labels in 'In digestion' were pointed out as being effective. Several students working on different learning objects suggested context-sensitive help and hint screens as a better means to break text into manageable chunks, and having them available when needed.

Where text is required for initial instructions, students felt that it should be no more than a paragraph. They also felt they should be able to bypass the initial instructions if they were returning to the object. The rollover cues to suitable actions on the opening page of 'Shape fractions' provided sufficient information for students to start. In 'The multiplier', students were making decisions on the first screen; in 'Compound Shapes' they were doing so on the second screen.

The immediate decision making provided in many of the P–year 2 learning objects provided appropriate just-in-time instructions. 'Experience the weather' did not have an immediate decision for students to make, but provided a repeatable audio file that formed the basis for decision making. While this immediacy is vital for young students with a short attention span and who may not be able to read, it is important for older students as well. The Numeracy learning objects worked well for this reason.

Students appreciated the 'start again' button on 'In digestion'. The Gecko learning objects, such as 'Caving' and 'New developments', had a more effective option with a feedback page before the re-start.

Students were articulate and creative when suggesting what made an appropriate instruction or hint. This can be seen as an indication of the paradigm shift from text to visual learning. For example, a student who was considered below average academically suggested not only that the glossary of the learning object she was using would be better served by sound (for pronunciation), pictures and animations, but also that animations should be used whenever a 'thing' or process was being described. This student was unable to use the existing written pronunciation cues, and gained little from the explanation.

A pronunciation file, as provided in several tools, would be useful wherever students and teachers are being introduced to new terminology. Students' requests for optional audio instructions and feedback throughout learning objects also arise in later sections.

Students found navigation intuitive even when they did not read the instructions. A side effect of this was that they could complete a learning object without engaging appropriately with the content. In many cases, teacher input was required to set the context of the learning activity.

In 5.4.2.5, there is discussion of other issues relating to literacy and reading including the needs of students from non-English-speaking backgrounds and of those with low achievement in literacy. Issues relating to literacy in terms of typing and student feedback are dealt with in 5.4.1.7.

5.3.1.3 Icons

While students may not use text cues to the degree that their teachers would like,they are exceptionally competent in using buttons and icons. The learning objects in the Gecko series were understood intuitively even by the youngest students. The large and brightly coloured icons also added to the acceptance of the learning objects by the younger students. Students who had very little computing experience found the highlighting during rollovers in 'Shape fractions' simple to follow, and the animated arrows as suggestions in 'Finders keepers' removed a large amount of non-task-related searching.

5.3.1.4 Student choice and control

A noticeable difference between teachers, who belong to a text-dependent generation, and students, who belong to a visual generation, arose in their attitudes to sequential or non-sequential progression through a learning object. A number of teachers assumed that the only approach to a problem was sequential. This was revealed in the way they talked about lesson sequences. The same approach is found in a number of the talking-book learning objects that students generally found boring. Students expressed a very definite preference for learning objects that provided choices and control:

> S: having no control is boring – we get enough of that at home!
>
> O: [Why is this] the best one you have done today?
> S: You get to do what you want. Like choose what you want.
>
> S :Because after [designing] an assigned park for the town I think you should be able to do your own as the title claims.

Some students claimed that control of choices within a learning object improved memorisation:

> S: You can feed him whatever you want and you can choose what he does.
> O: And was that good or bad?
> S: It was good because then you have to experiment.
> O: OK. And do you reckon that helps you remember?
> S: Yeah.

Examples of where students found that controlling aspects of learning objects to be useful were:

- being able to water and fertilise the plant and see what happens in 'Plant scan'
- changing variables in scientific learning objects

- making navigational choices:

> S: Like when you are controlling the person it is fun to … get in corners and collect stuff.

- choosing their own multiplication problems. An observer noted that being unable to generate their own problems 'reinforces the ideas that doing mathematics is about finding answers to externally imposed problems'
- varying the conditions in 'It's a drag'
- controlling their environment, such as through colours and textures
- creating their own environment, for example, a park in 'Design a park'.

Students requested the ability to further customise the learning object environment through, for example:

- customising the vehicles in 'It's a drag'
- extra analogue control over speed rather than 10km/hr intervals in 'It's a drag'
- enabling gender customisation:

> S: … you have only got one character and sometimes the girls like to be girls on the computer …

- having the option of presenting a picture of their own in 'Picture this'
- customising mathematical equations:

> S: Instead of just pluses you can mix them up like plus, plus, minus, plus and stuff like that.

Students also appreciated the learning opportunities offered by making the wrong choice. These factors are consistent with the games environment that most students have experienced, which allows them to control what occurs on the screen in a meaningful way. Students expect the same from learning objects, and many become bored with learning objects that simply allow them to turn pages, or make trivial choices. The immediate feedback of many simulations, tools, and activity learning objects heightened student interest.

Another way in which choice is important is in learner control of the pace of learning. Students enjoyed being able to teach themselves at their own pace, something they had found difficult in class. Teachers found this especially useful for under-performing students:

> T: Because he knows that he can keep going back and he can keep trying until he gets it right and he can do it at his own pac**e** without somebody saying, 'That's due now' or 'You have to have achieved that by this time'. So he has got that self-paced kind of thing that he knows that he can keep having a go and he is used to that format from his PlayStation at home where he will have to work through a level to get to the next level and he will keep going back to it and he is quite happy to keep going back to it and not instantly getting through the levels. So they are sort of used to that in their own popular culture. They are used to staying at the one level and not necessarily reaching the next level but thinking, 'Oh, next time I will get it.' So they have that more positive thinking, 'That is accessible. I will get there' frame of mind rather than 'Oh I will never get there with this Science, with my spelling and with my this that and the other, my handwriting'.

Students reported game-playing as their most frequent non-school computer activity, ahead of Internet browsing. Within many of those games there is an element of competition, against the game or (less frequently) against other students. Two of the common devices to provide competition in these games are scores and levels. Students wanted these features in the learning objects, particularly simulations that had a 'gaming' feel to them.

A number of learning objects do this well. An incident with a student using 'New developments' highlights the importance of these features. A year 3 student opened the game,

made a few random adjustments and was rapidly losing interest. However, when he appreciated the significance of the brightly coloured dot function, his interest was renewed. When scoring is intrinsic, the game is better received.
There were observable differences in the approach students take to gaming. For some, it was the strategy that was important. These students were more likely to read instructions and discuss options with friends before making decisions. A larger proportion of students concentrated on time factors for measuring success. The speed orientation can detract from the teaching purpose, as in the case of the boy who ‘won’ ‘Finders keepers’ by clicking randomly and finished before the girl who had worked through the text, or the boy who ‘won’ ‘Save the lake’ by finding the answer from the five alternatives by chance.

While the lateral thinking that the learning object engendered was lauded, an observer suggested that ‘The multiplier’ could include some mechanism to prompt students to consider the most efficient division of the learning object into smaller shapes.

> O: The LO did not allow students to create their own shapes – the important mathematical skills of designing and problem-posing were therefore limited, reinforcing the traditional approach to teaching Mathematics whereby externally generated ‘problems’ are imposed upon students.

5.3.2 Enjoyment

Ideally, all learning should be enjoyable as this improves the learning process. This is particularly important for learning objects because the learning activities take place largely between the student (or small group of students) and the computer, with minimum supervision by the teacher. If students do not enjoy the learning object they will quickly be distracted. Three factors which arose in the field visits were the extent to which learning objects motivated and engaged students, the amount of humour and fun in the objects, and the factors that led to boredom.

5.3.2.1 Motivation and engagement

Overall, students found the learning objects stimulating and enjoyed using them.

> T: Everyone likes it in here. I reckon all my class would like it.

Teachers noted an obvious increase in confidence and enthusiasm as students used the learning objects. The success that students achieved was also a strong motivating factor.

> T: Kids can work independently and they often get an immediate reward and it is a reward they enjoy. They like doing it.

> T: One of the kids had one [vehicle] that stopped. He managed to stop within about a metre of the marker cones and he was quite excited about that. So I could see if I left him for another five minutes he would have been experimenting with the different conditions to try and see exactly where should I hit the brakes so that I can stop within a metre or as close as possible to the actual marker. So I could see that one would work quite well … And the engagement is just absolutely fascinating. They are just really switched on and they just love it – I think because learning objects are often showing them things that they haven’t seen visually before. The digestive system is a great one.

> T: And I think that is what grabbed me with the Science ones. They were very interactive, they were colourful, not much writing, lots of participation by the kids and they were picking up knowledge as they go. With the other ones you are walking around but with the Science ones, ‘Miss, come and see this’, ‘Come and look at this’, ‘Look at what is happening here’. Yeah, very, very interactive and the kids are absorbing the knowledge without even realising that they are picking it up and that is what it has got to be I think.

Motivation and engagement are important to capture the attention of students who do not normally enjoy the classroom experience.

> T: Oh yeah but the attention span is not there. He will go for a while but unless it is very riveting, the attention span is not there at all.

> T: They did the work more because they were motivated …

A range of evidence indicated that students, even those not normally interested in school work, were engaging with the learning objects.

> O: 'In digestion' made a big impact particularly with the visual humour – that did not distract from the teaching purpose. In fact the students' understandings of the content were better with this than any … other objects they used in this lesson. [They] were able to give specific, often quite high-level, ideas that they had taken on (for example, you still need digestive juices for fizzy drinks). The fact that it was not straightforward was a challenge, and the feedback was enjoyed. All writing in the boxes was read as they came up, as were the labels that appeared at relevant times on the diagrams. This did not happen with the other two objects.

> T: Well it was really obvious because they were saying, 'Oh this is awesome' 'Wicked' and that kind of thing that they say – their comments and their funny language. 'Hey look at this one.' And other kids that weren't supposed to be there were coming and looking over their shoulders and you'd say, 'Well you can have a look at that later' [and] direct them away from the computers. These kids were obviously getting really excited about what they were doing there.

> T: They have got to be fun because … students like [name] who has a few behaviour problems and [a] few learning difficulties, if you give them anything that doesn't look like fun then they will start rolling their eyes and, 'Oh this sucks' before they even get into it – and you don't want them starting off negative so you need something that is a little bit catching and 'Oh this looks good'. So those graphics are really important to get kids like [name] in initially and he was coping with the years 3–4 'Who's for dinner?' even though he is a very low [year] 3 because of the way it is set up to be like a game. And he got something out of it which is great and gave it a really good go. Yeah, colourful graphics and sounds and all the rest of it helped students like him.

> T: What always amazes me is when you first introduce the BELTS, the learning objects and you put kids in front of them, the classroom just about goes quiet.

Students found the learning objects motivating for a variety of reasons. The learning objects:

- gave them control:

> S: I usually like it when we can use them instead of just watching the teacher doing it because when you watch the teacher you 'Oh I want to do that'. But then you don't end up being able to do it because she just shows you and you go back to the desk or something so I like it when you can use everything and see what it is like and all that sort of stuff and you can see what you can do on it and what is interesting about it.

- challenged them:

> S: I guess because it is harder than most stuff and a challenge.

- allowed them to explore:

> S: You get to explore heaps – I mean lots!

- allowed them to compete with each other – trying to beat each other's score
- made young students feel grown up:

> T: Yeah helping them to feel grown up and you can do amazing things, but online and making the education explicit to them so that they are more aware that this is

> educational and they are more aware that they are doing a fun learning thing so that they can say at the end, ‘Well this is what I learnt’.

Students found the content of some learning objects interesting, particularly the clear factual information, the relevance of the content, the immediate feedback, the fact that there were consequences to their actions and the novel approaches to what is often mundane classroom learning.

5.3.2.2 Humour and fun

Humour and fun are important aspects of learning and many students found this in the learning objects used in classrooms investigated in this study. The humour may arise from an alien, a frog, human expressions or from on-screen activities. While some of the effects were perhaps not to the tastes of some adults, students found them engaging and humorous, for example, the choking and vomiting effects in ‘In digestion’.

Students highlighted the benefits of learning objects to other students:

> S: You don’t judge a book by its cover but some of the kids think, ‘No this looks totally boring’ and they won’t look at it all and they have got this funny little reporter dude standing there going ... and so you think this might have humour.

Teachers felt that learning objects needed to make the educational needs explicit, ‘even though there are fun things there as well’. Two particularly mature students reflected on the nature of humour in motivating learning in the following way:

> S3: And it is good like they could slip a joke into it … With these ones it looks interesting because there [are] little cartoon characters and they are able to slip a joke in.
> O: You like the cartoon idea?
> S2: If you can see behind the humour it is the same old, same old …
> S3: And so a way that you could learn by just clicking on something, making a bit of fun, and plus there is like arcade games put in there too.
> S2: … but because it is more for kids, some kids don’t actually see the educational bit – but it is educational because if kids can’t see the educational side of it then they are going to want get it. [Laughter]
> S3: So you are having fun and you are also learning something at the same time.

Game elements, mystery and exploring were also aspects of learning objects which led to student enjoyment:

> S: I like how we get to test it and like about what happens and so it is kinda like a mystery type of thing, finding out what is doing it.

> S: All the doors and the secret passages and stuff. And plus when you have got the treasure.

Teachers and observers noted a danger in students perceiving only the fun elements of learning objects – in their perceiving that all day they have ‘played’ on computers. Normal classroom activities, such as a teacher standing in a classroom showing posters or drawing things, issuing blackline masters, or even getting students to do group work and cut things out and paste them, are perceived as work, whereas on a computer they are perceived as fun.

5.3.2.3 Factors leading to boredom

While students generally found the use of the learning objects motivating, the term ‘boring’ arose a number of times in the interview transcripts. The amount and difficulty of text instructions were a major factor leading to perceptions of boredom.

> S2: Like if you put something you could write in brackets like in simpler form what it actually means because some people might not know what it [means].

In the students' vernacular, 'boring' seems to carry the connotation 'not engaging'. That is, if something is not commanding all of their attention, it is boring:

> S11: I'm bored now.
> O: You are bored. How long have you been on it?
> S11: Ah five minutes.
> O: So it really isn't something that is grabbing you? What about the 'Finders keepers' one, how long did that keep you …
> S10: That is boring.

Other factors leading to boredom were:

- the static nature of some learning objects, which could only be used once:

  > S: It is all right for the first couple of times and then it gets boring.

- writing predictions:

  > S: Like having to do all these tests … and then having to keep writing predictions and all that. That can get a little bit boring.

- when students had no control over what they were doing.

Students did not enjoy large amounts of typing. Where students worked through the learning objects that required them to input predictions, observations and explanations, they spent approximately three-quarters of their time on keyboard skills rather than activities associated with the learning purpose. In most cases they elected not to input a valid prediction but instead resorted to entering a random keyboard stroke to allow them to proceed to the next screen.

5.3.3 Accessibility features

Many of the learning objects have been designed to enhance their accessibility to particular target groups. These groups include Indigenous students, those from non-English-speaking backgrounds and those with disabilities. The pilot Field Review was designed to investigate the performance of learning objects in classroom settings with these students. However, no students with physical impairments were observed working with the learning objects. Furthermore, while Polynesian students were observed using learning objects in New Zealand, no Aboriginal or Torres Strait Islander students were observed in Australian schools during the study.

A teacher with a group of Maori students who were 'at risk' in numeracy and with limited private computer ownership found that computers could be used as a hook to teach many things. For this group, normal teaching didactics were difficult because the risk of losing face for giving an incorrect answer was greater than the gain from providing a correct one. The computer allowed students to participate without having to verbalise until they were confident to do so.

Apart from students within these groups, the majority had access to computers at home. Learning objects are therefore potentially available for self-paced extension work at home by students.

The text-heavy instructions in many learning objects advantage more literate students, and may be inaccessible to students who can't read text of this nature or difficulty. The literacy levels required to effectively use learning objects have been discussed in 5.3.1.2.

The lack of sound in many learning objects also disadvantaged students with weak literacy skills. However, some compelling evidence was obtained about how the use of learning objects empowered students with poor academic skills or with learning difficulties. This is discussed further in 5.4.3.1. The use of sound cues raises difficulties for deaf students and a warning light to mimic the alarm sound in these learning objects was suggested.

5.3.3.1 Improving learning objects

Students made a number of valuable suggestions about how learning objects might be made more interesting and accessible. A comprehensive list of improvements for each learning object is provided in Appendix 3. This section discusses generic suggestions for improvement.

Game design

Students had a number of creative ideas about ways to improve learning objects by incorporating game elements:

> S: Like with the native animals at risk on the roads you can have like a car and you have to try and miss all of the native animals. And with the cats you can go and be like this person and you can choose what person you can be and stuff and you can walk around and try and search for as many cats as you can that are trying to kill native birds and try to stop them and then you … Well I was going to say that you can earn money when you stop, and when you stop them normally and then earn money for every cat and then you can go and buy two bells or you can buy some birds and then it will be easy to stop the cats and then you get more money if you stop them with bells and stuff.
>
> S: [Have]security guards in the room and you have to dodge them and that.
> O: Oh, so dodging things and you are actually moving around and you've got a bit more control over what the guy is doing and what you've got to do with him. He has got to actually do more to get to the clues et cetera?
>
> S1: So for animation things you could put a castle with (S2 interrupts: 'cannonballs flying at it').
>
> S: … and you have got little fishing rods and you have to fish out the right number.
> O: How would you know when you had the right one?
> S: Because you can see them.
> S: But they could be floating on the water.
> O: OK. It would take you a longer time wouldn't it?
> S: Or you could see fish, little fishes and they had numbers on their side.
> S: And if a knight or something comes you have got to run away and hide behind a tree and then come back.
>
> O: So are you saying actually have a real camera in a real car and simulate it that way.
> S1: But not an actual car accident. Like smash it into a wall or something.
> S2: Like they do the tests for cars.
> S1: Yeah, that is what I meant with those little dummies in the car and you could smash it up and then you could see what it looks like from the inside then you could also watch it from the outside.
> S2: Just have camera angles one on that side and one at the front and one at the back and one in the car.

Levels of difficulty

A number of students wanted to incorporate various levels of difficulty into the learning objects. The year 6 students who devised the game for 'Earth alert' also initially incorporated levels into their game where, at higher levels, the rubbish was harder to find. On reflection, they decided that it would be better to make higher levels dependent on treating the rubbish in different ways. This demonstrates the awareness many students had of the learning purpose.

Similarly, an early years student felt that ‘Weather wear’ could be improved if there were levels. Level 1 would remain as it is, but a higher level would be introduced where students could select several items of clothing (for example, jumper and raincoat) for several types of weather. However, neither students nor teachers could determine on what basis the levels in the ‘Finders keepers’ and ‘Picture this’ learning objects had been decided.

The incorporation of levels of difficulty enables learning objects to be used by students of differing academic and linguistic ability in the same class. It also allows the object to be used on multiple occasions.

> S: If there was levels I suppose it would never get boring.
>
> O: OK. So there is some sort of penalty … you lose points or you lose men or whatever it is, if it is a war game … OK. But there is no penalty with this, is there, so you can just click until the right one comes up?
> S: Yeah … worked each time so I didn’t learn anything from it ... needs to be hard enough to fail sometimes.
>
> S: You probably could have put levels in it. Something like that.
> O: What would you put in the different levels? What would a low-level one and what would a high-level one look like?
> S2: Harder fractions. Probably mixed fractions and something like that, improper ones.
>
> T: I agree, I think that [in] ‘Finders keepers’ you certainly wouldn’t be doing it more than once because once you have done it you know what is going on. The maths ones you can vary the difficulty. With that one today you could get the children to select easier operations and then the next time go back in and get them to choose something more difficult so you can actually take it over different ability levels, which is good.

One student suggested that hints could be arranged into levels, so a beginner could choose to have explicit hints.

> T: There is action. OK. Do I have to read it or could that just be if I make mistakes? Like when you did the first one, T, you made a mistake the first time, maybe at that point the sound could come on because, ‘Ah, here is a kid who is cheating’. The computer could know that and then start to read it to you. Would that make sense?

Printed output

A final suggested improvement to learning objects was a need to be able to save and print student work in learning objects in which students entered their own explanations.

> O: Is that how you show the teacher that you have learnt?
> S1: No, we just show our teachers the report on the computer because you can’t find the print button.

5.4 Student learning process

'Student learning process' refers to the ways in which students interact with and engage with learning objects in order to learn. This section looks at how students in general use learning objects, how students of different backgrounds use learning objects, and the impact of multimedia elements of learning objects on student learning. The information in this section is the result of the following research questions:

Student use	Q11 – How do students (from different backgrounds and contexts) use learning objects in order to learn?
	Q12 – In what ways does the use of the learning objects guide learners to engage with, interact with, organise, represent, interpret and manage the content?
	Q13 – In what ways do students realise the knowledge can be applied in new contexts?
	Q14 – How does the use of the learning object enable students to make connections with their prior learning?
	Q15 – How do the multimedia attributes of the learning object influence the intended learning processes?

5.4.1 How students use learning objects

The way teachers incorporate learning objects in their units of work and how they introduce them, set expectations and monitor their use are critical factors in determining how students interact with learning objects. Observations provided some insight into the extent to which students structured their interaction with learning objects, how they made connections to prior learning, how they perceived working at their own pace, how they worked with each other and what sorts of feedback they preferred.

5.4.1.1 Patterns of interaction with learning objects

While some learning objects were essentially linear and simple, others were complex with multiple pathways, providing opportunities for students to explore them in different ways. Simple learning objects such as 'Caving' provided few choices for students. Once the object had been explored, a second try would take them on an identical path with identical information. Some of the learning objects using the Predict–Observe–Explain model, however, provided students with a multitude of options and, while the answers were the same, there was more than one means of achieving them.

Some students were systematic in the way they used learning objects. Some appeared to be well trained in taking roles at the computer. They read instructions carefully and followed the flow of the activity in an orderly way. One pair of students took notes to 'to help me find out what happens'. They used this as a guide to help them 'to decide what the thing [is] so if I just write it down now then I don't have to keep going back'.

In some cases, teachers provided students with worksheets to assist them with learning activities. Students using worksheets tended to work more systematically. Those without worksheets tended to forget the information presented at the start of the learning object, were more random in their choices and took a less linear path.

The majority of students used an intuitive and experimental approach. They liked 'figuring out the purpose' of the learning object, and working out the 'rules' for themselves by sampling instructions and trying out actions.

> S: I read a bit of it and then worked out what I had to do.

Learning to satisfy the 'rules' of the learning object appeared to motivate students. In 'Design a park', for example, students enjoyed the challenge of finding a park layout that satisfied the criteria..

Students' experiences with computer games had taught them to combine an intuitive approach with persistence in order to succeed in the challenge:

> S: … if you just press any of these, they will tell you and they'll highlight it but you can do it again until you get it right.

Some teachers felt that the hints provided in some learning objects were useful scaffolds for student learning. They observed that iterative use of hints at the point of need was effective in improving student understanding and performance.

> T: … in this case the hint has worked beautifully. The second attempt very much quicker ... yes and the second one absolutely correct first time around for the things that go into the area, now doing the calculation which is correct. So the first attempt took a while. [In] the second attempt, the instructions were clear enough – went straight through the hint – certainly worked beautifully.

The 'In digestion' learning object was complex, presenting four panels concurrently and complicated diagrams of internal organs labelled with technical terms. There were multiple decision points and multiple paths at each decision point. Two animations were running concurrently and further text information was available via links.

Despite this complexity, students found it relatively simple to use and were able to engage with it successfully and learn from it. In six classes that used 'In digestion', no student could clearly explain the precise recipe for success in completing the task. The paths taken by each student were also widely divergent and this made the learning object more appealing. They wanted to 'try out all the alternatives' as one year 6 student put it. Despite this, they were able to use the terminology and were forming conclusions based on detailed reading of the text information.

The complexity of design and the success of the interface encouraged students to stretch themselves. Although 'it's really hard to make stuff work', they weren't discouraged by failure and were motivated to work through the learning object multiple times. When the character in the learning object reacted directly to their choices, particularly in an unexpected way, students examined the information within the learning object in order to inform their next set of choices.

A systematic approach did not seem necessary to retain engagement or to promote learning for this very popular learning object. When interviewed, students were able to articulate things that they had learnt about digestion.

The tasks in the more rigidly constructed learning objects using the Predict–Observe–Explain model could also be solved by students working in a non-systematic manner. However, this was often a matter of chance and students were less able to say how they had reached their conclusions.

The students who were not systematic and who did not readily achieve success in the task tended to experience more confusion and frustration, and were less motivated to try alternatives. Feedback on the choices made by students during a learning object interaction was critical to the level of engagement, the willingness of students to try different paths within the object, and subsequently the amount of learning achieved.

5.4.1.2 Connection to prior learning

Evidence was obtained of students making connections to prior learning. This included using prior knowledge to solve a learning object task. Researchers observed students commenting that the activity reminded them of what they had done in other lessons and using prior learning in a process of elimination to choose what they needed to explore. Teachers felt capable of making judgements about this, based on the reactions of their students:

> T: I suppose the comments that they are making like … 'Oh, that is like last week' or 'that is like in the water cycle' [enable you to] see that they are relating to something else that they have done, whereas if they were just saying, 'Oooh. I don't know what is going to happen. I have no idea' then you can tell that they haven't connected it with anything else.

Three students using a Science learning object about identifying acids remembered that litmus turns red in acid. They enjoyed being able to make a connection between lemon juice and its ability to stop fruit going brown and that 'oranges and lemons [are] too acid for a worm farm.'

Several students were aware of the reaction between vinegar and 'bi-carb soda' (and other household chemicals) before using learning objects. They used their knowledge to predict outcomes of experiments simulated in learning objects.

One teacher encouraged students to make connections with prior learning from other contexts by comparing 'Plant scan' with classroom lessons on the human body.

> O: Have you heard of carbon dioxide before, incidentally?
> S: Yeah … When we done health. We are doing health at the moment. When you breathe in you breathe in air but when you breathe out you breathe out carbon dioxide.

Some students had grown their own plants in a previous year. While they found that experience had more impact than using a learning object, the learning object refreshed their memory and was useful in extending their learning.

> S: So it is simple because you know what leaves are and seeds and flowers and petals and everything.
> O: So you can eliminate them and then you have just got the last few left that you don't know?
> S: Yeah. See, it is simple because you know that they are roots … See now I am going to test and see if I got it right.

5.4.1.3 Self-paced learning

The capacity of learning objects to enable self-paced learning has been mentioned in 5.3.1.4. The benefit of this feature was revealed when one student, previously reluctant to do mathematics, told his teacher that he now enjoyed the subject. In a subsequent interview, this student and his partner reported that they enjoyed being able to teach themselves at their own pace. The Mathematics concept was fractions, one they had found difficult in class previously.

Another teacher saw the benefit of learning objects for students who do not respond well to lock-step lessons:

> T: Because he knows that he can keep going back and he can keep trying until he gets it right and he can do it at his own pace without somebody saying, 'That's due now' … So he has got that self-paced kind of thing that he knows that he can keep having a go and he is used to that format from his PlayStation at home. … So they have that more positive thinking, 'That is accessible. I will get there' frame of mind rather than 'Oh I will never get there with this Science, with my spelling and with my this that and the other, my handwriting …'

If the learning object presents a realistic, engaging challenge, such a student is willing to work through it several times. They benefit from being able to direct their own learning and achieve a sense of success that was not experienced in other classroom situations. The teacher is free to act as facilitator for the whole class because the student is engaged.

5.4.1.4 Cheating

Students and teachers felt that it was possible to 'cheat' using many learning objects. The concept of cheating can be seen positively as scaffolding and formative testing and feedback, not dissimilar to looking up the answers in a book. In several cases, however, the learning objects encouraged counterproductive cheating.

> T: One of the biggest downfalls is that there [are] so many easy ways to cheat and kids know that and they've picked up on that very, very quickly. They know that you have to put in your name or a scientific report, or the observations, you just go dit, dit, dit on the computer and it lets you move through and those kids don't actually do any real learning because in ten minutes they turn around and they say, 'I've finished'.
>
> S: … on one of the activities you can sort of cheat with one of the maths ones. Just type in an S and keep pushing 'answer' and it comes up with the answer.

The common opinion was that learning objects should discourage cheating, and encourage the use of formative feedback and encouragement for students to think and puzzle things out for themselves. One student felt that the design of one learning object encouraged students to cheat 'instead of reading it properly and do[ing] it right.'

5.4.1.5 Collaboration

Teachers generally encouraged group work among students. This was partly because of restricted availability of computers and partly because group work is a common classroom practice. Teachers valued the learning resulting from collaborative use of learning objects, including the role that students played in proactively assisting their fellows.

> T: Well I was watching this group here just now. I kept glancing over to make sure that they were doing the right thing and you could just tell. They are leaning in, they are pointing at the screen, they are having a discussion, even a little bit of argument … they are actually having a proper discussion about what to do next …
>
> T: The kids are quite happy. While they are working on one machine, they will zoom across the room to work on someone else's machine if they have problems with it … while they [have] one machine each they have actually got access to other people as well.
>
> S: I am just tutoring [another student] and showing her how it is done.

Students valued collaboration when interpreting instructions, exchanging points of view, collecting ideas and competing with friends. Below are rhe most common forms of interaction observed.

- Seeking help. This was to interpret instructions or read a passage of dense text. These exchanges were facilitated when students worked on the same machine. Students were far more likely to seek help from a friend at another machine than from the teacher:

> O: You like working together with another?
> S: Yes because the game got a bit hard now and again and sometimes I really need [name of student] to help me get down.
> S: If you are stuck on something and you don't know what to do you can always ask your partner if they understand it.

- Displaying success. 'Hey try this!' was a particularly common response
- Sharing ideas:

> S: It gets boring by yourself … Talk with each other and cooperate.

- getting ideas from others.

Students who preferred working individually indicated the following reasons:

- Too many people are distracting.
- There is too much talking.
- It is too crowded.
- Partners can be annoying.
- Working alone 'gives you a chance to see what you can do, [instead of] using someone else's brain'.
- 'I prefer working on my own because I like to learn a lot.'
- 'You don't have to argue, it is just yourself.'
- 'It is easier to control things … without people arguing with you.'

Many students reported that while they did want to work on their own computer, they wanted to compare their results and reflections with other students:

> S: I would like to work with other people, not just because I would sit down and let other people do the work, but … because I like to [work] with people. If I work alone I feel bored. Sometimes if I am with other people I can tell them what I think about it instead of just saying it to myself.

Some students preferred pairs to larger groups:

> S: I would rather pairs because you can share your opinions between each other and just get through things together. It could be easier.

Observers noted that students working in pairs were generally more productive. In groups of three, the two students not using the computer tended to go off-task, leaving the person on the keyboard to complete the work:

> S: Probably with one other person so that we can both choose which things we need because if you have four or five on the computer at the same time it gets really crowded.

5.4.1.6 Feedback

Students valued the feedback opportunities provided by learning objects. This allowed them to see the consequences of their actions and evaluate them:

> S: So it helps more having it on the computer where it tells you where you are wrong.

Students also wanted the success of their activities to be acknowledged:

> When you win, [you] have a certificate of congratulations and you have found three acids and one treasure.

Some types of feedback were more quickly recognised and better understood by students than others. Students tended not to notice on-screen numeric feedback, and needed their attention drawn to it by the teacher. In general, students were less interested in textual and numeric feedback. A number of learning objects effectively used sound cues for correct or incorrect responses, in some cases in tandem with graphical or text-based feedback. The visual feedback provided by ‘In digestion’ was particularly attractive to students.

> S: … If it turns red it shows you that you have been choking, if it turns you green you can have a tummy ache or you can throw up and if he winks or smiles that means that you have done it right.

Similarly, ‘Give me a brake’ combined a visual and a numeric component to the output. ‘The multiplier’ and ‘Dynamic Fractions’ provided different forms of visual output to express student performance.

In addition to the relevance of feedback, students appreciated detail and variety in the response. Within ‘The multiplier’ and ‘Dynamic Fractions’, students expected positive reassurance and reinforcement beyond a tick or a written message at the bottom of the screen. Students preferred feedback that included animations, sound effects and humour. When learning objects had both visual and text responses, the students invariably used the visual rather than the text.

Teachers also appreciated the ways in which learning objects supported learning through feedback.

> T: They can finish anywhere but then they keep having to revisit it until they know that there is a certain number of steps that you have to take before you get to enter your experiment in the Science show and get a successful result so although it is not a game, it is the same sort of feedback mechanism as the game and, with the River Adventures, that involved a bit of a puzzle at the end as well where you had to put the right animal, drag them to the right part of the river or creek or wherever they belonged … I have found [that] the more feedback they have the more successful that they are.

Students were more likely to be confused about the best strategies to employ and were less certain that they had completed tasks successfully where feedback was less explicit. ‘Area of compound shapes’ could have provided hints on more efficient ways to divide the shapes. In ‘Earth alert’, about half the students in one class did not know whether they had selected the best of the three alternatives even after reading through the accompanying text.

Students liked learning objects that provided a direct link between their actions and the response from the learning object. ‘It’s a drag’, ‘The Alpha, Beta, Gamma of Radiation’, ‘Check Your Wind’ and ‘Who’s for dinner?’ were well received for this reason. On the other hand, students quickly noticed when learning objects displayed inappropriate connections between cause and effect. This caused their interest and commitment to the content in learning objects to decline. For example, an early years student using ‘Weather wear’ felt that Gecko should have no chance of winning the race if he dressed in the wrong clothes.

Learning is reinforced when the output of the learning object is related to the learning purpose. ‘New developments’ shows how this can be done simply. By having key concepts embedded in student feedback rather than explained before the activity, the discovery element in the learning object is enhanced. Students are likely to read the feedback closely as it provides information necessary to solving the task. Furthermore, the interaction engages the learner and contextualises the information. Similarly, students learn *through* playing the game in ‘In digestion’.

There is a risk that learning will be compromised where games and rewards are unrelated to the learning purpose. For example, the treasure at the end of ‘Finders keepers’ is unrelated to the text analysis in the learning object, and may have subverted the learning process of the learning object. Students tended to bypass the learning to increase performance in the game. In ‘Treasure puzzle’, the connection between the learning purpose and the ‘reward’ exists, but is scientifically incorrect, and confused some students.

The lack of feedback on the typed answers in more complex learning objects using Predict–Observe–Explain was frustrating for students. It was apparent that numbers of students were not confident with their predictions and not comfortable completing a number of steps to build a hypothesis.

> S1: … you just wrote down what you thought and most of it might be the same thing and it didn’t actually tell you the right answer, if you were close to it or if you were far away from it. So you just don’t know, you are just saying the same thing over and over.
> T: So you are just in the dark and you would really like something to say warm, warmer – eh, you are close?
> S2: You don’t know anything about it so you don’t know what it is going to do.

5.4.1.7 Predict–Observe–Explain

A number of Science learning objects used a Predict–Observe–Explain (POE) approach. This required students to model scientific behaviour by first predicting the results of a (virtual) experiment, making observations during the conduct of the experiment and explaining what they observed.

The design of the Predict–Observe–Explain model appears sound. It contains a problem-based investigation with the required information embedded, and a system that allows the student to build up a series of reports. These reports capture findings that can be reviewed at the end of the activity to confirm a set of discoveries that lead to a conclusion.

In practice students encountered difficulties using these learning objects. Most of these learning objects were complicated, requiring a series of steps and placing a significant cognitive load on students. The two elements designed to assist with this – the POE report and the link to the instruction and information page – did not work well for students.

The ability to predict and explain relies on having some factual information and experimental results. No student was able to identify the link from within the object back to the instruction and information page. In ‘Save the lake’, students were aware that the instruction and information page was accessible at the start of the object. Consequently the only way they found to access it was to exit and re-enter the object. Students who did this lost what they had entered into the POE fields. This discovery prompted them to rely on memory and use vague comments such as ‘everything turns white’.

The POE learning objects required students to enter something in the POE fields before continuing. This compelled students to collect data in an organised way so it could be used later. In practice this mechanism became an impediment to student learning. Some students were observed laboriously entering word-perfect sentences and subsequently losing the impetus of the experiment. Others found that there was not enough room in the fields to write what they wanted to say.

> T: … the students put down their observations and some kids have wanted to write more but they have been blocked by the amount of characters that has been allowed for that space. So that is frustrating for a child who has got to write down this great observation and all of a sudden they are halfway through their sentence and it stops. It was difficult to use also because, with some of them, students were

> expected to write up a report but every time they flipped back they couldn't save that report.

Most students learnt quickly that it didn't matter what they entered in the POE field. There was no immediate feedback to help them decide whether their choices were correct and students did not understand that the reports were intended to build towards a scientific result. Under these conditions the POE reports were not valued but were perceived as confusing barriers.

The Predict–Observe–Explain approach is generally accepted as a Science teaching methodology. However, it failed when used in the learning objects because students, lacking any prior knowledge, conflated *predict* with *guess*, and could not differentiate between *explain* and *observe*. Few students understood that 'explain' required them to draw conclusions about what they observed:

> S: No they were easy but it just came up with 'What do you predict?' and then it could be 'What do you observe?' and then it was to 'Explain what you saw.' But if you just had the first one, 'Explain what you saw', it would have been much better because it is easier to understand instead of having to write it two times.

It was unclear whether students could be expected to display the complex combinatorial reasoning required for some of these activities even if the intended scaffolding of the POE report had functioned as expected. There is also doubt about whether primary school students have sufficient prior knowledge to draw conclusions from some of the experiments:

> T: The level that is set on some of those things, and some of the 'predict and observe' seems to me to be fairly high-level. In the primary school they do predict things but they probably wouldn't word it that way. You might say in primary, 'Can you tell me what you think is going to happen?' You will get some teachers using the words *predict* and *observe* and all those sorts of things but the structure of it seems fairly weighty and the wording in the stuff seems fairly weighty …

In many classrooms it was impossible to print out the POE responses with the limited facilities available. Furthermore, in every case observed, the students lost their work at least once before they completed the activity. Even without the problems of saving work (both teachers and students suggested links to save the material into Word), students still needed more effective, timely feedback on their efforts.

The interface and visual elements of the POE learning objects also received an unenthusiastic reception:

> T: They are boring because of the graphics and the text and the colours that they use. It is hard to see when they are mixing mixtures together it is really difficult to see what is actually happening ...

It is likely that the POE model could be made into a powerful constructivist tool. To achieve this the objects need context-dependent hints, multiple-choice type sequences of scaffolded choices and resolutions of interface problems.

5.4.1.8 Comparing learning object use to other teaching methods

Generally, students stated that they preferred using learning objects to teacher-led lessons or reading from books:

> S: It's like books when they come out in the movie: it's more interesting to see them in the movie than reading the book because in a book you can't really visualise everything, and if you think of the movie as the computer you can visualise everything – see it all, it is more interesting.

> S: With Science, the Science teacher just puts it up on the board and we have to write it down … [Learning objects are] better than what the Science teacher does.

By the same token, students were generally of the view that they would prefer to do the ‘real’ thing than use learning objects, particularly with science experiments.

> S: When you do it right [in an experiment] you feel good about yourself.
>
> S: [I] prefer to do [the] real thing. You can see more.

Some students felt that learning objects could be integrated more closely with traditional teaching activities:

> S: You could do that and you could also have some on the side, like actually doing the things, pouring all the stuff in, so you have seen what happens, not just viewing it on the video screen.
>
> S: I would probably do the computer first and then try it out in real life.
>
> S: I would try the real life first and see what happens and then I would go on the computer and see if it has a totally different reaction.

Similarly, some teachers wanted to use learning objects as preparation for hands-on lessons.

> T: So I thought, ‘Well they can actually do some hands-on chemistry for this as well’. And so they got some background knowledge first from the learning object and another website and then they went on to do some experiments of their own and to perform some experiments in front of the class and to explain the science behind the experiments as well as just doing them.
>
> T: And so they came into that hands-on chemistry thing with some really good background knowledge. ‘Oh, this is what happened online. Let’s see if what we do here … gets the same sort of results. This might fizz up. You had better get a bigger bowl to put underneath.’

5.4.2 Student characteristics

Learning objects offered different advantages and challenges to various students. Teachers were eager to see how learning objects could meet the particular needs of their students including those who were gifted, non-academic, or from a non-English-speaking or a non-mainstream cultural background.

5.4.2.1 Gifted and talented students

Interviews suggested that teachers saw the ‘high-end’ potential of the learning objects to do new things, and often more challenging things, with their gifted and talented students. Three such classes were observed, with teachers choosing the learning object on the basis of::

- the ability of the simulation to accurately represent reality, including the ability to control multiple variables, and the inclusion of the random number generator function to simulate probabilistic functions (with a year 8 class using ‘The Alpha, Beta, Gamma of Radiation’)
- the ability to see a different representation of, and extensions to, experiments done in class, and to develop pattern formation (about chemical change) that would not be possible with time limitations in class (with a years 4–5 class using ‘Inter-Galactic Cook-off’)
- the challenge it posed for more able literacy students (with a years 1–2 class using ‘Finders keepers’).

> T: These sorts of things are good because the kids are engaged and the kids are working with you. They want to learn.

5.4.2.2 Lower-achieving students

> No one can tell you what you are supposed to learn from something – you learn what you interpret from it.
>
> *An 'underachieving' year 10 student*

The learning objects have several advantages for low achievers. This is particularly the case where literacy skills are not critical and where 'rules' can be discovered and used with some certainty.

Compelling evidence was obtained about how the use of learning objects empowered students with weak academic skills or with learning difficulties. One student who was reported to typically display challenging behaviour and poor understanding 'had some basic understandings – better than what I was expecting'.

> T: No, the reading level is too difficult although it is read to them. I don't know whether you noticed the little boy who actually gave us the key into being able to go to – that was the one that talked about the doctor and how you opened up and you could see his lungs. That boy is not even probably capable of reading at a year 1 or 2 [level] and to put him in that situation he would have just frozen but I think [from] hearing him speak that there is an indication that there is greater understanding than would come from something like that. So the language at that level but also the other thing that I would do with a child like that is that I would pair him up with a stronger reader to be his coach to go through it – but not someone who would put him down because he can't read. But at this stage I'd like to do a bit more with it.

A number of students who typically performed poorly on activities requiring literacy skills were able to engage effectively with the scientific concepts in learning objects that did not rely on text but which used interactions with graphical information. Students were willing to persist to 'win the game' within the object. They were prepared to spend the time to learn rules that they could formulate as a result of feedback on their input to the object.

> O: So if you gave him the same thing with a writing exercise and he had to go back and keep writing it, he still wouldn't.
> T: He would get very frustrated and that is when his behaviour would start to escalate because he would feel that he was banging his head against the wall. It would only work if I was there with him one-on-one and I sat down with him in a quiet room, just me and him, and I gave him constant feedback and that is what the computer is doing in a way. It is giving him that constant feedback that he needs and demands really. So unless you can have a teacher one-on-one you could do that thing. You could have the same sort of success in the classroom but you need an adult working with the child one-on-one.

The game aspects of some learning objects were seen by teachers as accommodating various learning levels and styles. A game component allowing five minutes of play at the start was seen as important for all students, but especially for those of low academic ability. However, one teacher felt that the gaming component was not sufficient in itself and needed to be related to or followed by a substantial learning activity, because this 'draws out ability levels', allowing more able students to extend themselves.

This evidence indicates that learning objects can be effective in engaging students at risk of not learning. Literacy demands in many instances could be reduced by more considered and creative use of diagrams and animations, especially in glossaries, where a graphic can enhance comprehension of the text.

Motivation

In unstreamed classes, teachers reported that the lower achievers were more often motivated when working on learning objects than they were at other times. In one mixed-ability, mixed-gender year 8 class, a group of rowdy boys was attempting to dominate and distract the teacher while paying no attention to the content of the lesson. They were just as boisterous while gaining access to the learning object (‘In digestion’), which consequently took them twice as long as for other students in the class. The noise continued until one of the leaders called out to himself: ‘Wicked – have a look at this’. Once the animation had vomited twice (‘so it wasn’t all that easy after all!’) the challenge to get the animation to complete the ‘task’ became all-absorbing, and the volume of noise went down to a fraction of what it had been.

The group continued to work relatively quietly, until the teacher, having finished the computer work, attempted to re-engage them in a more traditional manner, at which point they immediately returned to their previous behaviour.

The open-ended and challenging nature of certain learning objects motivated lower-achieving students to persist and succeed.

> T: Just for the motivation for those kind of students – and it is good for them to be really open-ended as those ones are – so that [students] can approach them on different levels … although, with ‘Who’s for dinner?’ none of [the students] could survive. They all kept getting eaten but that didn’t bother them because that was all part of learning that it is hard to survive in the world. And so when they came back to that, they understood why they kept on getting eaten. Yeah, so the entertainment [and] the education … really need to be right up there together side by side.
>
> T: He felt proud of his achievement and his achievements we may think are very superficial. But let’s not take away achievements of any kind from those particular groups of kids who I think need all the success they can … so, revisiting for him was, ‘Hey I know what I am doing this time’, and he felt proud of that and he felt comfortable with that and he felt successful … he has gone away thinking he had a very successful learning experience.

Anonymous feedback

The impact of feedback on learning has already been discussed. However, the non-judgemental and anonymous feedback provided by learning objects was particularly helpful to lower achievers, who are frequently embarrassed about giving an answer in class. Commonly, teachers try to encourage them by asking them only when they are certain that their answers will be correct. Such students can miss out on the chance to test their competence in more challenging areas. The Help screens and hints in well-designed learning objects are available whenever they are needed. Students do not need to wait for advice from the teacher, and the computer provides the opportunity to try, and possibly fail, without public scrutiny. Several teachers reported this behaviour in students in years 3, 5 and 8, where students would not persist in written activities, but would persist with computer-based learning objects, even when they had quite low success rates. One year 3 student would not do the text-rich ecology worksheets prepared by the teacher, but repeatedly returned to the ‘Who’s for dinner?’ learning object. While he had no lasting success in keeping the tadpole alive (the hardest strategy to master of the three in the learning object), he was prepared to persist long after the ‘better’ (with text) student had given up.

Neatness and accuracy

Normal lessons require precision and neatness as well as ‘the right thinking’.

> T: If it was handwriting or something he sure would do it – or something that is really a quite boring, filler type of activity – but anything that involves creative writing, he will have a go but in a group situation he would feel [a] bit like, ‘The other children would get a bit frustrated with me writing slowly.’ A lot of behaviour-problem children … when they do some written work they want it to be perfect and if it is not perfect they get very frustrated and he is a bit like that. So he sort of lets somebody else take the lead in the group-work situation that involves writing and he will sort of be there but he could almost be a little bit withdrawn in that situation – just sort of hoping to avoid having to do much of the performance-type stuff.

Neatness was a common theme in interviews, especially for students the teacher considered less able. This was clearest in the Numeracy learning objects involving drawing diagrams. Students enjoyed the neatness, precision and speed with which they could produce results compared with pencil and paper. High achievers also liked this capability because they could test out more ideas in a given time.

The ‘drag to draw’ technique, which requires relatively fine motor coordination, was favoured by older students, and made the task of quickly drawing neat mathematical diagrams possible.

5.4.2.3 Rural and isolated students

Two rural schools were visited, and one semi-rural school. Although one of these schools reported frequent interruptions to Internet services, this did not appear to be a major issue in the use of the learning objects. In the other rural school, the teacher spent over an hour attempting to connect to the learning objects; however, this difficulty appeared to be unrelated to distance.

In the two most remote schools there was an important, and apparently widespread socio-cultural factor in operation. In these two schools there were significant populations of students from families of long-term unemployed people who had sought accommodation in the cheaper country areas. These students, as with the students from a low socio-economic suburban school, differed from the general school population in that they did not have computers and Internet access at home.

This produced two distinctive responses. Some students felt uncomfortable with computers and would not engage with them, while others felt that anything presented on the computer was novel and therefore created its own excitement.

5.4.2.4 Cultural issues

No Aboriginal students took part in the study. Two teachers reported that some parents of students from ‘non-mainstream’ cultural backgrounds were less prepared to have their students interviewed because of the fear that it was the students, rather than the learning objects, that were being assessed.

Maori and Pacifica students were observed, and their responses, together with those of the teacher, were generally positive. The notion of anonymity was observed to be valued by these students. They were seen to be uncomfortable publicly answering questions from the teacher, particularly where there was a risk of being wrong and especially when researchers were in the room. The learning objects provided an alternative means to explore ideas and gain feedback.

The teacher became a facilitator, working with individuals who had mastered one aspect of the learning object, to move them on by pointing to new features, or to other ways to do tasks. Without this involvement, particularly when using simulations, students were prepared to persist, but not take the risk of moving to a new level or new feature.

5.4.2.5 Students from non-English-speaking backgrounds and students with weak literacy skills

In several classrooms, teachers directed the researchers to students from non-English-speaking backgrounds. Generally these students were having no more difficulty with the learning objects than were any of the other students in the class. Admittedly in one or two cases no students, whatever their background, were reading the learning object’s lengthy instructions. They relied instead on the graphics and intuitive navigation.

Audio was an important feature for teachers of students from non-English-speaking backgrounds, as students could interact with learning objects using both text and aural cues. This is discussed further in 5.4.3.1.

5.4.2.6 Literacy and reading issues

> T: [For] the students who have a lot of trouble with their numeracy skills and the literacy associated with maths, computers have absolutely just given them a new lease of life.

Literacy learning objects are not the only learning objects requiring literacy skills. An appreciation of terminology and its use is an important part of any discipline. Students therefore need to be exposed to the necessary text and aural content.

Reading was an issue for most target groups in this pilot Field Review and the literacy requirements of some learning objects were too great for some students. This could indicate a mismatch between the literacy levels assumed by a learning object and its discipline-specific conceptual content:

> T: The activities aren’t too hard but some of the readings are quite tricky for your every[day] year 3 child.

In one case a student wanted to do ‘hard stuff’, interacting with diagrams and ‘playing around’ with activities, but with the proviso that the computer read out the content, so that s/he did not have to read it. When a learning object provided voice to support the text it was appreciated:

> S: Well it is useful because, instead of sitting there reading all the information all the time, you just go on it and put on the earphones and it sort of talks to you … It is easy for learning.

One student enjoyed the opportunity to process an animation with accompanying audio:

> S: … talks to you … because then you don’t have to read the writing and look at the thing at the same time.

The sociology of classroom peer acceptance was also a factor affecting student willingness to read. On a number of occasions a less dominant male member of the class would explain that it was embarrassing to be caught reading, or that the game format of a learning object was important because some specified dominant boy in the class would like it, so it was acceptable for others to do.

The study found that while the content of certain learning objects may have been at an appropriate educational level, and students understood how to interact with them, the required literacy skills mitigated effectiveness in some cases:

> S: A few people in my class wouldn't be able to do it.
> O: Why not?
> S: Because one of them – he has to go into year 2 to do all his spelling and that.
> O: Mmmm. So what do you think he would find difficulty with?
> S: Um, like, reading.
>
> S: Probably the respiratory system because I didn't understand most of that.
> O: That is really interesting. Why didn't you understand most of it?
> S: It has confusing words.

Students suggested that learning objects should be designed for various literacy levels. This would allow students to choose a level appropriate for themselves:

> S: … click a level at the very start. When you put your name in, there should be a level after that so you can choose and then when you get into there you should be able to – things like people should read it out for you and gradually it should be underlined word by word for people who can't really read.
> O: So you can choose the level of reading out as well. So [at] level 1 everything gets read (to you}, [at] level 2 [only] the important words, [at] level 3 you are on your own.

While some students did not read text instructions because they were too difficult, others chose not to because they considered this hard work or boring. Students wanted to 'get to the end' and found that they could proceed by 'cheating'.

> S: Yeah but if you just press any of these, they will tell you and they'll highlight it but you can do it again until you get it right so you can just keep going until you think you get it right but anybody could just cheat and do that instead of reading it properly and do it right.
>
> T: But it is like having the text there for the good, able readers, they still might want to rush through and get to the end and say, 'Oh yeah let's get to the end. Can't be bothered reading that.' Same as you can have the voice going without actually tuning in and listening to what they are saying so it is hard to monitor and measure that as well.

One technique that compelled students to read was the use of multiple-choice tests that had to be completed in order to proceed. However, some students realised that several learning objects allowed them to retry without consequences:

> O: Were you tempted to flick through and just click all of them until you got the right answer?
> S: I was.

An interesting and effective counter to this is used in the 'In digestion' learning object, where an inappropriate answer results in a greater workload (going back to the start). Students soon learnt it was better to read the information. Some students, using a games approach, suggested that where points were involved, incorrect answers should cost points. If sufficient points were lost then you should have to start again, possibly on a lower level.

5.4.3 Multimedia impact

The majority of students were aware of the multimedia potential of the computer. This was largely through games they had bought or accessed through the Internet. Although some students had no home computer, most students had access to a computer at school on a daily basis. Students, therefore, are used to using computers for entertainment. Some learning objects capitalise effectively on the interactive multimedia features used for entertainment and others employ different multimedia strategies to support learning.

5.4.3.1 Sound

Section 5.3.1.2 discussed the propensity for students to skip over text-rich content. Instead, they expressed a preference for various forms of audio support as an alternative or supplement to text, or ways in which sound could be used to enhance engagement with the learning object:

> S: Well it is useful because instead of sitting there reading all the information all the time you just go on it and put on the earphones and it sort of talks to you … It is easy for learning.
>
> O: So when you pick the weather, and people pick a right answer or a wrong answer, are you happy with the way that happens?
> S: No I reckon they should say, 'Why don't you try again because it is too hot in the Sahara Desert for it to rain' or something like that.
>
> S: With sound I would go out and take real sounds. I would go to car-smashing places … If it was realistic you'd pay more attention.

Teachers felt strongly that all text in learning objects should also be available aurally, although this should be possible to turn off. They felt that this was particularly important for the pronunciation of new terminology.

The learning objects for younger students recognise the literacy demands they place on students by providing voice support. However, it cannot be assumed that all students in mainstream classes can cope with the literacy demands of learning objects. In the case of 'Earth alert', the students could not understand why the learning object had audio at the start, but not later in the program. Similarly, a number of teachers commented that the instructions and extensive vocabulary in learning objects like 'Mine rescue' and 'Plant scan' warranted more use of audio. The introduction of technical language in many learning objects would be enhanced by a mouse rollover voice facility. The series of learning objects dealing with the human body has some excellent examples of how this can be done.

Audio was an important feature for teachers of students from non-English-speaking backgrounds. In one secondary school, the collaborating teacher had taken the learning objects to the special education teacher for her opinion. The school had a number of students from non-English-speaking backgrounds. The special education teacher was enthusiastic about the potential of the learning objects. However, she was disappointed to find that the audio option where all text could be read out was available only at the 'junior levels', such as in the Gecko suite of learning objects. Audio is desirable in all learning objects, to accommodate students from non-English-speaking backgrounds, those whose sight isimpaired, literacy-at-risk students and those with an aural learning style.

Sound was also an important feature in terms of student feedback. Students liked the use of 'Uh-oh' and the sounds on 'Shape fractions' to indicate errors. Students also suggested skid sounds in 'It's a drag', and thud sounds if the truck hit the end point in 'Give me a brake'.

Students liked sound effects and many requested more. Sound effects would need to be supported by other communication when they indicate information critical to the content of the learning object, for example, the fire alarm sound in 'Intergalactic cook-off' uses a small supplementary red light for classes where sound is not available.

> T: Some of the voices could be a little bit irritating and if you have got five computers in the classroom and somebody has got an amazing sound on one computer, you don't tend to have them all on. You tend to have a couple off and a

> couple on. And so some of them did it with the voice and some of them did it without the voice and the ones that are the poorer readers tend to choose to go with the voice.

5.4.3.2 Visual elements

Teachers and students appreciated the visual impact of the learning objects, including the use of icons, animations and other graphic elements. Graphics were seen to be potentially motivating, particularly for less successful students:

> T: So those graphics are really important to get kids like S3 in initially and he was coping with the years 3–4 'Who's for dinner?', even though he is a very low year 3, because of the way it is set up to be like a game. And he got something out of it which is great and gave it a really good go.

One teacher suggested that visual representation of mathematical concepts was particularly useful and had prompted one of her students to use appropriate terminology: 'It's about a third of what it was before' when talking informally to his friend.

Students found graphics useful as an aid to understanding new concepts.

> S: Yeah, just telling you but it is not using good enough information – like it needs a diagram or something there so you can really understand. If you read it, when you read it you probably understand but it would help to have a picture there.

Animation

Students were most receptive to animations and cartoons.

> T: Animated. Yeah, make visual stimulation – kids these days do respond well to visual stimulation. Of course you can overstimulate but they really respond well to it because that is the world that they have been brought up in.

Cartoons and animated characters used to invite learners into the learning object were well received by students because they were friendly. Students appreciated the simple personalised animation, for example they 'liked the frog guy because he is cute'.

> S: the best way to learn because they have got animations to show you how it is all done.

Animations allow simplification of information, so that students can focus on the underlying concepts. Animation to provide information and show processes in action was particularly successful in 'In digestion'. This was by far the most popular learning object and the use of cause and effect in the animation was an important element in its popularity and effectiveness as a learning tool. The internal view of the body, while reasonably complex, provided the key features relevant to bodily processes otherwise not available for students to view. Students had control over when to move to the next step in the process, so had ample time to observe it. The animation of the outside of the body used humorous facial expressions that changed according to the choices students made. The animations were an integral part of the object, animation and text were complementary and nothing beyond the generic opening sequence was extraneous. Because the learning object provided a number of paths and a challenge, students happily revisited it, gaining more information each time from both the animation and the text.

Simple cartoons popular with early years students were considered 'babyish' by some older students. However, simple but quirky cartoons, like the alien in 'Inter-Galactic Cook-off' were acceptable with this group. No students claimed to object to the use of cartoons, and several stated a preference for cartoons over video clips.

Animations are particularly important to a visually orientated generation. When students reported that learning objects were boring, it was invariably for two reasons: they had no control over the events, or the screen remained essentially static. Students were particularly receptive when they could engage with animations as part of an interaction within the learning object, and when there was a clear cause-and-effect relationship.

Video

Video clips have the potential to provide valuable, authentic evidence and information. A number of the Science learning objects used video with this in mind. Some clips worked well, such as bicarbonate of soda fizzing when acid was added. Not all clips were as successful, however, because the video window was small and the detail was not always clear. For example, in ‘Inter-Galactic Cook-off’, no chemical change was visible when lemon juice was added to milk, even though a chemical reaction did occur. Students were unable to observe this because the shot was not shown as an extreme close-up and the curdling was not made clear.

In ‘Save the lake’, the video of the precipitate forming included some looping frames of droplets entering the solution. This confused students, some of whom interpreted it as ‘smoke’ or ‘bubbling’. Some students did not have enough background information to know how much change to expect. When the litmus paper appeared paler because it was wet and catching the light, some students interpreted this as a change because they had no experience of litmus turning red.

Despite the brevity of video files as a concession to bandwidth, some students still experienced frustration when these files took longer than expected to download. This suggests that although the use of video is valuable, it needs to be used judiciously and reviewed with the understanding that students will not necessarily have the prior knowledge to interpret correctly what they see, particularly if the window is small. How the video is shot, edited and presented is critical to its effectiveness.

5.5 Student learning outcomes

'Student learning outcomes' refers to the observable progress students make towards understanding the content and concepts within a unit of work. Researchers observed students to ascertain their independent learning strategies in terms of knowledge reinforcement and revision over a range of learning objects and disciplines. Research into this area was guided by the following questions:

Learning outcomes	Q16. What assessment did teachers use to determine the intended student learning?
	Q17 – What evidence is there that learning is occurring as the learning object is used?
	Q18 – Which unintended outcomes arise from the use of the learning objects?
	Q19 – Are the benefits of the learning objects widespread or limited to some students?

5.5.1 Evidence of learning

The pilot Field Review was designed to collect data through a series of short visits to schools in multiple jurisdictions. It was therefore difficult to collect a large quantity of data on student learning outcomes. Suitable evidence was not available from some schools visited. This was because learning objects had not been incorporated into a lesson, but had been given to students to 'try out'.

Despite this, evidence of learning was obtained from the use of a number of learning objects. As one teacher reported:

> T: I don't think there was a kid in the class that hadn't got the concept. There was a lot of other mathematics that was happening at the same time in terms of the kids' capabilities with decimals, in terms of the kids' capabilities of calculating with decimals, in particular the half, and then their knowledge of and ways of representing a half using different language and different notation. They were all issues that came out of it so it has turned out to be quite a rich mathematical activity, and the kids have also used it as a springboard to do other things.

However, another teacher did not seem to be concerned with what students were learning. This teacher was not really concerned that the students were selecting randomly and not relating their answers to the purpose of the activities.

Some teachers were able to identify where students felt learning had taken place. In the case of one challenging student, the teacher felt 'from discussing with him that, for him, he had made really good developments, and he had been engaged with it, and he had learnt some basic Science concepts, so that is a big thing for him'.

Follow-up questioning which probed the understandings of students, revealed they understood the learning purpose of learning objects. For example:

> O: What were you meant to learn from it?
> S28: Fractions.
> S27: Equivalent fractions and stuff.
> O: What are equivalent fractions?
> S27: Like fractions that mean the same but they are written in a smaller form or a bigger form.

There was evidence that some students engaged in higher-level learning. One student was able to elaborate an understanding of metacognition in learning mathematics:

> S: Because it is something we can learn because you can stick it in your head and when you need it and you don't know that ... you just have to think back to things that are linked.

There was also evidence of changes in students' attitudes in addition to improvements in knowledge. Three students who used the 'In digestion' learning object stated they had changed their eating habits after using the learning object:

> S5: Well I used to eat all types of yuk stuff and now I stick to healthy stuff.
> S7: Yeah I eat different foods.
> S9:I used to eat a lot of chocolate but now I have cut down on my chocolate.
> O: Have you?
> S9: I eat an apple a day, or maybe two and I only have some chocolate each day.
> O: And that came from the learning object?
> S9: Yeah.

Teachers believed that learning objects provided students with the opportunity to learn in different ways. An observer felt that 'the [learning object] definitely developed connections and understandings that had not previously been made or developed through the methods by which fractions had been taught in class'.

Teachers reported, however, that some types of learning objects needed to be used multiple times to be effective:

> T: Actually today I noticed a couple of kids really got into the tables that have had a few problems and I thought that could make a difference given a few more times.
>
> T: They were all able to come back and talk with really good knowledge, but none of them really knew much knowledge after their first go.

One teacher urged caution in attributing learning to engagement, implying that more research needs to be done before learning objects can be judged educationally sound if measured traditionally by test performance, observing:

> T: I mean those kids were having fun, they were bouncing off each other. They were interacting, they were sharing ideas, are they better able to go and sit and do a pen and paper test? No I don't think they are, but from that experience they got success, from that experience they were able to share, from that experience they were able to participate in an activity. I think that is all really positive but is it really going to make them better? I am concerned that it is not and that worries me …

5.5.1.1 Reinforcement and revision

Students were able to use the learning objects to reinforce previous lessons and consolidate their learning.

> S: Like I have actually learnt about the flower, how all the water goes ,but it is sort of alright to just reflect on what you have learnt.
> O: So you already knew that?
> S: Yeah I knew bits and parts of it.
>
> O: So is it helping you learn about fractions or just using stuff you already knew about fractions?
> S18: It is like revision. It is a lot better because you know how you are doing it. You have got your own choices. You can do what you want.
>
> S6: Yeah it helped me because you forget after a while and this refreshes my memory.

Teachers were also aware of the potential of learning objects in this area.

> T: I think it just makes them aware that maybe what they are not doing and how to improve their own writing because it is very hard, when you are teaching them to pinpoint exactly what they need to do to improve and I think this just pinpoints it beautifully in a very entertaining way.
>
> T: Actually today I noticed a couple of kids really got into the tables that have had a few problems and I thought that could make a difference given a few more times. We haven't had that long working with them. I think it is probably only about four or five weeks and I don't think that is really long enough to make a difference on the whole but I think it will, especially some of these kids that are having trouble learning things one way. It is another approach that they can use.

Teachers appreciated being able to sequence the learning experiences from simple to complex. An observer with expertise in Mathematics liked the ability of the 'Compound Shapes' learning object to reinforce learning across a number of areas. The object could be used to reinforce the process of calculating the areas of triangles and rectangles. It was also able to reinforce the method for finding areas of compound shapes by separating these shapes into component shapes, allowing students to graduate from simpler to more complex shapes.

5.5.1.2 Inhibitors to learning

There were a number of deficiencies in learning objects that inhibited learning, despite the demonstrable learning outcomes achieved with many learning objects. These deficiencies have been canvassed in earlier parts of this report. Potential concerns for learning are:

- Inaccurate or insufficient information in the learning object

> S: Assume the alcohol is an acid because the litmus faded.
>
> T: I have got to make this out of copper or ceramic or glass or aluminium or wood or plastic or steel, and out there is space I have got to come back into earth. Now do you know anything about when we are out in space and we are coming into earth?
> S15: No.
>
> O: Have you heard of litmus before?
> S: Never.

- literacy demands

> O: Terminology (pollination, germination) beyond her – knew the word not the meaning – keeps reading to get the meaning.
> T: Here is the description. Go find for me what this actually looks like. But if I can't read, then guess what. I can't read the text, and particularly as that text was authentic, and so authentic that it alienated [them] before it started unless I am going to stick my head over their [shoulders].

- lack of teacher support

> S: They weren't all that easy to follow.
> O: I see. So how did you work this out? Did your teacher help?
> S: Well she said that we have to figure out.

- lack of integration into the teaching program

> T: Students can navigate through Science learning objects easily and pick up none of the learning on the way … [They] don't need to do the reading – and don't, because they can get the thing to work without using the concepts ... needs classroom link.

- success achieved through guesses or trial and error

> S: So then I went onto the aluminium smelter and put stuff on that and then picked an aluminium smelter and then it wasn't that so I just did eeny meeny mo between that and I picked copper from the mine.
>
> O: You are working out the area of the separate bits? How many pieces – 12 pieces. It must have been a very big sheet to start with.
> S5: No. I just cut it up into …
> O: And how are you making the decisions about where to cut it?
> S5: I just cut it anywhere.

- learning object design that does not accurately represent the disciplinary ideas being conveyed.

> O: Multiplier does not represent the partitions proportionally so does not spatially support the numerical ideas, therefore important links between multiplication and area are not able to be made. [Reviewer's note: this not only seriously undermines the mathematical integrity of the learning object but also limits its use as a learning tool.]

Misconceptions were fostered in a number of ways through some of the early Science learning objects. In 'Treasure puzzle' the graphical design showing a cartoon animation of liquids travelling uphill may develop misconceptions. Other examples of student misconceptions are:

> S1: ... because when you carried out the test with, say for example, the litmus paper, if there was acid from the battery factory in there it would turn red. The whole test tube would turn red.
>
> O: So what is your solution now? Where is the … what is the problem with the lake? What has to be fixed?
> S1: Well the copper mine – because they are pumping, well not pumping
> S2: The copper.
> S1: When it goes in … when they wash it out some of the copper trickles out into the lake ... and it goes straight down to the bottom because it is solid and just stays there and because copper gives off radiation – well not radiation but forms of radiation – to the water, it will eventually hurt the fish and turn the lake into an inhospitable piece of land.

5.5.1.3 Unintended learning outcomes

Few unintended learning outcomes were observed during the course of this study. A possible reason for this was that the students were not working for long enough to reliably identify any transfer of learning to other circumstances. However:

- One teacher used Science learning objects to focus on language outcomes.
- Opportunities existed for learning through different styles.

> T: The grade one/two ones S1 and S2 they learnt more about parts of the river than what I thought because they are both bright … they actually got quite a bit of Science out of it whereas maybe normally they would be more towards the creative things so having those literacy things built in really helped them learn the science better as well.

- Opportunities existed for students to show their individuality and particular strengths.

> T: In a mixed class, younger students did better because they were colourful characters.

- Students made connections beyond the scope of the learning object.

> T: Some students realised that polyurethane can be used for different things than skateboard wheels, like footwear.

5.5.1.4 Mathematics and numeracy

Students were documented learning from a number of Mathematics and numeracy learning objects. Evidence indicates they learnt about shapes, the commutative rule and using number lines for calculating fractions.

One pair of students had not encountered the concept of number lines before using the learning object. They were confused during the use of the learning object but were subsequently able to understand and apply number lines.

> S: And I knew absolutely nothing about the number line before … We have learnt how to turn a grid into a number line and a number line into a fraction and a fraction into an equivalent fraction.
>
> O: When you were doing it, when you were selecting out the fractions, how did you select out the fractions, how did you know what the right fraction was to use?
> S1: Next to it there was a notebook and it tells you the fraction and how much of the park you need to have that sort of space.
> S2: Denominator.
> O: How did you figure out what one-fifth was or whatever?
> S2: There was a number line at the bottom of it and it pointed, [to] show you how much was on your actual grid.
> O: So you used the number line down the bottom there?
> Both: Yeah.

In some instances the students preferred to use more familiar methods to calculate their answers. They used the computer to enter the answer, rather than using the help features programmed into the learning object.

> O: The girl doing the calculations counted on her fingers. It appeared that the one using the mouse was doing some of it in her head. Until I interviewed them it was not clear that they had all grasped the concept of number pairs.

Some students used strategies when using the Mathematics and numeracy objects, and were able to articulate them.

> O: You took zero time to decide that one. How did you know that?
> S1: Like a third of six is (counting) like there is six rows and you have to work out a third because it says here – so you just count in twos because two is a third of six.
> O: So did you actually look at that and just see it as a third or …
> S1: Yeah.

5.5.1.5 Physical science

Learning outcomes were also evidenced in the use of physical science learning objects. Students demonstrated an understanding of patterns in relationships between variables. ‘It’s a drag’ enabled some students to understand the stopping distances of vehicles when incorporated into the teacher’s learning program. One keen and intelligent student but with weak literacy skills, understood the purpose of ‘It’s a drag’. He had studied reaction times in class, but the learning object lesson had more impact because:

> S: You are actually seeing what happens. This actually made me realise how much 10 k can make a difference.

Other students using ‘It’s a drag’ understood:

> S: …that more weight means it takes longer to brake and more speed. It depends on the surface as well.

Many of the activities allowed students to use differing psychological approaches. These differences are best shown in the way they approached ‘It’s a drag’ and ‘Give me a brake’. For their first attempt using the learning object, risk takers set the speed at maximum, tyres as bald, road conditions icy, and used the large truck size. Risk avoiders set the speed at 60km/hr, and used a small car with good tyres on a bitumen road. Each set different goals, but learnt the same concept. The learning was no less 'ethical' for the risk takers – their comments invariably showed a greater appreciation of the dangers of their decisions. For example:

> S: It's really freaky – it's kinda scary when you think about it.

This was a typical response from a risk taker looking at the stopping distance. The risk avoiders generally responded that either they had stopped in time, or that the stopping distance was about what they had expected. Teachers' approaches to the object roughly paralleled those of students. More female teachers were cautious of this learning object, while risk-taking male teachers felt the experience would prepare them for risk avoidance in real circumstances. Many students' comments would seem to reinforce that view.

However, other students did not appear to learn from this learning object:

> S: I don't think it was teaching much because you are choosing what type of tyres, what type of road … wet, dry or icy – and I don't think it is teaching anything because you are just clicking start. Or it could be teaching how ... the car is like the brakes in real life if you have got one. That is about it.

Depending on how the lesson was integrated into the teaching program, students need not engage with the science of 'It's a drag', but only with the practical application to driving, and competitions about reaction times.

> T: … for some students the science involved in the task would be completely lost. Many boys were overheard competing about their reaction time and did not appear interested in the scientific inferences that might have been made regarding stopping distance and speed.

The learning that occurred was appropriate to the students' development.

> S: It links into HD [subject] where we have done pre-driver awareness. Basically they talk about stopping distances and whatever in that – and basically that has just really brought it all home and shown just how far it takes.

Learning was demonstrated by different students at all levels. Some learnt scientific facts from the objects. Some students learnt basic household chemistry:

> S4: Yeah we learnt that vinegar is an acid.
> S3: And so is fizzy drink.
> S4: And we drink fizzy drink almost every day.
> O: So what does that mean?
> S4: It means that we are drinking an acid.

Similarly for 'Skateboard race':

> O: Did you learn anything new?
> S2: Oh yeah, that that stuff was in skateboard wheels. I just thought they were all rubber.
> O: OK. What about you?
> S1: Yeah, I didn't even know what polyurethane was and what it done.
> S2: Yeah, it explained what it was.

Others were able to demonstrate higher-order learning involving the control of variables, such as demonstrations of learning from the 'Check your wind' object:

> S: You had to pick a place and then you had to pick a certain length and width of the propeller on one of those big wind stands and you had to try and get that to go from December, [through] January, February all the way to November without using any battery power so you just had to use the wind power to get the lighthouse to shine out. So I figured out how long and thick you have the propeller – like I had a thick and thin one, I mean a tall and thin one – and I went through that without any battery power. But [when] I used a little and thick one … I was about 95 per cent of battery power left.

Some students demonstrated the ability to link learning gained through the learning object with other contexts:

- There was evidence that students were making links between the learning objects and other classroom activities.

> S: So when you do a test it tells you about what you just tested, like alcohol. I reckon that is cool because if you have got a project about how lemon juice wrecks teeth you could go to this and it would teach you stuff.

- Students were also able to situate their learning in relevant everyday activities, such as the student who loves drinking lemon juice, but now understands that this causes tooth decay, and the students who tested alcohol on their teeth because:

> S: When we get older we are probably going to try alcohol once or twice and we want to see what it will do to our teeth.

- Students linked the content of the learning objects to their current interests.

> S: It is good for people our age that are getting their learner's licence and that.
> O: Have you got yours yet?
> S: No I am going for mine on the 15th. That's when … I turn 16 so I will go for it then. Like to show us what that difference is of slowing down and not speeding all the time even though we are not supposed to go over 80 – but just driving a bit slower. It shows how much it can save your life and another person's.
> O: Does that link in with anything else you have done in class with any of the other activities around the place?
> S: Well we have done … what, just in computing?
> O: Well wherever in the school, other courses or things in computing.
> S: We are doing it in maths as well. Graphs and that, showing what the difference of speeding is … doing graphs and different charts and that you can use with them.
> O: Different charts?
> S: Like pie charts, and pie graphs and bar graphs and all that. And we are using speeding as [an] example for that.
> O: OK. So how does this compare with doing it in maths as far as getting …
> S: It is better because … like in maths we are just using sheets and it has just got the information but you can actually try it out with this which I think is much better and more exciting than just looking at a sheet.

Students made connections between the learning object context and their existing conceptual frameworks. In some cases the information provided reinforcement for accurate scientific knowledge.

> S: I did know because lemon and orange is an acid. They have acids in them and I knew from the fact that we have a worm farm at home and you cannot feed the worms oranges or lemons because they are too acidy for the animals to eat. So I knew that they would be acids.

In the case of 'Treasure puzzle', information proved contradictory because of a built-in misconception in this learning object. When students finish the puzzle they are meant to burn down a door with the acids they have collected. This leads to the impression that all acids can corrode any material. Some students recognised the unreality of this:

> S: I learnt that acids can burn doors. I mean it probably can't. Especially not lemon juice and fizzy soft drink and vinegar. Probably proper acids would.

Where cognitive dissonance occurred, the results were unpredictable. For example, one student exhibited a number of misconceptions about chemicals after using 'Save the lake', in this way:

> S1: ... because the copper mine ... the right ... it destroyed it because when you carried out the test with the potassium iodide [had trouble pronouncing words] it stayed up the top and turned to a powder and then it sunk to the bottom which means it contains traces of copper which is a soluble element so that would sink to the bottom of the lake and now the copper mine had to remove the chemicals, remove the copper and treat the water. So they had to take it out. And that is with the litmus paper as well and everything. If there was acid in the water it would turn red but it didn't so you eliminated the causes because that would be battery and then the fertiliser. There was the second one, the other test and everything so eventually there were two, the second one, the silver nitrate nearly sunk to the bottom but it still stayed up the top but potassium iodide actually stayed up the top a bit but then sunk to the bottom.
> S: Yeah very quickly.
> S1: ... like a, yeah very quickly, and formed like a white powder on top so by that you could determine that it was ... because of the information which had been included.

5.5.1.6 Biology

Students were able to demonstrate that they had learnt in Biology, for example:

- biological processes

> S: Well I found out some things that I never knew … the roots take in nutrients and water and the leaves take in carbon dioxide, and with that together it produces oxygen.
>
> S: I learnt that leaves took in the oxygen, and that they had system tubes [sic] in them showing where the food and the water went through and them things in the middle of the flower are seeds.

- to make comparisons, such as between plants and humans.

> T: How do plants get their carbon dioxide?
> S18: Holes in their leaves.
> T: Exactly, through the tiny holes in their leaves. What do we use to get our air?
> S19: Our mouth.
> T: And when a plant sweats [sic] through its leaves we call that?
> S20: Transpiration.

Students also showed how one learning object could provide the basis for different types of learning. Responses to 'In digestion' showed the range of learning that can occur, including:

- factual knowledge

> S: Because it shows you how the food digests in the body because I never knew it goes into the little one [intestine] and then the big one I thought it went into the big one and then into the little one.
>
> S: Well I learnt stuff like the juices help break it down and you have small holes in your intestines to help break the food down and stuff.
>
> S: Leaving food in the large intestine too long can make you constipated.

- process knowledge

> T: Because I know when I first did that with my students a lot of them came away and they said, 'Oh I didn't realise there were so many organs or things inside of us'. And because they are explicitly shown, well this is where the food goes and if you don't eat the right food then this is what happens and where it comes out then.

- links between theory and experience.

> S: If you don't eat the right foods you get diarrhoea.

As noted for the physical science learning objects, the nature of well-designed learning objects can lead to learning via different pathways. For example, in 'In digestion', some students worked constructively, trying to keep the character healthy, while other students worked destructively, trying to make the character sick. The evidence indicates that both types of students learnt equally well.

5.5.1.7 Literacy

Students using a literacy learning object were able to demonstrate an understanding of the meta-language of language:

> T: [It has] got to do with … the word that is describing the noun and they are starting to talk in that meta-language which shows me the kids learnt it. And I found using the learning object was valuable with those kids because it showed me, and it articulated to them what they knew about language.

Another teacher was sceptical about the level of literacy learning achieved by students. This is an issue requiring further research.

> T: I think the kids have learnt content from it but whether it is the literacy that they have learnt, like did Jake go away knowing what a noun was or did Jake go away knowing that there are different styles of text? I don't think that he would have been able to articulate that.

5.6 Results of the student survey

As described in 3.5, a student survey was designed and trialled in the four schools in the pre-pilot study. The survey instrument (see Appendix 1.4) consisted of four parts: a set of 20 general questions, and three sets of discipline-specific questions relating to Science, Literacy and Numeracy, containing three, four and five questions respectively. The 20 general questions were designed to answer aspects of the generic research questions in Table 3.2, under the three themes:

- usefulness to students (items 1, 2, 6, 7, 11, 20)
- learning process (items 3, 4, 5, 8, 9, 10, 12, 13, 14)
- learning outcome (items 15, 16, 17, 18, 19).

Each question was based on a four-part Likert scale.

Six classes returned the surveys and a total of 134 responses were received. This is sufficient for a meaningful analysis.

Descriptive statistics of the student survey results are presented in Table 5.1. Positive approval ratings (‘agree’ or ‘strongly agree’) ranged from 56 per cent to 95 per cent. That is, the item with the lowest approval was rated positively by 56 per cent of respondents and the item with the highest approval was rated positively by 95 per cent of respondents. These results will be discussed in more detail below.

5.6.1 Rasch Analysis

Rasch analysis provides an assessment of the validity of survey questions. It analyses whether the survey will provide internally consistent results irrespective of the population taking it. It also indicates ‘bands’ for answers on the Likert scale for each question in the survey. The bands indicate the ratings on certain items relative to the other items in the survey, given that populations taking the survey display a range of values or characteristics that dispose them to answer in a particular way. If threshold for bands can be successfully determined, it indicates that the survey items are sound and that the data collected on them will be reliable.

Responses were analysed using the RUMM computer implementation (Andrich et al. 2002) of the Rasch Extended Logistical Model (Andrich 1988). The RUMM software package uses the Rasch latent trait measurement model, and is suited for cumulative scales.

Analysis of the item response curves (IRC) and threshold maps for individual questions (Andrich et al. 1997) indicates that student respondents are interpreting and answering the questions in a meaningful way and in a consistent manner.

An initial Rasch analysis was conducted using all items in the survey. A Rasch threshold map for this analysis is shown in Figure 5.1. It can be seen that two items had reversed thresholds within the initial analysis. This indicates a problem with the nature of the item set. There are three probable reasons for this:

- The set of items investigates two separate aspects of the students’ experience: the presentation of the information, and the learning that results from that presentation. Where items reflect differing dimensions of the experience, they should be analysed separately. The fact that they did not conform to the Rasch model should be seen as confirming the validity of the items.
- There was a small number of responses to the literacy and numeracy items, and this would make their estimates less certain.
- The respondents are reacting to qualitatively different stimuli (such as the differing sets of Science items).

The analysis suggests that the Science learning objects gained least student acceptance. Students may be assessing their interactions with the Predict–Observe–Explain element of the learning objects as less satisfactory than the technical performance of the learning object. This confirms the qualitative results in 5.4.1.7.

Table 5.1 RUMM2010 display: percentage responses to each student questionnaire item

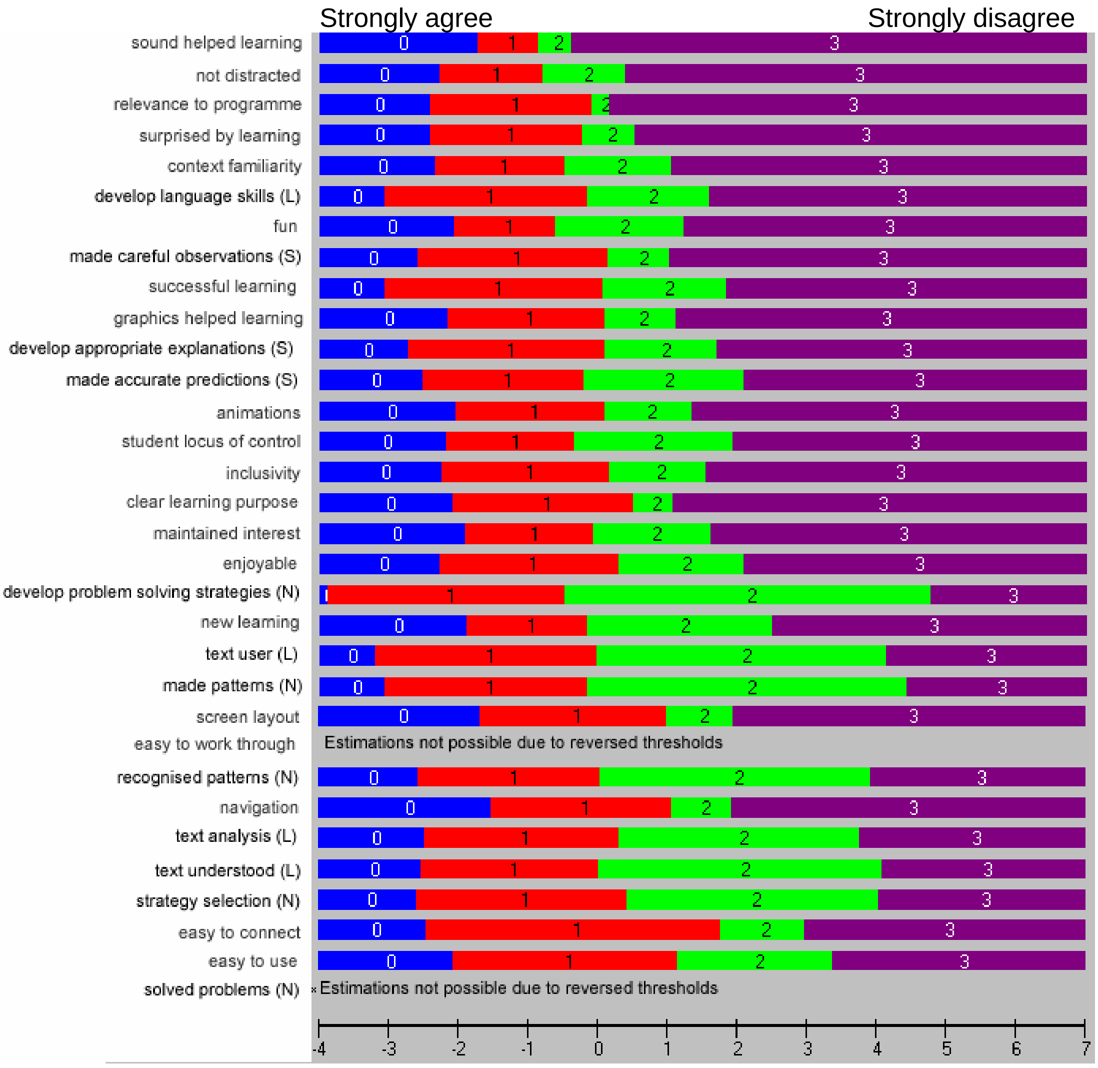
Item	Strongly agree (%)	Agree (%)	Disagree (%)	Strongly disagree (%)	n
Usefulness to students (technical)					
1 easy to connect	22	73	5	0	131
2 easy to work through	39	55	6	1	132
6 navigation	39	53	8	1	127
7 screen layout	34	57	8	1	130
11 fun	23	42	30	5	129
20 easy to use	28	64	8	0	128
Learning process					
3 sound helped learning	24	32	27	17	121
4 graphics helped learning	24	54	18	4	128
5 animations helped learning	26	53	19	2	127
8 inclusivity	22	55	20	3	129
9 clear learning purpose	26	57	14	3	129
10 context familiarity	17	51	27	5	127
12 enjoyable way to learn	23	58	18	2	129
13 not distracted	19	40	30	11	129
14 student locus of control	20	52	25	2	127
Learning outcome					
15 new learning achieved	26	50	23	2	128
16 relevant to teaching program	18	55	20	8	122
17 successful learning	13	63	22	2	127
18 surprised with learning	18	52	23	6	130
19 interesting	27	48	21	3	129
Science					
21 made accurate predictions	20	56	23	1	50
22 made accurate observations	19	61	18	3	49
23 made accurate explanations	19	62	18	1	49
Literacy					
24 developed language skills	14	61	23	2	51
25 developed text understanding	21	59	21	0	52
26 operate on text	12	65	24	0	52
27 analyse ideas in text	23	61	16	0	51
Numeracy					
28 recognise patterns	18	61	21	0	28
29 make patterns	14	57	29	0	30
30 develop problem-solving	5	62	33	0	29
31 choose strategies	18	65	18	0	28
32 solved problems	27	73	0	0	27

The student acceptance of the Literacy outcomes was more variable. It should be noted that these responses are from a relatively small sample who used only two Literacy learning objects (‘Picture this’ and ‘Letters to the editor’).

While the sample size is even smaller for the numeracy learning objects, the initial responses obtained through this survey suggest that these learning objects have performed very well in the eyes of the students in developing numeracy and mathematical skills in several important areas.

It is possible that the relative performance in these three learning areas may also be a measure of the success of quality assurance improvements made by the Le@rning Federation during the life of the initiative, since the best performances have been from the most recently released learning objects. However, while the results of the analysis of the complete set of items are suggestive, they should be treated with caution, for the reasons given above.

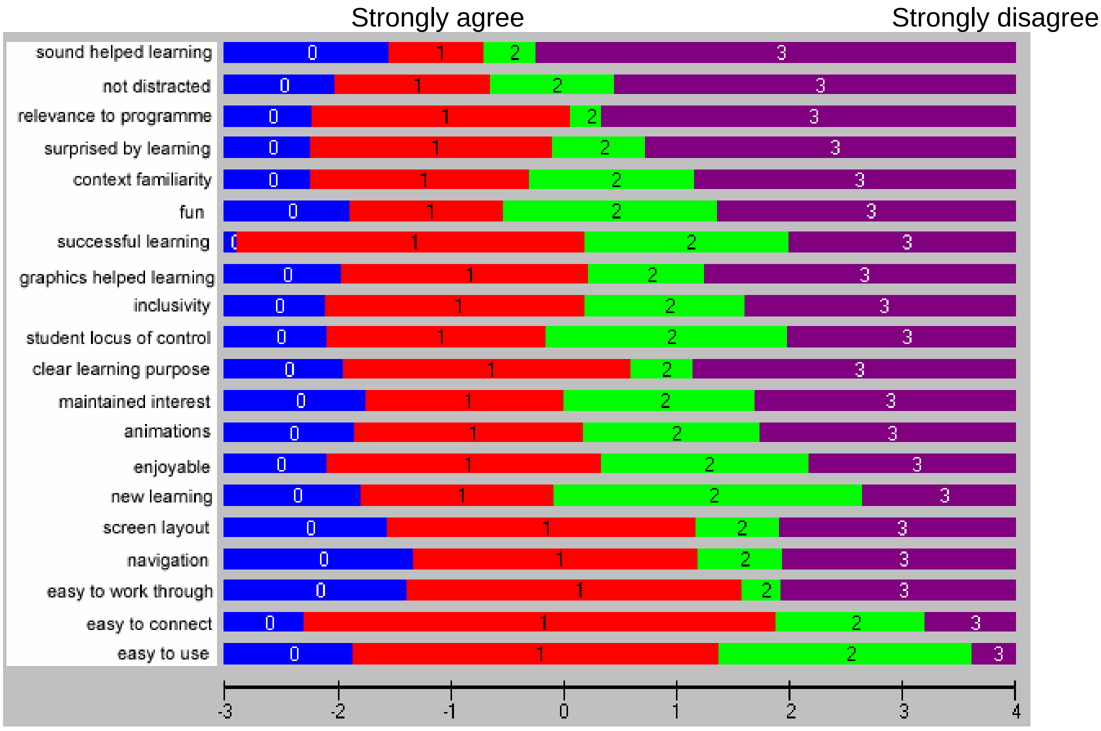
Figure 5.1. Rasch threshold map of user acceptance of learning object characteristics for the complete set of items, including discipline-specific items



Note: items at the top of the figure with the widest band 3 have the least user acceptance, while those at the bottom of the figure with the narrowest band 3 have the most user acceptance.

A second Rasch analysis was performed for the 20 general items – those responded to by all students. The Rasch threshold map of the analysis (shown in Figure 5.2) indicates that the student responses to the 20 general questions conform well to the Rasch model. This provides support for the contention that students see generic factors relating to the use of learning objects as part of a single construct. That is, they think about and judge the generic factors consistently. It is possible to place them all on a single scale that represents greater or lesser degrees of educational soundness, including usefulness to students, student learning process and outcomes. Figure 5.2 is a respondent-independent scale of the user-acceptance of individual learning object characteristics, with the items at the bottom having the most user acceptance, and those at the top having the least acceptance.

Figure 5.2. Rasch threshold map of user acceptance of learning object characteristics



Note: items at the top of the figure with the widest band 3 have the least user acceptance, while those at the bottom of the figure with the narrowest band 3 have the most user acceptance.

Table 5.2: Acceptance (as 'agree' or 'strongly agree') for general items relating to the three student themes

Technical factors	Acceptance (%)	Learning factors	Acceptance (%)
Usefulness to students		**Learning process**	
1 easy to connect	95	3 sound helped learning	56
2 easy to work through	94	4 graphics helped learning	78
6 navigation	92	5 animations helped learning	79
7 screen layout	91	8 inclusivity	77
11 fun	65	9 clear learning purpose	83
20 easy to use	92	10 context familiarity	68
		12 enjoyable way to learn	81
		13 not distracted	59
		14 student locus of control	72
		Learning outcome	
		15 new learning achieved	76
		16 relevant to teaching program	73
		17 successful learning	76
		18 surprised with learning	70
		19 interesting	75

Table 5.2 summarises the user acceptance (number of responses either agreeing or strongly agreeing) with the 20 general items, organised according to the three student themes.

Together, Figure 5.2 and Table 5.2 indicate that the usefulness to students factors received more user acceptance than the learning indicators. They suggest that learning objects require an appropriate level of computer literacy for the intended audience. Students felt quite comfortable with the technical aspects of the learning objects: finding information on the screen, navigating through the screens and providing appropriate inputs for the activities. These findings reflect qualitative observations in the classrooms. It is not surprising that students failed to report any difficulty in connecting to the learning objects, since the issues that arose during the review in this area generally impacted on the teacher rather than the students.

There is a distinct difference between the students' high rating of 'enjoyability' compared with the much lower rating of 'fun' value. This suggests that they are distinguishing educational value from entertainment value, and comparing it favourably with other classroom teaching experiences (although less favourably with *Game Boy* and other similar entertainments).

Items relating to student learning process and outcome received less acceptance. On the one hand, items 15 (new learning), 12 (enjoyable way to learn) and 5 (animations helped learning) were rated fairly highly by students. These findings support The Learning Federation's underlying rationale that new and interesting types of learning can be achieved through interactive multimedia.

On the other hand, several items gained less user acceptance, but these ratings reflect qualitative observations in the classrooms. The low ratings do not necessarily reflect the quality of the learning objects *per se*, but how they were used by students and teachers, given the limitations of real classroom environments. Several items warrant particular comment.

- Item 3 (sound helped learning). Many classes were using learning objects that did not have embedded sound. In some classrooms, the teacher did not permit sound as it distracted other students, while in other cases school policies or hardware did not permit the utilisation of sound in the learning objects. Qualitative observations (see 5.4.3.1) suggest sound was important in assisting learning when it was available.
- Item 13 (not distracted while using the learning object). The qualitative data suggest that students using learning objects involving text entry screens become distracted from the learning purpose by the mechanics of typing. However, another major source of distraction arose from interactions with other students who shared ideas and inputs resulting from their own interactions with the learning object. In this sense the distractions were an important pedagogical component of the learning experience.
- Item 16 (relevance to the classroom learning program). Responses here were partially dependent on the range of learning objects available at this early stage of development, and on how much time teachers had to incorporate the learning objects into their teaching. Only three of the six responding schools and 11 of the 20 classrooms in the overall pilot Field Review used learning objects purposefully in lessons. The low ranking of this item reflects the newness of the initiative, rather than the value of the learning object. An analysis of data separating students who used the learning objects in structured lessons, as opposed to those whose use was not integrated into the teaching program, was attempted. However, attempts to analyse the data gave a poor fit to the model with inconsistent results (such as reversed thresholds) on several items.

In summary, the Rasch analysis has proved to be a powerful tool for analysing data collected through simple teacher-administered surveys. By virtue of the technique's ability to provide person-independent assessments of characteristics, and item-independent assessments of respondents on the same scale, the Rasch analysis has provided useful baseline data that can be used to benchmark individual attributes of future learning objects. The technique also provides an opportunity to develop items assessing other characteristics.

The current analysis largely reinforces the findings of the qualitative research presented in the previous sections.

Chapter 6 Discussion

This first stage of the Field Review has shown that The Le@rning Federation's learning object model is appropriate for use in the classroom environment in a range of schools. While issues relating to the design and development of learning objects remain, the focus can now change to how learning objects are integrated into the classroom environment and what pedagogical strategies are employed by individual teachers. This chapter commences with a model of the educational environment that emerged from the pilot Field Review. The issues raised in the pilot Field Review are examined in relation to this model.

6.1 The educational environment model

The data obtained during the pilot Field Review emphasised that learning objects are not independent of the teaching and learning environment. Any field review must necessarily consider how they fit into the educational environment. We have conceived of a classroom environment as shown in the centre of Figure 6.1. The three main components are Students, Teachers and Resources. Clearly, learning objects are one type of resource that teachers will use to enable their students to learn. The intersections of the Student, Teacher and Resource (learning object) circles are the most important areas in the classroom environment section of the model.

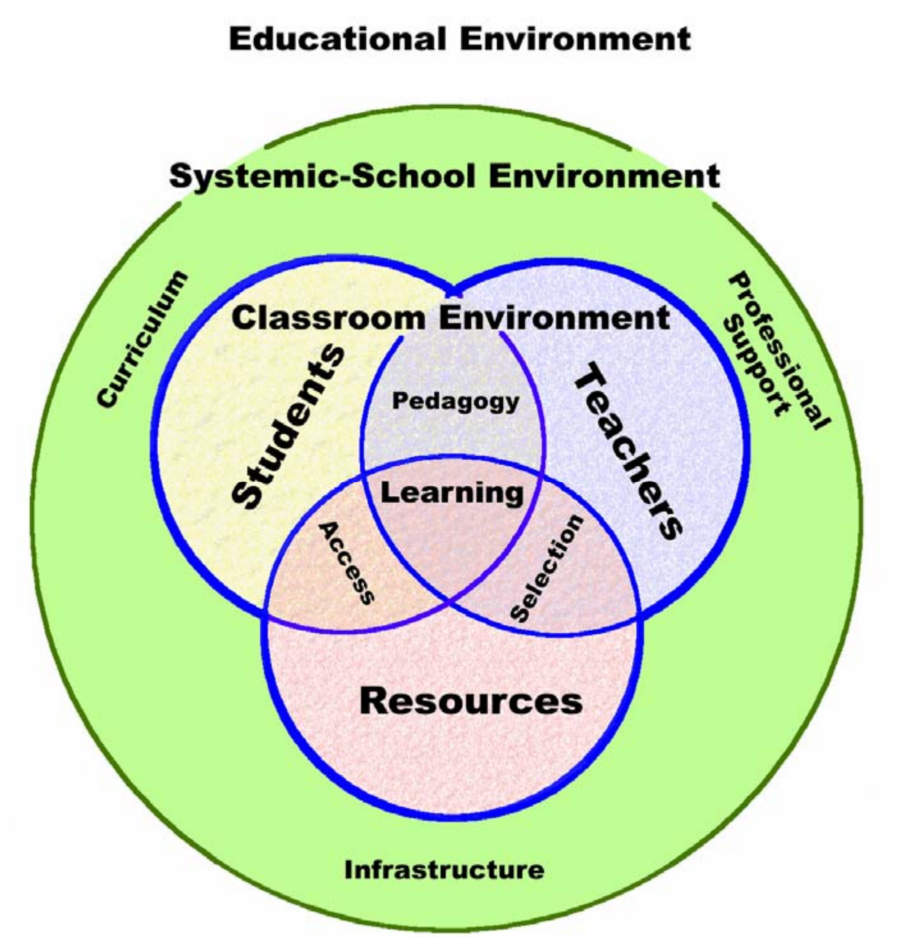


Figure 6.1 Model of the educational environment indicating the ways that students, teachers and resources interact with each other and within the larger school/system environment

The larger circle in Figure 6.1 represents the environment of the school and its educational system. Together, the classroom environment and the school/system environment make up the educational environment. The school/system environment impacts on the classroom in three ways: through the *curriculum*; through *professional support* and development of teachers; and through provision of appropriate *infrastructure*. In the context of this research, the infrastructure is primarily ICT-based, enabling students and teachers to access the learning objects appropriately.

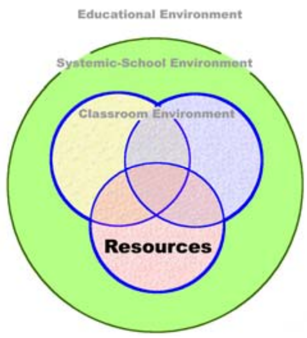
While the educational environment model (Figure 6.1) was derived from evidence collected in this pilot Field Review, it is also derivative of the program logic developed at the beginning of this research (see Figure 3.1). In the program logic hierarchy, school- and system-level support was an overarching factor influencing success, and well-designed learning objects were a prerequisite. Two subsequent factors in the program logic were the selection and use of learning objects by teachers. In Figure 6.1, this is illustrated in the intersection of Teachers and Resources labelled ‘Selection’. Similarly, the next two factors in the program logic hierarchy concern enjoying and learning from learning objects – the intersection of Students and Resources labelled ‘Access’ in Figure 6.1. The final binary intersection in Figure 6.1 – ‘Pedagogy’, the interaction of teachers with students – did not arise from the program logic, but was an important factor arising from the data.

The educational environment model suggests that effective learning arises at the intersections of Students, Teachers and Resources. For learning to be maximised, these three factors must be brought together and the intersection expanded.

The remaining sections in this chapter analyse the results presented in Chapter 5 within the components of the classroom environment model, beginning with the three classroom components, and then their respective intersections. The chapter concludes with a discussion of the impact of the school and system on the classroom.

6.2 Components of the Classroom Environment

6.2.1 Resources (learning objects)



A wide range of resources are used by teachers and students in classroom practice. However, in the context of this study, the focus is the learning objects. A prerequisite for use is ready availability to both teachers and students through the infrastructure in the school. This issue is discussed under the heading Infrastructure, later in this chapter.

6.2.1.1 Usability

The evidence presented in Chapter 5 indicates that, predominantly, students were able to use the learning objects without undue difficulty. They found the learning objects easy to navigate and, with some exceptions, understood the learning purpose and processes to complete tasks and used the media well to assist learning. Content was structured and provided in useful chunks.

Students demonstrated an enthusiasm for using learning objects that was not always apparent in their approach to other classroom activities. In many cases, the user interface and design of the learning object engaged students who found the bright colours and simple graphics pleasing. Humour, particularly through quirky animated characters, was especially appreciated. The multimedia attributes of learning objects, particularly sound and animations, linked to interactivity were strong factors in this engagement.

Sound was used for both effect and information. Sound effects contributed to humour and motivation, and were seen as an important part of the learning experience by both students and teachers. Sound made learning content accessible to many students whose literacy levels did not allow them to read on-screen information easily. Sound was also valuable when it was used to assist students to learn new terms and pronounce difficult words. Unfortunately, sound availability was not as widespread in the learning objects studied as students and teachers required.

Recommendation 1: All text in learning objects should be available aurally.

Factors affecting the use of audio include policy and hardware issues. For example, some schools did not have sound cards in their computers or had disabled all sound. Other schools did not allow audio without earphones because of the distraction to other students.

Recommendation 2: Logistical issues need to be resolved at the school level to ensure that all computers are sound-enabled.

As with sound, graphics provide an alternative to text-based information, affording students with reading difficulties another way of learning. Students enjoy graphics. Wherever they do not compromise the learning purpose, graphics should be used in place of text. Graphics do not always need to be realistic. However, they do need to be clear and factually reliable. On buttons, icons were preferred over text, and colours were particularly important for younger students. The entire suite of offerings for younger students was well received for that reason. Older students tended to be more discriminating, but this was more in the area of content rather than graphic presentation. The learning objects dealing with the human body (for example, ‘In digestion’ and ‘Take a deep breath’) show some excellent ways in which graphics and animation can be used to illustrate terminology in new and engaging ways.

Recommendation 3: Graphics and animations should continue to be used extensively.

The user interface is the entry point and provides the tools for navigation and interaction. While some learning objects had very simple interfaces, others, such as ‘In digestion’, were relatively complex and provided a number of pathways. However, in the case of ‘In digestion’, complexity did not detract from effectiveness because the challenge within the learning object encouraged students to stretch themselves and learn from feedback. It also provided a number of levels of information that students could access when needed. This worked well with students, most of whom were observed to use learning objects intuitively, in an exploratory fashion, in the same way that they use computer games. Unfortunately, the design of some learning objects did not easily accommodate this approach, imposing more structured pathways on the students and relying on detailed instructions at the beginning.

Students did not like reading large sections of text and were less inclined to make appropriate use of learning objects containing text-heavy instruction pages. Students generally preferred to skip instructions and experiment with the learning object. Some were unable to read the instructions or became confused by them, struggling with the text rather than the concepts. Students with weak literacy skills were sometimes better able to engage in learning because some learning objects provided non-textual ways of interacting with the concepts.

Students did not read the instructions for a number of reasons. Instead students:

- preferred to experiment rather than work sequentially
- lacked the literacy skills to read the instructions
- found the instructions confusing
- wanted to use their time ‘doing’ rather than reading
- felt that the font sizes of instructions were too small in some cases.

‘In digestion’ maintains a clever balance between text and graphical information. While ‘In digestion’ did not appear to impose structure on students, it is in fact a highly structured learning object. Its success relies upon the way students are immediately engaged in making choices and gain necessary information through feedback on their input. Feedback, therefore, arrives at the point of need and in segments small enough for students to assimilate and incorporate in their next stage of interaction. The design of this problem-based learning object could be valuable when considering the design of future learning objects.

6.2.1.2 Accuracy

The content accuracy and integrity of learning objects are important, as the study found evidence that some teachers were using learning objects as pivotal teaching resources. Some factual inaccuracies were detected in learning objects in the first round of Science development.

Potential concerns for learning are:

- inaccurate or insufficient information in the learning object
- learning object design that does not accurately represent the disciplinary ideas being represented
- fostering of misconceptions through inaccurate visual representations, such as liquids travelling uphill
- lack of immediate feedback to confirm student choices, resulting in misconceptions being propagated.

Integrity is also compromised where there is a mismatch between the literacy demands and the level of the concepts explored in the learning objects, and where students can succeed by guesses or trial and error.

Details about these issues have been communicated to The Le@rning Federation. The Le@rning Federation has indicated that it has addressed areas for improvement identified through draft versions of this report, and through its own quality assurance procedures.

The Schools Online Curriculum Content Initiative is a new development, and internal processes are still undergoing development and improvement. Therefore the organisation needs to demonstrate that it can identify areas needing improvement and implement changes. The Le@rning Federation has developed detailed specifications and processes, continually under review, including its quality improvement processes and feedback loops (Atkins 2003).

6.2.1.3 Characteristics of successful learning objects

This pilot Field Review confirms The Le@rning Federation’s decision that learning objects should be independent resources with enough flexibility to be used in a range of lessons in a number of different ways. Students expressed a strong preference for learning objects that provided them with choices and control over elements within the learning object environment. They liked to see immediate feedback on their input and appreciated learning objects that gauged their success or progress. They wanted to learn by making the wrong choice, and they wanted various levels of difficulty. The preceding characteristics are all common in computer games. Learning objects designed as games, with a clear goal or reward, were also seen by teachers to be valuable and to have the ability to accommodate various learning levels and styles. However, a proviso was that the game components of learning objects should be directly linked to the teaching purpose, and rewards and penalties incorporated in a way that promotes learning.

The game component of ‘In digestion’ is inextricably linked to the teaching purpose, as are the ‘penalties’ and all other parts of the action. Students learn *through* playing the game. However, in ‘Finders keepers’, the gaming component, navigating around the house, is separate from the learning activity of text analysis. In this case, a number of students were observed to circumvent the learning activities in order to finish the game quickly. There were no penalties for this. To be effective, it is important that learning objects are designed so that students can only succeed in games by demonstrating and applying the intended learning.

Learning objects can exploit the entertainment potential of computer or arcade games and provide structured learning activities that offer levels of difficulty and enable manipulation of variables to accommodate students with a variety of skills, knowledge and learning styles. They can also provide complexity and surprise. Elements of the unexpected were found to motivate students to engage with the learning object more thoroughly and for a longer period of time. Students also liked working with each other on learning objects, some enjoying competition.

Comfort and familiarity with multimedia elements and conventions influenced how well learning objects were used. Not all students understood how to follow text links to ‘help’ and were more likely to follow graphical cues and avoid reading. Students, especially those with weak literacy skills, liked the use of sound to alert, add effect and provide assistance. They responded with varied success to visual complexity. This meant that some helpful features of learning objects were overlooked by students until they were pointed out by the teacher.

Students were particularly receptive to animation and cartoons, preferring them to photographs or video clips shown in small windows. They were also useful from an educator's point of view as they can be simplified to focus on what is pertinent for learning. Accuracy and clarity of graphics and animations are critical. Researchers found students had difficulty providing appropriate input when they were confused about what the graphics were demonstrating. This significantly undermines the value of a learning object.

The ability of multimedia to accept student input and provide meaningful feedback is a key benefit of learning objects. 'In digestion' is an example of a learning object that recognises and harnesses the learning potential of these elements successfully. This was not the case in some Science learning objects following the Predict–Observe–Explain (POE) model. The highly structured nature of the POE learning objects suggests they can be used as stand-alone resources. However, observation in the case-study schools indicated that they were unlikely to be used effectively without being contextualised, explained and monitored by the teacher.

A synthesis of the results of this pilot Field Review has led to the development of a set of characteristics of a successful learning object. These are summarised in Table 6.1. Not all of these characteristics will be appropriate for each of the six types of learning objects identified in 4.3. Some of these characteristics are already part of The Le@rning Federation's design specifications and this evidence serves to support The Le@rning Federation's specifications.

Table 6.1 Characteristics of successful learning objects

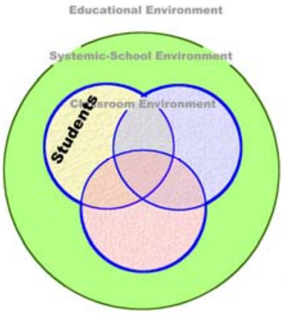
Generic	Exploration by students is encouraged.
	Learning objects are rich enough to allow use on multiple occasions.
	Students are motivated to undertake multiple attempts.
	Gaming techniques, such as rewards and consequences that are relevant to the learning purpose, are used.
	Where appropriate, levels of difficulty are incorporated to provide activities suitable to students of varying academic and literacy levels.
	Instructions are provided when they are needed rather than only in advance.
	A statement of the learning purpose is accessible throughout the learning object.
	Learning activities challenge students and are suitably complex while maintaining a simple user interface and reducing literacy demands.
	Timely feedback is provided to students, preferably in multimedia format.
	Students can modify earlier results on the basis of additional experience, or can demonstrate understanding at any time.
	Mechanisms to scaffold student learning are incorporated.
	Students are able to transfer their work to printers or other applications such as Word and Excel.
Text and graphics	Text-intensive instructions are avoided, especially on initial screens of a learning object.
	Graphics, animation and voice support are used in preference to, or in conjunction with, text.
	The amount of text on each screen is limited to six lines or less.
	The need for students to enter their own information is carefully considered and only used where it adds to the learning purpose.
Sound	Sound is available wherever possible, both for information and effect, and to minimise literacy demands.
	Sound can be toggled on and off.
Animation and video	Video clips are distinct and easily interpreted by students.
	Animation is used in preference to video when focus on important features is enhanced by it.

There is a need to develop a variety of learning objects and assist teachers to choose the learning objects that would best suit their needs. The current offerings of The Le@rning

Federation are a useful start, and a larger corpus of materials will make the resources more appealing to both teachers and students.

Recommendation 4: Additional learning objects should be developed in order to provide a substantial and coherent range of resources in a variety of content areas and at a range of levels.

6.2.2 Students



The case study approach used in this pilot Field Review enabled the investigation of how students of different abilities and backgrounds used learning objects. Almost all students observed were able to use the learning objects and gained some benefit from their use, regardless of background.

Some teachers in the study were interested in providing learning objects to students judged to be gifted or talented because they considered the learning objects would challenge their ability and extend the scope of lessons. However, learning objects were also found to benefit lower achieving students for a number of reasons. They provided these students with motivation to engage in activities and anonymity when providing answers or input. Students who may be embarrassed to participate frequently in class for fear of ridicule or failure were observed to persist when attempting learning objects.

Not only did learning objects provide a non-judgemental environment, they enabled alternative ways of succeeding. Students could tackle activities involving experiment and strategy with fewer barriers from text and facts. They were also able to produce high-quality work in cases where writing or drawing on paper proved time-consuming and difficult.

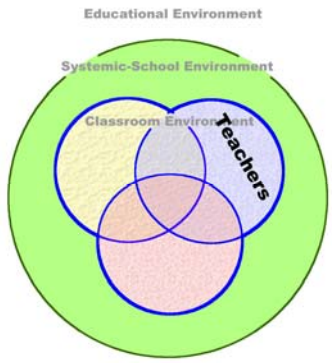
Students were comfortable using the ‘help’ or ‘hint’ features of the learning objects. These provided timely advice without the student having to wait for the teacher’s attention. The ability of learning objects to respond individually and patiently to student needs was found to have a significant impact on student enjoyment and persistence.

Students from non-English-speaking backgrounds were found to use the learning objects as easily as other students, although they tended to avoid reading lengthy sections of text. They were able to navigate around learning objects using visual clues and intuitive logic. Teachers felt learning objects with more audio content would particularly benefit these students, and others with weak literacy skills.

Students from Pacifica backgrounds were found to benefit from the use of learning objects for many of the above reasons. Unfortunately, no Aboriginal students returned permission forms for taking part in the research and, therefore, no evidence was obtained about use of learning objects by Australian Indigenous students. Similarly, no students with physical impairments were observed during the course of the pilot Field Review.

For many of the above reasons, teachers were enthusiastic about the ability of learning objects to cater for different cultural modes of learning or individual styles of learning. Visual learners were provided with new and stimulating ways to learn. Graphics and animation contributed to this and enabled the demonstration of abstract concepts generally found difficult to teach.

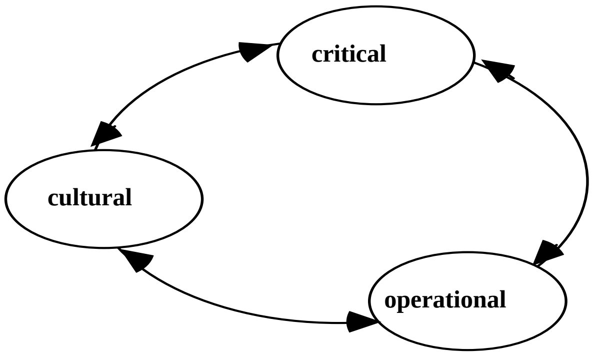
6.2.3 Teachers



Teachers do not form a homogeneous group. What they each require from learning objects will vary. Among the determining factors of these requirements are a teacher's familiarity and confidence with both the technology and the content area, and their beliefs about teaching.

The *Digital Rhetorics* project (Lankshear et al. 1997) recognised that perhaps the strongest and most promising development of recent times has been the emergence of what can now be called a 'situated social practice' model of technology learning. This is an emphasis on situated, 'authentic' learning and cultural apprenticeship, within a critical socio-cultural view of discourse and practice. This brings together established work in Australia addressed specifically to language and literacy learning (for example, Boomer 1989; Cambourne 1988) with work in literacy studies and the socio-cultural paradigm, such as that of Gee (1990) and Lankshear (1997). Significantly, though, it explicitly stages a dialogue with 'constructionist' work in computer culture and learning (Papert 1993, 1996). The 'situated social practice' model of technology learning was first developed in relation to subject-specific literacy learning (Green 1988), and has been successfully deployed in ICT and education (Green 1996). This study will develop the model further for exploring teacher development.

The model involves a '3D' view of technology learning. It brings together three dimensions or aspects of learning and practice: the *operational*, the *cultural* and the *critical*. Rather than simply focusing on 'how-to' knowledge, as it usually is understood (that is, technical competence and so-called 'functional literacy'), it complements and supplements this technical competence by *contextualising* it, with due regard for matters of culture, history and power. This is a holistic, cultural-critical view of technology learning that explicitly takes into account contexts, contextuality and contextualisation (Lemke 1995). The point to emphasise here is that none of these dimensions of discourse and practice has any necessary priority over the others. All dimensions need to be addressed simultaneously. Essentially this means that it is counter-productive to *start* with issues of 'skill' or 'technique' outside an authentic context of situated social practice. The model (from Durrant & Green 2000) can be depicted thus:



This model, derived from an integrated, socio-cultural view of technology learning, helps to conceptualise and map teacher development.

The *operational* dimension includes but also goes beyond received or usual notions of technical competence and 'how-to' knowledge. The emphasis is on finding out how to make a computer operational, how to 'turn it on' and make it 'work', from the basics of making sure the cables are connected and switching it on, to opening up files and documents, along with related activities such as opening and searching a database or using a CD-ROM.

Understanding and deploying the *cultural* dimension involves recognising and acknowledging that ICT practice and learning are always more than simply a matter of being able to operate technology systems; rather, such operational capacities are always in the specific service of doing things in the world, and to achieve our own (and others') purposes. It follows that the emphasis is most appropriately placed on authentic contexts, forms and purposes of learning and teaching.

The *critical* dimension draws in explicit consideration of context and history, and also of power. It takes into account that school knowledges are always partial and selective. They are always someone's 'story', in the sense that the curriculum always represents some interests rather than others, and that it is a complex socio-historical construction. For critical ICT learning, teachers and students need to be able to assess and evaluate software and other technology resources (for example, databases, interactive CD-ROMs, the World Wide Web) in a spirit of informed scepticism. They need to be able not only to use such resources and to participate effectively and creatively in their associated cultures but also to critique them, to use them against the grain, to *appropriate* and even re-design them. The development of the critical user of ICT is understood within this framework.

Teachers' beliefs about teaching, and their consequent pedagogical approaches, affect how they structure lessons and evaluate student learning, and impact on the way they use learning objects. This means that there is no ideal learning object that will suit all teachers, but that resource providers, such as The Le@rning Federation, should aim to provide a variety of resources. These issues are discussed further in 6.3.1.

Teachers in the pilot Field Review were concerned with making the content of the learning objects meaningful to students and wanted to integrate them into their teaching and learning programs. Learning objects were intellectually stimulating for teachers. They reinvigorated teachers and introduced challenges. In some cases teachers overcame initial fears of using ICT when they were exposed to learning objects and realised the positive impact objects could have on their teaching. There was evidence of a 'trickle down' effect as enthusiasm was passed from teachers to students, and to other teachers.

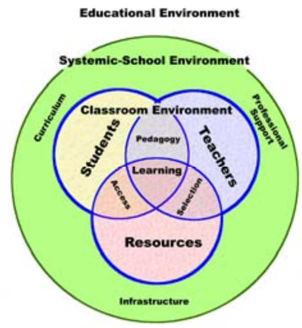
In keeping with this, teachers indicated they wanted more learning objects from which to choose. They expressed a need for reliable online resources that were easy to sort through, select and download. They expressed a need for resources that extended and supported their knowledge of curriculum areas, in turn bolstering their confidence in the classroom.

Teachers were quick to identify the strengths of learning objects and developed teaching strategies to capitalise on these. Teachers recognised that learning objects had the potential to:

- cater for a range of cognitive abilities
- allow for individual progression
- provide new opportunities for collaborative learning
- match students' cognitive capabilities
- assist in providing links between concepts and contexts
- provide scaffolding and reinforcement.

Both students and teachers expressed a preference to perform activities using real materials rather than through computer simulations. Learning objects, therefore, need to exploit their ability to provide students with novel content and learning situations beyond the scope of the classroom.

6.3 Interactions within the classroom environment model

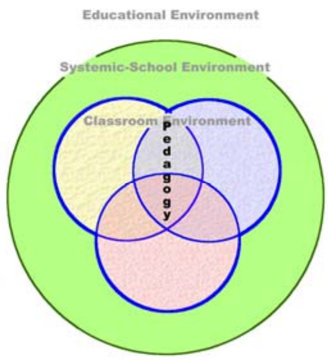


As outlined in Figure 6.1, there are three components of the classroom environment: learning objects, students and teachers. Maximising the potential of learning objects lies in maximising the following intersections of::

- Pedagogy – student with teacher
- Selection – teacher with learning object
- Access – student with learning object.

The common intersection of these three corresponds to effective learning. Each of these intersections is described in more detail below.

6.3.1 Pedagogy: student and teacher interaction



This study reconfirms previous findings that suggest that teachers' beliefs about teaching and learning influence their choice and use of learning objects (see 6.2.3). In practice, researchers found that while teachers were eager to exploit new learning opportunities offered by learning objects, some teachers replicated acceptable, inexpensive classroom activities.

Teachers believed their teaching benefited from the introduction of learning objects. Some teachers found that learning objects presented new ways for them to view the curriculum or led them to appreciate a wider variety of learning perspectives. Often the use of learning objects prompted them to reconsider their assumptions about teaching and learning.

In documents produced by The Le@rning Federation there has been discussion ofthe impact of pedagogical philosophy on learning object design (Atkins 2003, pp. 6–8; McRae 2001, pp. 71–81; Muirhead & Haughey 2003 pp. 8–9). Other authors have discussed the role of pedagogical philosophy in ICT-based learning (Kennedy & McNaught 1997; Phillips 1997; Reeves & Hedberg 2002), based on Reeves' seminal work on pedagogical dimensions in interactive learning systems. These 14 dimensions derive from an initial continuum between behaviourist and constructivist epistemologies, which assume respectively that knowledge exists independently, or is constructed by an individual or group.

Based on thorough research (McRae 2001), The Le@rning Federation specified that learning objects should be designed from a constructivist perspective, although they were also intended to be pedagogically neutral:

> The objects should contribute to the learning of the user. They are not meant to be assessment experiences or revision experiences or drill and practice experiences. They are meant to contribute to the understanding of concepts and processes and the development of skills. This does not mean that assessment, revision or drill and practice cannot be exhibited through interaction with the learning objects but this is not the primary focus. (Atkins 2003, p. 1)

Notwithstanding the design of the learning objects, teachers' own beliefs about pedagogical philosophies impact on how they use learning objects. Kennedy and McNaught (1997) and

Bain, McNaught, Mills & Lueckenhausen (1998) investigated how university teachers designed and used learning objects.

A range of factors affect a teacher's comfort and confidence in using learning objects, including their available time to plan, and their familiarity with the curriculum, their students and the systems and facilities in their school. The teacher's expertise, both in ICT and in discipline areas, is also important in relation to how it interacts with the teacher's pedagogical approach to produce various modes or dimensions of operation (see 6.2.3). While the pedagogical approach may be relatively fixed, the teacher's mode of operation will vary with the factors that contribute to confidence, such as content knowledge and comfort with technology.

The way in which these modes were observed in the Field Review is described below, and illustrated by vignettes from the data.

6.3.1.1 Critical mode

In this mode, the teacher is not just concerned with the use of the technology, but examines why it is being used. This mode was the least common during the review. However, it was interesting to note how some teachers had taken objects and used them in social and disciplinary contexts that were different from that for which they were designed. One teacher used the Science object 'It's a drag' in a road safety lesson with year 10 boys who were about to get their driver's licences. Before using it, this teacher had carefully considered the ethical issues of having students trying to have a crash. Another teacher used the Science object 'Weather wear' with an early years student who needed social counselling.

Vignette 1: Critical mode – concept learning

Learning object: 'The Alpha, Beta and Gamma of Radiation'
The learning object depicts a radiation source and a Geiger counter. It is possible to change the radiation type, the nature of the barrier between the source and the counter, and the distance of the counter from the source. The user sets the variables then presses a button on the screen to start the activity. Three forms of radiation (alpha, beta and gamma) are counted and displayed numerically in a table on the screen. A random number generator component has been used to better simulate the probabilistic nature of the phenomenon. There is also a sound effect simulating the clicks on the counter. The simulation runs for a fixed period, and the user can reset conditions and repeat the experiment.

Classroom environment
Teacher 1 was a discipline specialist with many years of experience, active in professional associations, and teaching a year 8 'gifted and talented' class. He was comfortable with ICT, having used computers innovatively in the classroom for several years, and was able to create webpages, and do some basic programming. Activities in the class were varied, extending into ecology-based holiday camps and out-of-class solar car construction. The in-class program was constructed to allow the students one day to work on their own projects. One student had calculated the spin of the sun from NASA website photographs of sunspots. Another found a new comet. A third, without realising that such a thing existed, had calculated absolute zero to within a few degrees.

Teacher purpose
In discussions with the teacher after the lesson, he made it clear that he was not using the learning object for the facts, but for the way it could allow students to collect individualised data that enabled them to use a cognitive process. It was the development of those processes that interested him. He was keenly aware of the importance of pattern recognition in science

(and mathematics), while recognising the importance of probabilistic factors. The learning object satisfied both these requirements. He had hoped that it would be possible for students to develop further experiments of their own, or that he could use other combinations of variables in order to demonstrate other principles.

Learning object use
The observed lesson started with a 'mental Science test' on deducing the names of complex organic chemicals from formulae or structures to focus attention. Then the main lesson was introduced by the teacher saying: 'Today we will investigate the inverse square law', and then going on to talk about the nature of radioactivity, and demonstrating an array of radioactive substances (with suitable regard to safety). The next part of the lesson involved a demonstration of the radioactive component from a smoke detector. With the assistance of students, the teacher used a range of real isotopes and adjusted the distance between Geiger counter and the isotope, recording the clicks per minute. Students were, as he predicted, initially surprised by the non-linear relationship. The influences of error and chance were discussed during the demonstration.

At this point there was a major departure from the lesson plan as the school's IT administrator had prevented access to Flash learning objects in classrooms, even within the school intranet. This had occurred during the previous week, but teachers had not been notified. It had been planned that the students would repeat the experiment several times. The teacher would supply the initial testing conditions, and students would record data on prepared sheets, average, and then plot it. They were then to be led towards the inverse square relationship. From there he had intended to close the lesson by mentioning some other inverse square laws (such as gravity), their historical development and their importance as a cognitive tool in science. Unfortunately, it was not to be the case. Data was simulated by a student teacher in the classroom, similar to that which would have been obtained using the learning object, and students graphed the data to get the shape, and were challenged to deduce the relationship between the distance and the rate of clicks.

Evaluation
The teacher's concern with general scientific principles, rather than contexts, was indicative of the critical mode. He was not concerned with explaining the use of smoke alarms, although he used this context to introduce the topic. Nor was he particularly concerned with the nature of radioactive materials, although he used this content to carry his teaching purpose. Rather he was concerned with having students recognise a fundamental recurring pattern in Science – the inverse square law – and through that, appreciate the importance of scientific numeracy. In the same manner, he was appreciative of the probabilistic representation of data as a means for students to experience this generic aspect of natural phenomena. This teacher was acutely aware of the underlying beliefs and values of the discipline, and his concern throughout the planning and delivery of the lesson was to accurately represent these to the class, choosing his resources based on the accuracy and adequacy of this representation.

When the learning object was not accessible to students in the classroom, the ICT component was abandoned, but the lesson proceeded and the learning purpose was achieved through other means. This successful outcome can be attributed to several factors. First, this teacher's confidence with computers allowed him to quickly recognise the potential causes and problem-solve to overcome them. Secondly, as an experienced teacher familiar with the workings of the school, he was able to maintain his role as a teacher, and locate alternative resources. Finally, as a knowledgeable, reflective, disciplinary expert he was clear about his teaching purpose, having critically examined how the context and content related to the discipline as a whole. This provided him with the confidence and experience to adapt the lesson to changing circumstances without losing purpose. The result was that operational considerations never overwhelmed the critical approach he had developed for the lesson.

6.3.1.2 Cultural mode

In this mode the user is focused on using the technology in an appropriate context. Teachers in this group were adapting the learning objects to suit their programs. Several teachers had designed detailed units of work using the learning object as one component. Teachers with a cultural mode of operation tended to focus on selecting learning objects that matched the content themes of their teaching programs rather than the learning process development of their students. In one case this led to a teacher selecting a learning object that out stripped the cognitive abilities of the students in order to preserve program content continuity.

Vignette 2: Cultural mode – thematic links

Learning object: 'Save the lake'

This learning object presents an ecological context to examine two groups of chemical concepts: chemical change, particularly precipitation reactions; and acids, bases and salts, with an emphasis on the behaviour of indicators.

Users pass through a series of information screens where they are introduced to the four chemical tests used in the learning object, and to five possible sources of chemical pollution in Lake Baikal.

The learning object requires students to use combinations of tests to reason which pollutant is responsible for the ecological damage that is occurring. The acid can be excluded on the basis of a one-step litmus test. Each of the remaining four sources must be evaluated through combining information from more than one test.

Users type a prediction into a textbox, then observe any changes in a small video clip and type their observations into another text box. They are then prompted to type an explanation into a third text box, after which they may, if they wish, suggest the source of pollution by pressing a button. A number of information screens follow. If correct, they are provided with a report form which involves filling out a text box where they are prompted to 'Write what you have learnt about chemicals that are soluble'.

Classroom environment

The school was new and set up with computer access as a priority and the lesson was conducted in a computer laboratory to which the teacher has continual access. The students used banks of portable machines connected by wireless to the school intranet.

The teacher was highly motivated, self-disciplined and directed, and proficient and confident in using new technologies and new approaches. Still young but Acting Deputy for the school, the teacher seemed to be a person to whom the other teachers went for ICT advice. While enthusiastic about environmental issues, she did not display a strong background knowledge in chemistry.

Her upper primary class, drawn from an ethnically diverse middle-class suburban area, were highly disciplined, and, even with a wait of virtually an hour for some to get online, very patient. As a group the students were articulate.

Teacher purpose

The teacher used the learning object as an integrated component of a wetlands program she was conducting with her upper primary class. In the post-lesson interview, the teacher was relatively happy with the lesson, although she felt that 'teachers need to be in their science comfort zone' to teach it. She felt that its value lay in the match of learning object content (wetlands pollution) and her program, and argued for a precise fit between the two, or for teachers having the ability to modify learning objects so they could match programs more closely. She was unhappy that she could not modify the learning object to include local content, such as by inserting a picture.

Learning object use
The previous day was spent introducing students to the learning object, and how to access it (through BELTS). One test was carried out.

The morning of the ICT lesson was spent with a local catchment officer at the local wetlands who, according to the students, taught them 'lots of names of plants'. In the afternoon they came back to the classroom to use the learning object.

The teacher moved around the room during the class, talking with students about their work, and relating the pollution depicted in the learning object content to their other work in the local wetlands. Students took between ten and twenty-five minutes to discover that copper was responsible, but generally made the discovery by chance, randomly selecting a new cause after each randomly selected test.

Finding the solution required a combination of reasoning skills that was beyond the capacity of most year 6–7 students, and almost all students failed to use a strategy to determine the pollutant. As students 'solved' the problem by random selection of pollutants, they lost interest in the learning object.

The teacher provided a separate worksheet for them to fill out, and these were made available to the researchers. The worksheet comprised two parts: a table to explain the processes by which conclusions were reached, and possibilities for ecological action.

Evaluation
The teacher's concern with the wetlands context, rather than with what instructions to provide, or the underlying general chemical principles, is indicative of the cultural mode. Her concern to 'customise' the learning object to include local materials, such as photographs of the adjacent wetlands, reflects a 'cultural' concern with the context in which the learning objects are delivered. Cultural concerns were similarly reflected in her (incorrect) concern that Lake Baikal was a 'mythical' lake, and that the specific forms of industrial pollution it contained were not relevant to the local wetlands visited by her class. In fact, the school's wetlands sit atop an aquifer that has considerable and well-publicised chemical pollution problems, but these were either not appreciated or not seen as being sufficiently similar to the problems of Lake Baikal.

Critical limitations
The teacher was highly skilled and confident in the management aspects of teaching. However, like virtually all primary-trained generalist teachers, she had limited formal background in Science, and in chemistry in particular. This placed several limitations on her mode of operation in the classroom. First, she was not in a position to appreciate the subtle beliefs and values, such as the use of critical tests in hypothesis refutation, that underpin this learning object. Secondly, she was not familiar with the particular content involved and unable to appreciate the importance of the tests as representatives of broader chemical concepts. This learning object also had a number of factual errors that were not noticed. These three content-associated limitations formed a barrier to her developing the reflective approach indicative of a critical mode of operation.

6.3.1.3 Operational mode

In this tier the user is concerned with the basics of making something work. Approximately half of the teachers in this study had major concerns about creating an accessible learning object-based lesson for their class.

Vignette 3: Operational mode: task list

Learning objects: 'Dynamic Fractions'**,** 'Park Fractions'**,** 'Design a park'
'Dynamic Fractions': The learning object is context-free. The user sets controls on the upper right of the screen to determine how the activity will be run. Fractions are displayed in four forms: as shaded cells on a grid, as a number line, as a numerical fraction and as an equivalent numerical fraction. The user creates a grid on the screen, choosing the number of columns and rows and, depending on how the controls are set, can use the activity to solve problems or as a tool to check for equivalence. Other possibilities are available, depending on the teacher.

'Park Fractions': The learning object uses the context of a park to teach about fractions. Fractions are represented as coloured cells on a grid, and by a slider on a number line. Users are given a fraction of the park that is required for a specific purpose (for example, 1/8 for swings), and the user fills in the cells. Alternatively the user may be asked to move the slider on the number line or to type in the fractions.

'Design a park': This follows the same format as 'Park Fractions', but divides the park into five rather than four zones, and provides a 'times tables' screen to assist users.

Classroom environment
The teacher was an experienced classroom teacher, but had no special expertise in computing, and admitted to feeling tentative about teaching Mathematics at upper primary level. She followed developments in curriculum policy closely, and was keen to implement new departmental strategies, although relied heavily on the expertise of another teacher and on departmental advisers in the ICT area. The class was drawn from a wealthier suburban area, and was highly disciplined. They used a computer laboratory with a data projector and large screen. Computers were arranged in rows on each side of the room. Each student had their own computer and, while largely working alone, discussed their work with their immediate neighbours.

Teacher purpose
The teacher felt that learning objects were particularly valuable because they were 'good to teach the mundane concepts … a good review process … (and) … good for learning tables'. She was particularly impressed with the learning objects when one child remarked that he normally hated Mathematics but he liked it now. The teacher found the Mathematics concepts in the learning object difficult rather than the extensive instructions. She recognised the need for students to have some prior knowledge, but felt limited by her own lack of confidence in the area. She valued the support the learning objects provided in this area, and particularly liked the ability to 'sequence the lesson in BELTS', finding the sequencing useful as personal professional development. She was positive about the speed and quality of external support she had received when having technical problems. She felt the learning objects allowed her to conform to the collaborative approach advocated in the jurisdiction's new curriculum initiatives since the students worked in pairs, and she dispensed with the 'chalk and talk' from the front of the room.

Learning object use
The teacher used three fraction-related Mathematics learning objects in one 45-minute lesson. The lesson was introduced with a lock-step set of instructions about how to start the computer and access the learning objects. The teacher used BELTS instructions to sequence the learning objects, starting with the most abstract ('Dynamic Fractions') and working to the other, more contextualised learning objects. The instructions were three lines of text in small font, each directing students to the next learning object. She provided settings for screen buttons on the blackboard, but provided no guidelines on how to use them, nor any goals for students to work towards.

After delivering the instructions using the data projector, the teacher moved to the front corner of the room where she remained for the rest of the lesson, giving occasional instructions for classroom management. The students worked quickly through 'Dynamic Fractions'. None read the three pages of instructions. They considered that they had mastered the learning object when they completed one fraction correctly. Students generally limited themselves to 'easy' or known fractions and did not explore or challenge themselves. They had 'learnt the rules of the game'.

While the class had been studying fractions, they had not been exposed to the number line used in the learning object. Nor did they link their work with the learning object to the fractional equivalence that they had been studying in class. They then browsed through the first of the contextualised learning objects in the same manner, before proceeding to the second. A number of students could not differentiate between these two similar learning objects. More time was spent on the 'Design a park' learning object, but mainly with students counting squares rather than looking at the visual representation of the different fractions. For the students, the activity had become technology – they were learning how to navigate through the learning objects, rather than mathematics. One student summarised class feelings by describing the learning objects as 'very educational but a bit boring'.

About ten minutes before the end of the lesson the teacher allowed students who 'had finished' to use *Cahoots*, a time-filling 3D simulation that allows students to create a scene by dragging-and-dropping items from a panel.

Evaluation
The teacher's concern with the instructions provided, rather than the learning involved, is indicative of the operational mode. Her instructions and interactions with students centred on the operational issues of working the computer and maintaining classroom discipline. There was little attempt to contextualise learning that would be expected from somebody working in the cultural mode. In fact, the least contextualised learning object was presented first, and there was no attempt to make the context of the other learning objects meaningful to the students, despite a number of current local issues about parkland in the immediate vicinity of the school.

While willing to take on new policy initiatives, in the area of computing the teacher was relatively reliant on outside assistance. At the same time she did not feel completely comfortable with the discipline area and was unsure about both the content and the commonly used techniques to teach it. For example, she had not used the number line in teaching Mathematics before. These factors contributed to her inability to use the available learning objects in a contextualised way and teach in cultural mode, or to reflectively examine her use of them in a critical manner.

The three modes of operation are not independent. A teacher exhibiting a cultural or critical approach has already come to terms with issues relevant to lower categories. This interplay of modes functions in a similar manner to Maslow's hierarchy of needs (1954) in which higher needs are not relevant to the individual unless the lower needs have been met. In this case, a teacher cannot be concerned with evaluating the use of the learning objects for learning until she or he has been able to integrate them into the teaching program successfully. They cannot be integrated into the program until they have been made to work with the infrastructure that the teacher has access to.

In general, however, certain modes have been found to predominate under specific circumstances and according to an individual's underlying teaching beliefs. Teachers differ in their *computing literacy* and in their *content knowledge*.

- There is a wide range of degrees of computer literacy within the teaching profession, from those at the 'where is the On button?' stage to those who are developing their own computer-mediated resources. While a number of teachers observed in this study had relatively high interest in ICT, and relatively strong computing literacy, it can be expected that the majority of teachers have limited confidence and expertise (DEST 2001).
- A wide range is also evident in degrees of disciplinary literacy. This is particularly prominent at the primary level where teachers are generalists, teaching all learning areas, and especially in Science. The majority of learning objects studied in this pilot Field Review were Science objects being used in primary schools by non-specialist teachers. These teachers often lack disciplinary confidence and may be only one step ahead of their students (McComas 2000).

The effect of a teacher's confidence and pedagogical approach on his or her mode of operation is summarised in Table 6.2. Operational behaviours can be expected where teachers are lacking in confidence as a result of unfamiliarity with the content or technology. Cultural behaviours can be expected where the teacher employs a behaviourist approach, viewing the content as the central issue rather than the process by which the knowledge is obtained. Lower confidence levels caused by lack of familiarity with content or technology may also prevent the teacher from concerning himself or herself with critical issues. Critical behaviours, therefore, can only be observed when the teacher has a constructivist approach and feels confident with the content, technology and his or her role as teacher.

Teachers who use an operational mode can be expected to use learning objects that satisfy operational requirements. They are happy just to get them up and running. A talking book will suit operational goals for a teacher who lacks confidence in the technology and content, because it provides the body of knowledge without teacher intervention. Learning objects that satisfy critical requirements, however, are unlikely to be chosen, or will be used relatively ineffectively. On the other hand, a simulation may suit the critical goals of a teacher with a good disciplinary knowledge who can direct students how to set and modify the parameters within the simulation to achieve the effects the teacher wants them to experience. For example, students using Science learning objects requiring manipulation of several variables were observed to learn less effectively if their teacher was in operational mode than if the teacher was concerned with cultural or critical matters, such as the processes by which the

Table 6.2. Relationship between teacher's mode of operation and confidence and pedagogical approach

		Pedagogical approach		
		Behaviourist		**Constructivist**
	Novice	Operational	Operational	Operational
Teacher's confidence		Cultural	Cultural	Critical
	Expert	Cultural	Critical	Critical

students were learning. The latter provided a structured lesson plan to develop those processes, whereas teachers concerned with operational issues provided far less guidance for their students.

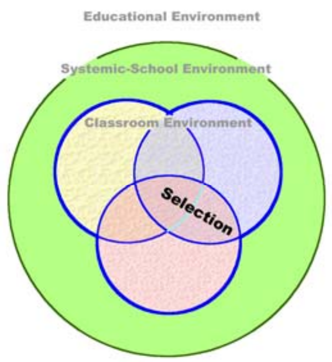
To be effective in the twenty-first century, teachers need to change from an operational to a critical mode. It was observed that teachers in operational mode can be motivated and educated by learning objects that satisfy cultural requirements by providing alternative strategies for teaching familiar concepts. Evidence has been presented in this report that learning objects facilitate this change in mode of teaching. Nevertheless, teachers will need support in changing their approaches. Professional support and development are discussed in 6.4.2.

Given these arguments, the suite of learning objects needs to have material that can address each of these modes, in line with The Le@rning Federation's aim that learning objects should be pedagogically neutral (Atkins 2003). Learning objects could be considered to have three possible roles for the teacher. They can:

- support the teacher to teach in the manner that he or she is used to
- motivate the teacher to provide more enriching experiences for their students
- enable the teacher to discover more enriching teaching methodologies.

These issues, which are broadly congruent with McRae (2001, pp. 92–4), indicate that learning object designs have a role in changing teachers' perceptions about learning objects. Learning objects must be attractive enough for teachers to choose them (as described in the following section), but should act as motivators for the professional development discussed in 6.4.2.

6.3.2 Selection: the learning object and teacher interaction



Reasons for teachers' selection of learning resources are complex. The Le@rning Federation's specifications indicate that learning objects need to recognise the hallmarks of acceptable pedagogies such as methods that accommodate construction of meaning, individual progression, multiple intelligences, collaborative learning and scaffolding of knowledge. Within the first round of learning objects, though the range is still small, there are possibilities for teachers to utilise pedagogies appropriate to their situation.

6.3.2.1 Selecting learning objects

Overall, teachers expressed enthusiasm about the potential of learning objects to introduce a wider variety of learning activities into the classroom. Among other things, they believed that learning objects were best used to conduct lessons that were otherwise dangerous or beyond the scope of existing school infrastructure or budgets. Teachers gave examples of science experiments needing chemicals or materials they would be reluctant to use with students. Teachers also felt that the simulation aspect of many learning objects increased the viability of time-dependent activities such as science experiments requiring a number of days or weeks to complete.

Teachers also appreciated the potential for learning objects to demonstrate sensory experiences outside the range of normal resources and activities, such as functions of the human body or plant systems, and geographically distant locations. Many of the learning objects fulfilled this potential but others provided material and activities within the repertoire of most classrooms and teachers still used them even though they had indicated that they preferred to use the real experience if possible.

Teachers had mixed experiences in locating appropriate learning objects using the BELTS demonstrator program. This is discussed further in 6.4.1, but should be qualified by the fact that BELTS was still under development at the time of use by teachers. Notwithstanding any technical problems, teachers experienced difficulty in locating learning objects of an appropriate level for their students' needs. Several teachers felt that the metadata about the schooling levels of learning objects were inappropriate. Partly because of this, some teachers used learning objects whose concepts or graphics were ill-suited for the cognitive abilities of their students and this led to learning objects failing to meet the learning needs of students.

Recommendation 5: The Le@rning Federation should review the metadata descriptors of learning objects in consultation with practising teachers.

Teachers also wanted contextual information about how learning objects could be used – they wanted to know how other teachers had used them. The current metadata standard does not allow for such peer review. While mechanisms for peer review of ICT-based learning resources have been proposed in the tertiary sector (McNaught, Phillips, Rossiter & Winn 2000; Taylor & Richardson 2001), such mechanisms have not matured, nor have they been applied to the schools sector.

In the absence of peer-review of metadata standards, the most appropriate way of sharing information about how learning objects may be used is through online communities of practice, such as those developed for the Quality Teacher Program in Western Australia (Cummings & Aquilina 2003, 2004), and in the tertiary sector (Phillips 2002, chapters 1 & 2). This is one form of professional support discussed in 6.4.2.

A second alternative is for the learning objects to contain associated information providing teachers with explicit guidance about the ways in which a particular learning object may be best utilised, either through release notes or by the information being embedded within the learning object.

6.3.2.2 Planning lessons

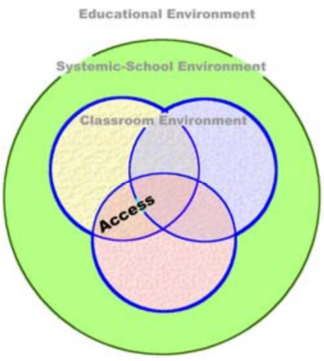
Teachers are aware that they must plan learning experiences that match the differing capabilities and learning needs of their students. As discussed earlier, the teaching mode affects how teachers use learning objects. Some teachers spent time leading into the learning object and set clear tasks to be achieved. Others selected learning objects thematically related to recent class work, but with little preparation or integration evident. Approaches included:

- a single learning object constituting the focus of a lesson or lesson series
- a number of learning objects used as resources for a lesson or lesson series
- a learning object used as one of a number of activities within a lesson.

Where the learning objects were an integral part of a wider project or series of lessons, there was evidence of intended follow-up. In some cases completed worksheets were forwarded by the school. In classrooms where little preparation or integration was evident, it appeared that follow-up was unlikely.

Because of their multimedia components, it is sometimes difficult for teachers to assess how learning objects make demands on students' literacy, memory and cognitive abilities. A mismatch in any area will result in a less successful learning experience, so selection, task setting and monitoring the use of learning objects needs to be done thoughtfully. Peer support and professional development have a role to play in enhancing the way in which teachers employ learning objects.

6.3.3 Access: the learning object and student interaction



Learning objects were found to have a variety of benefits for students. Students in general appreciated the novelty and found many of the learning objects interesting, engaging and motivating. Teachers reported instances of increased levels of concentration, enthusiasm and successful learning when students used the learning objects.

There is evidence that students with a range of abilities can achieve success through learning objects. Learning objects engaged students resistant to traditional classroom approaches or those with low levels of academic performance. Disruptive students were observed in the case studies participating actively in learning object lessons, and withdrawn students were observed purposefully investigating activities. Students were motivated in their use of learning objects when they:

- were challenging
- allowed them to explore
- gave them control
- provided useful feedback
- allowed them to collaborate with each other.

Students appreciated being able to regulate the pace of their learning. They were able to take time to investigate concepts they found difficult in class or to repeat activities as they chose. The ability to engage with a self-contained, self-paced task was valuable for certain students who did not accommodate easily to the fixed-period lessons common in most schools. Students also enjoyed selecting their own multiplication problems or setting the variables in Science experiments.

The diversity of students' approaches to learning, their learning styles, and the diversity of means used to understand a phenomenon, provide many powerful opportunities for using the multimedia capacity of learning objects. Students rely on the learning purpose being transparent and central to the activity that they are undertaking with the learning object. They expect their input to be meaningful, and to affect the conduct of the activity. For these reasons, contextualised information, hints and timely feedback were observed to be valuable in directing and affirming student input and understanding.

Learning was most effective in an environment where the teacher provided guidance and scaffolding, where students were able to refer to and utilise prior learning and were able to apply it within learning objects to reinforce and extend their knowledge and skills.

Key recommendation 1: The Le@rning Federation should continue to realise the potential of learning through multimedia.

6.3.3.1 Visual learning

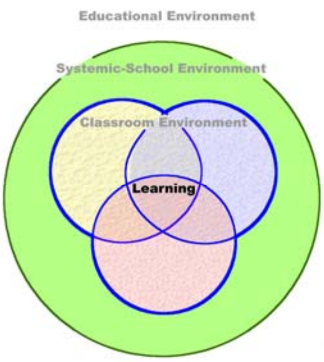
> Digital learning can make visual representations of knowledge (through static or moving images and animation) readily accessible. It can 'show', model and explicate in ways that verbal … communication alone cannot. (McRae 2001, p. 56)

McRae argues that learning objects need to de-emphasise written text and emphasise the visual. Similarly, school students are growing up in a generation where visual stimulation is commonplace, whereas this was not so common when their teachers were young. Therein lies a gulf in education that the learning objects have the potential to bridge, possibly better than any other educational technique.

Methodology and standards will change with the paradigm, and this is certainly the case with the shift from the textual to the visual where students, as experts in the new paradigm, are discerning and demanding when it comes to good communication. The challenge for learning objects is to keep up with, or ahead of, this paradigm shift whose pace and parameters are set by other aspects of technology, particularly in the entertainment field. Entertainment programs do not have to impart concepts and meaning in order to justify their existence, while that is an important requirement of learning materials.

Teachers strongly valued the ability of learning objects to provide visual learners with new and stimulating ways to learn. The Mathematics and numeracy learning objects were singled out as particularly innovative in this regard.

6.3.4 Effective learning



The educational environment model (Figure 6.1) suggests that effective learning arises where the three factors Students, Teachers and Resources intersect, leading to optimal learning conditions. This implies that both students and teachers are at ease with the learning objects; there is a shared understanding of the learning purpose and the way the learning object is to be used, and the learning object fulfils the teacher's need to address the curriculum and the students' need to construct meaning and receive appropriate support and feedback during that process.

Resources are most valuable when they can be readily matched to the curriculum and integrated into learning programs. As more learning objects are produced, this match will be easier. Learning objects that are rich enough to have multiple uses are particularly valuable.

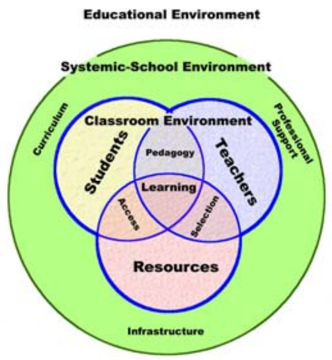
The intersection of the student and the learning object implies that the design accommodates the key elements that satisfy students' needs: challenge, student control, freedom to explore, capacity for collaboration, and timely instructions and feedback on input. The more these needs are satisfied, the better.

Pivotal, however, is the teacher's ability to understand and interpret the learning objects in relation to the curriculum and their students' needs. Confidence plays a significant part in this. Teachers in critical mode are the best placed and are more likely to construct lessons in which students can interact with learning objects in the most effective manner. The relationship the teacher has with the students is critical to the success of learning with learning objects, just as it is with other resources. Encouraging and supporting teachers to develop a critical mode of teaching is just as important to the successful uptake of learning objects and effective learning as is sound design and construction of learning objects.

6.4 The school and system-level environment

Figure 6.1 posits that the classroom environment exists within a broader school- and system-level environment. There are three mechanisms in which the classroom environment interacts with the broader educational environment:

- The relevance of the *curriculum* to students and its coherence
- The provision of appropriate *infrastructure*
- The *professional support* and development of teachers.



The first of these mechanisms is beyond the scope of this pilot Field Review. The Le@rning Federation was given the task of providing learning objects relevant to the types of students and the curriculum requirements of each of its stakeholder educational systems. No evidence was obtained that this was not the case.

The two remaining issues, infrastructure and professional support, are discussed in more detail below. These two factors were identified by McRae (2001, pp. 91, 93), as conditions 'which must be met' for the initiative to be successful.

6.4.1 Infrastructure

The ability of the teacher and student to access the learning objects depends both on the technical infrastructure and the skills of the individual teacher or student. The pilot Field Review found a wide variety in terms of computing facilities, technical support and policies for using technology within schools. There was also a wide range of levels of teacher competence and confidence with using the available technology and the learning objects. Without appropriate facilities and both technical and operational support, uptake of the learning object model is uncertain, and is likely to be limited.

The Le@rning Federation's learning objects are not supported by all operating systems. The researchers understand the pragmatism of that decision, and would expect that for learning objects to continue to be useful, they will be periodically updated to work with future operating systems.

Recommendation 6: Learning objects should be periodically updated to work with future operating systems.

While it is accepted that the BELTS delivery system is in its developmental stages, a number of problems arose from its use that may affect its use in the classroom, if not addressed. A number of improvements have been suggested in 5.2.

McRae (2001, p. 16) reported that 'effective whole-school planning is critical to the successful implementation of ICTs'. For learning objects to be effective in classrooms, all parts of the school community need to be aware of, and support, the initiative. This includes effective IT support.

Widespread learning object use will require re-examination of IT policies and procedures in some schools, where download limits are imposed to reduce costs, and where Internet access can be revoked as a component of behaviour management policies. The widespread use of learning objects will require the Internet to be viewed as a core activity, rather than a recreational or reward activity.

Key recommendation 2: Appropriate technical and system infrastructure should be identified and established at system and school levels to expedite the uptake of learning objects in schools.

6.4.2 Professional development and support

Teachers felt more professional support was needed to maximise their use of learning objects for effective learning by students. This need was confirmed in the case studies, where the researchers observed instances of learning objects failing to be used adequately.

Professional development of teachers in selecting, structuring, implementing and monitoring the use of learning objects must be a priority if their full potential is to be achieved in the classroom. This includes identifying time management issues and providing strategies to overcome the time constraints experienced by teachers.

Teachers sought a range of types of support:

- Guidance in identifying learning objects with appropriate content and factual material around which to structure programs
- Advice on techniques for presenting the learning object, in particular suitable introductions and conclusions to the session
- Advice on class-management techniques suitable for lessons incorporating learning objects
- Advice on how and where specific learning objects fitted into the local syllabus
- Advice on how to integrate strategies used in the learning objects into their own curriculum development.

Teachers almost universally felt that professional development should be brief and focused, and they expressed a preference for ongoing professional support rather than single professional development sessions.

The development of online communities of practice is suggested as one means to achieve ongoing professional support. An electronic community of practice should enable:

- conversations with peers about techniques to adapt generic learning objects for specific themes
- debates with peers and the wider academic community about the role of the curriculum, and the part that ICT can play in its development
- conversations with peers about how to identify and use learning objects that will meet special needs of specific students
- sharing worksheets and other materials that can be used by students while they are interacting with the learning objects
- discussion about how to assess learning achieved through using learning objects.

This conclusion supports the first recommendation of Muirhead and Haughey (2003):

> The Le@rning Federation should take immediate steps to expand its current mandate to develop communities of practice among learners and instructors involved with the content development initiative …

Coupled with this is the need for others within schools to be familiar with the requirements for successful use of learning objects. This includes professional development for both technical support staff and administrators, as part of a whole-school approach.

Key recommendation 3: A substantial and sustained support program should be provided for teachers, school administrators and support staff to develop awareness of learning objects, to encourage and facilitate uptake and to support development of skills and strategies in their use.

It is also recommended that a book be commissioned by The Le@rning Federation to help promote best practice among teachers, and to ensure that the learning objects and similar resources are used to their full potential by teachers. This book would be based on the experiences of teachers using learning objects in a range of contexts, and be linked to the findings of this pilot Field Review and subsequent research.

Recommendation 7: The Le@rning Federation should commission a book highlighting innovative ways in which teachers have used learning objects.

Chapter 7 Future research agenda

The final chapter of this report has two main aims: to summarise the outcomes of the pilot Field Review in terms of its terms of reference; and to identify issues that are likely to benefit from a continuing research agenda. It includes a recommended approach to future research. The chapter is brief as most of the information on which it relies has already been presented in previous chapters.

7.1 Outcomes of the pilot Field Review

The pilot Field Review undertook research to address the following terms of reference:

1 Evaluate the pedagogical application of the learning object model and the online digital content developed by The Le@rning Federation at system, school and teacher levels.

2 Identify the key components that impact on the application and effectiveness of the learning object model and online digital content, including:
- curriculum provision
- pedagogy
- resourcing
- professional development.

3 Design specifications for a longer-term research study.

It is essential to recognise that the design of learning objects and their introduction into classrooms is an initiative in its early stages of development in Australia and New Zealand. Although online curriculum has been a focal point for curriculum development and implementation and evaluation in the vocational education and training and university sectors for several years, The Le@rning Federation's Schools Online Curriculum Content Initiative breaks new ground in the schools sector in terms of the nature of the materials, their audience and the context in which they are to be implemented.

It is important in examining such an initiative that the focus be formative – examining how well the initiative is being implemented and what improvements might be made – rather than summative – deciding the worth or expansion of the program. In a report evaluating a similar initiative in its earlier stages of implementation, the ANTA national Toolbox initiative in the VET sector, the following observation was made:

> The national Toolbox initiative presents a tremendous opportunity for furthering and sustaining the National Training Framework. It also offers a significant contribution to improving the quality and quantity of learning … Its most significant obstacle will be resisting short-term imperative for long-term gains. The concept of Toolbox will evolve over time as understandings are developed from experience. While this will not diminish the utility of the sets of products developed, it will increase expectations and change requirements. Consequently decision-makers and policy makers must foster and provide sufficient flexibility to ensure this occurs. (Queensland Open Learning Network 1998–99, p. 12).

Just as feedback on each series of toolboxes prompted refinements in production and implementation in the next, so it is anticipated that future series of learning objects will benefit from the experience of the early rounds. Continued development will build on lessons learnt and will respond to the increase in expectations that will emerge as teachers and students use these resources more often. In light of the early stage of The Le@rning Federation's Schools Online Curriculum Content Initiative, this pilot Field Review reports on issues of use and implementation to address formative decisions rather than evidence of impact to address summative decisions.

In examining implementation, the evidence obtained in this study has led to the identification of several areas where some improvement is required. The Le@rning Federation has indicated that it has addressed a number of these areas through its own quality assurance procedures. The approach for future research outlined in 7.2 demonstrates a change in focus to one concentrating more on issues of impact and effectiveness (although not exclusively) to assist in deciding the overall effectiveness of learning objects in schools.

The pilot Field Review has demonstrated that the learning object model and online digital content is applicable in the classroom, despite some teething problems (see 5.2, 5.3 and 5.4, summarised in 6.2). Both students and teachers find learning objects useful and effective for learning, and students in particular are enthusiastic about the motivational and educational potential of learning objects. The pilot Field Review provides preliminary evidence that, given the right conditions, learning objects can lead to improved and different learning outcomes (see 5.5, 5.6, 6.3.3 and 6.3.4). Thus, the pilot Field Review has found that there is sufficient reason to continue with The Le@rning Federation's Schools Online Curriculum Content Initiative.

Key recommendation 4: The Le@rning Federation should continue to build a resource bank of learning objects in the targeted curriculum areas at a range of levels.

Within the context of the above finding and recommendation, the pilot Field Review found that once teachers gained familiarity with learning objects and their potential in classrooms, learning objects were welcomed as a useful resource to improve both their teaching, and the learning of their students. This report highlights a number of positive aspects of the learning object model and online digital content. In addition, the review found that there are areas in which learning objects could be improved, particularly in learning object design and online digital content.

In the design area, the pilot Field Review found that learning objects could be improved in a number of ways: through better use of animations and visual elements; better use of sound; reducing large areas of text; relocating instructions to the point of need; greater use of non-linear design; better use of immediate feedback on learner input; and more considered use of exploration and game strategies. These areas were identified in a range of schools and in more than one learning object. Future research needs to continue to examine these aspects to ensure that learning objects engage and motivate students.

In terms of content, the pilot Field Review found that many learning objects provided stimulating and diverse learning experiences for students. It is one of the potential strengths of learning objects that they are able to provide new geographical experiences and simulate dangerous or expensive learning activities at a relatively low cost. Section 6.2.1 suggests a number of areas where content could be improved based on feedback from teachers and students. Future research on learning objects should continue to collect feedback from teachers and students on content accuracy, appropriateness and clarity.

The Le@rning Federation has developed detailed specifications and processes, and is continually improving these, including its quality improvement processes and feedback loops, in order that future learning objects can be more educationally effective from the beginning.

Key recommendation 5: The Le@rning Federation should continue to improve its educational design, content procurement and quality assurance processes, informed by the results of this pilot Field Review.

Recommendation 8: The Le@rning Federation should ensure future research provides information useful to the continued enhancement of learning objects.

The pilot Field Review found that the role of the teacher was essential to effective use of learning objects. Teachers' pedagogical beliefs and experience with ICT impacted strongly on the way they used learning objects. Learning objects need to be attractive to all types of teachers, but also should be able to expand teachers' pedagogical horizons. Professional development of teachers is arguably the largest current impediment to the wider adoption of the learning object model and online curriculum content.

The pilot Field Review has demonstrated that learning objects have a valuable role to play in the classroom, at present and increasingly in the future. The Le@rning Federation has a model for learning objects that has demonstrated the capability to provide high-quality learning resources, and, given the right conditions, teachers and students are both capable and enthusiastic about the educational potential of learning objects. The stage is now set for the Field Review to expand the number and range of learning objects, for access by teachers to be improved, for professional development to be designed and made available to teachers, administrators and support staff, for the technological infrastructure to be enhanced, and for communities of practice of teachers using learning objects to be established and supported.

Key recommendation 6: The Le@rning Federation Schools Online Curriculum Content Initiative should continue to be funded and evaluated.

7.2 Proposal for an ongoing research agenda

The pilot Field Review was designed to be an exploratory study and as such was restricted by several crucial factors. In particular, there was a limited number of schools with access to the learning objects; there was limited time for some teachers to integrate the learning objects into their learning program; and there were relatively few learning objects available. The pilot Field Review team was able to observe only one complete set of learning objects – the first set of Science learning objects. In addition, a small number of Mathematics and numeracy learning objects, and a smaller number of Literacy learning objects were studied. Each of these limitations can be overcome with the continuation and expansion of the initiative, and through future research.

Key recommendation 7: The Le@rning Federation should proceed with research to investigate the educational soundness of learning objects embedded in classroom practice.

One of the terms of reference of the pilot Field Review was to develop the specifications for longer term research into the learning object model. This section outlines the recommended approach for this research agenda.

7.2.1 Key research or evaluation questions

Consideration of the findings of this report has enabled the research team to identify the following key research or evaluation questions and sub-questions that The Le@rning Federation and other stakeholder groups might usefully ask about learning objects:

1 What is the uptake of learning objects by level of schooling, jurisdiction and discipline area?
  - a Which learning objects or series of learning objects are most used and why?
  - b What are the strengths and weaknesses of each learning object and series of learning objects?
  - c What patterns of use, if any, emerge in the use of series of learning objects?

2 How efficiently and effectively are learning objects used by students and teachers?
  - a Do learning objects make learning more efficient (that is, require less time by teachers and students)?
  - b How do students learn when using learning objects?
  - c Are there discernable patterns in skills and knowledge development by students and teachers, that arise from the use of learning objects?

3 What is the measurable impact of learning objects on student learning?
  - a What role do learning objects play in enabling students to learn?
  - b What are the factors that lead to enhanced learning by students using learning objects?

4 What skills and knowledge are required by teachers to efficiently and effectively use learning objects, and how are these best provided?

5 What are the appropriateness, use and impact of learning objects for specific target groups of students?

In undertaking research to address these five questions, consideration needs to be given to the following broad directions for future research:

- Although each of these questions needs to be addressed separately at early years, primary and secondary school levels, it is evident that the educational jurisdiction is not critical. This enables the findings of research conducted in one jurisdiction to be generalised to all other jurisdictions unless an argument can be mounted to demonstrate why this should not be done. This will enable smaller, simpler studies to be undertaken. The Le@rning Federation has a responsibility to ensure the findings of these studies are valid and credible so that other jurisdictions will accept and apply the results and conclusions.

- Given the developmental nature of learning objects, it is considered most appropriate to investigate the use of series of learning objects (rather than individual learning objects in isolation) within discipline areas to get a broader view of their appropriateness, use and impact and to gain a better understanding of how they are integrated into the curriculum by teachers.
- It is likely that there will be more implementation and adoption difficulties with new learning objects than with older ones, and cycles of improvement will be necessary. Therefore, the length of time a learning object has been available to schools needs to be considered when investigating its use or impact.

The complexity of the research questions indicates that a program of research activities will be more fruitful than a single large-scale study of The Le@rning Federation's Schools Online Curriculum Content Initiative. It is therefore proposed that The Le@rning Federation develop a medium-term program of monitoring, research and evaluation.

Recommendation 9: The Le@rning Federation should develop a multifaceted approach to future research.

The educational design and development process used in learning object development is commonly accepted as being cyclical. Several authors recommend linking evaluation of educational technology developments to phases of the production process (Alexander & Hedberg 1994; J. Bain 1999; Phillips, Bain, McNaught, Rice & Tripp 2000; Reeves & Hedberg 2002). Figure 7.1 illustrates a five-stage production and implementation process (analysis, design, production, implementation and maintenance), with corresponding evaluation phases shown below. Such an approach can be used to develop a research plan for research questions 2, 3 and 5 above.

For question 1, program evaluation techniques such as those described in Worthen, Sanders & Fitzpatrick (1997) and Owen & Rogers (1999) are appropriate.

For question 4, action learning (Kemmis & McTaggart 1988) is an appropriate approach. The concept of a community of learning within schools (that is, groups of teachers using action learning and peer support strategies to develop their skills and understanding and to share

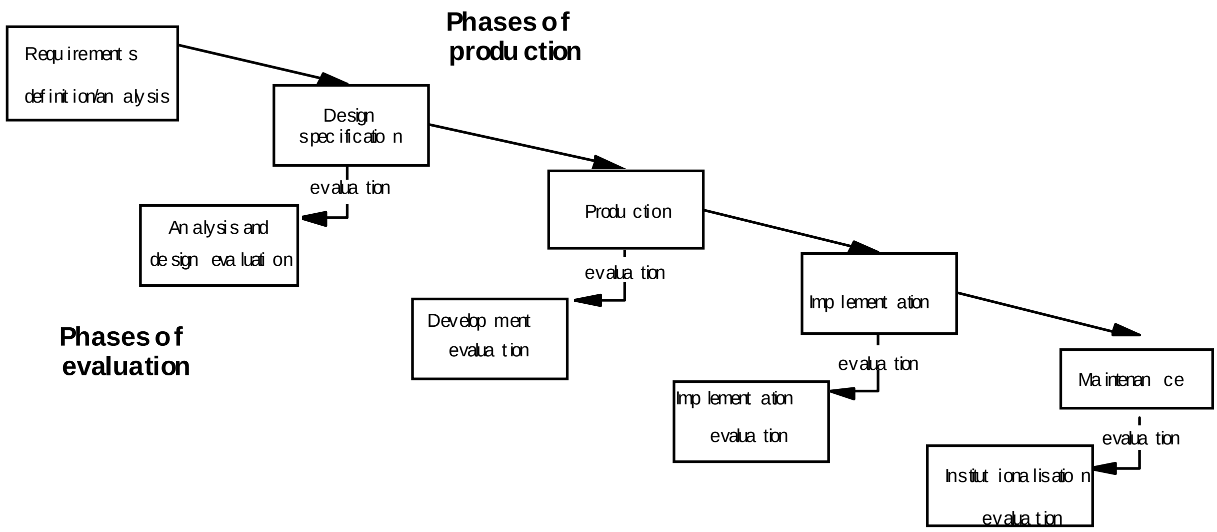


Figure 7.1. Mapping of the phases of a production process to corresponding evaluation phases

experiences) should be one of the professional development approaches examined because of the extensive training in and use of this approach in the Quality Teacher Program that is currently operating in each educational jurisdiction in Australia.

A framework that might be used to clarify the role of different evaluation approaches has been developed by Alexander and McKenzie (1998). Although the framework was compiledfor student learning in universities, much of it is relevant to student learning at any level of education. The framework has been applied in this context in Table 7.1, where proposed research or evaluation questions and sub-questions are listed, as are suggested approaches to investigate these questions.

Table 7.1 Key research/evaluation questions and strategies for ongoing research program

Key research/evaluation questions and sub-questions	**Research strategies**
1. What is the uptake of learning objects by level of schooling, jurisdiction and discipline area? a Which learning objects or series of learning objects are most used and why? b What are the strengths and weaknesses of each learning object and series of learning objects? c What patterns of use, if any, emerge in the use of series of learning objects?	This is largely a monitoring process and could be undertaken by linking a monitoring and feedback mechanism to the process of accessing learning objects. This initiative-wide approach could be supplemented by adding these questions to case studies undertaken to address other questions.
2. How efficiently and effectively are learning objects used by students and teachers? a Do learning objects make learning more efficient (that is, require less time by teachers and students)? b How do students learn when using learning objects? c Are there discernable patterns in skills and knowledge development in students and teachers arising from the use of learning objects?	These questions are best addressed by an evaluation based on a clear conceptualisation of how students and teachers use learning objects, agreed definitions of efficiency and effectiveness, and a set of case studies across school levels, disciplines and jurisdictions. Case studies should investigate classroom use of learning objects over a substantial period.
3. What is the measurable impact of learning objects on student learning? a What role do learning objects play in enabling students to learn? b What are the factors that lead to enhanced learning by students using learning objects?	These questions require in-depth experimental or quasi-experimental research designs to identify the differences between student learning where learning objects are present and where they are not. These research studies should be done by those with expertise in educational measurement and done on a discipline basis, perhaps based on the Rasch analysis reported in 5.6. However, large-scale quantitative research should be done only after issues associated with embedding learning objects into mainstream use have been well-resolved.
4. What skills and knowledge are required by teachers to efficiently and effectively use learning objects, and how are these best provided?	This area is likely to be best addressed through a training needs assessment of teachers at different school levels and in different disciplines, a literature search of professional development for implementing technology-based curriculum initiatives, and the development of a program of action learning.
5. What is the appropriateness, use and impact of learning objects for specific target groups of students?	In looking at learning objects and student learning for particular student groups, case studies over a reasonable period of time, say 1–2 years, are likely to be necessary to capture sufficient information to draw credible conclusions. The cultural differences between some of the target groups also indicate the appropriateness of case studies.

7.2.2 Structure of overall research program

There are two recommended approaches for implementing and coordinating this program of research and evaluation activities. The first is a centralised research program to examine each research or evaluation question or set of questions. This program would be developed and coordinated by The Le@rning Federation, and delivered under contract by researchers/evaluators. A tender process is customarily used for establishing such contracts.

The second approach is to direct the five key research/evaluation questions to investigating classroom use of a series of learning objects in single disciplines and by specific age groups. There would be benefits from holistically evaluating one set of learning objects from one learning area in one jurisdiction from the perspective of a disciplinary specialist, while grounding it in a common framework to provide continuity and comparability.

Appendix 1: Permission forms and instruments

1.1 Permission forms

1.2 Template for most student interviews

1.3 Template for interviews with junior primary students

1.4 Survey of students

1.5 Template for interviews with teachers

1.6 Survey of teachers: usefulness of learning objects

1.7 Survey of teachers: computers and subject area

1.8 Template for field notes

1.1 Permission forms

School of Education

Dr David Lake
BSc(Hons), DipEd, GradDip.(Out.Educ), BBus, MAgSc, PhD, MACE, MIBiolCBiol

MURDOCH UNIVERSITY
PERTH, WESTERN AUSTRALIA

Parental permission form

Date: 12 September 2003

Project Title: The Le@rning Federation: Field Review

I am a lecturer at Murdoch University investigating the ways in which teachers and students use computer-based learning objects as part of an Australian and New Zealand-wide project funded by national and state governments. The purpose of this study is to investigate how teachers select computer-based resources, and what students find most engaging in these resources.

You can help in this study by consenting to your child being observed and recorded as he or she works in class, and then to be interviewed after the class. It is anticipated that the time to complete the interview will be no more than 30 minutes. Contained in the interview are questions about what your child finds interesting and useful about the learning objects used during the lesson. We will also ask participants to complete an anonymous survey form. Participants can decide to withdraw their consent at any time. All information given during the survey is confidential, and no names or other information that might identify you will be used in any publication arising from the research. Feedback on the whole study will be provided to teachers, but no individual or school will be identified.

If you are willing for your child to participate in this study, could you please complete the details below. If you have any questions about this project please feel free to contact either myself (Dr David Lake) on (08) 9360 6305 / 0407 716288 or Jan Christie in the Centre for Learning, Change and Development on (08) 9360 2344. We are happy to discuss with you any concerns you may have on how this study is being conducted, or alternatively you can contact Murdoch University's Human Research Ethics Committee on (08) 9360 6677.

Investigator: Dr David Lake

****

I have read the information above. Any questions I have asked have been answered to my satisfaction. I agree for my child

(student's name)………………………………………… to take part in this activity, however, I know that he/she may change his/her mind and stop at any time. I understand that all information provided is treated as confidential and will not be released by the investigator unless required to do so by law. I agree for this interview to be taped.

I agree that research data gathered for this study may be published provided my child's name or other information that might identify him/her is not used.

Guardian's signature:
Date:

School of Education

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MURDOCH UNIVERSITY
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Teacher's permission form

Date: 12 September 2003

Project Title: The Le@rning Federation: Field Review

I am a Lecturer at Murdoch University investigating the ways in which teachers and students use computer-based learning objects as part of an Australian and New Zealand-wide project funded by national and state governments. The purpose of this study is to investigate how teachers select computer-based resources, and what students find most engaging in these resources.

You can help in this study by consenting to members of your class being observed, and participating in an interview after the class. It is anticipated that the time to complete the interview will be no more than 30 minutes. Contained in the interview are questions about what your find useful when selecting teaching resources, particularly computer-based teaching resources. Participants can decide to withdraw their consent at any time. All information given during the survey is confidential and no names or other information that might identify you will be used in any publication arising from the research. Feedback on the whole study will be provided to teachers, but no individual or school will be identified.

If you are willing to participate in this study, could you please complete the details below. If you have any questions about this project please feel free to contact either myself (Dr David Lake) on (08) 9360 6305 / 0407 716288 or Jan Christie in the Centre for Learning, Change and Development on (08) 9360 2344. We are happy to discuss with you any concerns you may have on how this study is being conducted, or alternatively you can contact Murdoch University's Human Research Ethics Committee on (08) 9360 6677.

Investigator: Dr David Lake

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I have read the information above. Any questions I have asked have been answered to my satisfaction. I agree to take part in this activity, however, I know that I may change my mind and stop at any time. I understand that all information provided is treated as confidential and will not be released by the investigator unless required to do so by law. I agree for this interview to be taped.

I agree that research data gathered for this study may be published provided my name or other information that might identify me is not used.

Teacher's signature:

Date:

1.2 Template for interviewing most students

1 Tell me about the activity.

2 Is this the sort of activity that can keep the attention of people like those in your class?
- Was there anything new in the lesson for your class?
- Were there any links to other things you learnt in class?
- Is there anything here you think you should be learning in class?
- Was the activity not suited for some members of your class?
- Was there anything unusual you might learn from this activity?

Now we want to see what you think makes a good computer activity.

3 If you were designing the activity, how would you do it?
- What would you design differently?
- What would be important to have in the activity?
- How could you get students to enjoy the activity?
- How would you use sound, pictures and other effects in the activity?
- How could you allow the students to control the activity?
- How could you design it so students can:
  - engage in the activity
  - control what happens in the activity
  - interpret things in their own way while doing the activity
  - organise their work while doing the activity?

4 If you were the teacher, and could arrange things however you wanted to, how would you run the lesson using this activity?
- How would you do things differently?
- How would you fit the computer activity into the lesson?
- What else would you want students to do if the activity allowed it?
- Does the activity suit all students?
- How can you find out how much you learnt?

1.3 Template for interviewing junior primary students

1 Tell me the story of the game.

2 Now I want you to pretend that you're telling somebody how to make a game like this useful (puts on Programmer's Cape).

- What is important to have in the game?
- How do you get students to have fun and want to play more?
- Would your make sure that kids who don't know anything about … would still understand it?

3 I want you to pretend that you're my teacher (puts on Teacher's Cape).

- What do you want me to learn from this game?
- Have you done anything else about … in class?
- What else do you know about …?

4 Remember, you are the teacher, so I want you to think like a teacher.

- Tell me what you want me to do.
- What do you want me to learn?
- What else would you want the class to do if the computer game allowed it?
- How would you know how much people had learnt?
- How will you make it fun for me?

1.4 Survey of students

Activity reviewed	

Place a circle around the most appropriate answer for each question as in this example:

How often should you wash a dog?	*Daily*	*Weekly*	*Monthly*	*Rarely*

1	It was easy to connect to the activity in the classroom.	Strongly agree	Agree	Disagree	Strongly disagree
2	I could easily work through the activity.	Strongly agree	Agree	Disagree	Strongly disagree
3	The sound in the activity helped me to learn.	Strongly agree	Agree	Disagree	Strongly disagree
4	The graphics in the activity helped me to learn.	Strongly agree	Agree	Disagree	Strongly disagree
5	The animation in the activity helped me to learn.	Strongly agree	Agree	Disagree	Strongly disagree
6	I could easily find my way through the activity.	Strongly agree	Agree	Disagree	Strongly disagree
7	I could easily find what I needed on the screen.	Strongly agree	Agree	Disagree	Strongly disagree
8	All the students in my class could do the activity.	Strongly agree	Agree	Disagree	Strongly disagree
9	I can see what the activity was teaching.	Strongly agree	Agree	Disagree	Strongly disagree
10	The situations in the activity were familiar.	Strongly agree	Agree	Disagree	Strongly disagree
11	The activity was fun the whole way through.	Strongly agree	Agree	Disagree	Strongly disagree
12	This was an enjoyable way to learn.	Strongly agree	Agree	Disagree	Strongly disagree
13	I did not become distracted during the activity.	Strongly agree	Agree	Disagree	Strongly disagree
14	The activity allowed me to control what happened in the activity.	Strongly agree	Agree	Disagree	Strongly disagree
15	I learnt something new during this activity.	Strongly agree	Agree	Disagree	Strongly disagree
16	The activity was about things we were doing in class.	Strongly agree	Agree	Disagree	Strongly disagree
17	I learnt what I was meant to from the activity.	Strongly agree	Agree	Disagree	Strongly disagree
18	I was surprised by the sorts of things I learnt in the activity.	Strongly agree	Agree	Disagree	Strongly disagree
19	The activity interested me.	Strongly agree	Agree	Disagree	Strongly disagree
20	The activity was easy to use in the classroom.	Strongly agree	Agree	Disagree	Strongly disagree

Please turn over

Answer only those questions below that are appropriate for your use of the learning object. That is, if you used the learning object to teach science, then answer only questions 29–31

Science only

21	I made accurate predictions during the activity.	Strongly agree	Agree	Disagree	Strongly disagree
22	I made careful observations during the activity.	Strongly agree	Agree	Disagree	Strongly disagree
23	I developed appropriate explanations during the activity.	Strongly agree	Agree	Disagree	Strongly disagree

Literacy only

24	The activity developed my language skills.	Strongly agree	Agree	Disagree	Strongly disagree
25	The activity developed my understanding of the text.	Strongly agree	Agree	Disagree	Strongly disagree
26	The activity allowed me to do something with the text.	Strongly agree	Agree	Disagree	Strongly disagree
27	The activity helped me to analyse ideas.	Strongly agree	Agree	Disagree	Strongly disagree

Mathematics and numeracy only

28	I recognised patterns in the information.	Strongly agree	Agree	Disagree	Strongly disagree
29	I could make patterns from the information.	Strongly agree	Agree	Disagree	Strongly disagree
30	I developed my own problem-solving strategies in the activity.	Strongly agree	Agree	Disagree	Strongly disagree
31	I chose the best method in solving problems during the activity.	Strongly agree	Agree	Disagree	Strongly disagree
32	I solved all the problems successfully during the activity.	Strongly agree	Agree	Disagree	Strongly disagree

1.5 Template for interviewing teachers

1 How well does the learning object match the pedagogy for the learning area? (What did you want the learning object to get across, and how successful was it?)

Scientific literacy
How does the resource permit the students to:

- make predictions you would wish them to
- make observations you would wish them to
- develop explanations using scientific understandings?

Literacy
How well does the resource:

- develop students' proficiency with language
- develop the students' understanding of the text
- permit the students to participate by doing something with the text (during or after the activity
- assist the students to analyse ideas in the text?

Numeracy
Did the learning object allow students to:

- recognise patterns in the information
- make patterns from the information?

How did the learning object allow students to

- develop problem-solving strategies
- use appropriate mathematical methods?

2 How did you use the learning objects? What made this resource useful to you?

- How did you select resources to use?
- How do you incorporate resources into your teaching?
- What would make the resources easier for you to use?
- How will you assess what you wanted students to learn?
- What might stop you or your colleagues from using a resource?
- How well did the resource fit the diversity of students in your class?

3 How did the students use the LOs?

- What affects how easily the students can work through an activity?
- What affects how much the students enjoyed the activity?
- How are you able to tell if the resource is engaging your students?
- Is there any evidence that students made connections with other learning?
- How do the students use the multimedia in the resource?
- Are you noticing anything to show what they were learning during the activity?

4 What is your general opinion of the learning objects?

- What are the benefits of the learning objects for you?
- How could the learning objects better support your program?

1.6 Survey of teachers: usefulness of learning objects

Activity Reviewed	

Place a circle around the most appropriate answer for each question as in this example:

How often should you wash a dog?	*Daily*	*Weekly*	*Monthly*	*Rarely*

1	It was easy to connect to the learning object in the classroom.	Strongly agree	Agree	Disagree	Strongly disagree
2	It was easy to connect to the learning object to plan the lessons.	Strongly agree	Agree	Disagree	Strongly disagree
3	The learning object was easy to use in the classroom situation.	Strongly agree	Agree	Disagree	Strongly disagree
4	The sound in the learning object aided the students' learning.	Strongly agree	Agree	Disagree	Strongly disagree
5	The graphics in the learning object aided the students' learning.	Strongly agree	Agree	Disagree	Strongly disagree
6	The animation in the learning object aided the students' learning.	Strongly agree	Agree	Disagree	Strongly disagree
7	The students could easily navigate through the object tasks.	Strongly agree	Agree	Disagree	Strongly disagree
8	The students used all the appropriate learning features in the object.	Strongly agree	Agree	Disagree	Strongly disagree
9	The object was suitable for all students in my class.	Strongly agree	Agree	Disagree	Strongly disagree
10	Students could see the relevance of the object for their learning.	Strongly agree	Agree	Disagree	Strongly disagree
11	Students could relate to the contexts portrayed in the learning object.	Strongly agree	Agree	Disagree	Strongly disagree
12	The object engaged the students for the whole activity.	Strongly agree	Agree	Disagree	Strongly disagree
13	The object related well to what I wanted to teach.	Strongly agree	Agree	Disagree	Strongly disagree
14	The students remained on-task throughout the activity.	Strongly agree	Agree	Disagree	Strongly disagree
15	The learning object allowed students to be active learners.	Strongly agree	Agree	Disagree	Strongly disagree
16	The learning object allows students to construct their own understandings about the topic.	Strongly agree	Agree	Disagree	Strongly disagree
17	The students achieved what I expected of them when using the learning object.	Strongly agree	Agree	Disagree	Strongly disagree
18	The learning object illustrated what I wanted the students to learn in an appropriate way.	Strongly agree	Agree	Disagree	Strongly disagree
19	It was easy to integrate the learning object into my teaching program.	Strongly agree	Agree	Disagree	Strongly disagree
20	I could easily assess what students had learnt from the learning object.	Strongly agree	Agree	Disagree	Strongly disagree
21	I found it easy to find learning object that are suited for my students.	Strongly agree	Agree	Disagree	Strongly disagree

Please turn over

22	I found it easy to find the learning object most suited for my teaching program.	Strongly agree	Agree	Disagree	Strongly disagree
23	The students found it easy to understand why they were doing the activity in the learning object.	Strongly agree	Agree	Disagree	Strongly disagree
24	I found it easy to adapt the learning object for my teaching purposes.	Strongly agree	Agree	Disagree	Strongly disagree
25	Students learnt other knowledge beyond what I had anticipated while using the learning object.	Strongly agree	Agree	Disagree	Strongly disagree
26	Students learnt other skills beyond what I had anticipated while using the learning object.	Strongly agree	Agree	Disagree	Strongly disagree
27	The learning object suited my teaching purposes.	Strongly agree	Agree	Disagree	Strongly disagree
28	The learning object suited the needs of my students.	Strongly agree	Agree	Disagree	Strongly disagree

Answer only those questions below that are appropriate for your use of the learning object. That is, if you used the learning object to teach science, then answer only questions 29–31

Science only

29	The students made appropriate predictions.	Strongly agree	Agree	Disagree	Strongly disagree
30	The students made appropriate observations during the activity.	Strongly agree	Agree	Disagree	Strongly disagree
31	The students gave appropriate explanations during the activity.	Strongly agree	Agree	Disagree	Strongly disagree

Literacy only

32	The learning object developed students' proficiency with language.	Strongly agree	Agree	Disagree	Strongly disagree
33	The learning object developed the students' understanding of the text.	Strongly agree	Agree	Disagree	Strongly disagree
34	The learning object permits the students to participate by doing something with the tex.	Strongly agree	Agree	Disagree	Strongly disagree
35	The learning object assists the students to analyse ideas in the text.	Strongly agree	Agree	Disagree	Strongly disagree

Numeracy only

36	The students could recognise patterns in the information.	Strongly agree	Agree	Disagree	Strongly disagree
37	The students could make patterns from the information.	Strongly agree	Agree	Disagree	Strongly disagree
38	The students could develop own problem-solving strategies in the activity.	Strongly agree	Agree	Disagree	Strongly disagree
39	The students chose the best method in solving problems during the activity.	Strongly agree	Agree	Disagree	Strongly disagree

1.7 Survey of teachers: computers and subject area

Name	

Not everybody is totally involved with every aspect of their profession. We would like to find out how you see your experience and 'comfort zone' with (a) computers in the classroom, and (b) the subject area where you are expecting to use the learning object that we will be using in your program.

Place a circle around the most appropriate answer for each answer, as in this example

How often should you wash a dog?	*Daily*	*Weekly*	*Rarely*	*Never*

You and computers				
How confident do you feel about using computers in your teaching?	Very confident	Moderately confident	Low confidence	No confidence
How often do you use computers outside the classroom?	Daily	Weekly	Rarely	Never
How confident do you feel about using new computer applications in the classroom?	Very confident	Moderately confident	Low confidence	No confidence
How confident do you feel about including in your lessons computer-based activities that do not come with detailed instructions?	Very confident	Moderately confident	Low confidence	No confidence
How confident are you when different students are doing different computer based tasks in the same lesson?	Very confident	Moderately confident	Low confidence	No confidence
How often do you use computer-based activities in student assessment?	Daily	Weekly	Rarely	Never
How often do you plan lessons where the computer is a key component?	Daily	Weekly	Rarely	Never
How often do you develop your lessons by considering what computer based resources are available?	Daily	Weekly	Rarely	Never
How often do you use computer-based resources as a means to integrate different topics?	Daily	Weekly	Rarely	Never

You and the relevant subject/learning area for the learning object				
How confident do you feel about teaching this subject/learning area?	Very confident	Moderately confident	Low confidence	No confidence
How confident are you that you know the necessary facts in this subject/learning area?	Very confident	Moderately confident	Low confidence	No confidence
How confident are you that you understand the important theories and principles in this subject/learning area?	Very confident	Moderately confident	Low confidence	No confidence
How often do you watch television programs relevant to this subject/learning area?	Daily	Weekly	Rarely	Never
How often do you read articles in the popular press relevant to this subject/learning area?	Daily	Weekly	Rarely	Never
How often do you read books or journal articles relevant to this subject/ learning area?	Daily	Weekly	Rarely	Never
How often do you plan lessons in this subject/learning area around pre-packaged resources (for example, blackline masters or textbooks)?	Daily	Weekly	Rarely	Never
How often do you plan lessons in this subject/learning area around ideas from books?	Daily	Weekly	Rarely	Never
How often do you develop original resources for lessons in this subject/learning area?	Daily	Weekly	Rarely	Never

1.8 Template for field notes

Date	**Reviewer**
School	
School description	
Teacher	
Teacher description	
Class level	**Learning area**
Class description	
No computer	**Students/computer**
Classroom description	
Learning object	
Learning object description	
What preamble did the teacher provide	
What instructions were given to the students	
What print materials were provided	
How long did the students have to work on the object	
Notable incidents/themes with students	
Notable incidents/themes with teacher	

Appendix 2: Summary of the schools visited

School 1, Western Australia

School 1 is situated on the outskirts of Perth, Western Australia. The suburb has only recently been developed and the area is considered to be of middle socio-economic status.

Two researchers observed learning object use in one K–P class as part of the pre-pilot study. The room had one computer and students took it in turns to work in pairs. The learning object was ‘Weather wear’. The teacher had been covering ‘weather’ as a topic throughout the week. The learning object was associated with a number of activities throughout the week – observing weather charts and ‘River journey’, another learning object.

The teacher introduced the lesson by beginning a story about how to dress for the weather. Students then began work on the learning object while others engaged in parallel activities including a dress-up game. The class was well behaved and students were familiar with working in pairs on the computer, including turn taking.

The lesson was delayed when the teacher had difficulty downloading the learning object. The teacher had demonstrated the use of learning objects as linked into class activities and part of an integrated curriculum. However, she believed this was difficult to do in general as the range of appropriate learning objects for the age group of her students was limited.

School 2, Western Australia

School 2 is situated in a low socio-economic area of Perth, Western Australia. Teachers face a variety of challenges at this school, including coping with significant behaviour problems. Attacks on staff or other students are not uncommon. Education is viewed as a low priority by some parents in an area with many social problems.

Researchers visited four classrooms ranging from year 4 to year 7 as part of the pre-pilot study. One of these classes contained 12 students considered to be gifted. Each class had one computer. One student at a time left general class activities to work on a learning object.

Few students had returned permission slips allowing them to participate in the study. Teachers remained with the classes while students worked with researchers. Classrooms were rowdy and teacher energy was often taken up with maintaining discipline.

Teachers in this school had difficulty accessing the array of learning objects as most class computers plus those in the computer laboratory used Windows 98, an operating system not supported by The Le@rning Federation. One teacher downloaded the wrong learning object but decided to use it instead of braving the search/download process again.

Despite this, teachers chose learning objects that tied in with their current Science lessons. One teacher led the main class in a chemistry lesson making sherbet while those using the learning object completed ‘Intergalactic cook-off’, a similar virtual exercise. Another teacher began a lesson on respiration by tying it in with a school sports activity and discussing factors that affect breathing. The learning object chosen was ‘Take a breath’.

One teacher commented that the learning objects were useful to demonstrate ‘abstract’ concepts or those not readily demonstrated in the classroom. One teacher displayed an integrated curriculum approach, using a Science learning object to teach both Science and Literacy. Generally the learning objects were viewed as a teaching support that did not take the place of live classroom activities.

School 3, Western Australia

School 3 is located in Perth, Western Australia. It caters for years 8 to 12. While the catchment area is considered a moderate to high socio-economic area, the student range is extremely broad. The school is large, with over 1,000 students currently enrolled.

One classroom was visited as part of the pre-pilot study. It contained 23 year 8 students considered to be academically gifted. The subject was physics and students used ‘The alpha, beta, gamma of radiation’ – a learning object that involved the manipulation of Geiger counter readings. Each student had sole use of a computer.

Students in this class were particularly motivated to learn and were unperturbed by the complexities of learning objects or the computer problems encountered when running learning objects. The teacher was enthusiastic and experienced and involved students in outside activities and projects.

The lesson as planned did not take place on the day of the observation. Students attempting to run the learning object soon discovered themselves that access to the necessary Flash files was denied. In this school, four hours were spent setting up the webpage for the lesson.

The teacher had chosen to embed the learning object within a self-contained lesson plan. Half of the session time was allocated to the preamble and half to the learning object. The teacher introduced the relevant concepts in mathematics and physics and used the learning object as a tool to demonstrate these through simulated experiments with radioactive material. Assessment in this case was not the aim of the activity. Rather, the computer was used to enable the students to conduct experiments that could not be carried out in a classroom environment.

In order to maintain a ‘real life experiment’ lesson, sheets were provided for students to record their findings from both demonstrations and the simulations.

School 4, Western Australia

School 4 is located in Western Australia. It is a new school in its second year of operation, built to cater for residents of a newly released housing area. Families are mainly of middle income and there is a high proportion of students from non-English-speaking backgrounds.

The researchers visited a year 7 classroom as part of the pre-pilot study. Each student had access to a wireless laptop computer. The teacher was motivated and confident using ICT resources in the classroom. She was also enthusiastic about innovative teaching ideas. The students were well behaved and the class was orderly.

The ‘Save the lake’ learning object was used with the entire class. Students had been introduced to the learning object previously. They were shown how to access it from BELTS and completed one example. On the morning of the learning object activity, the students went on an excursion to a local wetlands area.

Students had difficulty accessing the learning object despite the preparations. It took over an hour for the majority of students to log in because of Internet constrictions.

Students had difficulty with the demands of this learning object. The teacher had selected this learning object as it matched the needs of her curriculum. However, it appeared to overreach the cognitive abilities of the age group. This was despite the fact that the learning object was labelled as suitable for years 5 to 6.

In general, difficulties stemmed from confusion over predicting chemical reactions and a lack of the basic chemical knowledge required to make this task meaningful. Instructions were text-heavy and only glanced over by most students. Few students took notes although this was necessary for completing the tasks.

Researchers also noticed a number of technical inaccuracies with the learning object that were not picked up by the teacher. These served to compound student confusion. The teacher thought the lesson had gone well although she noticed the level of confusion, which she was not able to account for.

School 5, Tasmania

School 5 is a small school situated in rural Tasmania. It is relatively isolated, with the Community Hall the only other town facility. The school is surrounded by bushland and a creek runs through the grounds.

Students are generally from lower socio-economic backgrounds, their parents being either farmers or long-term unemployed people. The school has two teachers and two classrooms. In some cases siblings are in class together.

Two researchers visited School 5. The class they visited consisted of 29 students from years 1 to 6. Four computers were available, located along the back of the classroom. Students worked in groups of two or three.

The teacher was new to the school, having arrived four weeks earlier. She was particularly interested in teaching Science and had participated in a learning object expert focus group. The teacher was familiar with the learning objects selected, which were 'Explore soil', (year 2) and 'Earth alert' (year 4).

The teacher had prepared a series of activities relating to each learning object. Students had worked on both the set activities and the learning objects over a number of weeks. During the observation the teacher attempted to introduce several new learning objects. Unfortunately the teacher was unable to download and run these. Eventually she ran the learning objects from disk but was unable to choose the learning objects she wanted, selecting instead from an inappropriate age range.

School 6, Tasmania

School 6 is a boys' school in Hobart, Tasmania. It is located in an inner-city suburb undergoing redevelopment, and caters for years 7 to 10. Previously threatened with closure, School 6 remained operational through a renewed focus on discipline and achievement.

Researchers visited a year 10 class using the 'It's a drag' learning object to learn about road safety. The teacher was experienced in incorporating ICT resources into her lessons and had participated in the development of learning objects. The lesson took place in a computer laboratory where every student had access to a machine.

The lesson was well planned. Students used the learning object to generate stopping distances, which were then entered into an Excel spreadsheet. This involved Mathematics as students were asked to graph their findings and calculate average stopping distances. Road safety had been an ongoing class theme and the object was linked to previous lessons and activities including a current media campaign.

Students worked fairly efficiently, responding well to the structure and purpose of the activity. Many appreciated the concrete learning aspect as they would soon be learning to drive.

School 7, Queensland

School 7 is located in an established suburb undergoing redevelopment. Students are from a mix of socio-economic backgrounds. As some parents in the area are choosing to send their students to non-government schools, this government school has a comparatively greater proportion of students from relatively less-privileged families. The school caters for a wide range of academic abilities.

Researchers visited one class of year 6 students. The teacher was confident and the class was well managed. The students were from predominantly European backgrounds and were of varying academic capabilities.

Students had been working on developing their own learning objects as a classroom exercise. They had not worked with learning objects before although the teacher had explained in advance what would be happening during the lesson. Students were asked to analyse two learning objects in order to determine features that they would include or avoid in the design of similar learning objects for a Mathematics topic. Students had a choice of six learning objects to work through: 'It's a drag', 'Skateboard', 'Experience the weather', 'New developments', 'Treasure puzzle' and 'Caving'.

The lesson had been well planned. The teacher was able to provide researchers with worksheets that indicated how she had integrated the use of learning objects into her lessons. There were five computers in the classroom. Students worked in pairs while the teacher led the rest of the class in another activity. She was available to both groups when needed.

School 8, Queensland

School 8 serves the growing regional centre of the Darling Downs in Queensland. It caters for students in years 8 to 10. Between 400 and 500 students attend. The school is relatively new and teaching staff benefit from shared teaching philosophies and enthusiasm.

School 8 is an agricultural school with a high proportion of rural students from lower socio-economic backgrounds. The school was considered a centre of excellence for Mathematics, Science and IT when it was established in 1998. Despite this, some of the computer equipment is now out of date as funding for maintenance is poor.

Two researchers visited one classroom together. The teacher in this room was experienced and energetic, pursuing many outside hobbies. He had graphic design experience, leading to a competency and interest in computing and technology. The class contained a wide range of student abilities.

Students worked in a large computer laboratory containing 30 machines, each student having sole access. Computers were arranged in groups of four, back to back. The teacher had a data projector to instruct students. Learning objects used among the class were 'In digestion', 'It's a drag' and 'Check your wind'.

The session was not embedded into a larger lesson plan. Instead the teacher briefly linked the learning objects with previous work and then focused on how to access and use the learning objects. An initially rowdy class soon quietened down when they became involved in 'In digestion', the students enjoying the humour and graphics of this learning object. The teacher chose this learning object as he judged it would effectively capture student interest. As the lesson progressed the teacher allowed the students to concentrate solely on working through the learning object, making general suggestions to guide progress.

The opportunity to embed learning objects in lesson plans is limited by the lack of computers in classrooms. Students spent an hour in the computer laboratory for this session. The teacher noted that the centralised location of ICT resources made it difficult to develop specific learning activities in which to locate the learning objects. He intended to avoid situations where learning objects were used as stand-alone resources.

School 9, New Zealand

School 9 is a small rural school with 130 students from years 1 to 6. Students are mainly the children of local landowning farmers or farm managers. The building and classroom furniture are old. However, the use of ICT as a teaching resource is established.

Teachers in this school were relatively comfortable with the use of ICT in the classroom. Some were taking diploma courses and a number of ICT activities had been initiated. A large-screen television was used to transmit computer screens to students.

Three classrooms were visited, in year levels 1–2, 3–4 and 5–6. Two or three students at a time were taken from their peers to undertake a learning object task for the benefit of researchers. These were students selected by the teacher as 'those most likely to cope'. The remaining students in each class continued planned activities supervised by the teacher or left the room altogether to play sports.

All classrooms had one or two computers situated at the back of the room. Selected students were stationed there with the researcher(s). Students were expected to use the learning object as they would any other computer-based activity. Teachers therefore generally assumed that the researchers were there to investigate the suitability of the learning object merely in terms of student interaction with the learning object. Researchers observed students using Numeracy, Literacy and Science learning objects.

In this school, only one teacher was observed attempting to tie the learning object into a wider classroom lesson. Other teachers were absent from the area entirely and students turned to researchers for help when attempting to either initialise the session or when they ran into difficulty navigating the learning object.

Children in this school seemed very comfortable using computer-based resources and were noticed adopting familiar roles as either decision makers or navigators.

School 10, New Zealand

School 10 is located in one of the lower socio-economic areas of Auckland. The school shares a campus with a senior school. However, despite this proximity, few resources are shared. The school has a high proportion of Maori and Pacifica students.

One classroom of year 7 students was visited. A lesson was delivered using the 'Shape fractions' learning object. The lesson was held by an experienced ICT teacher and took place in the computer laboratory.

In this class all students were of Maori or Pacifica background. The academic progress of these students outstripped their ability to verbalise their learning in a conventional manner. The students performed well academically – they were enthusiastic and related well to the teacher.

The teacher had received some professional development at her own insistence before the learning objects were used in the classroom. She was familiar with the learning objects and was able to make informed decisions about their integration into the lesson. For this reason, many of the observations noting less than optimal use of learning objects concern interaction of the students with the learning objects – for example, students' decisions to skip over or ignore text.

The teacher clearly viewed learning objects as a teaching tool, assessing student progress in terms of the entire program rather than their performance with just the learning object. Learning objects were selected according to their relevance to the planned curriculum.

Students had access to 30 computers – one per student. The lesson, however, was interactive and students were encouraged to work together. A data projector was used when the teacher chose to instruct the class as a whole rather than individually. All were very familiar with the use of ICT resources, to the extent that some students were able to program in JavaScript™.

The teacher embedded the learning object in the lesson, beginning by demonstrating simple fractions to the class. Problems encountered during previous Mathematics lessons emerged and consequently the students used the computer for about a third of the allocated time. No additional print material was provided. Students were seen to have difficulty with the learning object ('Shape fractions'), which could have been above their ability level.

The teacher encountered various technical problems in her effort to access learning objects. When Internet access was disrupted, use of the learning objects was discarded for that lesson. As well, network managers moved the learning object, making it difficult for the teacher to locate it quickly and easily. Use was also hampered by download limits.

School 11, New South Wales

School 11 caters for students considered to be from an upper socio-economic area. Researchers visited one class, which was conducted in the classroom and in the computer laboratory, where the classroom teacher was joined by an experienced ICT teacher. The laboratory contained 30 computers allowing two students per machine.

The observed teacher incorporated the use of learning objects into a classroom lesson plan. In the observed lesson, students began a learning task working on the mat in their classroom, and at the introduction of computers the students changed location and lesson delivery.

The use of an experienced ICT teacher, perhaps stationed at a centralised computer laboratory, meant that classroom teachers were able to use learning objects even if their own ICT background was limited. However, this arrangement meant that learning objects were not integrated into the everyday learning environment to be used as a cross-curricular support or resource.

School 12, New South Wales

School 12 is located in rural New South Wales and serves a small country community. The school caters for students from years 1 to 10. One class was visited, which contained students in years 7 and 8. Computer access was not concentrated in the classroom. Instead, a ‘computer lab’ situation had been created and students moved to the library to use 12 computers located in two banks. This equated to 1 to 2 students per computer.

As a class the students were deemed to have below-average literacy levels with abilities ranging from low to moderate. Several students were particularly disadvantaged in this area. Students used the ‘Finders keepers’ learning object and were then able to choose science objects to work on. They remained at the computers for as long as the learning object required.

The teacher was familiar with the use of ICT resources and also familiar with the aims and operation of The Le@rning Federation. Learning objects were treated as simply another self-contained computer exercise.

School 13, Northern Territory

School 13 is located in an inner suburb of Darwin in the Northern Territory. It is a well-equipped school catering mainly to families in a higher socio-economic area. The school recently received a major grant that was used to upgrade and develop ICT resources.

Researchers visited three classrooms containing students from years 5 to 7. One of these classes had been created for students whose parents had opted for them to receive computer-based learning. Children in this class worked on a computer each and did little work in traditional textbooks. This class was taught by an organised, enthusiastic teacher with an interest in ICT.

Students were observed using the learning objects ‘Finders keepers’, ‘Area of compound shapes’, and ‘The multiplier’. In two of these classrooms students were given no introduction, but were merely instructed to ‘have a go’.

Use of the learning object was embedded into the lesson only in the computer-based learning class. The learning object was used as one of a suite available in a series of geometry lessons. In other classes teachers expected learning objects to work as stand-alone teaching resources.

The lack of guidance undermined the success of the learning objects. Some students were confused by the instructions, others were reluctant to work on one example until completion and some learning facilities provided by the learning object were overlooked or misunderstood.

Despite difficulties, students were generally interested in the learning object activities and energised by the novelty of the lesson.

School 14, Northern Territory

School 14 is situated on the outskirts of Darwin in the Northern Territory. The suburb is new and expanding and students are from fairly high socio-economic backgrounds. Currently the school caters for about 500 students.

Researchers visited two classrooms containing years 6 and 7 students. Both lessons took place in a computer laboratory. Students worked individually or in pairs. Students were observed using a variety of Science and Mathematics learning objects.

Learning objects were embedded into the lesson in one of the classrooms visited. Here the teacher used ‘In digestion’ and ‘Take a deep breath’ to build on a recent learning module about systems of the human body. Students combined this with other learning objects about plants and fish and discussed the operation of different types of systems as a class. A worksheet was provided that indicated the overlap between human and plant systems.

In the second class the teacher viewed the learning objects as a stand-alone resource and looked upon their use as a ‘treat’ for the students. She selected learning objects about fractions and explained that these exercises would be a review of material previously learnt in class. Students enjoyed the learning objects and liked maintaining control over their learning pace. With little teacher input, however, researchers observed students bypassing learning activities and focusing on the game element.

Appendix 3: Detailed summary of learning objects encountered in classes

Preamble

Forty learning objects were being used in classrooms in Australia and New Zealand as part of the pilot Field Review. Some learning objects were observed only once and others were viewed in more than one classroom. In some cases student usage was brief, especially when students had been given learning objects to 'play with'. In other cases, student usage was extensive. Teachers used learning objects in a wide variety of ways, and usage by students varied according to the number of classroom computers available.

Analysis of the use of each learning object, summarised in tabular form below, is based on evidence from students, teachers and observers (one Literacy learning object, 'Letters to the editor', has not been included because very little evidence of its use was obtained). The Le@rning Federation's description of the learning object is followed by a description of the context in which use of each learning object was observed, the strengths of the learning object, any issues that may require resolution, and a summary of the effectiveness of that learning object.

Literacy

Finders keepers

Title	**Finders keepers 1, 2, 3**
User level	Years 5; 6; 7; 8; 9
Discipline	Literacy
Description	Students move through a 3D house in search of hidden treasure. They collect clues along the way, answering multiple-choice questions about everyday texts, such as a postcard, TV guide, advertising poster and an email message. A correct answer earns useful objects and helps students break the code that protects the hidden treasure.
Structure/type	Activity (multipath game format)
	Student activity: Interactives; Comprehension activity; Analysis; Modelling; Multiple-choice questions **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Special features	Three levels. Links for more difficult words.
Learning purpose	This learning object assists students to identify language and organisational features of texts. The learning object also encourages them to consider the intended audience and purpose of each text. Students are able to use the learning object to break up difficult words and look up their meanings. This is the first in a series of three activities in order of text complexity. **Content/concept:** English: Brief texts; Comprehension; Critical literacy; Everyday texts; Text types; Unfamiliar vocabulary **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 9, years 1–2 2. School 13, years 6–7 3. School 12, years 7–8
Used how	1. The learning object was used without introduction or context. The teacher selected the learning object and left students with observers. 2. The teacher provided a comprehensive introduction and assistance via prompts and questions during use. 3. A list of learning objects was given to students to use with no

	specified goal.
Strengths	Usefulness to teachers T: … I really liked the authenticity of the text … many of them come from homes where … they don't have piles of books or novels on the shelves and I think it validates for them that literacy is something that is seen in everyday life … it is very relevant to the NSW syllabus. Usefulness to students The arrow animations provided clear clues to assist navigation. Students used to games quickly engaged with the navigation and the quest to find the treasure. O: I noticed there is a button there for tricky words; did you use that at all? S: Oh, I have only just noticed it. Student learning process and outcomes The game format was useful for students at risk. T: … the kids like it don't they? I mean you see that, they actually enjoyed playing a computer game that is what they perceive it is …
Issues	Usefulness to teachers Complexity differences between the three levels are not transparent to teachers. Usefulness to students There was a heavy memory load for students to carry as they navigated around the house. This meant students focused on navigation components unrelated to literacy issues. Close-up navigation was difficult for younger students to visualise (for example, walking into walls or the banister rail). T: Well those bars just annoy me because that railing –you can't see over it from the stairs and the kids have difficulty manoeuvring around that. Student learning process and outcomes Students aren't clear about the learning purpose of the learning object and some concentrate on the navigation rather than the literacy content: O1: What is the purpose of the game do you think? S1: Reading maybe. O: OK. Good. Particular things about reading that it is pointing to or just generally about reading? S1: Reading, working out clues, uses your head a bit more. O2: Did you think you learnt anything while you were doing that? S2: No, not really. S3: I like steering it. It's fun. Bump it. I like steering it, bumping everything. Students can guess multiple-choice answers without engaging with, or even reading the text. T: … they can just click and not engage in the text … If a kid makes a mistake, to have a verbal coming back at the kid helps them to focus. 'What am I really supposed to do?' You can't ignore this annoying voice in the back of your head. 'Read the test again. Notice these words.' – whereas you can when that is just flashed on a screen. I can just bypass that very quickly. The 'reward' in the game is unrelated to literacy performance. T: My upper kids … engaged with it but didn't learn anything and ultimately thought it was boring because all it was, was a game because there weren't any challenges, there wasn't a stop the clock, there wasn't a 'beep you got that wrong you

	will be deducted by …'

Summary

The reward is not relevant to the learning purpose.

> S: I like [that] you can go through and get the money and go through all the clues and that.

However, teachers may select the learning object to develop self-esteem in some learners.

> T: … it was nice to see one of the kids who was involved in the evaluation beforehand was actually 'I know what I am doing'. And he felt really proud of his accomplishments. Now whether he was engaged in literacy … and his achievements we may think are very superficial but let's not take away achievements of any kind from that particular group of kids.

Picture this

Title	**Picture this**
User level	Years 5; 6; 7; 8; 9
Discipline	Literacy
Description	Students select a topic from a list. They read a passage of text and draw what they visualise. They then see an artist's impression of the scene described and answer multiple-choice questions on the text.
Structure/type	Activity
Special features	Artist's impression and multiple-choice quiz
Learning purpose	Visualisation and comprehension of written material
Used by	1. School 12, years 7–8 2. School 11, year 5
Used how	1. Students used a number of learning objects without specific direction from the teacher. 2. This learning object was used by the teacher in an art literacy exercise. The teacher read out a passage and students drew their impression of what they heard. Then they used the computer to look at the artist's impression and discussed the differences in what they had drawn. They answered the multiple-choice questions and then wrote a continuation of the story or a view from another character's perspective. Having completed this, the students worked on another passage in pairs. When finished they looked at other examples but were not required to complete a task.
Strengths	Usefulness to teachers T: … these kinds of kids don't put pictures in their head … and I think it is important to show kids that when I am reading, I am seeing a picture and … use that as a springboard to reinforce that. I see that as a springboard purely for then getting kids to interact with a computer. T: Use it for a number of lessons. I mean two or three lessons, three maximum because kids might get bored with it. Usefulness to students Students enjoyed this learning object but had difficulty articulating why. They liked the graphics and navigation was simple. Students felt the voice was useful for comprehension and creating atmosphere. Student learning process and outcomes The learning object promoted picturing in the preamble to using the computer.
Issues	Usefulness to teachers Complexity differences between the three levels are not transparent to teachers or students. Some teachers may have had expectations that the learning object would provide more scope for students.

	T: I thought that that was going to take me through a modelled exercise where I had seen the picture in front for me. I thought that we were then going to jointly construct … to be able to create my own animation of a simple text that I had chosen to give a kid. So for me it didn't go far enough. Usefulness to students The learning object was not challenging enough for the age group. Student learning process and outcomes When students are given unsupervised access, they skip the visualisation and drawing stage. The early presentation of the pictures made it difficult for students to form their own pictures first. There are no consequences for wrong answers in the quiz. This meant students could keep clicking and guessing.
Summary The teacher liked the concept and would be interested to see it developed further. The learning object appeared to be effective only if the students were unable to access the artist's impression before drawing their own. This means teacher guidance is important. T: Unless the teacher is doing that (preparatory and follow-up activities) … the kids basically, 'Done that. Looked at that. What's next?' So I think … it needs … some teacher input on how to use that in the classroom.	

Mathematics and numeracy

Years 2–4

The number partner

Title	**The number partner**
User level	Years 2; 3; 4
Discipline	Mathematics and numeracy
Description	With this learning object students learn how to break up numbers into pairs of smaller numbers, for example, 15 = 9 + 6. Students work through examples of whole number pairs and sample questions. They then apply these principles to solve additions or subtractions. A partitioning tool is used to break up numbers under 30. The learning object is designed to assist students to recognise number patterns and to use the strategy of 'counting on' to determine numbers that make part of a pair.
Structure/type	Tool/drill
	Student activity: Interactives; Analysis; Experiment; Modelling **Learning design**: Independent learning; Experiential learning; Problem solving; Visual learning
Special features	A number line that shows number pairs for each example.
Learning purpose	To break numbers into pairs; Subtraction; Addition; Counting; Whole numbers; Number patterns **Skills/processes**: Analysis; Application; Comprehension; Knowledge
Used by	School 9, year 4/5
Used how	The learning object received almost no preamble in the classroom observed. Students used the learning object in groups of three while the rest of the class did other activities.
Strengths	Usefulness to teachers The learning object was found to be useful as a drill and students could use it independently. However, most students at this level would require more direction to understand the pattern. Usefulness to students The number line provided a visual clue to the number combination. Students did not have difficulty reading the instructions. The character made the learning object more friendly and students navigated the activity comfortably. S: You get a mistake and then (on paper) you have to rub it out and (on the computer) you can make a backslash. S: ... putting your hand up waiting... and on the computer … if you are not sure and you type the answer you can just put a tick and it would come up with the answer if it's right or not. Student learning process and outcomes Better students did the calculations in their heads, while those less confident counted on their fingers. A few made the connection between the pairs of sums but at least half didn't or only did so after prompting by the observer. Many students used the learning object as a simple addition exercise. A few saw the number pairs and used that knowledge to shortcut to the second answer.
Issues	Usefulness to teachers This learning object requires teacher input for best results. It also needs to be pitched to the right students as it is too easy for some. Usefulness to students The students observed did not take advantage of the information that

	explained what number partners are and how they can be used. Students commented that the interface was rather plain. In addition some thought it would be more beneficial if there were levels of difficulty as well as other kinds of calculations. Student learning process and outcomes Even with the repetition of number pairs (for example, 12 + 17 = 17 + 12), a significant number of students – without teacher input – did not appreciate the pattern in the numbers but approached each case as a separate problem. Some students did 20 problems without making the connection. It was also observed that less able students were shy of being in charge of the calculation.

Years 3–6

Design a park

Title	**Design a park**
User level	Years 3; 4; 5
Discipline	Mathematics and numeracy
Description	In this learning object students help Terry the town planner to design a site plan for a park. Students assign regions on a grid for different uses, for example, picnic, swings, sandpit and pond. This tool is used to explore how to express fractions and display them in different ways. Students select boxes within the grid and view or enter corresponding fractions and their equivalents. Students are able to interact with a dynamic number line to express fractions differently.
Structure/type	Tool
	Student activity: Interactives; Analysis; Experiment; Modelling **Learning design:** Experiential learning; Independent learning; Visual learning; Problem solving
Learning purpose	Fractions; Equivalent fractions; Grids; Number lines; Design **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 14, years 6–7
Used how	Students worked in pairs for one hour to cover a number of related learning objects about fractions. Students were instructed on which learning objects to do and in what order. They read the learning object instructions for themselves. No specific goal was set for them.
Strengths	Usefulness to teachers The teacher found this learning object was a new tool to motivate reluctant mathematics students. T: The students who have a lot of trouble with their Numeracy skills and the Literacy associated with maths – computers have given them a new lease of life. Well it's an incentive. It's a learning tool that they are keen about and now I have got a child saying he loves maths so much now and fractions used to be gruelling for them. And yeah, I can just see they are so engaged in learning here. Student learning process and outcomes Students found this learning object more engaging than 'Dynamic shape fractions', which gave them no sense of creating something. S: It makes it better because you've got to figure out what the equivalent fractions are, you have got to put in what they tell you to put in and then you get to pick what [to] do for the rest.
Issues	Usefulness to teachers

	Students required teacher guidance to set goals for work on this learning object. Usefulness to students Students count squares rather than using the visual representation of the fractions. It is possible to make grids that do not match the fractions. This caused confusion for students who started again rather than changing the grid – hints would be helpful. Placing a bike track confused some students – a track is usually linear rather than a cell in a grid. The ear icon was not intuitive or large enough for many students, although otherwise it was a useful feature. No observed student saw the two animations in the introduction to the learning object. Student learning process and outcomes Without guidance, some students had trouble when they selected dimensions that did not accommodate the required fractions. There are some complex elements to this activity which were not adequately investigated by all students. The tables function was not understood or used. Teacher assistance would be valuable here.
Summary Even though the representation of the elements of the park was crude, having first worked on the more abstract 'Dynamic shape fractions', students were far more engaged in creating a park where they could make some of the design decisions. S: Yeah this one is better … because you can create your own.	

Dynamic shape fractions

Title	**Dynamic shape fractions**
User level	Years 3; 4; 5; 6
Discipline	Mathematics and numeracy
Description	Students use this tool to explore fractions and display them in different ways. They are able to divide simple shapes into equal parts. Students select regions, then express the area selected as a fraction (or equivalent). They can manually select fractions or choose other options to set variables displayed.
Structure/type	Tool
	Student activity: Interactives; Analysis; Experiment; Modelling **Learning design:** Independent learning; Experiential learning; Problem solving; Visual learning
Learning purpose	Explore expression of fractions; Equivalent fractions; Division; Regular shapes; Sectors; Radius; Segments **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 14, years 6–7
Used how	Students worked in pairs for one hour on a number of related learning objects about fractions. The teacher instructed students on which learning objects to do and in what order. Students were told to read the learning object instructions. No specific goal was set for them. Students in this class had prior experience with fractions.
Strengths	Usefulness to teachers The learning object formed valuable professional development for teachers, showing new ways to think about multiplication. Usefulness to students Students worked out how to use the learning object themselves and

	gradually came to understand the dynamics of the learning object by using the number line and experimenting. Working in pairs assisted with this approach. Students found the buttons clear and intuitive. The system of providing hints after several tries was found to be excellent (although most students observed had given up before this and started a new example). Student learning process and outcomes For a number of students the learning object served as revision. Some who were comfortable with mathematics indicated they would prefer to work with pen and paper. S1: … got nowhere to work … It helped you learn but it wasn't all that interesting. Other students who lacked confidence in mathematics valued being able to manipulate the physical representation of the fractions, and started within their comfort zone. S2: (Start) easier then I am going to go onto harder as I learn more about it. The learning object has advantages for students who respond to working in a risk-free environment – no shame for a wrong answer. The visual display is effective for students with weak language skills. One student made a breakthrough using the tool and confidently concluded: S: We have learnt how to turn a grid into a number line and a number line into a fraction and a fraction into an equivalent fraction.
Issues	Usefulness to students Students required teacher guidance to set goals for work on this learning object. The three decimal place measurements for the irregular triangular shapes were difficult for many students to understand and to enter. There were relatively long instructions. Some students read them reluctantly and others ignored them. Some students considered them difficult to follow. S: Just wasn't clear. Students used intuitive methods and experimentation. Student learning outcomes The learning object needs a mechanism to encourage students to persevere. A score ratio of correct answers, not dissimilar to those found in games, would help.

Shape fractions

Title	**Shape fractions**
User level	Years 3; 4; 5; 6
Discipline	Mathematics and numeracy
Description	Students use this tool to explore fractions and display them in different ways. They are able to divide simple shapes into equal parts. Students select regions, then express the area selected as a fraction (or equivalent). They can manually select fractions or choose other options to set variables displayed.
Structure/type	Tool
	Student activity: Interactives; Analysis; Experiment; Modelling **Learning design:** Independent learning; Experiential learning; Problem solving; Visual learning
Learning	Fractions; Equivalent fractions; Division; Regular shapes; Sectors;

purpose	Radius; Segments Skills/processes: Analysis; Application; Comprehension; Knowledge
Used by	School 10, year 7
Used how	In preparation, all students had a 30-hour intensive program on computers and lessons on fractions. The class worked line by line through the learning object instructions.
Strengths	Usefulness to teachers This learning object was found to be good for drill and reinforcement as well as exploration. It was also useful for activities difficult to show or do physically. Usefulness to students The interface was found to be colourful and appealing. Students were able to manipulate shapes easily. Student learning process and outcomes Students whose language skills are not strong can get results and understand concepts.
Issues	Usefulness to teachers Students required teacher guidance to set goals for work on this learning object. Usefulness to students The operating instructions for this learning object were hard to read. No student who opened this section read more than the first few words. Students also had trouble when using the grey indicators around the edge as markers, since the number of divisions need not match the required fraction – for example, trying to divide 10 markers into sevenths. Precision in placing lines became a problem for students when dealing with large denominators (for example, twelfths). Student learning process and outcomes Students would have benefited from a choice between hard, medium and easy fractions. Where students had difficulty with a question, they simply started again with another question rather than developing a strategy.
Summary This learning object is useful as it allows students to experiment and be wrong without losing face. The teacher needs to set goals and explain features to most students.	

The multiplier

Title	**The multiplier**
User level	Years 3; 4; 5; 6
Discipline	Mathematics and numeracy
Description	‘The multiplier’ is a sequence of five learning objects with strategies to help students do multiplication ‘in their head’. Students use a partitioning tool to help solve multiplications, for example, 36 x 29. They are able to split a multiplication into easy parts, use simple multiplication, and then solve the main equation. Students use strategies like ‘making to 10’ and ‘doubling’. The learning object starts with the simplest level: 2-digit by 1-digit multiplications, for example, 6 x 29. It moves on to more complex calculations: 2-digit by 2-digit. Students can work with calculations generated randomly (one pair of activities) or they create problems using their own numbers (another pair of activities). Feedback at every step is provided by an animated character. Students

	work through a comprehensive tutorial on multiplication strategies. There is also a non-interactive version of the tutorial, suitable for screen readers. This can be used by visually impaired students. The sequence of activities is: 1. Generate easy multiplications (for example, 6 x 29) 2. Make your own easy multiplications (for example, 6 x 29) 3. Generate hard multiplications (for example, 36 x 29) 4. Make your own hard multiplications (for example, 36 x 29) 5. Go figure (tutorial suitable for screen readers).
Structure/type	Drill/tool
	Student activity: Interactives; Analysis; Experiment; Modelling **Learning design:** Independent learning; Experiential learning; Problem solving; Visual learning
Learning purpose	Multiplication; Number patterns; Counting; Whole numbers; Factors; Area **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 14, years 6–7 2. School 13, years 6–7
Used how	1. Students worked in pairs for 1 hour on a number of related learning objects about fractions. Teacher instructions were limited to which learning objects to do and in what order. Students were instructed to read the learning object instructions for themselves. No specific goal was set for them. 2. No guidance
Strengths	Usefulness to teachers The learning object provided ways of showing abstract concepts in a virtually physical way. This formed valuable professional development for teachers as it demonstrated new ways to think about multiplication. Usefulness to students The learning object used simple, intuitive navigation. Students appreciated the hints and table array. S: You can multiply numbers in a different way – so it's interesting. Student learning process and outcomes This learning object provides a means to encourage alternative strategy formation with mathematical problems ('The multiplier' was well supported by hints). T: That was a challenge but it was good too because they were learning a concept and it was a really foreign concept and to see it visually displayed like that really helped some kids to switch on: 'Oh that is how they break it down into tens and units'.
Issues	Usefulness to students The learning object would be more useful if it kept a record of which multiplications had been attempted. Student learning process and outcomes Observers found that students did not always read the instructions and experienced confusion trying to work through the calculations using experimentation. Students also found it was not easy to guide the partition tool to the desired places. The final mental addition (of several numbers) caused students more problems than the multiplications. Some students had problems finding suitable dividers for very large number multiplications. For example, 32 x 19 might be divided up into 19

	x 10, and then 10 x 22, but students would still be left with 9 x 22 without access to further dividers. T: … other kids, it just went straight over their heads. 'What in the hell is going on here? And if I put in a number and press, it will tell me the answer anyway.'

Years 6–9

Area of compound shapes

Title	**Area of compound shapes**
User level	Years 6; 7; 8; 9
Discipline	Mathematics and numeracy
Description	This learning object requires students to estimate the area of a complex polygon. Students are encouraged to try counting squares on a grid to help them estimate. They are then able to cut the shape into rectangles and triangles and use a formula to calculate the exact area for each of the simple shapes. Students then find the total area for the original polygon. They can then try dividing the shape again into fewer pieces.
Structure/type	Tool
	Student activity: Interactives; Analysis; Experiment; Modelling **Learning design:** Independent learning; Experiential learning; Problem solving; Visual learning
Special features	Calculates area of irregular polygons.
Learning purpose	Calculate area **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 13, years 6–7
Used how	The observed lesson was part of a series of geometry lessons and a suite of learning objects. It was used to reinforce previous work. As a starting point students were asked to sketch the floor plan of their dream house, consider the strategies they were using and report on these later. The learning object was used for one hour.
Strengths	Usefulness to teachers The learning object provided reinforcement of previous learning and introduced students to a range of mathematical skills such as formulae for area, conversion of fractions and decimals, estimation of area and calculation skills. This was a more effective instructional method than a book or worksheet. The learning object provides opportunities to develop strategies and to share and critique them in class. Usefulness to students The learning object provided an example first. The calculation of area was faster and more enjoyable than hands-on methods or books. Dimensions were automatically provided for a triangle where area was difficult to calculate. This learning object was fairly easy to operate. A calculator was available for more complex calculations. Student learning process and outcomes This learning object is engaging for students, who can work at their own speed. The learning object encourages students to visualise shapes within shapes. Examples are graded from simple to more complex. The learning object allowed practice on a range of different starting shapes and fostered spatial and numerical estimation skills. The layout and design are generally appealing.

Issues	Usefulness to teachers T: Links to everyday life and meaningful contexts are not built in. Not easily extendable. Limited interaction between students – teacher must build this on. Usefulness to students Students found the learning object confusing at the start. Shapes created are small and difficult to view – some pieces are cut very thin. Some students had problems converting fractions to a decimal form that could be accepted by the computer. (1/2 = 0.5). Some students did not notice the calculator and used paper and pencil. Student learning process and outcomes The learning object would only let students cut from given points and not necessarily those they would choose for optimum expediency – which limited opportunities for developing the most efficient problem-solving strategies and was frustrating. The original shapes disappeared as they were cut up. This discouraged experimenting to find the best ways of cutting the original as it was not possible to compare various solutions. This suggests formulaic procedures are encouraged rather than the development of logic and reasoning. Students could not create their own shapes, so the ‘problems’ were externally generated. This meant some students could not necessarily see where they might use the skills in real life despite the teacher’s effort to provide a meaningful context.

Science

Years K–2

Caving

Title	**Caving**
User level	Years K–P; 1; 2
Discipline	Science: Animals; Ecology
Description	The learning object requires students to help Frog explore a limestone cave. Students identify glowworms, bats and rock features such as stalactites. They take photos and match up pictures with their labels.
Structure/type	Talking book/activity
	Student activity: Interactives; Comprehension activity **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Special features	Sound, drag-and-drop
Learning purpose	Identify features in a cave **Content/concept:** Science: Animals; Geology; Rocks **Skills/processes:** Comprehension; Knowledge
Used by	School 7, year 6
Used how	Students in an IT class were investigating the learning objects as examples from which they could draw conclusions about what makes a good multimedia resource, so they could construct their own.
Strengths	Usefulness to students Clear, bright buttons made it simple to navigate. Sounds and voice used to read text were considered useful. S1: This is very good for little kids. Student learning process and outcomes The low levels of memorisation required made this learning object appropriate for young students. S3: What things look like in a cave if they have been there for many years. Like the glow-worms, the bat, the echo chamber, the muddy water, the stalactites. S4: You'd be learning how to read a little bit and matching different stuff.
Issues	Usefulness to teachers This learning object was useful as one of a suite of learning objects for evaluation by students. Usefulness to students Students had opinions about the graphics of this learning object. S2: If they are for older kids they should be more realistic. S4: But my little brother he is in grade one, he wouldn't be able to read 'leave cave'. I reckon that if you press it, it should say 'leave cave'. Student learning process and outcomes S2: I don't think it is very good … because you just walk in and take photos of everything. It is not very interesting.

Create a soil environment

Title	**Create a soil environment**
User level	Years K–P; 1; 2
Discipline	Science
Description	Students help Gecko to grow flowers or vegetables in a garden bed. They are able to compare results when adding things such as water; organic matter; digging tools and earthworms.
Structure/type	Activity
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Learning purpose	Plants; Vegetables; Flowers; Flowering plants; Nutrition; Water; Rain; Soils; Environment; Growth **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 12, years 7–8
Used how	No context was provided for the learning object. Students used a number of learning objects without specific direction from the teacher.
Strengths	Usefulness to teachers No evidence Usefulness to students Students found the voice instructions clear and easy to use. Rapid access to the activity at the start and meaningful closure were also strengths, as was the addition of weeds, which prevented students from simply clicking on all options. Student learning process and outcomes No evidence
Issues	Limited observation
Summary Limited observation with students students for whose age group the learning object may have been inappropriate.	

Experience the weather

Title	**Experience the weather**
User level	Years K–P; 1; 2
Discipline	Science
Description	Students use this learning object to explore weather variations in four environments: desert; mountain; rainforest; and polar. Students dress Gecko in clothing suited to the weather conditions. Weather scenarios are: sunny; windy; rainy and snowing.
Structure/type	Talking book
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Learning purpose	Weather; Clothing; Climate; Deserts; Mountains; Rainforests; Temperature; Snow; Winds; Sun; Rain; Human behaviour **Content/concept:** Science: Heat **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 7, year 6
Used how	Students in an IT class were investigating the learning objects as examples from which they could draw conclusions about what makes a good multimedia resource. This was to assist them in constructing their own.

Strengths	Usefulness to teachers The learning object was observed being used as an analytical exercise for students older than the target group. Usefulness to students The voice instructions were clear and easy to use. Photographs were clear and age-appropriate. Student learning process and outcomes Not relevant
Issues	Usefulness to students The last page of the learning object appears to be a matching activity of the same form as those found in a number of other learning objects. In this case, however, it is a summary. This caused confusion among students. Student learning process and outcomes The learning object provided few opportunities for students to make decisions. Some content errors and contradictions were also noted, such as: 'the heat dries up the rain really quickly,' and 'because of the high humidity, even sweat does not evaporate'.
Summary The placement of the activity, the meaning of the photo icon and the nature of the concluding screen were found to be confusing. This is because students had used other learning objects that did not follow the same pattern.	

Explore soil

Title	**Explore soil**
User level	Years K–P; 1; 2
Discipline	Science
Description	This learning object allows students to explore a soil environment. Students select living things and weather features and see a simple demonstration of their impact on the ecosystem. They are able to observe the interactions between animals, plants and soil. The learning object includes tips on how to build a soil environment at home.
Structure/type	Talking book
	Student activity: Interactives **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Learning purpose	Soils; Ecology; Nutrient cycles; Earthworms; Groundwater; Plants; Leaves; Animals; Environment **Content/concept:** Science: Animals; Ecology; Environment; Plants **Skills/processes:** Comprehension; Knowledge
Used by	School 5, years 2–6
Used how	A series of activities was prepared for a two-week period during which students returned to the learning object for new perspectives. On the day of the observation, however, students had completed work on this learning object and begun another. The teacher discussed similarities between previous work and the learning object. However, the contextualisation remained weak.
Strengths	Usefulness to teachers No evidence Usefulness to students Students enjoyed the humour and liked making choices.

	Student learning process and outcomes No evidence
Issues	Usefulness to students The content and animation of the learning object were too simple for the group observed. Students expected more content and were searching for a button to take them further. Intervening navigation was confusing – students could not make alternative choices or go to the next question. Some students could not find an end button. Student learning process and outcomes The learning object provided limited student decision-making opportunities. Student choices were random rather than considered. The learning object provided insufficient student feedback.
Summary Limited observations were conducted with students for whose age group the learning object may have been inappropriate. This learning object presented information and relatively few learner choices.	

Mineshaft

Title	**Mineshaft**
User level	Years K–P; 1; 2
Discipline	Science
Description	Students direct a mine cart down a shaft. They discover rocks and minerals and learn about how they are used.
Structure/type	Talking book
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Learning purpose	**Topic:** Mineralogy; Fossils; Rocks; Copper; Coal **Content/concept:** Science: Fossils; Geology; Mineralogy; Rocks **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 7, year 6 2. School 12, years 7–8
Used how	1. Students examined features of a learning object in order to design their own. 2. No context was provided. Students used a number of objects without specific direction from the teacher.
Strengths	Usefulness to teachers One teacher used the learning object as a resource for an analysis and evaluation exercise. Usefulness to students The voice instructions were clear and easy to use. Students also found the navigation clear and intuitive. The drag-and-drop exercise was easily accomplished. Student learning process and outcomes No evidence

Issues	Student learning process and outcomes The learning object provided few opportunities for students to make decisions. This learning object allowed students to move to the ‘Well done’ in the conclusion without completing the activity. In terms of accuracy, fossils are rarely unearthed in mines because they are found in sedimentary layers at the surface.
Summary This learning object was observed with a group older than the intended audience and without a specific learning purpose.	

New developments

Title	**New developments**
User level	Years K–P; 1; 2
Discipline	Science
Description	Students help Gecko to survey populations of mammals and birds. They are able to test how urban development impacts on wildlife and explore the balance between development and wildlife conservation. The simulated environment includes national parks, a creek, wetlands, bridges, towns and a farm.
Structure/type	Simulation
	Student activity: Interactives; Analysis **Learning design:** Experiential learning; Independent learning; Visual learning; Problem solving
Special features	Drag-and-drop with consequences
Learning purpose	The purpose is to test how urban development impacts on wildlife. Other aspects of the learning object include: Rivers; Streams; Ecology; Habitats; Wetlands; Animals; Birds; Mammals; Populations; Wildlife conservation; Built environment; Bridges; Cities; Towns; Buildings; Houses; Roads; Farms; Urban ecology; and Surveys. **Content/concept:** Science: Animals; Built environment; Ecology; Environment; Habitats; Simple experiments; Sustainable development **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 7, year 6
Used how	Students in an IT class were investigating the learning objects as examples from which they could draw conclusions about what makes a good multimedia resource.
Strengths	Usefulness to teachers This learning object was useful as one of a suite of learning objects for evaluation by students. Usefulness to students The scoring scheme was useful to re-engage students whose interest was flagging. The voice instructions were clear and easy to use. Student learning process and outcomes Students were able to articulate their learning:
Issues	Usefulness to students The limited number of choices (4) for possible development sites meant that some students became frustrated trying to find hot spots in otherwise potentially sound areas (for example, the beach). There were limited alternatives for students when placing the bridge. Students were not able to change decisions. Students were also confused to discover that it was possible to place a city on a location, and then remove it by placing a

	national park over it, but it is not possible to place a national park on an area and then put a city on the same location.

Summary

This learning object was viewed as part of an analysis and evaluation exercise undertaken by IT students rather than as a learning object used for the learning context for which it is principally designed.

News story

Title	**News story**
User level	Years K–P; 1; 2
Discipline	Science
Description	Students help Gecko find out about where newspapers come from. The learning object allows students to follow the production cycle of a newspaper: forest plantation; paper mill; printing press; newsagents; readers; and waste paper recycling. Students learn about the environmental benefits of planting trees and recycling paper.
Structure/type	Talking book
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Visual learning; Problem solving
Learning purpose	**Topic:** Forests; Paper; Recycling; Wastes; Trucks; Trees; Conservation (Environment); Reforestation **Content/concept:** Science: Environmental influences; Machines; Sustainable development **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 12, years 7–8
Used how	The learning object was provided without a context. Students used a number of learning objects without specific direction from the teacher.
Strengths	Usefulness to teachers This learning object is a useful Society and environment topic, not a Science topic. Usefulness to students The voice instructions were clear and easy to use. The animations were colourful and the learning object was easy to navigate. Student learning process and outcomes No evidence
Issues	Usefulness to students The learning object provides few opportunities for students to make decisions. Once decisions have been made, they cannot be reversed. The animations of factory processes are unlikely to be meaningful to the intended age group. The learning object becomes very repetitive.

Summary

This learning object was observed with a group older than the intended audience and without a specific learning purpose.

River journey

Title	**River journey**
User level	Years K–P; 1; 2
Discipline	Science
Description	The purpose of this learning object is to move Frog in his boat downstream along a river. Students stop along the way to check water temperature, salinity, clarity and current speed. The learning object also requires students to associate four randomly generated animals with different river habitats.
Structure/type	Activity
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Visual learning
Learning purpose	Biological science; Earth and space: Soils; Sand; Topsoil; Clay **Content/concept:** Science: Animals; Ecology; Environment; Habitats **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 12, years 7–8. Many students had very weak literacy skills 2. School 2, year 5
Used how	1. Students selected learning objects from a list and worked through them individually with minimal teacher input. 2. Students worked as individuals or as pairs for 1–15 minutes until they had exhausted the learning object. They were provided with no clear teacher direction or goal.
Strengths	Usefulness to teachers The learning object provides a good thematic match for teachers designing lessons in this area. It provides good reinforcement of and exploration of thematically related content. Usefulness to students The learning object features rapid access to the activity at the start, and meaningful closure. Students found the restart button useful and the voice instructions clear and easy to use. The buttons also had clear rollover changes and text support, large size and vivid colours. The visual depiction of variables was suited to younger students. Student learning process and outcomes Students spoken to in detail demonstrated a good understanding of the content of the learning object and indicated enthusiasm for it. Student use of the learning object varied considerably. Some paid close attention to instructions and were hesitant to explore. Others disregarded the instructions, including audio, and made random, then iterative movements around the learning object, focusing in particular on the animations. Not all students arrived at the matching exercise.
Issues	Usefulness to students The river mouth confused some students who, despite the label, thought the depiction was further upstream. This is because the detailed depiction contains mangroves, which do not appear in the broad picture. The majority of students took little notice of instructions. Many had difficulties with the navigation. Their use of the learning object did not reflect any appreciation of purpose.
Summary While aimed at a very young group, this learning object was enjoyed by students in higher grades. The animations were engaging – more so than the static elements. A purpose needs to be set for students.	

Soil types

Title	**Soil types**
User level	Years K–P; 1; 2
Discipline	Science
Description	The learning object allows students to build sandcastles from three different soil types: sand, loam and clay. They compare results when adding water or compressing soil. This learning object introduces basic soil properties of density and stickiness.
Structure/type	Activity
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Learning purpose	Soils; Sand; Clay; Topsoil **Content/concept:** Science: Earth; Geology; Physical change; Simple experiments **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 12, years 7–8
Used how	The learning object was used with no context. Students used a number of learning objects without specific direction from the teacher.
Strengths	Usefulness to teachers No evidence Usefulness to students Students found the voice instructions clear and easy to use. The learning object allowed for rapid access to the activity at the start and meaningful closure. Clear graphics were used to present information, support interaction and provide feedback. The activity was well scaffolded. Student learning process and outcomes This learning object required low levels of memorisation. This made it appropriate for young students.
Issues	Limited observations
Summary There was limited observation of this learning object in use. Where it was used, it was with students for whose age group the learning object may have been inappropriate.	

Volcanoes

Title	**Volcanoes**
User level	Years K–P; 1; 2
Discipline	Science
Description	This learning object generates a sequence of three interactive learning scenarios about geological formations. Students explore underground to learn about rock structures. They collect rock samples, then match these with original locations or uses. Students can explore: • a limestone cave (includes animals) • a volcano (includes eruption) • a mineshaft (includes uses of minerals). These activities are reinforced with options to look up further information and answer questions.
Structure/type	Talking book/activity
	Student activity: Interactives; Comprehension activity **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning

Learning purpose	Animals; Ecology; Landforms; Rocks; Geology; Groundwater; Volcanoes; Igneous rocks; Magma; Heat; High temperatures; Soils **Content/concept:** Science: Animals; Earth movements; Geological features; Geology; Heat; Rocks; States of matter **Skills/processes:** Comprehension; Knowledge
Used by	School 12, years 7–8
Used how	The teacher provided no context for the learning object. Students used a number of learning objects without specific direction.
Strengths	Usefulness to teachers The learning object provides information and a simple activity for investigation and reinforcement. Usefulness to students The voice instructions were clear and easy to use. Variables were presented in a form suited for the intended age group. Students appreciated the humour used at the conclusion. Student learning process and outcomes No evidence
Issues	Student learning process and outcomes Decision-making opportunities were highly structured but students could bypass the information on which the matching activity is based. The placement of rock samples can be (and was) completed quickly without engagement with the content. Students found the placement of labels confusing and this affected their use of the quiz. There are some content inaccuracies: the magma chamber was sealed at its base; only the vent and not the lower column is molten, and only the crater has volcanic rock; and ash was found in a column rather than outside.
Summary This was used by students much older than the intended level and without a goal. Students were not engaged.	

Weather wear

Title	**Weather wear**
User level	Years K–P; 1; 2
Discipline	Science
Description	Students first listen to a daily weather report. They then dress Gecko in clothing suited to the weather conditions. Finally, students sail in a yacht race with Gecko.
Structure/type	Activity
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Learning purpose	Select appropriate weather wear **Content/concepts** Weather; Clothing; Yachts; Rain; Sun; Winds; Coasts **Skills/processes** Application; Comprehension; Knowledge
Used by	School 1, early years
Used how	The learning object was one of a number of class activities related to the weather. The students were read a story then showed the learning object. The teacher conducted some discussion about choosing appropriate clothes for different weather. The class had one computer for use by pairs of students.
Strengths	Usefulness to teachers This learning object was relevant to the needs of young students.

	Usefulness to students The voice instructions were clear and easy to use. Students found the learning object engaging, with age-appropriate graphics and animation. The accompanying audio was useful and students were able to navigate easily. The learning object can also be played a number of times because weather conditions are randomly generated. Student learning process and outcomes The simplicity of animation ensured few distracters for young students. Researchers noted that girls appeared to engage more with the clothing choices than did boys.
Issues	Student learning process and outcomes Students were required to make only one decision to complete the activity but could replay the task. The feedback animation, a race, was not dependent on student choices so there were no consequences for Gecko if the wrong clothes were selected. The result of the race is not related to the learning purpose. Boys were more interested in getting to the race than in selecting clothing and paid scant attention to their selections.
Summary This learning object was engaging for the students. However, the lack of relationship between selecting the clothes and the outcome of the race, detracted from the effectiveness of the learning object.	

Years 3–4

Earth alert

Title	**Earth alert**
User level	Years 3; 4
Discipline	Science
Description	The learning object requires students to tune in to an environmental news program called ‘Earth alert’. They solve four ecological problems involving pest animals or human activities: domestic cats; European wasps; sea stars; and rural drivers. The learning object includes suggestions for exploring solutions to an environmental problem in the local area.
Structure/type	Activity
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning; Collaborative learning
Special features	Navigation using a simulated remote control
Learning purpose	**Topic:** Environment; Birds; Habitats; Introduced species; Marine ecology; Ecology; Populations; Fishing boats; Greenhouse effect; Cars; Ships **Content/concept:** Science: Ecology; Habitats; Human intervention; Local environment **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 2, years 6–7 2. School 12, years 6–7 3. School 14, years 6–7
Used how	1. Students worked cooperatively on one learning object, which was thematically linked to other projects being undertaken. The teacher had taken students through the learning object earlier so they were familiar with how it worked. They were given a ‘SWOT’ sheet to provide focus and ‘write down what they’ve got from it’. The teacher intended to follow the use of the learning

<table>
<tr><td></td><td>object by having students make a newspaper based on the content of the learning object.
2. Students used a number of learning objects without specific direction from the teacher.</td></tr>
<tr><td>Strengths</td><td>Usefulness to teachers

A teacher was able to integrate this learning object as a resource into diverse parts of the program.

T: I think it is important that they actually talk to each other about it and they are going to learn something like that in pairs …

Usefulness to students

The necessary text was chunked into small pieces over several screens. The red text for main instructions was useful. Students appreciated the animation with humour.

S: It looks interesting because there is little cartoon characters and they are able to slip a joke in.
S: … the facts are really interesting and the pictures are really funny.

Student learning process and outcomes

Students could choose a topic and one or more solutions.

S: Like you get to pick a channel and then it tells you go through and then you get to click a solutions so it is more fun …

Each solution option selected by students had feedback. Students were able to articulate what they had learnt after using the learning object.

S1: About helping the world and making animals safer.
S2: And like to warn people and help them like how they can change stuff with the solutions. Like they can sort of do some of the simpler ones.</td></tr>
<tr><td>Issues</td><td>Usefulness to teachers

T: I know some of them [learning objects] have something that you can print off and then it is assessed. But … there was nothing that … you can assess.

Usefulness to students

The learning object was text-dependent. Voice support was not available throughout the body of the learning object (for example, ‘Solve a new problem’). The scroll bar is easily overlooked, so many of the students continued to the next screen without reading some of the text.
Students thought animation could be more extensive.

S: like just in cartoons where a cat pounces on a bird or something.
T: I just think it could have been a bit more as a news report and … interviewing people a little bit more.

Student learning process and outcomes

Student work could not be recorded.

T: There was nothing where any children could actually fill in or type in anything of their own information.

There was no distinct conclusion to the activity.
The learning object indicates that 93 animals are hit by cars in Australia per day. This figure is unlikely to be correct and should be checked.</td></tr>
<tr><td colspan="2">Summary

This is a useful Society and environment learning object but it is not designed to lead to a Science learning outcome.</td></tr>
</table>

Fish out of water

Title	**Fish out of water**
User level	Years 3; 4
Discipline	Science
Description	In this learning object students test the breathing capabilities of a human, a fish and a frog. They predict whether each would survive in air or water. Students test their prediction by placing the animal into a simulated laboratory tank and adding water or air. They view an animation of the animal's breathing process and answer questions about survival. The test animal will ask for help if it begins to run out of oxygen.
Structure/type	Simulation
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Learning purpose	**Topic:** Respiratory system; Adaptation (Biology); Fish; Frogs; Humans; Lungs; Blood vessels; Circulatory system; Amphibians; Marine animals **Content/concept:** Science: Animals; Human body **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 14, years 6–7
Used how	This learning object was used along with 'Plant scan' and 'In digestion' as a comparison of plant and human systems. The teacher reviewed student understanding of these systems via discussion and provided a Venn diagram for students to complete. The teacher then demonstrated how to use the learning object and read out the instructions for the students.
Strengths	Usefulness to teachers This learning object is useful as part of a suite of related learning objects to make comparisons about biological systems. The learning object provides rich information. Usefulness to students The learning object provides a number of navigation choices for the student, including links for vocabulary and further information. Information within the learning object is presented using text and animation. Student learning process and outcomes The learning object allows students to explore and make predictions. The outcomes of the predictions are shown.
Issues	Usefulness to students This learning object is relatively complex in construction and requires a great deal of navigation through text-rich pages. This may present difficulties for the targeted students. The sound option does not appear to work. The glossary is written without graphics, animation or voice support. Student learning process and outcomes The learning object supports little decision making by students. Some of the vocabulary was found to cause problems. Students felt they had to rely on other data to make their predictions.
Summary Little time was spent with students who had used this learning object but the discussion indicated that they had not engaged deeply with it. The group observed was at a higher level than the target audience.	

In digestion

Title	**In digestion**
User level:	Years 3; 4
Discipline	Science
Description	This learning object allows students to follow the passage of food through the human body. Students select food and interact with an animation that shows major digestive processes. This includes descriptions, questions and a choice of what to do next (for example, add saliva; chew food). The animated body reacts according to the food combinations and other choices made. The simulation is reinforced at each stage with options to look up further information and answer questions.
Structure/type	Simulation
	Student activity: Interactives; Experiment **Learning design**: Experiential learning; Independent learning; Problem solving; Visual learning
Special features	Highly interactive, with humorous consequences for student choices
Learning purpose	**Topic**: Digestive system; Food; Intestines; Mouth; Oesophagus; Stomach; Tongue; Saliva; Nutrition; Humans; Sugar **Content/concept:** Science: Digestion; Human body; Nutrition; Simple experiments **Skills/processes**: Analysis; Application; Comprehension; Knowledge
Used by	1. School 8, year 8 2. School 14, years 6–7 3. School 12, years 7–8
Used how	1. The teacher provided a very brief introduction to show students how to access the learning object. Students then explored it independently. No task was set. 2. The learning object was used along with 'Plant scan' as a comparison of plant and human systems. The teacher provided a diagram and reviewed student understanding of these systems via discussion. The teacher demonstrated how to use the learning object and read out the instructions for the students. 3. The learning object was used in an unstructured way by some class members.
Strengths	This learning object received praise from students and staff and appeared to lead students effortlessly to learning. Students were keen to use it a number of times with different combinations of choices, thus reinforcing their learning. It rapidly engaged a group of boisterous boys who soon became absorbed and task-focused. The learning object also provided powerful new ways to visualise concepts not otherwise accessible. The animation was more effective than photography – clear, but not offensive. T1: Just having a cartoon is not enough. You have to have a cartoon with attitude … they had little facial ticks … and the facial expressions that the guy had … when he was constipated … or throwing up were absolutely hilarious. And so that pulls the kids into trying to do something else to him. Usefulness to teachers T1: It's not patronising. … it is at a level that is very broad. You can talk up the primary school kids … and you can still work at high school level, even senior high school level … This learning object is easily integrated into a topic on health. Usefulness to students There was suitable humour in the animation. The androgynous graphic of the youth allows both girls and boys to relate to the person. Simple yet

	effective graphics enable students to relate to the process from familiar and unfamiliar viewpoints. There is simple, well-placed and contextual text material as well as links for further information. Students were able to navigate easily. While there were multiple panels and a range of both textual and diagrammatic information to negotiate, a student commented that it 'let you choose instead of going in one direction'. S1: It shows the different names for the parts of your body like here you can click and find out more. S2: If you didn't understand something it has just got a button that comes up next to it and you can click it and it show it and explains it. Student learning process and outcomes There were subtle cause-and-effect relationships, including many opportunities for non-trivial decision making by students. Students rated highly the ability to make their own choices within the learning object. Student decisions along with the rewards and consequences of student choices are closely linked to teaching purpose. Students were motivated to use the links to find further information. Students confidently and correctly related elements of the content such as process and terminology. S1: It shows you how to eat so if you didn't add something, if you didn't wish to chew, chew swallowing, you start choking. If you didn't add your saliva, you would start choking. So you add them both so you can swallow easily. Then sometimes if you do it too quick you throw up. You churn your stomach like this one here; I done it too quick and now I have a tummy ache. So I have to start again. But if I do something wrong in the small intestine I start back where I started. So I think this is really good. S2: … you go on the computer and it is easier and do the process instead of someone telling you it. You know what it is about. S3: Well you got to choose and, like I said, trial and error, it means you remember and it stuck in your head pretty good.
Issues	Introductory animations delay entry to the activity. There is a 'skip' button, however.
Summary This learning object was popular with all students who used it and this suggests its applicability is beyond the years 3–4 level. Students were keen to replay it and explored links with further information. Their retention of information appeared solid. The following relates to year 8 students who were given little introduction to the learning object. O: Did you feel you could follow all the information on the screen, because there were quite a lot of different things happening at different times? S1: Yeah. I think it was pretty easy to follow.	

Old Bernie's pond

Title	**Old Bernie's pond**
User level	Years 3; 4
Discipline	Science
Description	The learning object directs students to help clean up Old Bernie's pond. Students see the pond in its present state (polluted and invaded by introduced species). They choose options for some possible solutions to restore the pond. Students then check the ecological outcomes of the restoration choices and try other options until the pond is healthy. On completion they earn a Pond Restorer Certificate.
Structure/type	Activity
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Special features	Toggle buttons which add or subtract elements that will impact positively or negatively on the lake
Learning purpose	**Topics:** Habitats; Ponds; Freshwater ecology; Ecology; Environment; Revegetation; Birds; Animals; Plants; Fish; Weeds; Trees; Water; Populations; Introduced species; Wastes; Pollution; Conservation (Environment); Frogs **Content/concept:** Science: Animals; Ecology; Habitats; Human intervention; Natural environment **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 12, years 7–8, including students with weak literacy skills
Used how	The teacher provided no context for the learning object. Students used a number of learning objects without specific direction from the teacher.
Strengths	Usefulness to teachers This learning object was used along with other learning objects with related themes. Usefulness to students Students found this learning object easy to navigate. The health of the pond changes according to decisions made by the students. Students can revisit poor decisions and reverse them. Student learning process and outcomes Links provide further information about items such as 'carp'. This type of information is reinforced in the feedback students receive on their actions. S1: About pollution and stuff like that … Mainly about native animals and stuff …
Issues	Usefulness to students Student input or decision making is to accept or reject a number of fixed alternatives. Questions are relatively sequential, which makes student structuring difficult. A repetitive and unhelpful animation of Old Bernie working, which runs once the student has made a decision, delays feedback. Student learning process and outcomes S: It's not as fun. I think it is more that you are not actually doing anything, well you are a bit … Student learning outcomes S: (mimicking computer) 'Meant to be in their house otherwise they eat everything.' Which wasn't very creative.
Summary Students had few difficulties with this learning object but did not find it particularly engaging.	

Old Bernie's story

Title	**Old Bernie's story**
User level	Years 3; 4
Discipline	Science
Description	The learning object requires students to interview Old Bernie about a local pond and its environment. Bernie and his family have lived near the pond for generations. Students ask him a series of questions about the ecology of the pond and how things have changed. Bernie replies via video clips.
Structure/type	Activity
	Student activity: Interactives; Experiment; Estimation Analysis **Learning design:** Experiential learning; Independent learning; Visual learning
Learning purpose	**Topic:** Habitats; Ponds; Freshwater ecology; Ecology; Environment; Birds; Animals; Plants; Fish; Weeds; Trees; Fire; Water; Populations; Surveys; Introduced species; Wastes; Pollution; Conservation (Environment); History **Content/concept:** Science: Animals; Ecology; Habitats; Human intervention; Natural environment **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 7, year 6 2. School 11, year 6
Used how	1. Students in an IT class were investigating the learning objects as examples from which they could draw conclusions about what makes a good multimedia resource. They were involved in a project to construct their own. 2. No data was collected.
Strengths	Usefulness to teachers Teachers are able to integrate it as a resource into diverse parts of their program. This is a useful Society and environment learning object but it is not designed to lead to a science learning outcome. Usefulness to students The learning object was easy to navigate. Student learning process and outcomes No evidence
Issues	Usefulness to students The scroll bar makes it likely that students will miss some text. The learning object is text-rich with no voice support after the introduction. There are no graphics, animation or voice support in the glossary. Little student decision making is involved although the inclusion of both negative and positive actions means that students need to engage with the content. Student learning process and outcomes Students are required to take actions without background information (for example, what do carp do to the ecosystem?). Some actions are trite (for example, remove rubbish and add rubbish bins).
Summary Students did not find this learning object particularly engaging.	

Plant scan

Title	**Plant scan**
User level	Years 3; 4
Discipline	Science
Description	The learning object requires students to show the alien Zorpac how much they know about plant life on Earth. Students answer a quiz on plant structure and function.
Structure/type	Talking book/activity
Special features	The correct function is matched with plant parts.
Learning purpose	**Strand**: Science: Biological science **Topic**: Photosynthesis; Transpiration; Light; Plant physiology; Flowers; Roots (plants); Stems (plants); Nectar; Pollen; Pollination; Leaves; Nutrition; Seeds; Botany; Germination
Used by	School 14, years 6–7
Used how	This learning object was used along with 'In digestion' and 'Respiration' as a comparison of plant and human systems. The teacher provided a diagram and reviewed student understanding of these systems via discussion. The students were then taken through the learning objects.
Strengths	Usefulness to teachers This learning object can be used along with other related learning objects. A discussion making comparisons between humans and plants was undertaken that required students to use what they had learnt. Usefulness to students A voice provided assistance for pronunciation. Student learning process and outcomes Students enjoyed the quiz activities. S1: Well I found out some things that I never knew like that the roots take in nutrients and water and the leaves take in carbon dioxide and with that together it produces oxygen. I never knew that.
Issues	Usefulness to students If students want to explore more items, they are taken via the same animation that delays re-entry to the activity. Even after selecting 'skip', they are shown a repeated sequence that adds no value on second viewing. The cartoons used may be over-simplified. The animation of processes is under-utilised. Text is used to deliver information about transport of liquids and nutrients when animation would have been more powerful. Students found some terms difficult, and did not find spoken support for jargon. This resulted in mispronunciations. Several students were unfamiliar with the convention of underlined hyperlinks. Text was used in the glossary where diagrams and animations would have been more effective. S1: It's alright but it doesn't rate with 'In digestion'. Student learning process and outcomes A number of students commented that they already knew the information. However, new material is not available to students until they have tried the test and selected the correct answer. They may be marked wrong up to seven times before they select correctly. Some students were simply pressing buttons and not reading. 'Following their noses' meant subverting the assumed systematic use designed into the learning object. O: So did you go through everything? S2: Not everything because I got bored.

	A lack of clarity led the teacher and subsequently the students to believe that phloem have a straw-like structure. The use of colour conventions (blue for water, red for 'blood') resulted in misconceptions. Students suggested they wanted more control such as the ability to water and feed plants and see what happened.

Superhuman

Title	**Superhuman**
User level	Years 3; 4
Discipline	Science
Description	This learning object presents a biology laboratory where you can change the body of a man and woman by exchanging human arms or legs with a range of animals. The skeletal structure of each of the animals is shown and the learning object provides tips to help students understand the implications of substituting limbs. The learning object demonstrates how the structure of the animal's body is related to its function and environment. Included is a printable worksheet for designing customised 'superhumans'.
Structure/type	Activity
Learning purpose	**Strand:** Science: Biological science **Topic:** Adaptation (Biology); Vertebrates; Birds; Mammals; Wings; Evolution; Mutation; Bones; Skeletal system; Humans; Genetic engineering
Used by	School 14, years 6–7
Used how	The class had done a module on body systems including digestion and respiration and were going to compare human and plant systems. Systems were reviewed and discussed briefly. A Venn diagram was provided for students to complete to show the overlap of systems.
Strengths	Usefulness to teachers This learning object was useful as part of a suite of related learning objects for making comparisons between biological systems. Usefulness to students The glossary assisted students with the terminology. The learning object provided opportunities for exploration and students could go deeper using the links. There were multiple paths and navigation choices for students. Humour also enhances use of the learning object. Student learning process and outcomes S: … it would get boring because I know what happens.
Issues	Usefulness to students The introductory animation delays entry to the activity. The glossary was also text-rich with no graphic, animation or voice support. The instruction box asked a series of questions that needed to be memorised by students when they proceeded to the screen where they typed in the answers. This placed a heavy memory load on students and provided little scaffolding. Also, the scroll bar was overlooked by some students, meaning that they missed reading some of the text. Student learning process and outcomes While there were options for investigation, students did not find them challenging. The feedback provided was not interesting or surprising enough to continue to engage them. S1: … it got boring … it was easy … At first I'd go through it and I'd do it all and then it would get boring because I know

	what happens. O: How many times would you go though the Superhuman one adding things in? S1: Two times. S2: (Rated at) five (out of ten) … (it needs) more options and a bit more exciting probably … surprises.
Summary This learning object did not appear to be very engaging because the outcomes were considered too predictable. In part this may be due to it being used along with ‘In digestion’ which was received enthusiastically.	

Take a deep breath

Title	**Take a deep breath**
User level	Years 3; 4
Discipline	Science
Description	In this learning object students visit a virtual laboratory and see a young girl exercising. They look at cross-section views of the circulatory and respiratory systems. Anatomical diagrams have labels and descriptions of important organs and tissues. The learning object contains animations showing how we breathe and how the heart pumps blood to the lungs and body. Students then predict the effects of walking or running on heart rate and breathing. All activities include extension information and further questions.
Structure/type	Simulation
	Student activity: Interactives; Experiment; Problem solving **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Learning purpose	Respiratory system; Lungs; Circulatory system; Blood; Blood vessels; Heart; Exercise; Health; Humans; Anatomy; Abdomen; Thorax; Mouth; Cells; Walking; Running; Physiology **Content/concept:** Science: Animals; Health; Human body **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 8, year 8 2. School 14, years 6–7
Used how	1. This was one of a number of learning objects viewed by students with some introduction, but not integrated with other work within the lesson. 2. In this school the learning object was used as part of a comparison between human, animal and plant systems. The teacher provided a Venn diagram as a stimulus. Class discussions were conducted after using the learning object. The learning object was also used as an English stimulus for vocabulary, reading and note taking. The class had also used the learning object in association with a WebQuest.
Strengths	Usefulness to teachers The learning object was used as part of a comparison of human, animal and plant systems. Usefulness to students This learning object is information-rich, with excellent animations of internal processes. The animations are accompanied by voice. Links in the text provide further information. Students have a choice about the order in which they explore the learning object and there appeared to be no problems with navigation. In general it appeared students could understand the graphics and look at the labels if they were unsure.

<table>
<tr><td></td><td>Student learning process and outcomes
The animation caught the students’ attention, as did the read-outs of heart rates and similar information. The learning object was met with varying levels of enthusiasm. One pair of students became very interested. They read carefully, engaged in discussion and prediction and worked through the learning object enthusiastically, enjoying finding that their predictions were right.
S1: They actually show you how it works … Like the rib cage opens up a bit when you breathe.
Students appreciated being able to make choices.
S2: Well they let you click on this stuff.
S1: Yeah, you choose what you want to do.
Students experimented and there was a range of levels of understanding.
S1: I have read harder.</td></tr>
<tr><td>Issues</td><td>Usefulness to students
This is a complex learning object with a large amount of information available in a number of forms.
Type-in activities do not scaffold student predictions sufficiently. It would be useful to show the ‘before’ and ‘after’ heart and breathing rates.
Deleting text to type over it irritated students.
The glossary provides no graphic, animation or voice support. Quite capable students were unable to understand the explanations given.
No student observed used the icon to find the voice support.
The instructions for the comparisons to be made in the activity were confusing and resulted in poor data (students compared the heart and breathing rates appropriate to their chosen levels of activity, rather than the rates at current level of activity and resting.)

Student learning process and outcomes
The information about blood vessels was simplified but in some cases information was inconsistent.
The external (walking) animation is not synchronised with the internal (breathing) animation, so it becomes a distracter.
A vein is described (correctly) as a blood vessel that carries blood towards the heart. Then, despite the illustration showing the pulmonary vein, it is stated (incorrectly) that ‘it also carries a waste gas called carbon dioxide’.
Students observed while using this animation found it very interesting, but could not retell any of the events within it.
O: Which one did you learn least from?
S: Probably the respiratory system because I didn’t understand most of that … It has confusing words.</td></tr>
<tr><td colspan="2">Summary
Students found the learning object engaging but the degree to which they gained value from it depended on the learning context and whether a task was associated with it. Because of the rich possibilities of this learning object, goal setting by the teacher is recommended. Some students were totally engaged while others were less so and thought it ‘didn’t tell you enough information’. When the latter student was asked whether it was better to learn with the teacher or on computer (s)he replied, ‘I’d do it on computer so I can skip the work’.</td></tr>
</table>

What on Earth

Title	**What on Earth**
User level	Years 3; 4
Discipline	Science
Description	The learning object requires students to help the alien Zorpac to find out about plant life on Earth. First students watch a demonstration about major functions in plants (e.g. photosynthesis). They then have a close-up look at each plant part to see how it works.
Structure/type	Talking book
	Student activity: Interactives; Comprehension activity **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Learning purpose	**Topic:** Photosynthesis; Transpiration; Light; Plant physiology; Germination; Flowers; Roots (Plants); Pollen; Pollination; Leaves; Nutrition; Seeds; Stems (Plants); Nectar; Botany **Content/concept:** Science: Ecology; Nutrients – transport; Photosynthesis; Plants; Water transport –plants **Skills/processes:** Application; Comprehension; Knowledge
Used by	School 13, year 6
Used how	No data
Strengths	Usefulness to teachers The learning object provides information about the parts of plants and how the plant functions. Internal, invisible processes are shown. Usefulness to students Students can explore different parts of a plant and plant functions. A glossary provides further information. Animations show processes accompanied by voice.
Issues	Usefulness to students After viewing one item, the ‘continue’ button takes students to the exit screen. If they want to explore more items they are taken via the introductory animation again, which delays re-entry to the activity. While there is a ‘skip’ button, students still re-experience a sequence that adds no value on second viewing. The glossary uses only text, while sound, diagrams and animations would have been effective.
Summary This learning object provides information but does not engage the student in any activity beyond selecting items to explore. There is no application or higher level use of the knowledge.	

Who’s for dinner?

Title	**Who’s for dinner?**
User level	Years 3; 4
Discipline	Science
Description	Students view a food chain and food web from a billabong habitat. They play a game to see how animals feed and survive. Students can play the role of a tadpole, fish or heron. They are required to find food and avoid predators to help their animal grow and breed. Eating high-value food sources may result in increased risk of attack by predators.
Structure/type	Activity
Special features	There is significant user control and choice. Outcomes are directly dependent on student input.
Learning purpose	Habitats; Food webs; Food chains; Herbivores; Carnivores; Populations; Freshwater ecology; Rivers; Ponds; Animal behaviour; Nutrition; Plants; Animals; Fish; Birds
Used by	School 12, years 7–8, including students with weak literacy skills
Used how	The teacher used this learning object as a springboard for revision and extension of earlier work. She worked through the vocabulary within the learning object and students created their own glossaries of new words. She extended the scientific content by finding websites related to food chains (spending about half an hour). Students then used that information as a model to build a food chain using Australian examples. Reflective discussion was built into the set of lessons.
Strengths	Usefulness to teachers This was a useful resource for stimulating thought. T: Well why is this happening? What does that mean in terms of the environment? Really made them stop and think and then when they came back to play, some of the things came out. They were more thoughtful. T: They are getting there on [a] different level … especially students who have a few behaviour problems and a few learning difficulties. If you give them anything that doesn’t look like fun they will start rolling their eyes … before they get into it … Yeah colourful graphics and sounds … helped students like him. Usefulness to students The graphical representations of the food web and food chain are clear and easy to use. The navigation is intuitive and the game format was popular with students who have problems with literacy-based materials. The learning object provides students with the opportunity to develop their own strategies to construct knowledge. Student learning process and outcomes T: There was Literacy within it; it doesn’t rely exclusively on being able to write a good essay or being a good speller. He can go in and play ‘Who’s for dinner?’ and he doesn’t need to be able to have a lot of background knowledge … and then be able to have a reflective discussion at the end. The learning object provides intrinsic performance-based feedback. Rewards relate to the learning purpose. T: He wanted to avoid the writing … he was wanting to go back and revisit the learning object all the time … he kept wanting to go back to get one of the animals to survive. S1: They [the pictures] help you with the reading and the words.
Issues	Usefulness to students Restarting the activity requires flicking through the initial text-rich

	screens. Students tended to ignore them. It would have been more efficient to have some screens optional once the student had been through the learning object once. The glossary does not contain graphics, animation or voice support. As the importance of interrelationships within the food web is what the student is meant to have learnt from the learning object, it seems unusual to place this information before, rather than after, the experience. As no student observed or interviewed had read this information, they were not able to comment on this placement.
Summary Students found the learning object engaging because of the game format. The scoring and survival elements meant students were keen to keep trying. Teacher assistant: Lots of conclusions about the food pyramid, the food chain. In other words, a large mass of living things at the base is required to support a few at the top. Very clear.	

Why recycle?

Title	**Why recycle?**
User level	Years 3; 4
Discipline	Science
Description	In this learning object students meet a group of children finishing their lunch at school. Each child chooses to dispose of their plastic lunch bag in a different way. Students predict where the bags might end up and possible environmental consequences. Through these activities they learn about the durability of plastics and environmental benefits of recycling.
Structure/type	Activity
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Learning purpose	**Topic:** Recycling; Wastes; Conservation (Environment); Pollution; Plastics; Packaging; Durability (Materials); Stormwater **Content/concept:** Science: Human intervention **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 12, years 7–8
Used how	The learning object was provided with no context. Students used a number of learning objects without specific direction from the teacher.
Strengths	Usefulness to teachers This learning object was used along with other learning objects with related themes. It is a useful Society and environment learning object but is not designed to lead to a Science learning outcome. Usefulness to students The graphics are clear and appropriate for years 3–4 onwards. Students were able to navigate the learning object effectively and a glossary is available for terminology. Students are supported in their ideas by the building of answers in two parts. This later becomes part of a report comparing student answers with the learning object answers. There are some surprises in these answers. Student learning process and outcomes No data
Issues	Usefulness to students The introductory animation delays entry to the activity. In some instances text is used in the glossary where diagrams and animations would have been more effective. There is no voice support for glossary entries.

	Predictions need to be typed over existing text in the text-box, which is not favoured by students. The scroll bar is easily overlooked, so students may miss important text. The character input limit for text boxes is approximately 160, which does not allow students to develop long answers.
Summary The graphics allow this learning object to be used with students older than the target group. The content is relatively simple and the navigation is easy to use. Students had few difficulties with this learning object but did not find it particularly engaging.	

Years 5–6

Intergalactic cook-off

Title	**Intergalactic cook-off**
User level	Years 5; 6
Discipline	Science
Description	In this learning object students are invited to compete in a televised cookery show. They must pass the Kitchen Chemistry Test to become the Grand Celebrity Chef. Students find five reactions that cause a chemical change using cooking ingredients such as acid-base reactions.
Structure/type	Activity
Special features	POE report; video window for reactions
Learning purpose	Distinguish between physical and chemical changes
Used by	1. School 2, years 4–5 2. School 12, years 7–8, including students with weak literacy skills
Used how	1. A full lesson the day before on physical and chemical change preceded the use of the learning object. The teacher refreshed students' memories on the day and questioned them at five-minute intervals throughout the lesson. No print materials were used. Students had up to 20 minutes to use the learning object. 2. Students used a number of learning objects without specific direction from the teacher.
Strengths	Usefulness to teachers This learning object provides reinforcement of science lessons. It also allowed other students to work on a separate activity at another workstation. T: I've just used it as another resource. Usefulness to students Students enjoyed the humour in the animation of the alien. They also responded well to the screen set-up: S: It has … got the buttons really clearly to see. Student learning process and outcomes The learning object demonstrated a reaction students were familiar with. This provided a comfortable start for some students. The learning object stimulated animated discussion about what was happening during each reaction. Students preferred being able to control elements of the learning object. O: What bits of it were more fun? S: The bits where you got to choose what you wanted to do and watch the movie but this bit here where you have to write … this is boring. Students preferred working together:

	S: .you share your expressions and things … share your knowledge.
Issues	Usefulness to teachers The context of the learning object – intergalactic – was considered to be too distant from the teaching purpose by some teachers. Vital jargon for the teaching purpose (physical and chemical change) was not clearly stated. Usefulness to students The video was slow to download and quality was 'dark' and 'fuzzy'. Students had trouble interpreting the information. Several students were unable to decide if they could see a reaction between alcohol and sodium bicarbonate. This could be made clearer with 'before' and 'after' photographs alongside each other allowing easy comparison. Navigation caused problems for some students, as did remembering what had been done. Students were not interested in reading information once they had made their decision. T: They couldn't find a print button … which was a shame because they did all this typing and they were really keen to see it printed … I tried to print it out but I had no luck either. Student learning process and outcomes Some students were confused when the eggshell did not react when burnt (although both the protein and the calcium carbonate should decompose). This contradicted the students' prior experience. Students were able to articulate what the learning object was about in general but did not indicate specific things that they learnt.
Summary This learning object has intrinsic worth but students need assistance to focus on the task and interpret the results. This is true with other learning objects using the POE report model. Students were comfortable with 'predict' and 'Observe' but did not use 'explain' effectively. Teacher probing and support helps. T: … when they were inaccurate it didn't make them want to go back and find out why, they just 'Oh well let's miss this and this'. Being kids they just wanted to jump to the fun …of the lesson and see what will happen. The learning object requires close reading and there is a significant cognitive load required to fulfil the task effectively. The use of the POE text fields and report needs to be well understood and monitored for best outcomes. T: When they first went in they enjoyed being able to type in their answers and their findings … but maybe that is because those two quite like writing so maybe with other fives/sixes they may be reluctant to have to type it in. They may find that frustrating … they enjoyed watching it …but they weren't really going into the background information behind it all and saying 'why is this happening?'.	

Life without chemistry

Title	**Life without chemistry**
User level	Years 5; 6
Discipline	Science
Description	This learning object allows students to rebuild a virtual city. They are able to make everyday things produced in factories. Students test industrial materials to make items such as cars, buildings and clothing.
Structure/type	Activity
	Student activity: Interactives; Experiment; Modelling **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Special features	POE (Predict–Observe–Explain report building)
Learning	**Topic:** Buildings; Built environment; Cities; Cars; Manufacturing;

purpose	Materials; Metals; Fibres; Fuel; Plastics; Polymers; Wood; Technology; Glass; Concrete; Rubber **Content/concept:** Science > Built Environment **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 12, years 7–8
Used how	The students used a number of learning objects without specific direction from the teacher.
Strengths	Usefulness to teachers This learning object was used with other learning objects with related themes. Student learning process and outcomes No data
Issues	Usefulness to teachers Many schools do not have the ability to print out results immediately and need to file student work. Teachers would like students to be able to transfer outputs to other programs. Usefulness to students The purpose of the learning object is not immediately clear; particularly the applicability of Predict–Observe–Explain in this context. The learning object is text-intensive. Furthermore, navigation difficulties often resulted in students losing all data and having to start over. About three-quarters of student time was spent on the mechanics of typing rather than in science-related activity. Student learning process and outcomes Students (and teachers) were unable to distinguish between 'observe' and 'explain' – very seldom did the 'explain' wording evoke any abstract generalisations. The Predict–Observe–Explain format does not provide feedback for students. The recognised choices limit lateral thinking in some areas. For example, steel is not recognised as a suitable structural material for buildings (only concrete). Hydrocarbons are not suited for making tyres, having been superseded by synthetic materials. There was little scaffolding for learning. The students required prior knowledge of the appropriate classifications (and jargon), relationships and models to make predictions. These were frequently lacking. There is limited opportunity for students to modify results on the basis of additional experience or to develop an overarching understanding until the completion of the activity.
Summary The content of this learning object did not seem clearly related to an investigative model. Therefore, the POE report model did not seem well suited to this learning object.	

Mine rescue

Title	**Mine rescue**
User level	Years 5; 6
Discipline	Science
Description	In this learning object students rescue three miners trapped by fire. They select and test gases to put out the fire and then help the miners to breathe.
Structure/type	Activity

	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Special features	POE (Predict–Observe–Explain report building)
Learning purpose	**Topic**: Gases; Chemical analysis; Disasters; Fire; Experiments; Nitrogen **Content/concept:** Science: Disasters; Heat; Simple experiments **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 7, year 6 2. School 12, years 7–8
Used how	Observation of this learning object was brief. 1. Students in an IT class were investigating the learning objects as examples from which they could draw conclusions about what makes a good multimedia resource. 2. Students used a number of learning objects without specific direction from the teacher.
Strengths	Usefulness to teachers No data Student learning process and outcomes No data
Issues	The following comments are based on researchers' observations. Usefulness to students The link back to the task is not obvious enough. Video clips within the learning object are small, indistinct and confusing. Negative tests (for example, bubbling helium through limewater) are particularly difficult for students to interpret. Student learning process and outcomes The learning object has a high cognitive load and assumes some background knowledge of substances like helium and ammonia. The instructions for bubbling gases through water need to remind the students that the water contains an indicator. Helium and nitrogen would both put out the fire safely, but provide negative limewater tests.
Summary As with other learning objects using the POE report model, this one has intrinsic worth but students need assistance to focus on the task and interpret the results. Close reading is required and there is a significant cognitive load required to complete the task effectively. The use of the POE text fields and report needs to be well understood and monitored for best outcomes.	

Save the lake

Title	**Save the lake**:
User level	Years 5; 6
Discipline	Science
Description	Life in Lake Baikal is dying because of something in the water. Students work out possible sources of pollution by using chemical tests. They match the chemicals they find with local industrial activities. Students then suggest changes to save the lake.
Structure/type	Activity
	Student activity: Interactives; Experiment; Analysis; Modelling **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Special features	POE (Predict–Observe–Explain report building); video to show reactions.

Learning purpose	**Topic:** Water; Pollution; Wastes; Chemical analysis; Acids; Salts; Copper **Content/concept:** Science: Pollution; Simple experiments **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	School 4, year 7
Used how	Students had been taken on a field trip to local wetlands as an introduction to this learning object. They had also made posters about the environment. The teacher had demonstrated one section of the learning object the day before. Students each had a computer and a worksheet.
Strengths	Usefulness to teachers The learning object allowed the students to work with reagents not freely available in most schools in a safe environment. Thematically the learning object complemented other class topics. Usefulness to students This learning object contains videos showing reactions and links to further information. POE reports potentially allow students to capture their findings and build toward a conclusion. Student learning process and outcomes S: I like having to do all these tests … and then having to keep writing predictions and all that, that can get a bit boring but the rest of it is really cool. I like watching what happens.
Issues	Usefulness to teachers Needs significant preparation to be successfully used Usefulness to students There are many text-intensive instructions and information screens. A number of students went straight into the experiments without reading the instructions at the start. Access to the instructions within the learning object via the ‘more information’ link was not clear. Because of this, students closed the learning object and restarted it to see the instructions. In that process they lost their POE input. Video clips were slow to load and were indistinct, too short and easily misconstrued by students (and teachers). Students variously interpreted the adding of a drop of solution to form a precipitate as: boiling, crust formation, the additive sinking or an explosion. Nor were students clear about what took place to cause this change. The video could be rerun only by going to the next screen and then clicking the back button. Students need to complete the activity at one sitting and cannot store their input and resume at a later date. Students encountered problems using the POE model. Students could not proceed unless they used the input fields Predict, Observe, Explain. However, what they put in the fields did not affect their progress or prompt feedback. They soon learn they can key in random characters. Alternatively, they focus on the wording of their input and spend less time experimenting. POE input fields also allowed too few characters for an answer of any complexity: 33 characters x 3 lines. This is not congruent with the level of thought required by some elements. The sequential navigation path led to many text-rich pages that students ignored in the absence of graphics or animation. Also, it was noticed that students did not necessarily explore links in the learning object. At the time of the observation, this learning object was not complete. It was not possible to compile all reports and recommendations. Exit from one part was only through closing the window and this meant the final report was not competed.

	Student learning process and outcomes There is no indication or modelling of the combinatorial reasoning required for the task. There is also a mismatch between the intended audience and the level of combinatorial reasoning required. Many students reached their conclusions by chance. This learning object also requires a high memory load with large amounts of discipline-specific jargon not freely accessible within the body of the activity. O: So can you remember that information? S: Not really with my head but a little bit. Some elements of the solution rely on outside knowledge not necessarily common among the students. The introductory text has factual errors: ▪ Litmus is redder in more strongly acidic solutions. ▪ Silver nitrate reacts with all salts (as opposed to all soluble chlorides). ▪ It is implied that copper iodide and copper carbonate precipitates are white (the former is dirty yellow; the latter pale blue). ▪ Students' tests show positive results on three out of four chemicals. Only one chemical is deemed guilty of harming the lake. The fact that not all dissolved chemicals caused degradation of the lake is confusing. No reason for this is given in the feedback.
Summary Students used the learning object effectively when they took their own notes for reference and worked methodically. Only one student was observed working this way despite all having been instructed to do so. Students felt they were able to use the learning object easily: 'It's pretty straightforward so you can understand everything as soon as you see it'. Their worksheets, however, showed that they had not used the information from the tests to reach their conclusions.	

Skateboard race

Title	**Skateboard race**
User level	Years 5; 6
Discipline	Science
Description	In this learning object it's the finals of the Super Skateboard Championship and someone has stolen the wheels from Noppy's skateboard. Students help make new wheels and test materials for strength and hardness.
Structure/type	Activity
	Student activity: Interactives; Experiment; Estimation; Analysis; Modelling **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Special features	POE (Predict–Observe–Explain report building); video showing testing results
Learning purpose	**Topic:** Strength (Materials); Wheels; Plastics; Polymers; Glass; Wood **Content/concept:** Science: Simple experiments **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 7, year 6 2. School 5, years 4 and 6
Used how	1. Students in an IT class were investigating the learning objects as examples from which they could draw conclusions about what makes a good multimedia resource. 2. Students were provided with little teacher direction.
Strengths	Usefulness to teachers

	This learning object allowed the students to work with reagents not freely available in most schools in a safe environment. Teachers can use the POE report as evidence of student activity. Because reports are printable, teachers can choose to use outcomes of the activity later. Usefulness to students Readily available test instructions meant students could always see the step to complete. Audio instructions were valuable for students with weaker reading skills. Students could choose one or more tests for each substance before testing the skateboard. Feedback was fast and reports restated the test chosen by the student. Students are able to review previous tests because their reports accumulate and can be accessed. Student learning process and outcomes Some students were more focussed than others and paid more attention to instructions. O: So you weren't sure what the purpose was? S: Not until about half-way through… Some students enjoyed testing the materials. They were engaged and indicated they learnt new things such as the durability properties of polyurethane and the kinds of tests that can be used. The outcome of the choices students make has relevant consequences.
Issues	Usefulness to students The low-resolution videos are difficult to interpret (for example, scratching polyurethane with a steel blade and concrete). The learning object also contains misleading instructions. For example, tongs are not used for bending polyurethane, despite the instructions. Student learning process and outcomes Students did not understand 'explain' and often duplicated what they had entered in their 'observe' field. It is possible (and was common in the students observed) to achieve the learning objective by chance, rather than using the appropriate reasoning. Students can write meaningless information in the POE fields. This would not be discovered unless the teacher asks to view the reports. S: When you type it in it should say 'OK' if it is something to do (with it) but if it is just gibberish stuff it shouldn't let you through. The animation of racing on wheels made from an inappropriate material showed the board breaking rather than the wheels. This could be confusing for students.

Summary

This learning object provides guidance, choice and relevant consequences of choices. The instructions are repeated and the testing is scaffolded. Even so, some students still 'missed' the instructions.

> S: Just have something that tells you about it and something that says, 'find the strongest material in here and you will be able to race in the skateboard championship'.

Students can exit testing a substance after one test or try more. The provision of post-test substance information works as a reinforcement and allows students to get involved sooner. One observer indicated that students were not readily able to draw conclusions about their observations or see ways the information and processes could be used for other situations. Contextualisation by the teacher is suggested for better outcomes.

Treasure puzzle

Title	**Treasure puzzle**:
User level	Years 5; 6
Discipline	Science
Description	In this learning object a treasure map leads the way to a locked door. Students must find three acids to open the door and claim the treasure. They test everyday substances to identify which are acids. Students are rewarded by a virtual treasure when they identify the acids.
Structure/type	Activity
	Student activity: Interactives; Experiment; Analysis; Modelling **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Special features	Predict–Observe–Explain fields appear at intervals and students must make an entry before they can advance. Their input is compiled into a report.
Learning purpose	Testing for acids **Content/concept:** Science: Simple experiments **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 9, years 5–6 2. School 5, year 4 3. School 2, year 5
Used how	1. Students took turns in groups of three while the rest of the class did a different activity. They had completed ‘hands-on’ work, testing weak acids, so had sound prior knowledge. The teacher had prepared a worksheet along with a printout of the information about how to identify acids. This was provided to some students but not others to see the effect. Students had been instructed to read all instructions before commencing. Each was allocated a role at the computer. Students had a clear understanding of the purpose. They spent about 10 minutes on the learning object. 2. The teacher gave students some prompts to keep them going. 3. The learning object was used as an activity in preparation for hands-on testing of substances.
Strengths	Usefulness to teachers The learning object was a useful reinforcement of hands-on science experiments. T: and so they got some background knowledge first from the learning object and another website, and then they went on to do some experiments of their own and to perform some experiments in front of the class and to explain the science behind the experiments as well as just doing them. T: to … engage them … to get them thinking ... to tap into what they already know. Usefulness to students Students with the worksheet were systematic in their approach to the learning object and used the printed information. Students who looked at the supplementary information about the substances learnt that: S: that will tell us whether it has got acid in it. S: I liked this one because at the end it says, ‘congratulations you’ve used your science skills to figure out three acids’. Student learning process and outcomes Most students were animated when using the learning object and interested in experimenting. It generated a good deal of predictive discussion and attempts at explanation within the group. Students also used their prior knowledge:

	But vinegar hasn't acid … because ... you put it on chips.
Issues	Usefulness to teachers A teacher observed that some students needed guidance with the task. T: I had to get them to go to that step because they just hadn't clicked on that to find out that that is what you do. They thought that was all there was to it. So that again would be a navigation issue I guess. It's not really obvious what to do next. Usefulness to students Students without the printout did not remember the information about how to identify an acid. This information was only available at the start and to return to it meant deleting any POE entries. These students needed prompting in order to continue because they were confused when no reaction occurred. The video required long download times and was of dubious value because detail was unclear and open to misinterpretation. Typing into the POE fields was demanding. The learning object did not always provide enough room and input did not affect the outcome. Students quickly learnt they could not advance unless they entered something, but that it didn't matter what they entered. S1: You have to type something in, or you can't move on. I don't like that … no, you just have to type anything. O: So when you press 'open' you get your report? S1: Yep. S2: It's so boring. Students suggested contextual help: S1: Press and maybe a little spring comes out and … give(s) hints. Student learning process and outcomes Some students went through the testing but didn't know whether they were correct or not until they tried the door. This suggests they did not assimilate the testing process … 'we are just guessing'. They learnt that they could bypass the testing and rely on the door. S: So we tried the door but it didn't work so we found it wasn't an acid. Students did not necessarily take advantage of the further information available via links. Instructions were only clearly available at the start. S1: Yeah, I think we have to get out of here and then go back in and we have to go back and do it all again. Student learning outcomes In the test, the fluid travels up the pipe against gravity. This is a fun effect but is incorrect science. S: I learnt that acids can burn doors. I mean it probably can't. Especially not lemon juice and fizzy drink and vinegar. Probably proper acids would. S: Acids and how you try and open a door with acid and find acids that can open a door. Misconceptions were common. O: What has blue litmus to do with testing? S: Like they mix it together to make the acid.
Summary While most students appeared engaged, the consistency of learning varied. Students whose knowledge was strong were able to consolidate. The worksheets assisted focus. A good number of students had difficulty interpreting the visual information and whether anything was happening. The video was 'a bit small'. One student suggested: 'having a picture thing before and then a picture thing after'.	

Years 9–10

Check your wind

Title	**Check your wind**:
User level	Years 9; 10
Discipline	Science
Description	Students test design settings for a windmill to generate electric power for an island lighthouse. They are able to set the blade length and pitch of the windmill to suit wind conditions over a whole year. The learning object requires students to consider seasonal variations and attempt to maximise energy efficiency of windmill operation while minimising the back-up use of diesel fuel in power generation. Students can test wind conditions for a variety of locations in Australia and New Zealand.
Structure/type	Simulation
	Student activity: Interactives; Experiment; Estimation; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Special features	The learning object allows students to vary a number of elements such as blade length, blade angle and wind strength, which are then used in providing virtual experimental data.
Learning purpose	**Topic:** Windmills; Wind vanes; Power stations; Stored energy; Seasons; Industrial design; Fuel; Batteries **Content/concept:** Science: Electricity; Energy transformation; Natural resources; Power technology; Quantitative data; Seasons **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 8, year 8 2. School 12, years 7–8
Used how	1. This learning object was one of a number of learning objects students were briefly introduced to and encouraged to explore. No specific goal was set. However the object did relate to 'hands-on' experimentation done in previous lessons. 2. Students used a number of learning objects without specific direction from the teacher.
Strengths	Usefulness to teachers The simulation provides opportunities to integrate the Science teaching with meaningful, Mathematics learning. T: It did act as a successful link to what we were doing and in most of the situations where they just chose locations it gave different results according to where they were … so it was actually a useful thing as far as that was concerned. T: I actually got a couple of kids who finished before the others and were starting to get bored. I gave them little challenges like, 'see what is the minimum speed that you can get …' Usefulness to students Regarding instructions: O: Did you read through all of those? S1: No. It's pretty straightforward. You just selected all the things. Regarding numerical and graphical representations of battery levels: S1: Both go together. You kind of need both. Student learning process and outcomes S1: It was really weird. It worked each time for me so I didn't really get anything from it …We did the forces thing so I knew a fair bit about it already. S2: Once you got the place to pick the position then it would be easy from there because you just pick the place and then

	the thickness or the thinness of the propeller and then you just play it and you've got to watch the battery power [to] see if it goes down. S2: … You didn't have to read stuff and really work it out. You just had a little bit of writing which you had to read and then it takes concentration – but then you can have fun as well.
Issues	Usefulness to teachers The algorithm does not respond at very low wind speeds and blade angles. The teacher reported that it 'went to zero' although there should be some output, and this conflicted with what his students had found in practical situations using similar apparatus. T: Even though it was good and it was a valuable learning experience they are probably going to think 'Oh, I've done that' and may not have done everything they can do with it. Usefulness to students The sophistication of the algorithm, which allowed students to control many of the relevant variables, meant that students who had not yet developed the appropriate cognitive skills required teacher guidance. This was not evident in the instructions. O: Was it easy to work out what to do? S2: Some of them didn't realise that they could change the wind speeds of the different areas …
Summary The teacher was able to use and reuse this learning object effectively for higher-level learning. It is important that teachers using this learning object clearly state the required tasks and purpose and put the activities in context.	

Give me a brake

Title	**Give me a brake**
User level	Years 9; 10
Discipline	Science
Description	This learning object allows students to investigate braking efficiency of cars and trucks by testing stopping distances under controlled conditions. Students check the effects of vehicle type, road surface type, water and ice, and tread thickness. They set initial driving speeds and controlled variables, then apply brakes and compare stopping distances. Students judge distances from target markers and answer questions about anti-lock braking systems and actual speed limits.
Structure/type	Simulation
	Student activity: Interactives; Experiment; Analysis; Estimation **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Special features	
Learning purpose	**Topic:** Friction; Brakes; Water; Ice; Roads; Speed; Safety; Reflexes; Velocity units; Deceleration; Distances; Cars; Trucks; Wheels; Inertia (Mechanics); Momentum (Mechanics); Road vehicles **Content/concept:** Science: Motion; Quantitative data; Safety; Simple experiments **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 8, year 8, mixed-ability Science class 2. School 12, years 7–8, including students with very weak literacy skills
Used how	1. Students were given only a brief introduction. The learning object was one of a number of learning objects used by students during the lesson. No specific goal was set for them. 2. Students used a number of learning objects without specific

	direction. They were told to read the learning object instructions for themselves.
Strengths	Usefulness to students The learning object enabled students to undertake tasks that rely on fine motor movements or expertise with machinery. Students valued having side and top views. The sound effects were appreciated. Student learning process and outcomes Students liked having control of the settings so they could explore different combinations. They enjoyed using the learning object a number of times to observe different outcomes. S1: I would never get sick of them. S1: Because you can change its tyres and it is gravel and see when you are going to stop or not. Students were using the tool and unconsciously observing the outcomes. O: So when is it hardest to stop? S2: On the dirt, in the wet weather and icy. O: How do you know which is the hardest? S2: I don't know. The learning object prompted some students to engage in conversations critically relating the learning object outcomes to safety and driving from their experience. S3: 100 kilometres per hour. A truck shouldn't do that. S4: Yeah, they shouldn't. O: I thought their limit was 100. S2: Yeah, but when we were going up the Range in a VW [with] 80 tonnes of bark chips, we had all our brakes on and we were still doing 80 kilometres.
Issues	Usefulness to teachers Teachers and students both requested continuous speed settings rather than the 10km/h increments, which they found limiting. An error in the algorithm results in the three sizes of trucks having the same stopping speed. Usefulness to students The sophistication of the algorithm, which allowed students to control many of the relevant variables, meant that students who had not yet developed the appropriate cognitive skills required teacher guidance. This needs to be pointed out to teachers. Students commented that it would be good to have consequences for not stopping in time, such as damage to the vehicle.
Summary This learning object has the potential to be used in a number of ways. Clear goal setting by the teacher is likely to produce more valuable learning outcomes and allow the reuse of the learning object.	

It's a drag

Title	**It's a drag**
User level	Years 9; 10
Discipline	Science
Description	Students investigate the braking efficiency of cars and trucks by testing stopping distances under controlled conditions. They are able to check effects of vehicle type, road surface type, water and ice, and tread thickness. Students set initial driving speeds and control variables, then apply brakes and compare stopping distances. They answer questions about friction, tyres and driver fatigue.
Structure/type	Simulation
	Student activity: Interactives; Experiment; Analysis **Learning design:** Experiential learning; Independent learning; Problem solving; Visual learning
Special features	Capacity to specify a number of elements such as speed, road surface, vehicle, tyres – which are then used in providing experimental data
Learning purpose	**Topic:** Friction; Brakes; Water; Ice; Roads; Speed; Safety; Reflexes; Velocity units; Deceleration; Distances; Cars; Trucks; Wheels; Inertia (Mechanics); Momentum (Mechanics); Road vehicles **Content/concept:** Science: Motion; Quantitative data; Safety; Simple experiments **Skills/processes:** Analysis; Application; Comprehension; Knowledge
Used by	1. School 8, year 8 2. School 6, year 10 3. School 12, years 6–7 4. School 14, years 6–7
Used how	1. The teacher provided students with a brief introduction. This focused on locating the learning object and providing an overview of how it operates. No tasks were set. 2. The learning object was part of an integrated theme on road safety. A class webpage developed by the teacher contained a well-defined task. Students used this learning object in conjunction with an Excel spreadsheet to record findings. 3. Students used a number of learning objects without specific direction from the teacher. 4. Students worked in pairs for an hour on a number of learning objects. The teacher gave instructions on which learning objects to do and in what order. Students were told to read the learning object instructions for themselves. No specific goal was set for them.
Strengths	Usefulness to teachers The simulation provides opportunities to integrate Science teaching with meaningful Mathematics learning. The simulations have the potential to be adapted into Mathematics projects. The teacher participating in the study was intending to use the outputs of 'It's a drag' in this way. This teacher explained how she had met student resistance in teaching graphing (using Excel) until she linked it with this learning object. Another teacher proposed using the learning object along with other hands-on activities relating to friction, forces and surfaces. Teachers could also see how this could be part of a range of activities operating concurrently within a classroom. T: … whole series of workstations, well the computer could be a workstation … So I can see a lot of uses for that one.

	Usefulness to students Student choice and control was appreciated and appeared engaging. S: Yeah, like the weather and the car and that is good that you can change everything instead of just having the normal car or something. You can be a truckie. The learning object may have more appeal for boys than girls: S1: Well I guess boys like cars and stuff. Most students found the interface intuitive. Some suggested more developed graphics including video, several view points, more complex backgrounds, gory consequences and two vehicles racing together for comparison. Another student thought the graphic features were adequate: '… they were pretty much all you need for the game itself.' This is arguably true, given that more complication is likely to result in cognitive overload and loss of focus. Student learning process and outcomes The learning object enabled students to undertake tasks that rely on fine motor movements or expertise with machinery. A few students became thoroughly engaged in pushing the limits of the settings. Content was relevant predominantly to the intended age group, but it was perceived that relevance diminished among younger students. Boys seemed more engaged than girls and used riskier settings. Most students believed that the learning object was about stopping and that different conditions affect distances and safety.
Issues	Usefulness to teachers T: There is no humour as such. It is just very functional ... they might have someone actually run over … a cliff face … anything like that to make it a bit more edgy, to give the kids some additional motivation [to] try to stop or not to stop. Usefulness to students The sophistication of the algorithm in allowing students to control many of the relevant variables meant those who had not developed the appropriate cognitive skills required the teacher's guidance. Some students thought there was too much text. Others bypassed the text and used the controls immediately. Still others did not see the Challenge and Information buttons at the bottom of the screen. Students requested an animation from the driver's perspective and 3D graphics. Teachers and students requested continuous speed settings rather than the 10km/h increments that they found limiting. Student learning process and outcomes It appeared that many of the students were not systematic in their use of the learning object, so learning was not as focused as it might have been. This reflected the way they were introduced to the learning object and the open-endedness of the lesson. T: Learning? Not sure. About tyres. Not sure how to know whether they choose correctly. They are trying alternatives at random. They were using the speed dial to indicate how fast they stopped. They had not discovered the read-outs [on the left] of the screen. Little kids would have trouble with all the reading. Little kids would not be able to read the buttons. S: Could do better graphics – better background. The trees could move. Could have animation when the skid happens – dust. Students in two schools noted that the three sizes of trucks had the same stopping speed. They suggested that challenges would make it more

	interesting and hadn't noticed the Challenge button at the bottom of the screen. Students coming up for their driving test believed it was meant to alert them to safety issues but felt it was too divorced from reality to be truly useful in helping them react. This suggests the learning object was being used thematically or culturally rather than conceptually.
Summary This learning object has the potential to be used in a number of ways. Clear goal setting by the teacher is likely to produce more valuable learning outcomes and allow the reuse of the learning object.	

The alpha, beta, gamma of radiation

Title	**The alpha, beta, gamma of radiation**
User level	Years 9; 10
Discipline	Science
Description	Students test different kinds of radiation with a range of substances and at a range of distances.
Structure/type	Simulation
Learning purpose	Investigate different kinds of radiation
Used by	School 3, year 8 gifted stream
Used how	This learning object was embedded in a lesson. The aim was to discover the inverse-square rule for strength of radiation over distance. The teacher conducted a real demonstration of measuring radiation at different distances and students were encouraged to predict the rule. The learning object was to be used to provide data for establishing the rule.
Strengths	Usefulness to teachers The learning object provided new ways to investigate dangerous substances. The experiments with the learning object were also easier to set up and maintain. The learning object provided a powerful algorithm that incorporated random variation to make more realistic and sophisticated data collection possible. The simulation provided opportunities to integrate the Science teaching with meaningful Mathematics learning. It tested the ability of students (and teachers) to set important variables to create 'fair tests'.
Issues	Usefulness to students Access to the Internet was unexpectedly closed down so students could not use the learning object. Values were hastily provided for the students manually and the lesson proceeded. There was no capability to transfer data from the learning object to third party programs such as Excel. Student learning process and outcomes The different thicknesses of paper, smoke and lead are misleading, as results should be given for materials of the same thickness. The underlying algorithms are sophisticated as the learning object allows students to control many of the relevant variables. This means that students who have not developed the appropriate cognitive skills require teacher guidance.
Summary This learning object is well designed. It can therefore be used in a number of ways, according to the discretion of the teacher. A well-defined context and task are required for best results.	

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