Interactive QuickTime: Developing and evaluating multimedia Learning Objects.

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Abstract

This thesis discusses the application of Learning Objects in supporting the teaching of principles of Audio Engineering - a subject traditionally taught face to face utilizing specialized audio equipment. Current educational thought postulates that Learning Objects can provide the basis for reusable, pedagogically rich learning environments. The project tested these assumptions and demonstrates design and evaluation principles that can be utilized in developing Learning Objects to meet the goals of providing reusable and pedagogically rich learning environments within such a traditionally face-to-face taught discipline.

This research project employs an action research method implemented over a period of two years and involved developing and piloting multimedia Learning Objects during this time. It is informed by current research and implements instructional design principles to enhance learning via multimedia Learning Objects, within two different Audio Engineering contexts, demonstrating their reusability.

The thesis also focuses upon the application of the multimedia architecture 'QuickTime' - which was chosen because of its cross-platform capability, multi platform delivery and scalability (Internet, CD-ROM, Hard drive...), ease of authoring, high level of interactivity possible, and excellent audio capabilities. The insights gained from developing and evaluating several interactive Learning Objects using QuickTime are highlighted.

The Learning Objects are evaluated using a modified version of the MERLOT evaluation criteria that provides an overall ‘rating’ as a quick guide to the quality of the Learning Objects. The Learning Objects received ratings from 3.95 to 4.27 on a scale of 1 to 5. Qualitative feedback from the evaluators indicated that interactivity and embedded assessment within Learning Objects are highly valued.

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1. Introduction

1.1 Defining Learning Objects

While definitions are varied, most researchers and practitioners would agree that Learning Objects are meant to enhance learning and to be reusable within a range of learning contexts. They are usually interactive digital resources illustrating one or a few interrelated concepts. They are small in size, but contain enough content and context to make them pedagogically useful. This project uses Wiley's definition of Learning Objects as a basis:

> Learning Object: Any digital resource that can be reused to support learning. The term "Learning Objects" generally applies to educational materials designed and created in small chunks for the purpose of maximizing the number of learning situations in which the resource can be utilized (Wiley, 2002, pg. 1).

1.2 Why Learning Objects?

Learning Objects are the descendants of the computer mediated learning (CML), and interactive multimedia movements (IMM). The late twentieth century educational environment was filled with expectation at how CML and IMM would revolutionize learning. The reality was that the cost of producing highly interactive CD-ROMs and online courses was in most cases prohibitive. CD-ROMs went out of date almost as soon as they were produced, and were often far too context specific to be reused in other learning environments than the specific one they were designed for. While moving away from these initial behemoths the last few years have seen the anticipation of how small, interactive, reusable Learning Objects will bring the cost of education down while increasing quality and access. Those with the biggest stake in the funding of education (governments and large multinational private companies) have encouraged research into the area of Learning Objects. The New Zealand government has provided significant funding for collaborative projects between tertiary education institutions in the broad area of elearning. Developing expertise in this area is seen as a way of competing in the global education market for a geographically isolated country such as New Zealand.

The vision of the Learning Object economy (Downes, 2003; L. Johnson, 2003) is one where, instead of constantly re-inventing the wheel, educators can access shared online libraries of quality interactive Learning Objects to enhance the delivery of their courses, and the quality of the learning experience for their students. While progress is being made, the dream is still to be realized in any major way, but it is a dream worth pursuing.

1.3. The Audio Engineering Context

Coming from a background of teaching Audio Engineering, the researcher was interested in exploring the potential of Learning Objects within this field. A search of Learning Object repositories, and the Internet, reveals there is a lack of quality multimedia learning resources for key Audio Engineering concepts, although some do exist (SAE Institute, 2001). Most relevant resources are text and audio based only. Online (Hambly, 2002) or CD-ROM examples provide little more than replacements for textbooks, although they do usually contain audio examples (Everest, 1997). There are a couple of notable exceptions (G. Neumann, 1996; Sides, 1995), however, these are large resources that were not designed as Learning Objects. Some resources are outdated, both technically and in content, while most resources focus upon text or audio examples only, with little user interactivity. Some online examples (Gibson, 2000; Mellor, 2001, 2003) do , however, provide facilities for email and discussion group support for students. In general these resources are designed as complete unique packages or courses, and have not been designed for re-purposing in other learning contexts. The quality of available Learning Objects for this context is low, and the general mode for learning the principles of audio engineering is still an on-campus/site hands-on approach.

1.4. The Research Objective

There is a gap between theory and practice in the use of Learning Objects in Tertiary education. Most research has focused on defining Learning Objects rather than practical design and implementation. As a result the overly hyped Learning Object economy has yet to be realized.

> During the Middle Ages, theologians and philosophers spent large amounts of time debating the precise number of angels that could dance on the head of a pin.

> The early Learning Object movement has spent similarly large amounts of time debating what the correct definition of a Learning Object should be (Roy, 2004b, pg. 1).

As an example, a search of MERLOT (1997) members shows that most of the key researchers in the field of Learning Objects (E.g. Wiley, Downes, Nesbit, Metros etc…) are listed as members and have roles as experts and reviewers. However, few of these experts have authored or submitted multimedia Learning Objects to the MERLOT database. Their objects may be in other databases or elsewhere that are not open to public access. However, we could ask: Where are the research-informed examples of quality multimedia Learning Object development and implementation within tertiary education?

The objective of this research was to bridge the gap between Learning Object theory and practice by utilizing established instructional design principles to produce quality interactive Learning Objects. These resources are intended to support both distance and face-to-face learning. By using Learning Objects the learning context and outcomes will be able to be modified by educators to suit the needs of different users.

The study attempts to break new ground within the context of Audio Engineering, moving beyond the established instructional pedagogy usually employed to teach basic concepts, and places interactive Learning Objects within a constructivist pedagogy.

Because the research is interested in producing change and creating usable Learning Objects the best research method fit is that of participatory action research (Wadsworth, 1998). The research report will serve as an investigation and summary of the current state of Learning Objects in tertiary education as well as a template for those who would like some practical guidelines for creating quality Learning Objects.

1.5. Research Participants

Two distinct groups of users were targeted to test the reusability of the Learning Objects: Audio Engineering tertiary tutors and their students (at MAINZ – the Music & Audio Institute of New Zealand, where the researcher taught during the implementation of this research), and Church Sound Engineers.

The first group of users (MAINZ Tutors and their students) encompasses a range of Audio Engineering related courses from Certificate of Foundation Studies in Music – Level 3, to Diploma of Audio Engineering – Level 6. Tutors from each of these different courses with different curricula and levels evaluated the Learning Objects, and thus provided an indication of the reusability of the Learning Objects within these different learning contexts.

The second group of users (Church Sound Engineers) consisted of representatives from five medium to large contemporary church congregations throughout Auckland. This group was chosen as it has been noticed that there is a lack of part time or flexible training opportunities for Church Sound Engineers in New Zealand. Appropriate Learning Objects could help fill this gap. These users are employed in a variety of professions, and generally take on the responsibility of operating their Church's sound equipment voluntarily. This group has different learning needs and demands than the fulltime on campus MAINZ students. Their goals were oriented towards gaining practical skills for a specific situation (sound for Church Services) rather than meeting the demands of a tertiary curriculum like the MAINZ students, and do not have the benefit of expert tuition or student peers.

The research involved designing and delivering, to these distinct groups of users, several appropriate Learning Objects. The users evaluated each Learning Object, over the period of a semester. Data collected from these evaluations was used to inform the development of new Learning Objects to be evaluated in the following semester by the same groups of users. There were four iterations of design, delivery and evaluation over the period of the study. The project provided reflective feedback from the target users for modification and development of the resources. The evaluation tool was developed utilizing the MERLOT (2000) peer review evaluation criteria. Evaluations of the Learning Objects were obtained form all key stakeholders in a participant-oriented approach.

As an extension of the research project, the Learning Objects were made available over the Internet for evaluation by several international experts, and were also contributed to the MERLOT repository for review. Unfortunately the MERLOT peer review process can take considerable time. At the point of writing, the Learning Objects have been accepted for review but no ratings or comments have yet been received from MERLOT evaluators.

1.6. The Learning Objects

The Learning Objects are delivered on CD-ROM, with links to a dynamic website for web-based versions plus additional material and evolving content. Authoring applications included: LiveStage Pro, Flash, QuickTime Pro, Dreamweaver, HMTL, JavaScript, Macromedia Freehand, Adobe Photoshop, and Final Cut Pro. These were chosen as the researcher is competent in utilizing them, and they provide scalability for repurposing Learning Objects for delivery via different mediums.

1.7. Research Questions

The following research questions are used as a basis for exploring the potential of Learning Objects within Audio Engineering.

(1). What are the key factors in designing Learning Objects that are reusable for learning concepts in Audio Engineering - a discipline that traditionally teaches these concepts in a 'face-to-face' 'hands-on' mode?

(2). To what extent can these Learning Objects support learner interactivity and interest, and thus provide pedagogically rich learning environments that engage and motivate the learner?

2. Literature Review

2.1. Learning Objects

"… a Learning Object is defined as any entity, digital or non-digital, that may be used for learning, education or training." (LTSC, 2002)

"Learning Object: Any digital resource that can be reused to support learning. The term 'Learning Objects' generally applies to educational materials designed and created in small chunks for the purpose of maximizing the number of learning situations in which the resource can be utilized." (Wiley, 2002, pg. 1)

As a relatively new concept within education, Learning Objects are the subject of debate regarding their definition. Wiley criticizes the LTSC (Learning Technologies Standards Committee) definition of Learning Objects for being so broad that it encompasses the whole universe (Wiley, 2000a). Most definitions focus upon digital Learning Objects, due to their ease of distribution and reusability. Douglas (2001) describes Learning Objects as small independent learning components that have metadata, and can be used individually or combined and modified for multiple purposes. These are basically 'building blocks' for instruction (Gibbons, Nelson, & Richards, 2000). Such broad definitions of Learning Objects have led to the Lego block analogy, small components that can be combined to create a larger unit. However, many people argue that Learning Objects must have a context and implicit or explicit pedagogy for them to be classified as Learning Objects rather than simply 'information objects'.

Wiley (1999) prefers an 'atom' analogy that emphasizes the context element of Learning Objects. Just as only certain atoms can combine with other atoms to form specific molecules, so there must also be design in the combining of Learning Objects. A Learning Object's context will determine its level of compatibility with other Learning Objects. Wiley (2000a) has proposed a taxonomy of Learning Objects, defining five types of Learning Object, classified according to their level of functionality:

1. Fundamental Learning Object
2. Combined-closed Learning Object

3. Combined-open Learning Object
4. Generative-presentation Learning Object
5. Generative-instructional Learning Object.

The Fundamental Learning Object is equivalent to what Wiley and other authors refer to as 'information objects', these can be as basic as a simple picture of an item and are comprised of a single media element. The combined Learning Objects are made up of several media elements, while the generative Learning Objects rely on intelligent programming that responds to user input. Closed Learning Objects contain preset media and information, while open Learning Objects are customizable. Wiley excludes Learning Objects that are not designed for reuse, such as complete digital books or other material that cannot be used beyond its original context. Wiley's definition of Learning Objects has received wide acceptance.

In her definition of Learning Objects, Metros emphasizes the 'learning' aspect of Learning Objects. "Learning Objects often are confused with information objects. True Learning Objects include Learning Objectives and outcomes, assessments, and other instructional components, as well as the information object itself" (Metros & Bennett, 2002, pg. 3). Metros elaborates further on her definition of Learning Objects:

> Instructors are comfortable incorporating audio/visual resources, readings, guest lectures, and other instructional activities into their traditional classes. Learning Objects are the new and improved, digital version of these activities. If designed within a sound pedagogical framework, Learning Objects can be accessed from anywhere at any time. Instructors can create an engaging experience by using Learning Objects in an interactive context. (Metros & Bennett, 2002, pg. 8-9)

Embedding formative or summative assessment within Learning Objects is an important way of focusing on the Learning Objectives of the Learning Object and providing the user with feedback on their understanding of the concepts. This is similar to Biggs' concept of course alignment, "We have first to be clear about what we want students to learn, and then teach and assess accordingly in an *aligned* system of instruction" - cited in (Biggs, 1999).

Bringing these ideas together: a Learning Object is a digital resource that ideally covers one main concept, and can be used within different learning contexts that are related to the basic information context of the Learning Object. A useful graphical outline of concepts and relationships surrounding Learning Objects has been created by the NLII Learning Objects Working Group (Dagefoerde, 2003b). Dagefoerde describes the diagram as a Learning Objects 'Ontology' (Dagefoerde, 2003a). The ontology's main benefit is in the breaking down of associated issues into manageable chunks.

Aspects of Learning Object design that have been the subject of recent research include: reusability, metadata standards, Learning Object repositories, reworking instructional design principles for applying to Learning Object design, the relationship between multimedia and Learning Objects, and software tools for creating Learning Objects.

2.2. Reusability

Reusability is the ability to use a Learning Object within different learning contexts. Since 2000, reusability of Learning Objects has become a major focus of their development. Wiley is a key researcher in the area of Learning Object reusability and maintains a website resource devoted to discussing issues of Learning Object reuse (Wiley, 2000b). The Centre for Learning and Teaching Through Technology (University of Waterloo, 2003) provides a brief description of the benefits and strategies for reusing Learning Objects and is a good introduction to this topic. The ability to reuse Learning Objects within different learning contexts is a central defining factor that differentiates Learning Objects from other learning materials. Several studies emphasize the need to plan for reusability in the earliest stages of Learning Object design (Boyle, 2002a; Currier & Campbell, 2002; Hawryszkiewyez, 2002; McNaught, Burd, Whithear, Prescott, & Browning, 2002).

Research has focused upon the need to create Learning Objects that are small enough to enable re-purposing, while retaining enough context information to remain educationally useful. Johnson describes this as an "inverse relationship between context and reusability" (L. Johnson, 2003). This size/scope relationship has been given the term 'granularity' (Wiley, Gibbons, & Recker, 2000). Granularity refers to the size of a Learning Object. Smaller Learning Objects contain less context specific information and are therefore more granular or reusable. South and Monson (2000) provide a useful explanation of the granularity of

Learning Objects, defining a 'learning threshold' and a 'context threshold' within which Learning Objects sit. They describe the trade-off for achieving useful granularity as the increased need for metadata and storage requirements. South and Monson also provide an economic argument for the reusability of Learning Objects. Although the initial development cost of Learning Objects is high, the ability to reuse these objects across a wide range of courses, and the ability to repackage Learning Objects for distance delivery courses, ultimately will save money. This is why large multinational corporations with in-house training programmes are very interested in Learning Objects. For example, Cisco Systems has done significant research into utilizing Learning Objects for training their employees.

> By leveraging Learning Objects in newly expanded learning approaches, such as guided discovery and exploratory, Cisco offers examples of ways in which learners may access more flexible and sophisticated resources to meet their learning needs and business goals. The guided discovery approach, in particular, provides real-world, problem-based learning experiences that can be delivered to busy, results-oriented knowledge workers, wherever and whenever they choose. Cisco plans to engage learners and ensure their success throughout the future learning experience for employees, customers, and partners (Cisco Systems, 2003a, pg. 27).

Acker makes an analogy with the current success of the Apple Computer's iTunes store and Learning Objects in education.

> Just as Apple Computer's micro-pricing of songs in its iTunes Music Library intermediates a more user-centric value proposition than pre-packaged CDs, Learning Objects are better adapted to serve individualized delivery preferences of Faculty, focus the attention and fiscal resources of students more successfully than the textbook, and offer rich new ecologies of learning for both (Acker, Pearl, & Rissing, 2003, pg. 2).

The marketing power is in the flexibility and value for money offered to the end user. Acker also notes that the breaking down of learning environments into bite sized chunks meets with resistance from some faculty members. Faculty "fear the deconstruction of their roles into: knowledge creation, knowledge packaging, knowledge delivery, and student assessment"

(Acker et al., 2003, pg. 2). However, he argues that this does allow faculty to become instrumental in tailoring education for individual students and providing a higher quality learning experience.

Downes (2001) makes an argument for the potential of Learning Objects to revolutionize tertiary education. He questions the need for the traditional delivery of courses to constantly recreate themselves in the name of academic integrity rather than utilizing more effective teaching methodologies. He calls his vision one of a Learning Object economy.

> The question is: could we teach first-year English using "Hamlet" modules? Could we reduce the cost of such learning by an order of magnitude? Are the endless creations of professors necessary for the eventual goal of cultural literacy? Is it reasonable to deny such an education (especially in less developed nations) in order to generate each course anew each year in each university classroom? (Downes, 2001 , pg. 9)

A recent collection of articles (Littlejohn, 2003b) discussing the reuse of Learning Objects focuses on seven issues:

1. How can digital resources be used to support learning?
2. How can resources be reused within a range of educational models?
3. Why is standardization necessary?
4. Is there an optimum size for reusable resources?
5. Should resources retain contextual information?
6. How are educational institutions likely to change?
7. Is global sharing of resources a possibility?

The Journal of Interactive Media in Education (JIME) has used Littlejohn's collection to facilitate reflection on the issues surrounding Learning Objects. JIME have published a special edition of the book online along with invited commentaries (Littlejohn & Buckingham Shum, 2003). The topics and discussion generated illustrate the current importance attached to the issues regarding the reusability of Learning Objects.

2.3. Metadata and Repositories

Metadata is descriptive information about the Learning Object, requirements, author, copyright, etc. Metadata standards have been developed by several international organizations, and there is on-going collaboration to make these standards inter-operable. For Learning Objects to be re-purposed, they need to be catalogued according to content and context within a standard 'library' format. This information is needed so teachers and students can search for and find appropriate Learning Objects. Metadata allows Learning Objects to be correctly catalogued within Learning Object repositories. Learning Object repositories are libraries of either actual Learning Objects or databases of hyperlinks to catalogued Learning Objects.

Standard descriptors for Learning Objects have been defined by several standards organizations. One of the oldest is the Dublin Core Metadata Initiative (DCMI, 2003). It was started in 1995 at a workshop in Dublin (Ohio), is based on an international academic community, and attempts to liaise with other metadata initiatives. Various templates are available for creating Dublin Core metadata, e.g. (Koch & Borell, 1997). This template is a convenient online html form for generating metadata in the Dublin Core format. The Instructional Management Systems project (IMS Global Learning Consortium, 2003) was established in 1996 for setting standards and specifications for learning technologies within US higher education. The Learning Technology Standards Committee (LTSC, 2003) was established in 1996 by the IEEE Computer Society Standards Activity Board to develop and recommend standards for learning technology. In particular they have developed the LOM - Learning Object Metadata specification (LTSC, 2001).

In 1999 the United States Department of Defense commissioned the Advanced Distributed Learning initiative to integrate the various developing standards for technology-based learning. This resulted in the Sharable Content Object Reference Model (SCORM) (Advanced Distributed Learning, 2004). The purpose of SCORM is to promote the development of Learning Objects and individualized learning technology, as this is believed to "enhance learning experiences while improving efficiency and reducing costs" (Advanced Distributed Learning, 2004).

Recent standards developments include integration with learning management systems that have previously only supported proprietary standards (CETIS, 2003; Currier & Campbell, 2002). CETIS (the Centre for Educational Technology Interoperability Standards) provides a link between standards organizations and United Kingdom higher education and further education institutions. Their website provides many useful links regarding metadata standards, an easy to understand background on learning standards, and a useful encyclopedia of learning standards acronyms. Metadata standards are not a major focus of this research, however, a standard template (Koch & Borell, 1997) was utilized to provide appropriate metadata for all Learning Objects created as part of the project.

Learning Object repositories are designed to facilitate access to Learning Objects. They generally consist of online searchable databases and often include evaluations of Learning Objects in their collections. A useful collection of links to online Learning Object repositories is hosted by the University of Alberta (Academic Advanced Distributed Learning Co-Lab, 2004). The site also provides a brief description and overview of each repository, giving a good comparison of each. One of the most established Learning Object repositories is the Multimedia Educational Resource for Learning and Online Teaching (MERLOT, 1997). Another popular repository is the World Lecture Hall (University of Texas, 2001). EdNA (Education Network Australia, 2004) is a large Australian-based repository. Most repositories are open to the international academic community, but may restrict submission of content to members of a particular institution (CAREO, 2003; Maricopa Center for Learning and Instruction, 2004). Some repositories are regionally based, e.g. COHERE, (2003); eduSource, (2003). Some smaller collaborative repositories focus on developing resources among a particular group of institutions. The Canadian based Co-Operative Learning Object Exchange (CLOE, 2003) is a collaborative project between sixteen Ontario universities. However, the CLOE administrators were happy to supply logon access to the researcher upon email request. CLOE has recently become a sub-community of the MERLOT consortium.

2.4. MERLOT

MERLOT is establishing itself as head and shoulders above most other Learning Object repositories. MERLOT is an open, online repository for Learning Objects and course modules and is based on scholarly peer review principles. MERLOT contains over 10000 listings from a wide range of disciplines. Membership is free, and members can contribute and evaluate

Learning Objects. When contributing material to MERLOT, the user fills out a short form that generates metadata conforming to the IMS and IEEE LOM standards.

One of the most recent developments is the movement towards integration of online course management systems (such as Blackboard) and access to Learning Object repositories. Blackboard is one of the most widely used course management systems worldwide. Blackboard has announced the establishment of a partnership with MERLOT, where MERLOT has joined the Blackboard building block developers group. Building blocks are add-on modules that add extra functionality to Blackboard. According to the news release: "The first Blackboard Building Block to be released will be a portal module that uses RSS content syndication to aggregate news about and links to the learning resources most recently added to MERLOT" (PRNewswire, 2004). The report also mentions: "MERLOT will develop a Blackboard taxonomy within the MERLOT learning directory, making it easier for MERLOT users to identify Blackboard-specific training materials". This last development has some academics worried that the MERLOT-Blackboard partnership may result in a non-open specification (Downes, 2004). Downes (2003) describes such agreements as a "closed marketplace". Providing ease of access and an integrated approach to sharing Learning Objects is a positive step, as long as it is not limited to specific commercial software.

2.5. Learning Object Development

As the research project is focused upon the educational design of Learning Objects, an investigation into instructional design principles was included. While there is a great body of research applied to traditional instructional design, there is relatively little research specific to design principles for Learning Objects. Wiley emphasizes the need for instructional principles "it is likely that the combination of Learning Objects in the absence of any instructional theory will result in larger structures that fail to be instructionally useful" (Wiley, 2000a, pg. 18). Instructional designers need to rethink their design methodologies when approaching Learning Object design. "There are relatively few studies and tools relating to the systematic analysis, design and documentation that should precede construction and delivery…" (Douglas, 2001). Ramsden summarizes teaching as "the nurturing of student learning" (Ramsden, 1992, pg. 166), and "a process aimed at changing student conceptions". Instructional design strategies need to facilitate this nurturing and conception change (Ramsden, 1988, pg. 21). Merrill notes that "theory building is our puny attempt to

understand our world by inventing artificial systems and trying them against our world… learning theories tend to explain how persons acquire and store knowledge, but they have very little to say about how an instructor should structure and sequence knowledge to promote efficient and effective learning" (Merrill, 1994, pg. ix).

Instructional design attempts to bridge this gap between theory and practice. Instructivist approaches are illustrated by Gagne's nine events of instruction, and concept of learning hierarchies (Gagne, Briggs, & Wager, 1992). Bloom's taxonomy (Bloom, 1956) is often used as a guideline for creating Learning Objectives for courses and is equally useful for Learning Objects. Constructivist approaches to teaching include problem-based learning (Moursund, 2003) and learner-centred teaching. Weimer (2002) describes five key changes to teaching practice in learner-centred teaching: the balance of power, the function of content, the role of the teacher, the responsibility of the learner, and the purpose and process of evaluation. Simulation based Learning Objects (Pappo, 1998) are often the best approach for technical subjects such as Audio Engineering (Sweller, 1999). Learning Object design is a subset of multimedia design (Gayeski, 1993; Schwier & Misanchuk, 1993) and e-learning (Salmon, 2002). Instructional design strategies from these two fields can be mined for Learning Object design.

A Learning Object designer's pedagogy will influence the decisions they make while developing Learning Objects. "Learning theories and epistemological assumptions of different instructional design paradigms are tools which educators can use to make informed instructional decisions as they undertake the task of developing curricula and designing instruction" (Vrasidas, 2000, pg. 14). "The design of IMM has many facets, not least of which are the pedagogical and epistemological views of the teacher or lecturer" (Kennedy & McNaught, 1997). While Learning Objects lend themselves to constructivist environments (Bannan-Ritland, Dabbagh, & Murphy, 2000), insights from other paradigms should not be overlooked. "Web-based education demands a well-prepared, thoughtful, and creative course design. A blend of objectivist and constructivist teaching methods is the best approach to instructional design" (Ritter, 2004, pg. 2). "The authors of this book see meaningful roles for both directed instruction and constructivist strategies and the technology applications associated with them; both can help schools meet the many and varied requirements of learning" (Roblyer & Edwards, 2000, pg. 49).

Informed teachers' develop their own pedagogy as a synthesis of various pedagogical models - choosing the aspects that align with their own learning and teaching style, and their developing understanding of the learning environment. This comes from reflecting upon their teaching experiences, and aligning this with current learning theory. The key is for the teacher/designer to recognize the strengths and weaknesses of their assumptions. There have been three key influences in the development of the author's pedagogy: (1) Constructivist learning theory, (2) Biggs – concept of constructive alignment (Biggs, 1999), (3) Diana Laurillard's Conversational Framework (Laurillard, 2002). These three have resonated with the author's personal experiences of teaching and learning, in particular in utilizing technology to enhance the learning environment for the teacher and students.

Williams (2000) argues that evaluation of Learning Objects should parallel development. He argues for a participant-oriented approach to evaluation. He then embeds these evaluation processes within the ADDIE development model (Assess needs, Design, Develop, Implement, and Evaluate instruction). This is a very useful approach, as many instructional designers and faculty have used the ADDIE model as part of their course design toolkit. Repurposing a development model for use in developing Learning Objects will provide a familiar scaffold for designers and faculty as they move towards Learning Object design. Williams also argues that evaluation of Learning Objects should be both 'external' and 'internal' – a similar concept to internal and external moderation of course materials.

Downes argues for a performance-based approach to Learning Object design, matching defined learning outcomes. "Specifically, the content of a Learning Object would be derived from a discussion of a course's (or lesson's) Learning Objectives, where the achievement of these outcomes can be measured in terms of students' performance. In sum, the overall content of a Learning Object would be similar in scope and nature to the content of a typical lesson" (Downes, 2001, pg. 7).

Multimedia design has a symbiotic relationship with Learning Object design. Learning Objects can be viewed as small interactive multimedia elements. The Learning Objects developed and delivered in this research project are digital and software based. Because multimedia has long been used to enhance education, there is plenty written on design principles for creating interactive multimedia (Boyle, 2002b; Brown, Green, & Zatz, 2001). Boyle (2002a) suggests principles from software engineering that can usefully be applied to

the design of Learning Objects: (1) cohesion - each unit should do only one thing - i.e. only cover one Learning Objective. (2) De-coupling - Learning Objects should not have dependencies upon other Learning Objects. Each Learning Object should be capable of being used independently. (3) Repurposable - Learning Objects should be pedagogically rich and able to be adapted by others. Boyle observes that multimedia objects have the potential to provide a constructivist learning environment, including learner control of pacing, visualization of abstract concepts, interactive feedback and student scaffolding. These insights guided the design aspects of this research project.

Boyle also attempts to establish a formal theory for educational multimedia design, employing proven strategies for promoting effective learning (Boyle, 2002b). While not achieving this goal, he does produce some useful practical guidelines as part of a Learning Object development case study (Boyle, 2002a). Boyle emphasizes that Learning Objects should be: pedagogically rich and effective, theoretically informed (from learning theory etc…), and empirically grounded.

Several authors have produced relatively practical guidelines for developing Learning Objects. Learning Object development involves: planning, instructional design, multimedia authoring, evaluation, assessment design, assigning metadata, and distribution (uploading to repositories). Polsani comments on the composition of Learning Objects:

> The formal composition of a LO is the arrangement of elements. An element could be text, image, video, animation, glossary, assessment, multimedia, etc. Preferably a LO should be a combination of multiple elements. The multiplicity not only reinforces the concept communicated, but it also opens up multiple avenues to foster a richer understanding of the idea(s) represented, facilitating learning based on learners' choices and learning characteristics (Polsani, 2003, pg. 5).

The New Media Consortium has recently published some useful Learning Object development guidelines (Smith, 2004). Smith covers the following topics:

- Designing to enable learning
- Designing the learner's experience
- Designing for accessibility

- Designing for reusability
- Designing for interoperability: adding metadata
- Where to start? Gathering requirements
- Choosing a technology and development tools

Cisco Systems has produced a useful resource titled "Reusable Learning Object Authoring Guidelines: How to Build Modules, Lessons, and Topics" (Cisco Systems, 2003b). This is a very practical resource that gives hints for defining learning goals and outcomes for Learning Objects.

2.6. Barriers to Learning Object Implementation

Lamb cites the main barriers to Learning Object implementation as: a lack of embedded pedagogy, intellectual property issues, and faculty workload (Lamb, 2003). Without significant embedded pedagogy Learning Objects become merely information objects and require more work from educators to create a Learning Objective. Many educators are reticent to share the resources that they have painstakingly developed, often for no reward apart from the fulfillment of doing so. Until Learning Object repositories have sufficient procedures for attaching intellectual property data to Learning Objects sharing of these resources will be limited. Some institutions approach this by creating locally accessible repositories, however, this severely reduces the ability to share these resources worldwide.

A 2002 survey (Barron, 2002) of 143 international training and elearning professionals indicated that the top two barriers to adoption of Learning Objects were: budgeting considerations, and the immaturity of Learning Object approaches. The design and development of Learning Objects is time consuming and therefore costly. Learning Object design is limited by the tensions between: reusability, granularity, context, and pedagogy, all which increase development time and cost. The quality of Learning Objects is also an issue. Low quality resources that students find unattractive or boring will not be reused. A team approach to Learning Object development will mean subject experts do not also need to be multimedia development experts. The limitations of development tools and current models of learning design are also barriers (L. Johnson, 2003).

Learning Objects have also been associated with instructional pedagogy and therefore been seen as limited to lower level courses. Wiley (2000a) argues strongly against the simple association of Learning Objects with 'knowledge objects' (made by researchers such as Merrill). Wiley argues for the ability of Learning Objects to support constructivist pedagogies, by defining a taxonomy of Learning Objects, illustrating the range of pedagogies that Learning Objects can be designed to support.

Overly detailed metadata requirements present time consuming barriers to authors and submitters. Metadata requirements need to be finely balanced to encourage their use. Finding quality Learning Objects can be an arduous task, but attaching evaluations to Learning Objects can save a lot of search time.

2.7. Evaluating Learning Objects

While there is much hype surrounding Learning Objects, well-developed evaluation practices are needed to quantify their actual benefits. The pedagogical usefulness of Learning Objects is a major concern of researchers (Wiley, 2000a, 2000b; Williams, 2000) and well developed evaluation processes need to be defined to measure this. One of the most mature approaches to evaluating Learning Objects is utilized by the MERLOT repository. The MERLOT Peer review process is modeled on the scholarly peer review process of peer reviewed journals (Hanley, 2003). The goal of adopting this approach to evaluation of Learning Objects is to encourage the adoption of Learning Objects within the higher education community. The MERLOT repository is divided into several subject categories/communities, with an editorial board for each category. Experts in each field are allocated to review submitted Learning Objects within each category. MERLOT members who are not assigned as peer reviewers can make members comments and evaluations of the Learning Objects as well. The result of the peer review process is a rating from one to five, plus comments for every Learning Object reviewed. The rating scale represents the following:

1. Materials not worth using at all.
2. Materials do not meet minimal standards but there might be some limited value.
3. Materials meet or exceed standards but there are some significant concerns.
4. Materials are very good overall but there are a few minor concerns.
5. Materials are excellent all around.

The ratings are used to give preferential listing in searches of the MERLOT repository, and provide users with a quick idea of the quality and usefulness of a Learning Object. Learning Objects with review grades of less than 3 are not displayed.

MERLOT has established generic peer review evaluation standards and guidelines (MERLOT, 2000). Because it is recognized that Learning Objects are developed and used within certain contexts, these contexts must be explicitly described when authors submit Learning Objects, and when reviewed. In other words, the context in which the Learning Objects are evaluated may be different to the context within which they were developed, and will impact upon the rating given, so the review context must be made clear within the review comments. The MERLOT evaluation questions fall into three main categories: (1) quality of content, (2) potential effectiveness as a teaching-learning tool, (3) ease of use. Bennett & Metros (2001) have created an evaluation checklist based on the MERLOT review criteria that makes the review process more accessible.

A criticism of the MERLOT evaluation process (MERLOT, 2001) is the small percentage of peer reviews actually conducted, and the apparent bias in the selection of submitted Learning Objects for review. At the time of writing, the MERLOT collection included 10607 Learning Objects, with a total of 1357 receiving peer reviews (12.8%), of which 1041 (76.7% of those actually reviewed) received peer ratings of 4 or higher. Each community editorial board handles selection of Learning Objects for review, but there are no explicit criteria for this selection. Higher quality Learning Objects take precedence in the queue for receiving reviews, but this is also apparently subject to the editorial boards areas of main interest. Some submissions appear to receive reviews almost immediately, while others sit in the queue for months or indefinitely. The number of peer reviewers currently available also limits the peer review process.

The CLOE project is another example of a well-designed Learning Object evaluation process. Their Learning Object review process is also based on peer review (CLOE, 2004).

As well developed as they are, the peer review approaches to Learning Object evaluation fall short of giving a complete evaluation of Learning Objects as they take into account only one category of stakeholder, and they are time consuming. Nesbit (Nesbit, Belfer, & Vargo, 2002) presents a review of Learning Object evaluation models, including the MERLOT peer review

process. One review methodology that has shown a lot of promise, and is cheap to implement are the popular web user reviews.

> In the search for an efficient model that preserves many of the advantages of participant-oriented approaches, we were impressed with many of the interactive tools for communication and collaboration provided in online communities. By supporting voluntary contributions from users with automated functions, these websites demonstrate the strengths of technology-mediated communities managed by their members (Nesbit et al., 2002 , pg. 3).

The downfall of this approach is the lack of expert and critical reflection that peer reviews can provide. Also these user reviews rely on high volumes of users to generate these reviews. Nesbit et al present a new model emphasizing the participation of all key stakeholders in a two-cycle process. These stakeholders include the developer, the teaching faculty, their peers, and the end user (often students).

> Unlike journal articles written by and for academic researchers, Learning Objects are created by teams of various types consisting of faculty, instructional designers, media developers and programmers; and they are used by instructors and students. As we have discussed earlier, assessment models that include representative participation from all stakeholder groups are far more likely to result in valid evaluations (Nesbit et al., 2002, pg. 4).

As always, the trade-off is between the quality of the evaluation process and the cost and time involved in its implementation. Nesbit argues for an evaluation process that involves representatives from all stakeholders, and is embedded within the development process of the Learning Objects. This is a development of Williams' participant-oriented approach to evaluation mentioned above (Williams, 2000). This evaluation process is very similar to the approach taken by this research project. In Nesbit et al's model, a panel of evaluators is composed of representatives from all stakeholder groups. The first phase of the evaluation is undertaken independently and results collated by a moderator, while the second phase takes place in a panel situation with all evaluators discussing the evaluation of the Learning Objects together. This is very similar to convening a focus group of evaluators. The difference, and the danger, is that a consensus ('convergence') of opinion is sought during the panel

discussion and the more vocal members of the group can dominate this convergence. The panel or focus group must be carefully managed by the moderator to allow for disagreement between the reviewers.

Nesbit identifies eight interrelated reasons for developing effective Learning Object evaluation systems:

> 1. Ratings and qualitative assessments aid individual users in searching and selecting objects.
> 2. Evaluations can provide guidance on how best to use an object.
> 3. Quality can be increased by formative evaluation throughout the design and development stages.
> 4. Evaluation standards can drive the practices of designers and developers.
> 5. Participation in evaluation activities can contribute to the professional development of those who work with Learning Objects.
> 6. Evaluation activities can build and support communities of practice in relation to Learning Objects.
> 7. Positive evaluations can promote social recognition of skilled designers and developers.
> 8. A trusted evaluation system may be an essential step toward the development of a workable business model for the economic exchange of Learning Objects (Nesbit et al., 2002, pg. 2).

An example of a case study evaluating Learning Objects that utilizes a participant-oriented approach has recently been commissioned by CLOE (Howard-Rose & Harrigan, 2004). The benefits of effective Learning Object evaluation systems have some positive impact upon all stakeholders in Learning Object design and use.

2.8. The Impact of Learning Objects on Learning

Clarke (2001) provides a useful collection of arguments for and against the potential of media to enhance learning. Cuban (2001) argues that simply providing computing hardware and software does not enhance learning – the tools must be used to create imaginative learning environments. This is where well-designed interactive Learning Objects can make a

difference. A recent Educause review white paper is very positive about the impact of Learning Objects in education.

> Learning Objects are important to higher education because their use in particular instructional contexts provides new ways of visualizing, thinking about, presenting, interacting with, and understanding complex topics. Although they are not a universal solvent, their use will increasingly differentiate "old" ways of teaching from "modern" teaching techniques. There is no definitive study that proves or disproves that the use of Learning Objects always improves learning outcomes, but there is a growing amount of anecdotal evidence suggesting that rich media, when used effectively, improve student satisfaction, student retention, time-on-task, and other significant indicators. Well-designed Learning Objects allow students with different learning styles to interact with the materials according to their preferred way of learning (Roy, 2004a, pg. 4).

Quantifying improvements to learning tends to be very subjective; therefore the development of reliable evaluation instruments is a crucial first step. Results of a web-based survey of 87 higher education institutions in May/June 2002 revealed "almost 75 percent of respondents agreed that Learning Objects are being used in instruction to improve the quality of the learning experience" (Metros & Bennett, 2002, pg. 6). Another recent study (Howard-Rose & Harrigan, 2004) evaluated the use of Learning Objects in nine Ontario university courses, and concluded that evaluation of Learning Objects provides valuable feedback to instructors and developers about how to enhance the quality of students' learning experiences, the usability of a Learning Object, and that good evaluations will have positive impact on future funding for developers and faculty. Runyon (Runyon & Von Holzen, 2004) promotes the use of Learning Objects as ideal for providing students with formative feedback during the learning cycle. They see Learning Objects as particularly useful in tackling concepts that students' traditionally have difficulty with.

> Learning Objects can be incorporated in campus-based, web-augmented or online course sites. They provide students with engaging, interactive material, which can be easily integrated into the learning process allowing the instructor to take their courses to a higher level of learning (Runyon & Von Holzen, 2004, pg. 2).

The future potential of Learning Objects to impact learning when integrated with intelligent computing has not yet been realized. We almost enter the realms of science fiction with the future claims made for Learning Objects. Hodgins (2000) postulates that we are on the verge of new discoveries about learning. He paints a picture of what this might be, suggesting that technology that can learn and adapt to an individuals learning needs is the future. He then expands on the systems that need to be in place to support this technology. At the present Learning Objects have not made teachers defunct, in fact teachers are the ones who put the learning into and around Learning Objects. Learning Objects can mitigate some of the characteristics of surface learning associated with: a heavy workload, excessive course material, a lack of choice, and a threatening and anxiety provoking assessment systems (Gibbs, 1990, pg. 8). This is because Learning Objects can provide students with a non-threatening learning environment where they have control of the pace of learning.

> When multimedia is used interactively, it has the potential to strike at the very heart of this traditional teaching and learning process. It has the potential to change the way we think about the whole process of teaching and learning. It has the potential to turn learning into a nonlinear process (D. L. Johnson, 1994, pg. 1).

Several researchers argue that Learning Objects can also support constructivist learning environments.

> In constructivist or active learning settings, learners can be presented with a variety of objects that may represent the same or similar content in different ways – using different terms and frames of reference. Differences and dissonances in the content and the way it is presented in the objects can then form the basis for self-directed learning as exploration and contextualization (Friesen, 2001, pg. 3).

> Learning Object systems present yet another technology-based instructional delivery environment with exciting features and attributes that can empower learner-driven experiences and promote cognitive processing if pedagogical considerations are taken into account in their development and evolution (Bannan-Ritland et al., 2000, pg. 1).

2.9. A Critique of Audio Engineering Learning Objects

The Audio Engineering Society provides a section of their website for critiquing and cataloging Audio Engineering courses. As part of their educational focus, they provide a very useful overview of the 'educated audio engineer'.

> The education of a practitioner of audio goes through at least three stages: the initial period of vocabulary, basic skill, and technical development; a work or field experience where this fundamental knowledge is applied; and a continuing education where advanced practices, new developments in technology, or career shifts are investigated and folded into the person's abilities (Pritts, 1998, pg. 2).

As briefly outlined in the introduction to this research paper, in general audio engineering educational resources are designed as complete unique packages or courses, and have not been designed for re-purposing in other learning contexts, and therefore cannot be classified as Learning Objects within the definition used by this paper. A search of the MERLOT and World Lecture Hall Learning Object repositories revealed no available Learning Objects specifically oriented towards concepts of audio engineering. There are Learning Objects in related fields, such as acoustics, general audio electronics, electricity and physics, (see for example (Bleda, Roma, Pueo, & Escolano, 2003)) but none directly relating to the audio engineering concepts that this project addresses (e.g. mixing, equalization, compression, gating, microphone comparisons etc…). However, there are several good resources available on CD-ROM and scattered about the Internet.

The School of Audio Engineering has a useful collection of on-line resource material relating to audio engineering (SAE Institute, 2001). Most of the material presented here is on-line versions of material that is available in any number of books on audio engineering. There is the occasional exception. The SAE reverberation calculator, for example, is an interactive JavaScript based form for simplifying reverberation calculations. Neumann have created two excellent interactive multimedia CD-ROMs that cover various aspects of microphone design and applications (Neumann, 2003; G. Neumann, 1996). These are complete packages created with macromedia Director that were not designed as reusable Learning Objects, but as a set of interactive questions for a competition. These two CD-ROMs illustrate some of the potential there is to utilize interactive multimedia in the filed of audio engineering. Another interactive

CD-ROM example again deals with different microphones and contains audio examples of their use (Sides, 1995). This CD-ROM was also created as a complete package, and is now very outdated in the quality of graphics and audio now available. There are many more excellent interactive CD-ROM resources for audio engineering (EQ Magazine, 2001; Everest, 1997; Russ, 1999; Rycote, 2003), but none of these have been purposely created as reusable Learning Objects.

This research project is interested in developing Learning Objects to meet some of the educational needs of the first stage of an audio engineers education outlined above.

2.10. Multimedia Authoring Applications

To produce interactive multimedia Learning Objects developers can either use powerful programming languages such as Java, or the less demanding object oriented authoring applications. The resulting Learning Objects must work on either windows based computers or Macintosh computers. Although the Macintosh platform has a small global market share, within the audio engineering field it has an equal or greater market share than windows based systems. Therefore Learning Objects created for the Audio Engineering field should be cross-platform. Hedberg discusses how the implicit learning theories behind multimedia authoring tools will affect the design of Learning Objects. "Of the many common tools, the older have taken a more structured approach borne out of behavioral learning theory. The more recent tools have striven to reduce the need for time or procedural structure to create an environment of intelligent objects" (Hedberg & Harper, 2002, pg. 4). Two of the most commonly used cross-platform multimedia authoring applications are Macromedia Director, and Macromedia Flash (Cuthbert & Himes, 2002; Gallenson, Heins, & Heins, 2002). Director is a powerful authoring application, but lacks sophisticated audio capabilities, and is currently limited to eight tracks of audio. For more powerful audio capabilities, Director can utilize the sophisticated audio capabilities of QuickTime.

> Combining this hidden power with Director as a container will lead to some interesting new territory. Indeed, if you are using Director mostly as a container for QuickTime, you might even find that you don't need Director at all for some jobs. After all, why waste processor power and RAM on two multimedia engines when one will do the job just fine (B. Young, 1999, pg. 2).

Flash MX includes built-in learning additions and templates for quickly creating interactive assessments (Macromedia, 2002). Macromedia promotes Flash as an authoring environment for Learning Objects (Heins & Himes, 2002). There are several examples of interactive audio mixers created using Flash (BLOB Productions, 2003; Porter, 2001). However, Flash is limited to a total of eight audio tracks. The most suitable environment for multi-track audio Learning Objects is QuickTime. Beverly describes QuickTime as "the on-line, cross-platform, multimedia architecture of the present and future" (Beverly, 2004, pg. 1). He then goes on to give several reasons why Wright State University have chosen QuickTime as their preferred multimedia delivery format.

- Apple has developed QuickTime as an open media architecture
- QuickTime includes state of the art codecs
- QuickTime 6 was chosen as the basis for the platform ubiquitous MPEG-4 standard
- QuickTime is freely available (Beverly, 2004, pg. 2).

With the introduction of interactive sprite tracks to QuickTime in version two, QuickTime has developed into a powerful interactive multimedia architecture with features that rival and in some areas exceed those of Macromedia Director. Resources that describe and illustrate QuickTime's capability include (Apple Computer, 2000; Peterson, 2003; Sitter, 2002; Stern & Lettieri, 1999; Totally Hip Software, 2003a, 2003b; B. Young, 2000a, 2000b). Peterson and Young are two of the foremost experts in authoring interactive QuickTime. Peterson is one of the gurus of QuickTime, and was helpful in responding to several personal email questions regarding the capability of QuickTime for this project. Peterson's book (2003) outlines many scripting ideas for creating truly interactive QuickTime objects. Brennan Young (2000a, 2000b) provides a lot of useful resources for LiveStage Pro (LiveStage Pro is the premier application for authoring QuickTime movies), a quick introduction to the principles of QScript, as well as pointing out some key concepts that are not so clearly established by the LiveStage Pro manual. Stern and Lettieri (1999) give an overview of the capabilities of QuickTime, and provide some hints and tips for authoring QuickTime.

2.11. Examples of QuickTime-based Learning Objects.

While there are many QuickTime 'widgets' (small interactive tools such as calendars, calculators, clocks, navigation banners etc…), there are few examples of purpose built interactive QuickTime Learning Objects as defined by this project. Most QuickTime Learning Objects would be best described as interactive video presentations. There are relatively few multimedia developers, and even less educational designers, who have explored the potential of interactive QuickTime. One exception is Deakin University. A 2001 report describes their experiences and benefits of utilizing QuickTime for authoring interactive multimedia Learning Objects. "By using QuickTime, the degree of expertise required to conduct a performance from multiple elements has been made as accessible as street theatre with lots of participants and yes when you build the show with multi-track theatricks, the audience will come!" (Segrave, Warren, & McNolty, 2001, pg. 12).

NASA use QuickTime for video and virtual reality within their Learning Technologies projects (Gaskins, Alfonzo, & Hogan, 2003; NASA Office of Education Technology and Products Office, 2004). Mellow (Mellow, Hanks, Pivac, Pivac, & Went, 2003) utilized QuickTime to create Learning Objects for sign language students. QuickTime was used for its cross-platform compatibility, and user playback control of the movies. Another example used QuickTime movies within a virtual experiment (Dantas, Kemm, & Weaver, 2003). Examples of utilizing QuickTime for streaming video within Learning Objects include (Cameron, 2003; Fardon & Henderson, 2003). In summary, all of these projects utilize only the most basic interactive features available within QuickTime. This project will explore the boundaries of what is currently possible using the QuickTime architecture.

3. Project Methodology

3.1. Method

3.1.1 Action Research

The project involved the design and evaluation of multimedia Learning Objects within the field of Audio Engineering. The project is qualitative in nature, and uses a small 'sample' of participants evaluating the developed Learning Objects. Qualitative research provides rich data for educational situations (Hoepfl, 1997). The project was conducted part time over a two-year period, and used action research as its methodology (Dick, 1997; Ellis & Kiely, 2000; Holian, 1999), involving one research cycle per semester. The design and development of Learning Objects follows the classic cyclical nature of action research, and educational research often puts the researcher in the key role of prime collector of data (Wadsworth, 1998). The action research cycles provide time for reflection and feedback between researching and developing an appropriate interactive learning resource and trialing the resource on users. This reflection and feedback provided data on the success of the embedded pedagogy within the resource and areas needing modification, which was then used to inform the design of the next Learning Object.

The approach of action research provides a close fit with the researcher's own view of education (student centred learning that is transformative – seeking to produce change in the students understanding) and preference for qualitative rather than quantitative research. Action research also provides a close fit with the underlying philosophy of Learning Objects – which has been described as constructivism by Bannan-Ritland et al (2000).

The research involved students from the researcher's own classes, as well as students from other courses at MAINZ, and a selection of sound operators from several churches in Auckland. Because the researcher is involved in the research process as a participant (as a tutor of a class of students that the Learning Objects were evaluated by), the research methodology is participatory action research. Wadsworth (1998) identifies the key characteristics of 'participatory action research' as: the researcher is a participant, the researcher is the main research instrument, it is cyclical in nature, involves action followed by reflection followed by informed action, and is concerned with producing change. This change

is ongoing throughout the process, and the research is interested in input from the participants/stakeholders.

3.1.2. The Research Cycle

The research cycle consisted of the design of a Learning Object, followed by initial evaluation feedback, then the equivalent MERLOT evaluation of the Learning Object by the two main evaluation groups. The results of the feedback and evaluations led to modification of the Learning Objects and key lessons learnt from the process were then used to inform the design of the next Learning Object. Due to time restraints, the time between the last two Learning Objects was the shortest.

The Learning Object evaluation process follows a similar approach to the model proposed by Williams and Nesbit (Nesbit et al., 2002; Williams, 2000), participant-oriented evaluation embedded within an ADDIE instructional design process. Data collection methods (as outlined in Table 1. below) included designing evaluation instruments for use by two different learning context evaluation groups, focus groups and keeping a reflective journal (Bain, Ballantyne, Packer, & Mills, 1999; Healy & Perry, 1998). Bain et al (1999) provides a useful overview of how reflection can be enhanced by reflective journal writing. His paper also provides a good 'taxonomy' of levels of reflection - a five-point level of reflection scale.

1. Reporting
2. Responding
3. Relating
4. Reasoning
5. Reconstructing

The research project focuses on applying what has been learnt about Learning Object design to developing Learning Objects specifically for Audio Engineering concepts. As initially discussed, this is currently a context not yet utilizing Learning Objects in any large extent. This project was thus breaking new ground for delivery and improvement of education within the field of Audio Engineering. The utilization of action research produced a research project that has real world tangible results that will benefit the researcher's educational practice, and the wider field of Audio Engineering within New Zealand.

3.2. Data Gathering

3.2.1. The data gathering steps:

Table 1. Data Gathering Processes.

Data gathering processes	**Sample Size**	**Explanation**
Initial need analysis	Five tutors – each represent one of the five MAINZ courses.	A short survey deployed to MAINZ tutors to establish the perceived need for interactive Learning Objects within the context of Audio Engineering, and suggestions for concepts to be covered.
Diploma of Audio Engineering student Evaluations	Up to 30 students for full class.	A short evaluation sheet to gain initial feedback on the pre-release versions of the Learning Objects from the researchers own group of students.
MAINZ Tutors and student evaluations	Five tutors – each representing one of the five MAINZ courses, and five MAINZ students (one representative from each course)	Each Learning Object was delivered to MAINZ tutors on CD-ROM with a paper copy of the modified MERLOT evaluation form for filling out. Tutors were asked to nominate a couple of students within their course to evaluate the Learning Objects as well.
Church sound operator evaluations	Five church sound operators – one from each of the five Auckland churches selected.	Each Learning Object was delivered to selected church sound operators on CD-ROM with a paper copy of the modified MERLOT evaluation form for filling out.

Data gathering processes	**Sample Size**	**Explanation**
Focus groups	Three representatives from each group plus the researcher.	Two focus groups were convened, one consisting of representatives from MAINZ tutors, and the other consisting of representatives from the church sound operators.
Web deployment of Learning Objects		The Learning Objects were progressively uploaded to an Internet server for access via the Internet.
Feedback from overseas international experts	Five representatives from various institutions and organizations	Several international audio and educational technology experts were contacted to evaluate the Learning Objects supplied on the website, using the modified MERLOT evaluation form. Evaluators were also sent CD-ROM copies of the Learning Objects to overcome slow download speeds from NZ.
MERLOT evaluations		After completion, the four Learning Objects were contributed to the MERLOT repository for MERLOT peer evaluation

Data gathering processes	Sample Size	Explanation
Reflective Journal		A reflective journal was kept detailing key events etc of the project. A Word document journal template was created for recording thoughts, events, and ideas throughout the time-span of the project (see Appendix 7). The template was designed to facilitate reflection and keep the comments focused on the pedagogical implications and outcomes of key events and experiences.

3.2.2. Data Analysis Method

The results of the Likert scale type evaluation questions were input into a Microsoft Excel spreadsheet for presentation in graphical chart summary format. The long answer type comment question responses were collected into Microsoft Word document summaries for each Learning Object and categorized according to the evaluation context group. Focus group question responses were written up in Word documents, and an electronic copy of the researcher's reflective journal was kept.

3.3. Selection of Sample Evaluators

3.3.1. MAINZ

As outlined briefly in the introduction, the first group of evaluators was comprised of representative tutors from the Music and Audio Institute of New Zealand (MAINZ). MAINZ offers a range of Audio related courses at foundation, certificate and diploma levels. The author of this research project was a tutor on the Diploma of Audio Engineering programme at MAINZ from January 1997 to March 2004. Tutors from each of the following courses were asked to evaluate each of the developed Learning Objects throughout the term of the research:

- Certificate of Foundation Studies in Music – Level 3
- Certificate of Live Sound – Level 4
- Certificate of Audio Engineering – Level 5
- Diploma of Contemporary Music Performance – Level 5
- Diploma of Audio Engineering – Level 6

All of the above courses are independent of one another, however, the common focus of these courses is their interest in Audio Engineering. The courses cover aspects of Audio Engineering relevant to live rock bands, recording, television, film, and radio studios. The MAINZ tutors provided expert feedback from within the context of the study, and also provided qualified feedback on pedagogical issues. Tutors were also asked to get a couple of representative students from their course to evaluate each of the Learning Objects from an end users perspective. Typically Audio Engineering concepts are taught hands-on in a studio or live band situation. This requires expensive audio equipment, and sharing of these expensive facilities between large numbers of students. Access to quality Learning Objects could provide increased access to learning these concepts.

3.3.2. Church Sound Engineers

The second group of evaluators (Church Sound Engineers) was chosen as a distinct context to that of MAINZ but still relating to Audio Engineering. It was postulated that this group would benefit from the use of the developed Learning Objects in their training programmes for their sound operator crews. The church sound operators typically are in charge of audio engineering equipment for live music, multimedia, and speakers during church services, and often are also required to record the sound from services. Contemporary music based churches were chosen as they have equipment rivaling that of live rock band venues and small to medium sized recording studios. The Church sound operators thus have a similar Audio Engineering context to that of the MAINZ courses, but without the benefit of experts in the field or teacher training. A range of mid-to-large sized contemporary music based churches were chosen for the study. These all have access to medium to large live sound equipment, and the larger churches also have access to small recording studio equipment. The churches included:

- Massey Community Church – congregation approximately 200

- Birkenhead Community Church – congregation approximately 300
- Lincoln Road Bible Chapel – congregation approximately 350
- Christian City Church – congregation approximately 400
- Christian Life Centre Auckland – congregation approximately 3000

The principle sound operator for each church was asked to evaluate each of the Learning Objects throughout the period of the study.

3.3.3. International experts

Near the end of the project the developed Learning Objects were demonstrated to a visiting international professor of Audio Engineering. This enthusiastic response to the Learning Objects stimulated the idea of soliciting evaluations from a representative group of international experts. These experts were drawn from the following:

- Maricopa Community College
- Loyola Marymount University, School of Film and Television
- Sound on Sound Magazine (an internationally respected UK Audio Engineering Magazine)
- Danish Broadcasting Corporation

These were chosen for their contact with the researcher, and expertise within the fields of Audio Engineering, or educational technology. Their feedback provided additional comparative evaluation of the developed Learning Objects.

3.4. Development of the Research Instruments

3.4.1. Initial needs survey

A survey was developed (see Appendix 1) to establish the need for the research and development of the Learning Objects. This survey was delivered to MAINZ tutors as representative experts in the field of Audio Engineering education in New Zealand. The aim of the survey was to establish the need for interactive Learning Objects within the field of audio engineering, and to establish some parameters for the research. The survey was kept short, consisting of nine questions, eight of which were long answer questions, and one yes/no question divided into eleven categories for selecting and suggesting subject areas for the

Learning Objects. The questions covered topics from interface design and computer specifications to the perceived benefits of such Learning Objects.

3.4.2. Diploma student survey

A short survey (see Appendix 2) was developed to gain user feedback from the researcher's own group of MAINZ students, the Diploma of Audio Engineering students. This survey was designed to gather pre-release feedback on the Learning Objects from an end user perspective. The questions were not borrowed from the MERLOT evaluation criteria, but did cover similar concepts. Each Learning Object was briefly presented to the class as a whole, and then the students accessed the Learning Objects either via the Internet or the MAINZ local area network (LAN) using their own wireless enabled Apple laptop computers. They then filled out the evaluation survey in class and handed them back, completing the survey within approximately fifteen minutes. The surveys had no bearing on their coursework and participation was voluntary. As second year Audio Engineering students they had experience using professional quality studio equipment, and significant theoretical knowledge of Audio Engineering concepts. The survey was kept short, comprising eight questions, the first five questions use a Likert scale rating response, and the last three questions are short answer type questions. The questions were focused upon the three main areas of interest of the research: reusability, interactivity, and pedagogy. The questions also elicited feedback regarding the Learning Object's interface.

3.4.3. Learning Object evaluation form

Evaluators were given a copy of each Learning Object on CD (cross-platform for both Macintosh and Windows operating systems), and an evaluation form (see Appendix 5). As established in the literature review, the MERLOT Learning Object evaluation criteria are well developed, and have been in use for several years. It was therefore decided to use the MERLOT criteria as the basis for the evaluation of the developed Learning Objects for this research. To make the evaluation process simpler for the evaluators, the checklist version of the MERLOT evaluation criteria was used. This check list was developed by as part of a conference workshop (Bennett & Metros, 2001). The evaluation criteria are divided into questions covering three main criteria: reusability, interactivity and pedagogy. The questions were modified for the context of this research project, and some questions were changed to

better reflect the research questions of the project as well. The resulting evaluation form is attached in the Appendix. The questions are grouped into the three categories: reusability, interactivity and pedagogy. The questions are structured as Likert scale rating responses to statements regarding the Learning Object, plus a section for long answer comments for each category. There are eight questions regarding reusability, and six questions in each of the interactivity and pedagogy categories respectively. The evaluation form questions were briefly moderated by a couple of MAINZ tutors before finalizing.

The evaluation form begins with some contextual information (brief metadata) about the Learning Object, plus descriptive information and contact detail questions regarding the evaluator. Because at least half of the evaluators would not have teacher training, some brief definitions of keywords were included on the form. These include definitions of the following terms: Learning Object, reusability, and pedagogy. A brief outline of the computer system requirements needed to run the Learning Objects is also included on the form.

3.4.4. Equivalent MERLOT rating

Although the study is qualitative, some quantitative data and basic analysis was helpful, especially in providing a way to summarize trends and comparisons in evaluation feedback. As described in the literature review, the MERLOT evaluation process includes a numerical assignment from 1 to 5 for each evaluation question. This allows an average overall rating from 1 to 5 to be assigned to an evaluated Learning Object. This gives potential users of the Learning Objects immediate feedback as to the overall quality of the Learning Object. This practice was adopted by this study, to provide a quick comparative rating for each Learning Object. Because the MERLOT evaluation criteria questions were modified to the context of the research project, the resulting rating is called an 'equivalent MERLOT rating'. An overall rating is derived from the average of all the evaluator responses, and separate ratings are derived from each separate category of evaluators to give a comparison in ratings given for each Learning Object when evaluated in different learning contexts. A comparison of the equivalent MERLOT rating for each Learning Object from the three main evaluation groups (MAINZ Tutors, Church Sound Engineers, and MAINZ students) is then made possible.

3.4.5. Focus group questions

Two focus groups were convened to gather additional evaluation feedback. One focus group was composed of representatives from the MAINZ tutor evaluators, while the other group was comprised of representatives from the Church sound engineer evaluators. It was decided to keep the distinct groups separate to stop the 'amateur' church sound engineers from being overwhelmed by the 'expert' MAINZ tutors.

The focus group questions (see Appendix 6) were designed to draw out issues that surfaced during the research/development cycles. There were thirteen 'official' focus group questions, and the focus groups were scheduled to last approximately one hour each. The questions covered a lot of the same ground as the evaluation sheets, but the face to face environment allowed for the researcher to attempt to draw out reflective comments and critiques from the evaluators. The questions also covered the implementation of the Learning Objects within the teaching/learning context. The focus group questions were briefly moderated by a couple of MAINZ tutors before finalizing.

3.4.6. Documentation supplied to evaluators

Evaluators were supplied with hard copies of three documents (see Appendix for copies):

1. Learning Object Design Information Sheet (Appendix 4).
2. Learning Object Design Project Consent Form (Appendix 3).
3. Learning Object/Module Evaluation Questionnaire (Appendix 5).

Evaluators were asked to sign and return the Consent Form, as well as the Evaluation Questionnaire. The Learning Objects were distributed to the evaluators on CD-ROM. Brief instructions were included on how to access the Learning Object, and computer system requirements were detailed. Because the Learning Objects were based on the QuickTime media format, the latest version of the QuickTime installer (for Mac OS 9, Mac OSX, Windows 95 through to XP) was included on the CD-ROM, and a link provided to the direct download from the Apple website.

3.5. Web Deployment and Metadata Creation

The goal of the project was to develop Learning Objects that were scalable for delivery over a variety of delivery formats. The Learning Objects were supplied to evaluators on CD-ROM, but were also made available from the Internet. As each Learning Object was developed, it was also uploaded to a web server to test its accessibility and download times over the Internet. Once all four Learning Objects were developed, a website was created to provide access and information that could be updated as feedback was received, and any 'bugs' found in the Learning Objects could be corrected and the updated Learning Objects made available from the website. The website delivery necessitated the inclusion of metadata about the Learning Objects. A web-based form (Koch & Borell, 1997) was used to create metadata in the Dublin Core format for each Learning Object. This metadata was included as a text document associated with each Learning Object, and the meta tags generated by the online form were also pasted into the <head> of each web page holding the Learning Objects. This allows search engines to correctly categorize the Learning Objects. The website also provided access to the Learning Objects for the international evaluators. The URL is http://ltxserver.unitec.ac.nz/~thom/ and there is a mirror site at http://defiant.unitecnology.ac.nz/learn/Sites/.

3.5.1. MERLOT repository

As an addition to the research project, the author decided to investigate the MERLOT repository as an author/contributor, and hopefully receive peer reviews of the developed Learning Objects. The MERLOT membership process was straightforward and free, an online form is used to create a member profile. Contributing the Learning Objects to the repository database was also a simple matter of filling out an online form for each, creating metadata in the IMS and IEEE standards. The Learning Objects were self-assigned to the most appropriate community category (of which there are currently fifteen, covering topics from biology through to world languages), which in this case is Arts/Music/Music Technology. However, the process for receiving peer reviews is unclear, and appears to be at the discretion of the community editors. At the time of writing, no MERLOT peer reviews had yet been received, however, the four Learning Objects have been accepted for review, hence MERLOT reviews should be available in the near future.

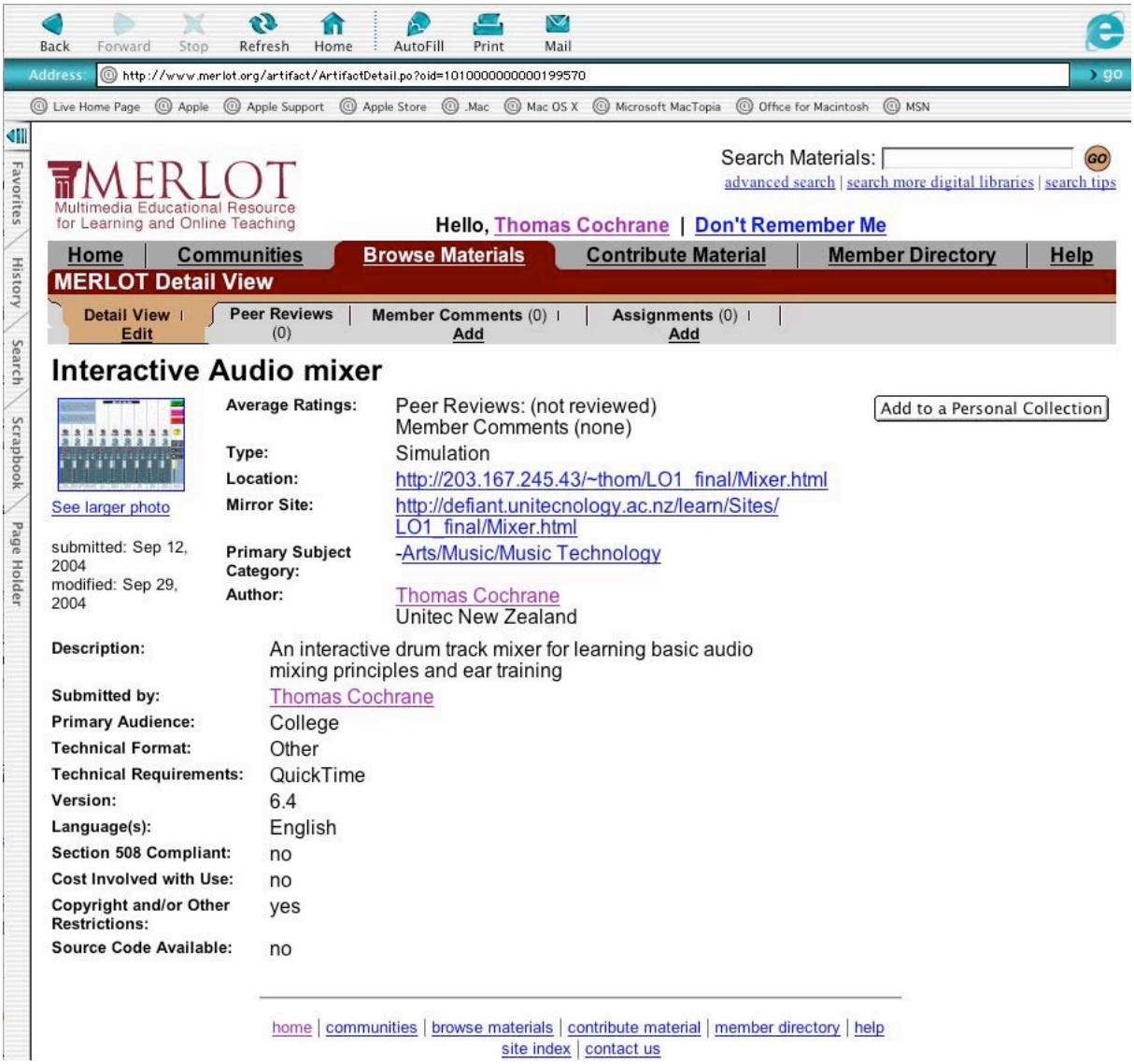

Fig 1. Screenshot showing MERLOT details for Learning Object one.

3.6. Learning Object Design

3.6.1. Target Audience analysis

While the MAINZ tutors, and the head church sound engineer will deploy the Learning Objects within their own learning contexts, the end users of the Learning Objects will be MAINZ students and church sound operators. The researcher has taught Certificate (level 5) and Diploma level (level 6) MAINZ students for seven and a half years, and been involved with helping church sound operators for even longer. Thus a good understanding of the target audience learning styles has been developed. Furthermore, at the start of each new year at MAINZ, the researcher has delivered a lesson on learning styles to the Diploma class, and

taken the class through the Honey and Mumford learning styles test (Honey & Mumford, 1982). Honey and Mumford defined four main learning styles: Activist, Pragmatist, Reflector, and Theorist. The results of this test over several years have shown the predominant (over eighty percent of every class) learning style of MAINZ students to be activists, with the second strongest style being pragmatist.

> Activists involve themselves fully and without bias in new experiences. They enjoy the here and now and are happy to be dominated by immediate experiences. They are open-minded, not skeptical, and this tends to make them enthusiastic about anything new. Their philosophy is: 'I'll try anything once'. They dash in where angels fear to tread. They tend to throw caution to the wind. Their days are filled with activity. They revel in short term crisis fire fighting. They tackle problems by brainstorming. As soon as the excitement from one activity has died down they are busy looking for the next. They tend to thrive on the challenge of new experiences but are bored with implementation and longer-term consolidation. They are gregarious people constantly involving themselves with others but in doing so, they hog the limelight. They are the life and soul of the party and seek to centre all activities around themselves (Honey & Mumford, 1982).

Feedback from the initial need survey confirmed this assessment of the target audience. It is the researcher's opinion that this would be a very similar outcome for the learning styles of most church sound operators as well. The implication for the design of the Learning Objects is that these users want a hands-on approach to learning, therefore the Learning Objects should simulate the real world situations and equipment as closely as possible, and provide high levels of interactivity.

3.6.2. Design Principles

The design of the Learning Objects is focused around three key concepts, borrowed from the MERLOT Learning Object evaluation criteria:

1. Reusability
2. Interactivity
3. Pedagogy

As with all Learning Objects, there is a tension between providing context and granularity. To promote reusability Learning Objects should be small without too specific a context, but they must also have enough context and content to make them pedagogically useful.

The researcher subscribes to a constructivist, learner centred approach to education; therefore interactivity and learner choice is built into the Learning Objects. Interface elements are designed to simulate professional quality audio equipment design and functionality. As an extension of this, user feedback and formative assessment were also built in to each Learning Object.

Commercial multimedia authoring software provides many tools that can be used to develop Learning Objects and deliver them across a variety of platforms, for example Macromedia Flash (Heins & Himes, 2002). While a range of authoring applications were utilized in the development of the Learning Objects, including: LiveStage Pro, Flash, QuickTime Pro, Dreamweaver, HMTL and JavaScript, QuickTime VR Studio, and Final Cut Pro, the key multimedia format used was QuickTime.

QuickTime (Apple Computer, 2004b; Beverly, 2004) was chosen as the architecture for authoring and delivery of the Learning Objects, for several reasons.

- Cross platform delivery (Macintosh and Windows environments)
- A large installed user base
- Availability of free download and installation of the QuickTime player and web browser plug-in
- Ability to create stand-alone interactive objects without requiring the user to purchase or learn a proprietary audio application (e.g. Pro Tools, Logic Audio, Cubase…)
- Support for a wide range of multimedia file formats
- Integration of Flash tracks
- Excellent synchronization of multiple audio tracks within a single ‘movie’
- Comparable level of interactivity to that of Flash and Director
- Scalability for delivery over different bandwidth formats (Web, 3G mobile devices, CD-ROM, Hard Drive)
- Integration of time code tracks for synchronization

QuickTime is a track-based multimedia architecture. A QuickTime movie can contain over two hundred different media formats, an unlimited number of tracks, and supports a wide range of state of the art compression codecs. It also supports JavaScript, Java, its own scripting language QuickTime script, and is based on XML.

Currently there is only one authoring application that taps the full potential of interactive QuickTime development – LiveStage Pro (Totally Hip Software, 2003b). Other less powerful QuickTime authoring applications are available, such as eZedia QTI, and Adobe GoLive. Using LiveStage Pro required learning a new authoring application and scripting language, however, it is very similar to Flash and Director. Flash and Director authoring applications were unsuitable (by themselves) for developing -the audio related Learning Objects, as they only support eight tracks of audio and provide limited synchronization of tracks. Some of the Learning Objects developed have over twenty-four audio tracks synchronized together within QuickTime.

The LiveStage Pro interface is somewhat similar to Macromedia Director, with a stage and timeline view as the main development environments. Media is created in external authoring applications then imported into LiveStage for arrangement and interactive scripting. LiveStage includes a range of preset scripts and a drag and drop interface resembling that of behaviors in Director. New features are constantly added to new versions of LiveStage Pro incorporating the latest features of each update to QuickTime from Apple Computer. Support for LiveStage Pro users is provided by the developer's website (Totally Hip Software, 2003a). Resources for authoring with LiveStage Pro are available from two developers in particular (Peterson, 2003; B. Young, 2000b), and from the QuickTime developers section of the Apple Computer website (Apple Computer, 2004a).

Using QuickTime allowed certain levels of 'real-time' control and signal processing of the audio examples included in this project. However, there are limits to what can be achieved within QuickTime. Certain aspects of the Learning Objects were therefore simulated rather than actual real-time processing of the audio files. More powerful real-time processing could be achieved by writing cross-platform digital signal processing software. This was beyond the expertise of the researcher and the time frame of this study.

Content areas were chosen from the researcher's experience gained from teaching Audio Engineering (those areas that students generally find difficult to grasp, and are key concepts) and from the feedback from the 'initial need' survey of potential end users. Learning Objects were developed that illustrate some of the following concepts in Audio Engineering: operation of an audio mixing desk, achieving an appropriate mix, microphone choice and placement, dynamics processing, and equalization. The Learning Object interface is presented as a floating window on the users desktop (or as an element within an html page if web delivered). This presentation format was chosen rather than a full screen mode, to emphasize the Learning 'Object' concept as a small unit of the learning rather than an end in itself (see the following screenshot examples of each Learning Object developed). The structure of the Learning Objects is designed for learner investigation, rather than forcing a linear progression through the sections of each.

The graphical interface of the Learning Objects is designed to resemble the actual physical equipment that users would normally be working with. This meant a departure from the graphical designs of commercial audio software and plug-ins, which tend to 'jazz up ' their interface elements with unrealistic lighting and shadow effects, to a more 'conservative' graphical representation.

Brief operational instructions are built-in to each Learning Object. In response to user feedback, the first page of each Learning Object opens with the overview and instructions for its use/navigation. Initially the author made the instructions available via a clickable '?' icon, but some users did not associate this with instructions and initially felt lost.

Context is established by the images of typical professional quality audio equipment – that students actually use within their courses and in live sound environments, and the use of actual audio files recorded using this equipment. This was achieved in a variety of ways, including the creation of virtual environments by using the panoramic and cubic virtual scene capabilities of QuickTime. In Learning Object 2 users can move around an example microphone setup on a typical stage and studio setting and zoom in for a closer look at the microphone placement. Background information and specifications of equipment is provided by appropriate images and brief text. Text is kept to a minimum in the Learning Objects as the emphasis is upon recreating an immersive simulated environment, rather than the typical textbook approach.

Different approaches to embedding pedagogy within each Learning Object to provide opportunities for learning feedback and formative assessment were experimented with. Evaluation feedback led to formative assessment being made more explicit in later Learning Objects. Chapter 4 of this paper outlines the development steps of each Learning Object. An ADDIE instructional design process was utilized.

3.7 Learning Object Evaluation

The evaluation process involved all major stakeholders in the Learning Objects, the designer, tutors, students, and other end users (Church sound engineers). As such the evaluation process follows a participation-oriented approach similar to that described by Williams (2000).

The equivalent MERLOT ratings are the average rating given for all categories and all evaluators (except for the ratings from international experts, as these are included for comparative purposes only), producing a single rating figure to be used as a crude rule of thumb in relation to the MERLOT rating criteria described earlier. This produced a rating from 1 to 5, with 5 representing excellence and 1 representing materials not worth using at all.

The responses to the evaluation questions are represented by the following Excel spreadsheet graphs for each Learning Object. Evaluators' comments for evaluation category are summarized after the charts for that category. Note that the international expert evaluations were obtained after the development of the Learning Objects, and therefore their feedback is not included with the evaluations from the design cycle, but as additional feedback for reflection at the end of each Learning Object evaluation section.

Compiled evaluation comments from the Diploma Audio Engineering students, and the main evaluators can be found in Appendices 7.8 to 7.15 at the end of the report. Representative comments are quoted within the main text in the relevant sections.

4. Results and Analysis

4.1. Initial Need Survey Feedback

The following summarizes the responses from four MAINZ tutors (from four different courses) to the initial need survey.

There was a unanimous yes response to the question: In your opinion, is there a need for interactive teaching material for audio engineering concepts? One tutor noted a particular need for an interactive mixing desk or simulated PA system.

Tutors were asked what would a useful Learning Object for audio engineering look like? All responded that the Learning Objects should look like the professional audio hardware and software currently used in recording studios and live sound situations. One tutor noted that "it would be interactive and feature realistic looking interfaces that would be as near to actual gear as possible". Including assessment within the Learning Objects was also seen as important.

Tutors indicated a wide range of computer system requirements would need to be met by these Learning Objects, ranging from older Macintosh and Windows PC systems to the latest. Support would be needed for OS9 and OS X on the Macintosh platform, and Windows 95 through to XP on the PC platform. Computer CPU speeds available for some MAINZ courses started at 533Mhz at the beginning of the research project, and one course used Macintosh laptops for course delivery. The best delivery format for the Learning Objects was seen as CD-ROM or DVDROM.

Tutors were asked to identify concepts that would be beneficial for students for the proposed Learning Objects top cover. Responses are summarized in table 2 below.

Table 2. Concepts to cover with Learning Objects.

Concept	Y/N	Comment
Principles of Acoustics	4Y	
Response of different instruments	3Y 1N	

Behaviour of sound in rooms	4Y	
Sound Pressure Level	4Y	
Principles of Sound Reproduction	4Y	
Microphones – Types, Use, Appropriate choice	4Y	More tools needed in most subjects
Loudspeakers and Amplifiers – Specifications and ratings	3Y 1N	
Mixing Desk operation	4Y	
Signal Flow	4Y	
Signal Processing	4Y	DSP technology useful
Ear Training – Achieving a good mix, Recognizing audio frequencies	3Y 1N	Already have CD based programs/books
OTHER: Synthesis Electronics		Signal Flow is a theme that perpetuates throughout. This could be easily demonstrated, etc using interactive learning models.

Tutors were asked if they had ever used multimedia Learning Objects to teach or learn audio engineering concepts, and to state what these were, and whether they were effective or not. Only one tutor indicated affirmatively, and his response indicated use of audio engineering related software and websites, but not purpose built Learning Objects as such. Most tutors teaching tools include text, overhead transparencies, and demonstrations of actual hardware and software used in the audio engineering professions.

Tutors indicated that the range of computer literacy of MAINZ students was from basic (particularly for Foundation and Certificate courses) to high (usually for the students on the

second year Diploma courses), but not to programming levels. Multimedia authoring software is the limit of MAINZ students' experience.

Tutors were asked how they you benefit from having access to a 'library' of interactive multimedia Learning Objects that covered a wide range of concepts in Audio Engineering. They responded that learner autonomy would increase, tutors would have more time, it would help students who relate to computers (cover a wider range of learner styles), and add a creative resource to their repertoire.

Design factors that were considered most important in creating useful Learning Objects for audio engineering included: those that looked realistic, those that react as similarly as possible to real – life situations, clear design/interface, audio integration, MIDI integration, ease of use, and at entry level, don't take anything for granted.

Finally, tutors were asked what questions they had regarding the study. Their replies included: just get on with it! It all sounds too good to be true, and "looking forward to seeing new resources".

The survey established that there is definitely a need for interactive multimedia Learning Objects on audio engineering principles. The survey also established system parameters and key concepts to be implemented as Learning Objects.

4.2. Learning Object 1 Design

4.2.1. Description

Learning Object 1 is an interactive drum track mixer for learning basic audio mixing principles and ear training.

4.2.2. Learning Outcomes/Objectives

At the completion of using the Learning Object, students should be able to:
(1). Describe the function of key parameters of an audio mixing desk.
(2). Demonstrate the ability to create an appropriate mix for a multi-track drum-kit.
(3). Critically evaluate an example mix.

4.2.3. Assessment Activities

The Learning Object was designed to include simple and flexible formative feedback/assessment. An example mix is provided, that includes audio and visual feedback to the student. Students adjust the parameters of the mixer to see if they can reproduce the example mix. Students also have the capability of creating and saving their own audio mix, which can then be sent to a tutor for feedback.

4.2.4. Initial Concept

One of the most basic skills an audio engineer must develop is the ability to operate a mixing desk and use it to produce an appropriate 'mix' (set relative volumes for each instrument, set panning to position instrument within the stereo field, and equalization, set appropriate overall volume via master fader) for a given situation. The Learning Object should provide real time control of these basic parameters with visual and audio feedback.

As this was the first Learning Object developed it also formed a case study in the capability of QuickTime as an authoring and delivery environment to achieve the interactive and cross-platform delivery requirements of the study. The design goal was to provide as much interactivity as possible, and emulate a real analogue audio mixer as closely as possible

(within the limitations of the delivery medium). Most mixing situations include multiple audio tracks, typically between sixteen and twenty-four individual tracks. This precluded the use of Director or Flash as the authoring environment, as these support only eight audio tracks at once. In comparison, QuickTime will support as many tracks as the CPU/hard drive can reproduce. To test the audio capability of QuickTime, it was decided to include nine tracks of audio in this first Learning Object. The usual first step in recording (or setting up in a live sound situation) a pop or rock song is to first record the drum track. A typical recording studio setup for recording drums includes nine tracks (kick drum, snare top, snare bottom, three toms, left and right overheads, and hihat), so this was chosen as the context for the Learning Object.

4.2.5. Technical requirements/Delivery formats

It was envisioned that the Learning Object should be available in a variety of quality settings for different data bandwidth delivery mediums: Website, CD-ROM, and Hard Drive. The main difference was in the audio compression quality used for each delivery medium. The version to run directly off a hard drive utilized uncompressed CD quality audio (16bit 44.1kHz), while the CD-ROM and web version utilized MPEG4 compression for high quality low data rate audio.
Functionality that was required included:

- Nine instrument Tracks
- Track volumes (faders)
- Track Panning
- Track Equalization
- Track Solo (select individual tracks while muting all others)
- Track Mute (turn track volume off temporarily)
- Master Volume

Real time control of all of these elements is possible utilizing QuickTime Qscript within LiveStage Pro.

4.2.6. System requirements

The goal was to produce a Learning Object that would run on most recent computers (cross-platform, Mac OS9 and OS X, Windows 98 and XP).

A PPC (PowerPC) Macintosh or Pentium Windows computer, with a CD quality sound card, 1024 by 768 colour monitor, and QuickTime 6 installed (QuickTime 6 Pro required for saving audio mixes). A CD-ROM drive and Internet connection is also required.

4.2.7. Development Steps

After deciding upon the subject area and basic learning outcomes for the first Learning Object, ideas were brainstormed for basic layout and how to achieve these within QuickTime (see fig 2 below).

Media requirements were defined, and media elements authored using appropriate software and hardware. A drum kit was setup in the MAINZ Diploma recording studio and recorded using industry standard microphones using ProTools hardware and software, then saved as an audio only multi-track QuickTime movie. The graphical interface for the Learning Object was based upon the Trident analogue mixing desk in the MAINZ control room1. The graphical elements were created using Macromedia Freehand software. LiveStage Pro was then used to integrate the media elements and script interactivity and audio control to faders, knobs and buttons. Learning the LiveStage Pro application and Qscript involved significant time. It is estimated that development of the Learning Object took at least one hundred hours. The final Learning Object was exported from LiveStage Pro as an interactive QuickTime movie, then uploaded to a web server using Dreamweaver, and burnt onto CD-ROM along with documentation and a copy of the evaluation form. Feedback was gained from two or three MAINZ tutors during the development of the Learning Object (pre-release versions) to iron out bugs and interface issues. The Learning Object was tested on several Macintosh and Windows computer systems for compatibility, and any differences in rendering on the two platforms were addressed. Initial user feedback was gained from Diploma of Audio Engineering students at MAINZ. Finally the Learning Object was then distributed to both the MAINZ tutors and church sound operators involved in evaluating it.

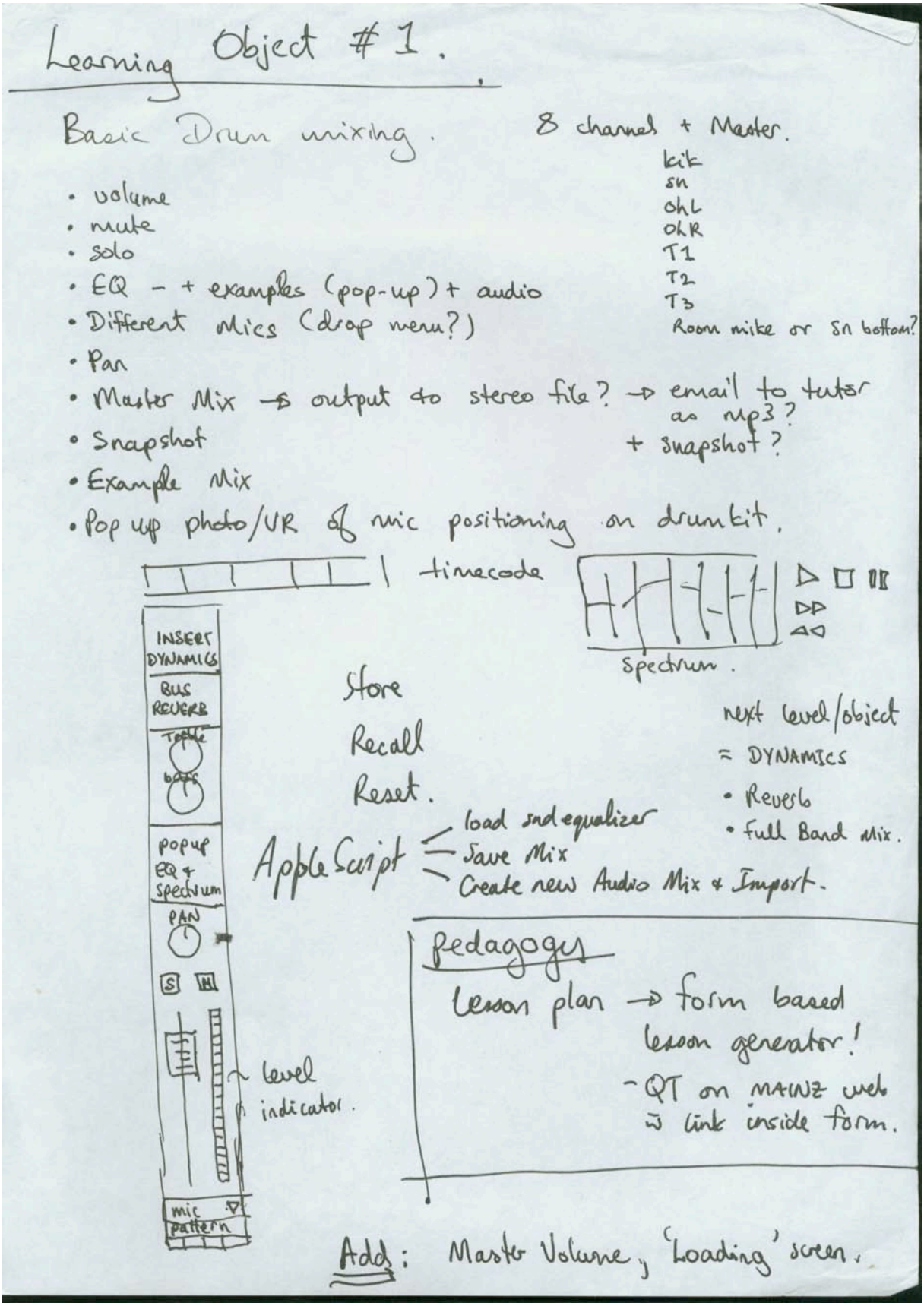

Fig 2. Initial brainstorm of Learning Object one.

4.2.8. Interface/Overview

The aim of the design was to produce as realistic a virtual environment as possible. The Learning Object consists of only one 'window' that represents the controls of a basic audio mixer. Initially the Learning Object opened directly with instructions accessible by clicking on the 'Instructions' icon. However, some users did not appear to explore this icon, and consequently required direct input from a tutor to outline how to use the mixer. As a result, the Learning Object was modified to display the 'instructions' upon opening; the user must then close the instructions by clicking on the instructions icon to gain full access to the mixer. The instructions were initially text only, but feedback from evaluators indicated that graphical representation of functions would be a good idea, so these were added to the modified version of the Learning Object.

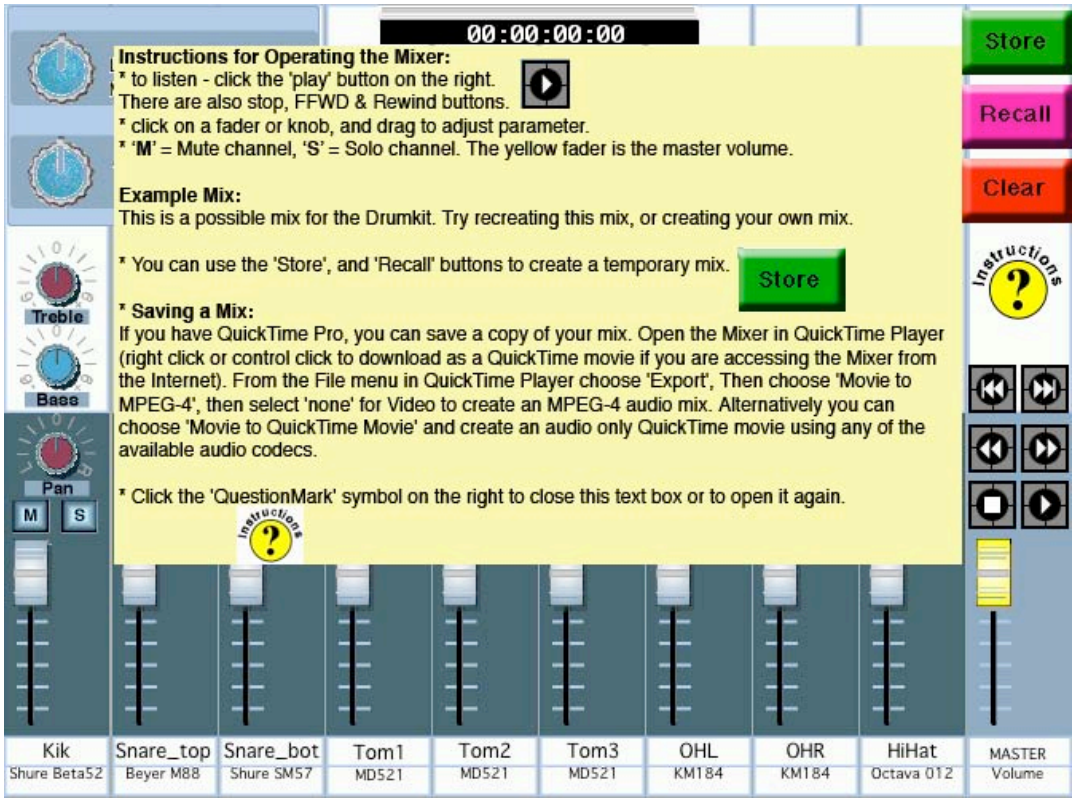

Fig 3. Screenshot of opening page of Learning Object 1.

The user can manipulate all features of the interactive mixer by clicking or clicking and dragging with their mouse on appropriate objects. Each track of the mixer has a label underneath – showing what instrument is recorded on this track and what microphone was used to record it. The 'Store', 'Recall' and 'Clear' buttons provide a snapshot memory for the mixer. Students can adjust parameters, store the values by clicking store, then continue

adjusting parameters, and then compare their initial settings by recalling them. This function stores/recalls all audio settings and button/knob/fader positions. The audio sample track is approximately a thirty-second loop. The time-code display at the top of the window displays the current position within the loop. This is a feature of QuickTime; it supports time-code tracks that are not available in Director or Flash. The 'Listen to example mix' knob disables user control of the mixer and plays an example audio mix that the user can use as a reference to see if they can adjust the mixer's parameters to achieve a similar audio mix. The 'View example mix' knob provides a snapshot of the mixer settings that were used to create the example mix.

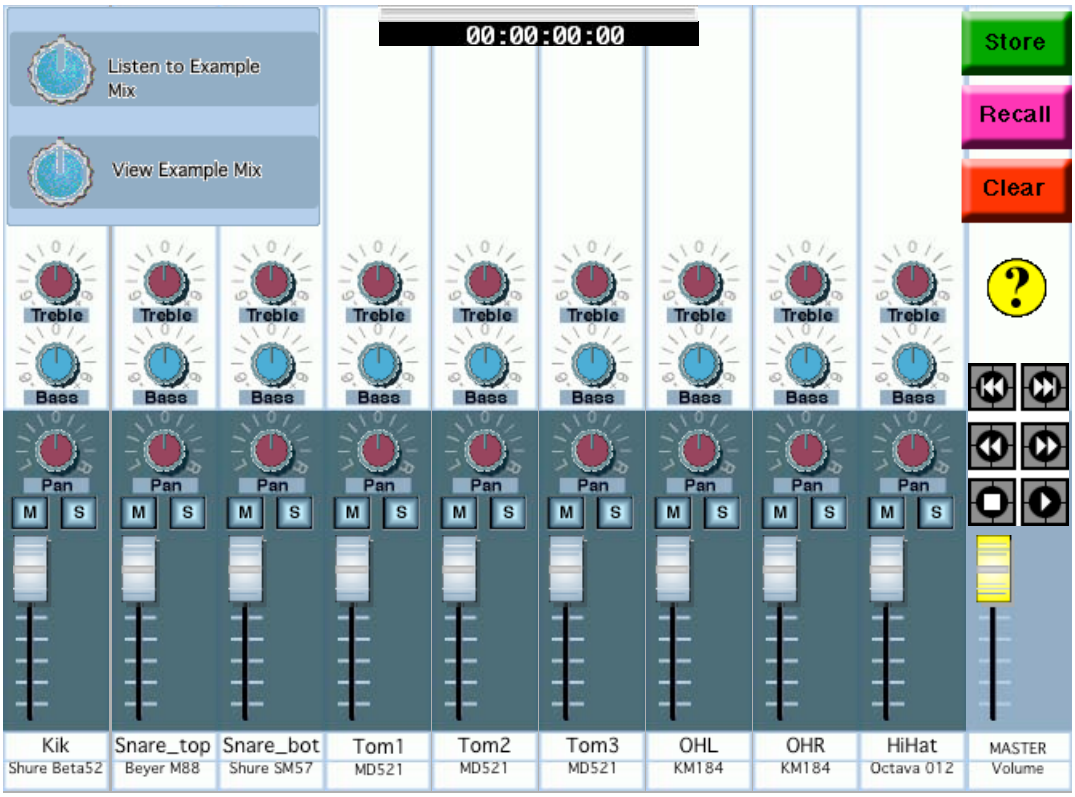

Fig 4. Screenshot of the main window of Learning Object 1 – an interactive audio mixer.

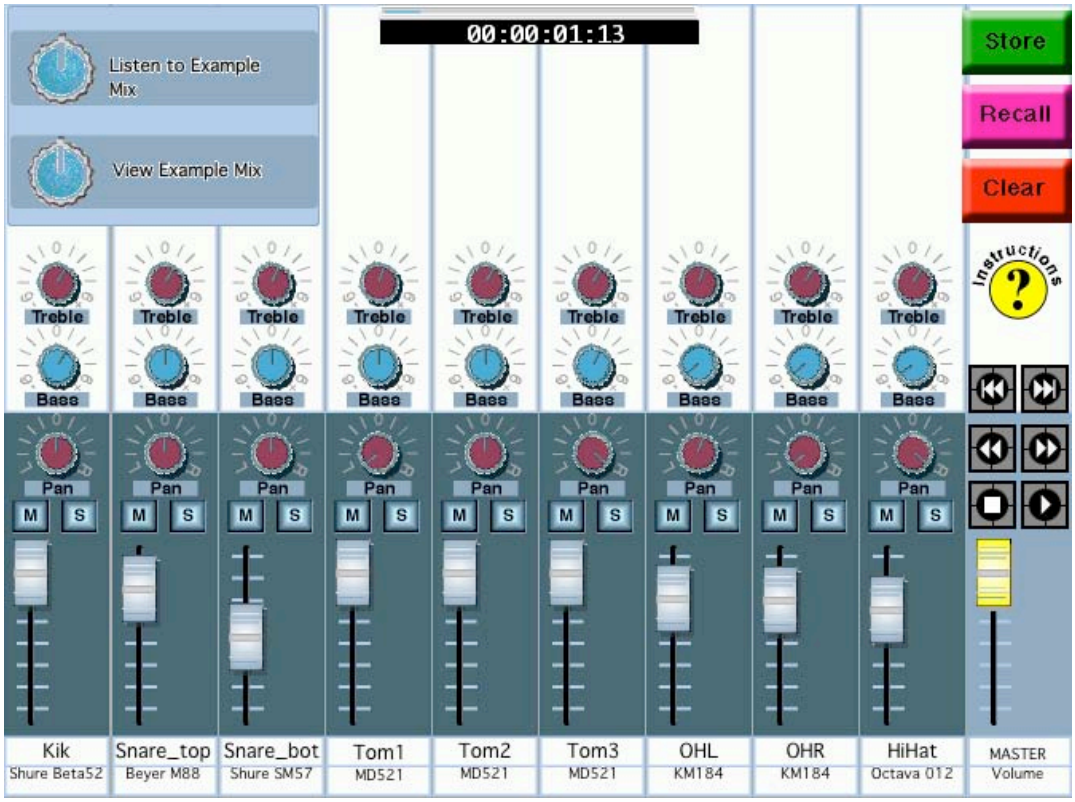

Fig 5. Screenshot showing adjustment of Learning Object 1 parameters.

4.3. Learning Object 1 Evaluation

4.3.1. Diploma Student Pre-evaluation

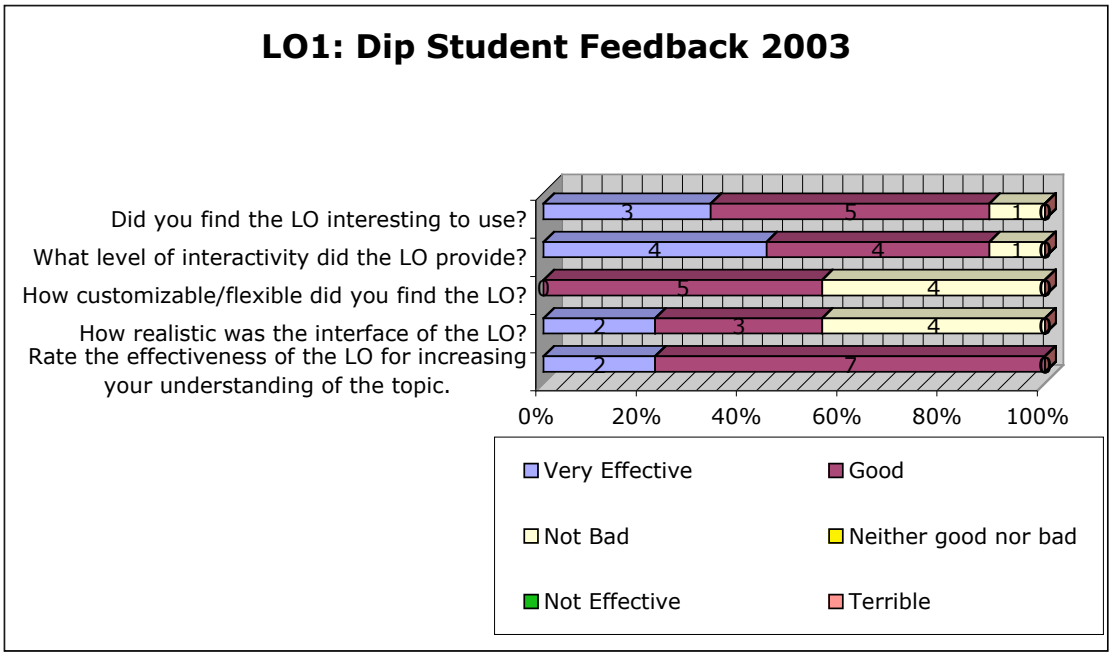

Fig 6. Summary of MAINZ Diploma Audio student's evaluation questions for Learning Object 1.

Above are the summary evaluation results from the researchers class of Diploma of Audio Engineering students. The Diploma Student evaluation was a pre-release evaluation to gather general feedback about the Learning Object, and discover any interface and user issues. Responses to all questions were positive from all the students. The Learning Object scored highest for effectiveness, and lowest for flexibility. The lack of flexibility reflects the single multi-track audio example that was used, and the inability for the user to choose a different audio example. The range of instruments in the audio example mix was also limited to drums, and most users commented that a complete band mix including vocals, guitars, bass etc would be beneficial. These limitations of the Learning Object were intentional. The number of audio tracks was limited so as not to overtax slower computer systems, and was used more as a proof of concept that could then be extended in a second version at a later stage. Embedding a single audio example also reduced initial development time. Most students were happy with the level of interactivity of the Learning Object, and found it interesting to use. Students tended to compare the visual interface of the Learning Object to that of software plug-ins for

ProTools and Logic Audio. These plug-ins have a more highly stylized appearance and feature lighting and shadow effects that were not a feature of the Learning Object.

The Diploma Students were asked to describe how the Learning Objects might be improved. Their comments focused on the Learning Object interface and functionality. Being familiar with audio mixing desks they compared the virtual features available and wanted more active features. These extra features were considered beyond the scope of the Learning Object that was really focused on the core elements of an analogue mixer.

There were a couple of interface bugs detected by students, including the slow response to users mouse movements on the interactive knobs. This feedback was taken on board and the script used to create interactive knob movement was redeveloped for a quicker response. However, some requests for enhanced functionality were felt to be beyond the design scope of the Learning Object.

Students were also asked to describe what situations the Learning Objects would be most effective in. They described a range of entry-level learning environments that were considered suitable, e.g. “For beginners to Audio, New cert students, secondary school studios”.

The general consensus was that the Learning Object would be useful in helping users learn the basics of an analogue mixing desk in a self directed environment. This matched the Learning Objectives outlined for the Learning Object.

After some small modifications to the Learning Object, it was sent out to the two main groups of evaluators – MAINZ Tutors, and Church sound operators, along with the modified MERLOT evaluation forms. The evaluations are summarized below.

4.3.2. MAINZ and Church sound operator evaluations for Learning Object 1:

Average MERLOT equivalent rating = 3.95

This being the first Learning Object designed and evaluated, it was expected that it would gain the lowest rating of all the Learning Objects, as the designer experimented with the

authoring environment (LiveStage Pro and QuickTime) and with the principles of Learning Object development for the first time.

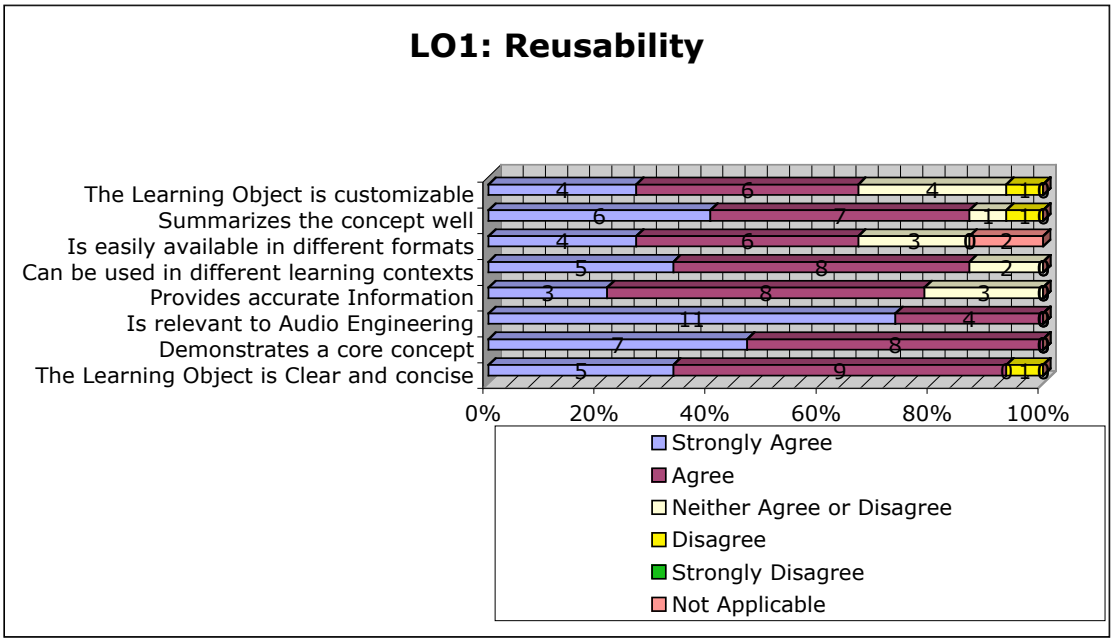

Fig 7. Summary of responses to evaluation questions relating to reusability for Learning Object 1.

Most responses were very positive to the questions regarding reusability. Negative responses were limited to the more inexperienced users – the church sound operators and entry-level MAINZ students (Foundation Studies students) who appear to require more scaffolding in support of a constructivist learning environment. “Users would need to be directed as to what to do with the program unless they were somewhat experienced with mixers” (Church sound engineer comment). The role of an expert tutor in embedding the Learning Objects within an appropriate learning environment for the learners was thus emphasized. The Learning Object scored well for relevance to Audio Engineering, and demonstration of a core Audio Engineering concept. Customizability and format availability received the lowest scores.

MAINZ Tutor comments mainly focused on the interface, indicated performance issues, and suggested extra functionality. Several comments expressed encouragement for the concept, such as “Excellent for a basic understanding of audio engineering – easily understood and functional”.

Church Sound Operator comments were positive, focused on the functionality of the Learning Object and the computer system requirements.

Some PC users experienced performance difficulties running the Learning Object, with the most common problem being drift between the audio tracks. This was not a problem on the Macintosh platform. The problem is possibly due to the variety of hardware configurations of PC systems. The Learning Object required significant audio processing, and therefore the computers required a relatively fast processor and a high quality sound card. A couple of PC users also experienced difficulties installing QuickTime on their computers. Some did not have administrator access, which is required to install QuickTime, while some became confused with the registration process during the QuickTime installation. The church sound operators did not have the benefit of access to IT support staff that MAINZ tutors did, so this was a barrier for them.

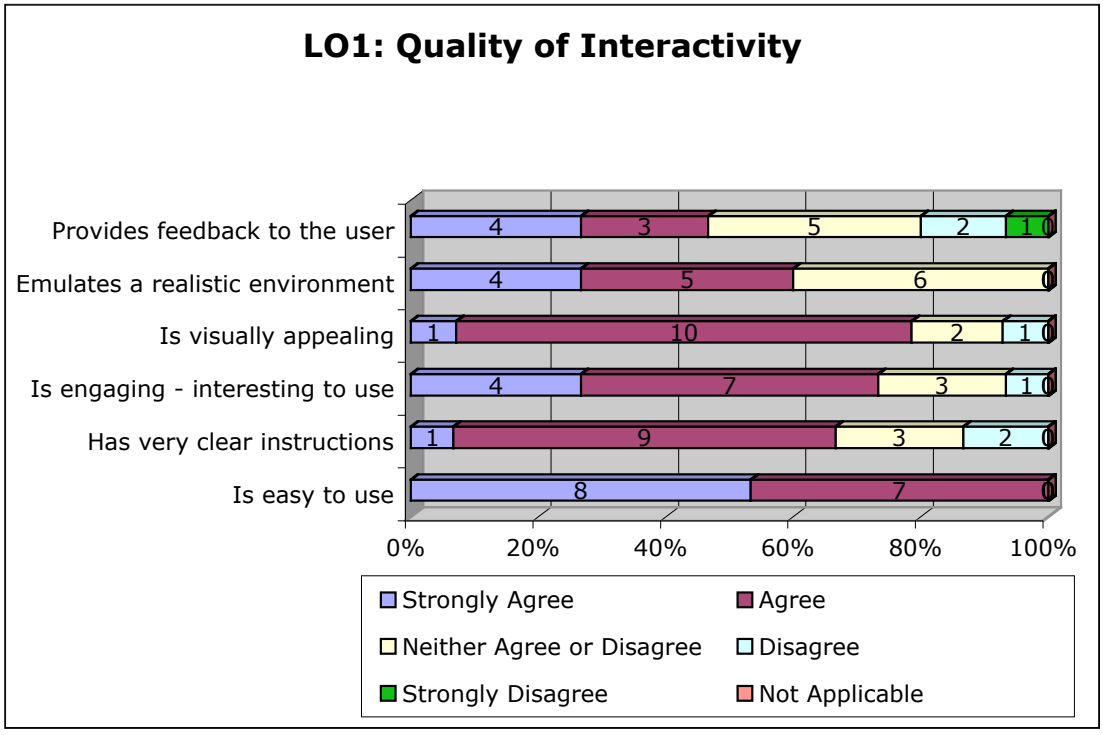

Fig 8. Summary of responses to evaluation questions relating to interactivity for Learning Object 1.

All users found the Learning Object easy to use. Users appreciated the ability to adjust the various parameters interactively. A couple of users did not find the instructions/help for the mixer. These were initially accessible by clicking on the question mark symbol. Without first

reading these, some users weren't quite sure what was expected of them. Some users commented that a more realistic environment would offer a wider variety of instruments for mixing.

MAINZ Tutors commented on the interface response and features available within the Learning Object. One useful suggestion that was later implemented involved the implementation of the Learning Object instructions, "I was a little unsure of the 'listen to example mix' and 'view example mix' ports – then I clicked on the ? button. At the start when first loaded, maybe this screen could 'popup' before the user starts playing".

Church sound operators like the concept and requested additional functionality. "Only simulates a very small portion of desk operation, but for basic work – excellent. Has huge potential if taken further".

MAINZ student comments focused on the graphics of the Learning Object and a perceived lack of instructions. The Foundation students are used to an instructivist learning environment, and were uncomfortable with the constructivist nature of the Learning Object. This needs to be recognized by the tutor and additional guidelines should then be given for these students.

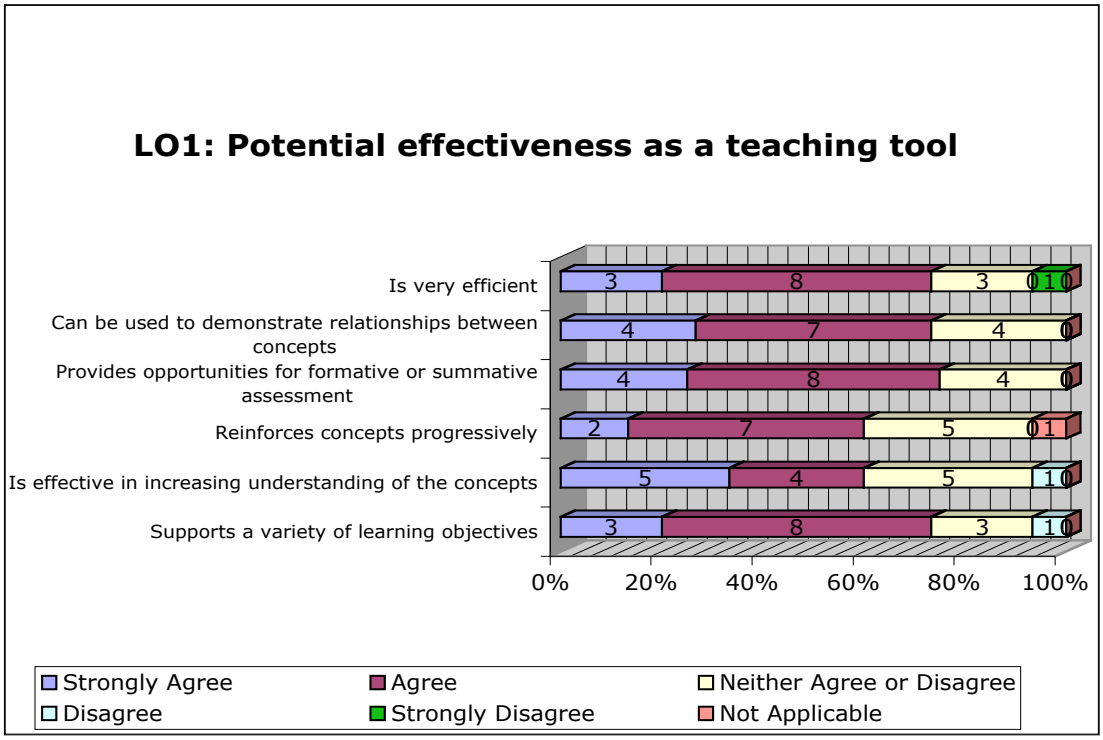

Fig 9. Summary of responses to evaluation questions relating to pedagogy for LO1.

Several of the non-teacher trained users wanted more obvious instructions, and greater implementation of formative assessment and feedback within the Learning Object. Users expressed their opinion that the Learning Object had a lot of potential, especially if some extra functionality were added in a later version.

MAINZ Tutors liked the implementation of several different media elements within the Learning Object – i.e. the combination of audio and visual feedback. They enjoyed using the Learning Object, and requested increased functionality in a future version.

Church sound operator comments were encouraging and focused on increasing the functionality of the Learning Object. “With appropriate exercises or a range of multi-track options, this tool would be fantastic!”

MAINZ Foundation Studies students once again requested more in depth instructions.

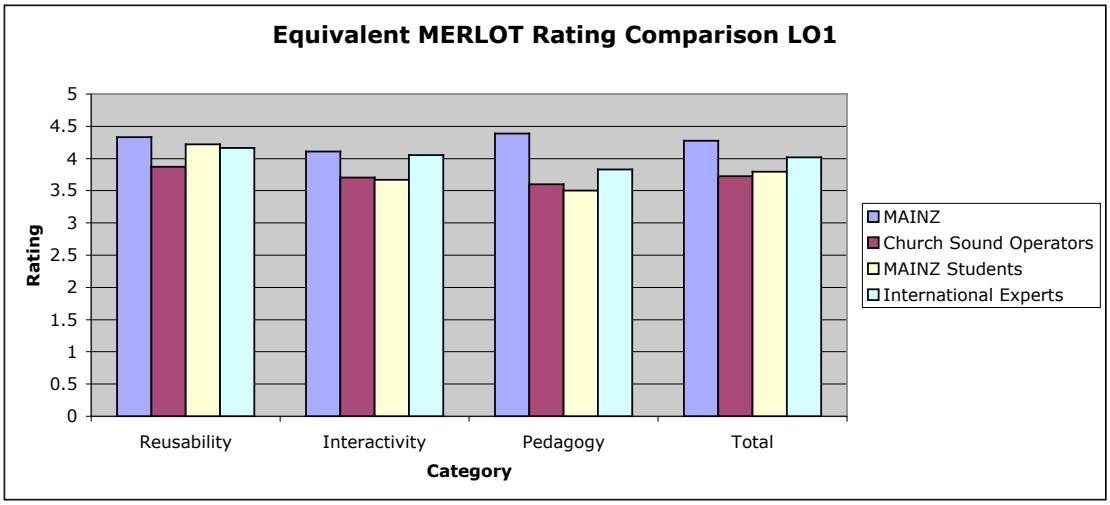

Fig 10. Summary of equivalent MERLOT Ratings for Learning Object 1.

The above chart gives a summary of the responses to each category from all the different groups of evaluators for Learning Object 1. All users found the Learning Object useful. As a first attempt at developing an interactive Learning Object the embedded instructional context was minimal, as it was assumed that tutors would want to create their own instructional context around the Learning Object. However, users without access to complementary instruction from tutors, or with little or no experience in the Audio Engineering context, really

needed the scaffolding of an embedded pedagogy and a more explicit formative assessment to give feedback on their learning progress. This is reinforced by the comments from international experts in instructional design, but no expertise in audio engineering. Those evaluators with significant audio engineering backgrounds (MAINZ tutors) did not see this as an issue.

4.3.3. International experts evaluations:

MERLOT equivalent rating = 4.02

The international evaluators were generally more enthusiastic about the potential of Learning Object one than the Church sound operators and MAINZ students. The interactivity of the Learning Object was highly rated.

> The first one that I accessed was the Interactive Mixer. It was fantastic. I was able to manipulate the music by using the different features of the virtual mixer. I really enjoyed using it - I found it to be fun - it was extremely interactive - I could turn the knobs and slide the bars and hear the difference that it made. I could also imagine the possibilities for use of this RLO to demonstrate musical principles in an audio engineering class (L. Young, 2004).

Their comments indicated that they recognized the need for embedding the Learning Object within an instructional context, but did not have the subject knowledge to conceptualize this context, whereas MAINZ tutors saw a variety of instructional contexts implicitly. The designer did not want to limit the reusability of the Learning Object by making the learning context too specific.

4.3.4 Modifying Learning Object 1

The following modifications were made to the Learning Object as a result of feedback and evaluations:

- Instructions were placed directly in front of the user when the Learning Object first opens

- Instructions were modified to include graphics as well as text
- The short-cut '?' icon to display the instructions was labeled 'instructions'
- Interaction of the knobs was modified to follow user mouse control more closely
- Only one version of the Learning Object was included on future versions of the CD-ROM
- Text fonts were modified to render properly on both Macintosh and Windows platforms

4.3.5 Lessons Learnt from Learning Object 1

- Make Learning Object operating instructions clearer and force users to read them at the start of using the Learning Object.
- Make pedagogy more explicit
- Provide explicit formative assessment
- Make Learning Object easier to install/start
- Provide users with only one version of the Learning Object on the CD-ROM, and provide a link (URL) to the web-optimized version.
- Be careful with text and graphics formats for best cross-platform compatibility.
- For best audio performance (especially on Windows PCs) run the Learning Objects off the users hard drive rather than directly off the CD-ROM.

4.4. Learning Object 2 Design

4.4.1. Description

This is an interactive microphone chooser/explorer, for learning some basic principles of microphone choice, including audio examples.

4.4.2. Learning Outcomes/Objectives

At the completion of using the Learning Object, students should be able to:
(1). Choose an appropriate microphone for recording a particular instrument.
(2). Demonstrate appropriate microphone placement for recording or live sound.
(3). Differentiate the sound of different microphones.

4.4.3. Assessment Activities

In response to evaluation feedback from Learning Object 1, the embedded pedagogy of Learning Object 2 was made more explicit. The Learning Object was designed to include a simple formative feedback/assessment in the form of an interactive test that is built into the Learning Object. Initial audio examples demonstrate the effect of different microphones used on the same instrument. Six example audio mixes are then provided, from which the student must select the microphone used for each instrument by listening to the characteristics of the recorded sound. A tick box next to the chosen microphone indicates a correct selection.

4.4.4. Initial Concept

A key skill for a recording or live sound audio engineer is to choose an appropriate microphone for the task. Every instrument has different characteristics and every microphone has characteristics that will match it to a particular instrument or not. Making a good microphone choice will make achieving the style of sound required much easier. A wrong microphone choice can even damage the microphone. Secondly, appropriate placement of the microphone in relationship to the instrument greatly affects the resulting sound. Learning Object 2 is designed to provide an interactive environment in which to learn these skills. One of the common situations in which multiple microphones are used on one instrument is in the

recording of drums. Appropriate placement of microphones around the drum-kit will minimize unwanted noise being recorded, and also minimize phase cancellation problems caused by differences in the length of audio paths to multiple microphones. A drum-kit was chosen as the source for recording multiple microphone sources for this second Learning Object. Using the virtual reality capabilities of QuickTime enabled the creation of a virtual tour of a live sound stage microphone setup, and also links to example studio microphone placement techniques.

4.4.5. Technical requirements/Delivery formats

It was envisioned that the Learning Object should be available in a variety of quality settings for different data bandwidth delivery mediums: Website, CD-ROM, and Hard Drive. Feedback from Learning Object one indicated that users were confused when presented with multiple versions of the Learning Object (on the CD-ROM). The main difference was in the audio compression quality used for each delivery medium. The audio quality of the MPEG4 compression was found to be subjectively high enough to demonstrate the audible differences between the different microphone responses. Therefore it was decided to provide only one version of the Learning Object that would be suitable for delivery via all three mediums, simplifying the choice for the end user.

Functionality that was required included:

- User selection of background information and specifications for commonly used professional microphones.
- Virtual tour of an example live and studio microphone setup.
- Playback of example audio multi-track drum-loop.
- User selection of microphone type for each audio track.

4.4.6. System requirements

The goal was to produce a Learning Object that would run on most recent computers (cross-platform, Mac OS9 and OS X, Windows 98 and XP).

A PPC (PowerPC) Macintosh or Pentium Windows computer, with a CD quality sound card, 1024 by 768 colour monitor, and QuickTime 6 installed (QuickTime 6 Pro required for saving audio mixes). A CD-ROM drive and Internet connection are also required.

4.4.7. Development Steps

This Learning Object includes the most media of all of the Learning Objects created, and requires the highest load on a computer's system of all of the Learning Objects. Initially the interface and media elements required to meet the Learning Objectives were brainstormed and roughly sketched out, as shown below.

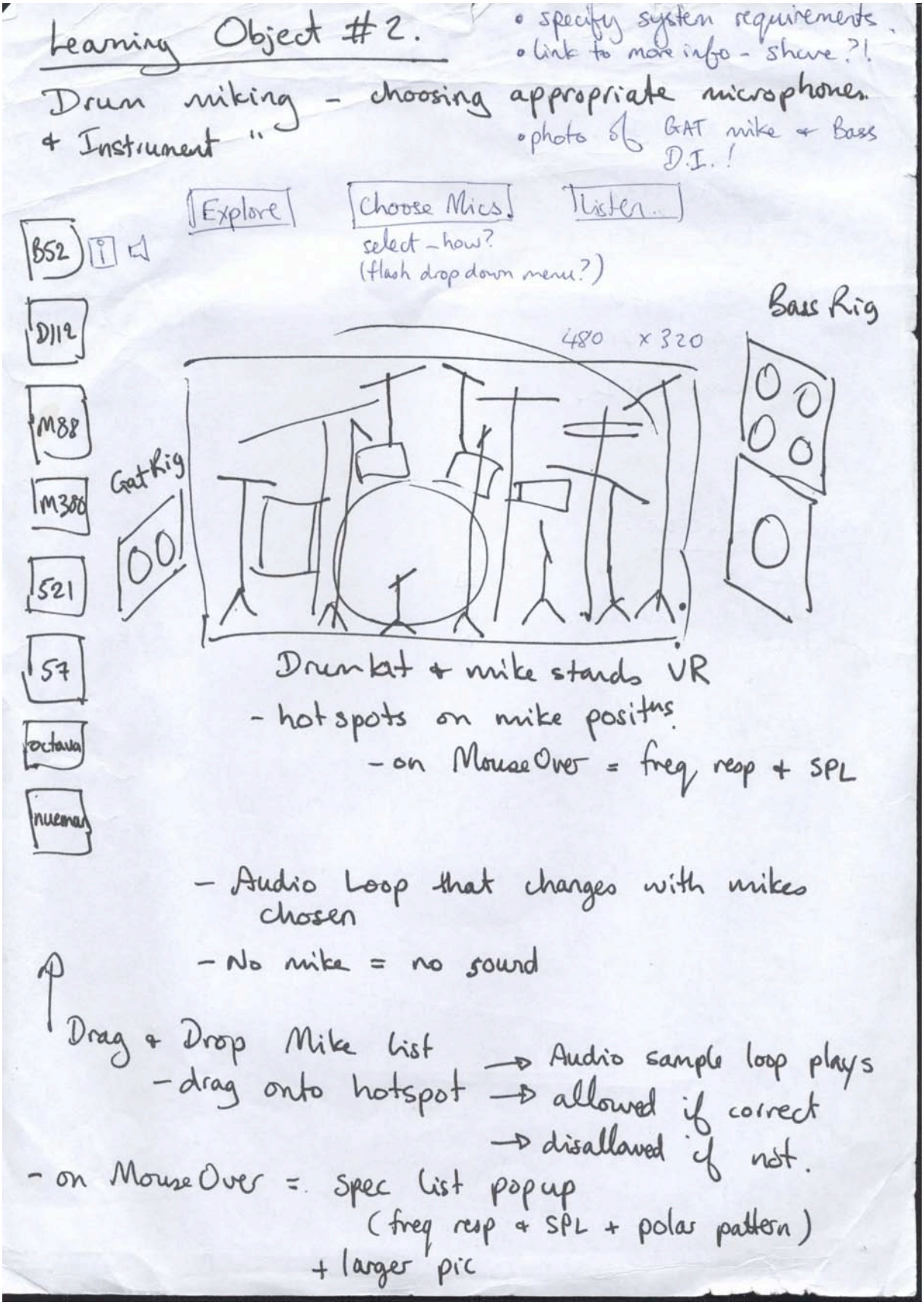

Fig 11. Initial brainstorm of Learning Object 2.

In response to so many requests for added functionality for Learning Object 1, it was decided to build in significantly more features into Learning Object 2. To create an immersive virtual environment, a QuickTime virtual reality tour of a typical stage setup was decided upon. A one hundred and eighty degree panorama of a live stage setup was created (created from 9 still photos stitched together using Apple QTVR Authoring software), and linked to shots of each microphone type placement within a studio setting as well. A drum-kit was setup and recorded with multiple microphones on each drum in the MAINZ Diploma studio. From this recording twenty-four audio tracks are synchronized and played simultaneously within the final interactive QuickTime movie. The graphical interface elements for the Learning Object were once again created using Macromedia Freehand, and then imported into LiveStage Pro for interactive scripting. Information and pictures of the different microphones used were sourced from the manufacturers, and original photographs taken of the MAINZ collection. Flash was used to create interactive drop-down menus for selecting different microphones. These Flash menus were then integrated as QuickTime tracks, interacting with the main movie via Qscript added within LiveStage Pro.
As with Learning Object 1, the second Learning Object was subjected to pre-release testing and cross-platform compatibility checks, and MAINZ Diploma Student feedback before being sent to the two main groups of evaluators. Although a much more involved project than the first Learning Object, the development of Learning Object 2 benefited from the lessons learnt from developing Learning Object 1.

4.4.8. Interface/Overview

The first ‘page’ of the Learning Object displays the user instructions – as suggested by evaluations of Learning Object 1, and the thumbnails of the microphones used/described – which is common to all sections of the Learning Object. The thumbnail images provide clickable navigation to larger images, specifications, and a polar response of each microphone. These details detail the main applications of each microphone, and how its characteristics affect the reproduced sound.

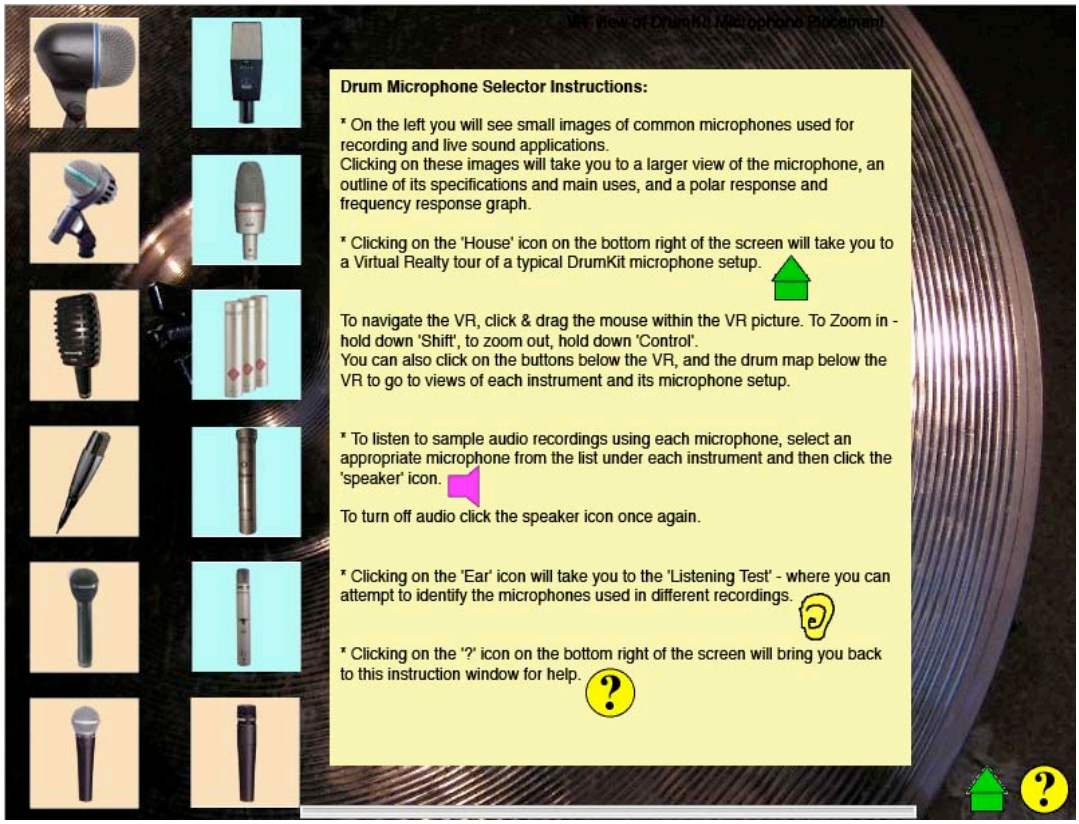

Fig 12. Screenshot of opening page of Learning Object 2.

A loading bar is included at the bottom of the window to indicate how much of the interactive movie has downloaded – if accessing via the Internet. The right hand bottom corner contains navigation icons to the ‘main’ page of the Learning Object.

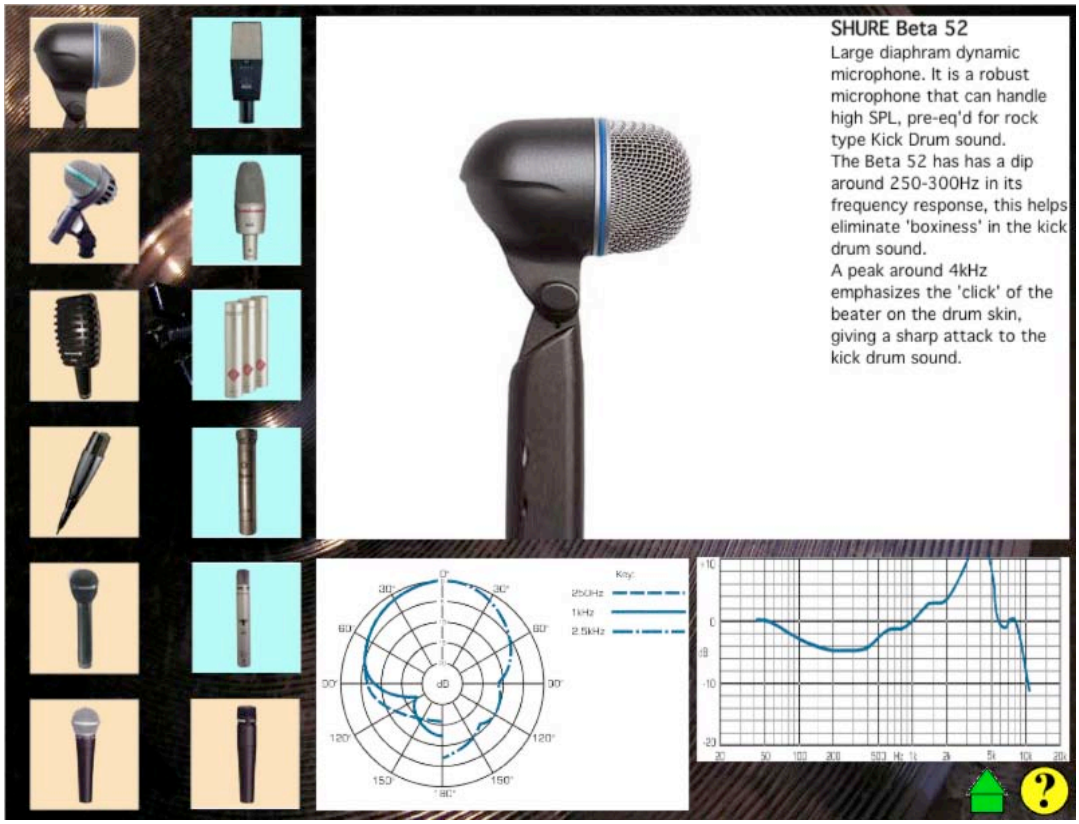

Fig 13. Screenshot of example microphone information in Learning Object 2.

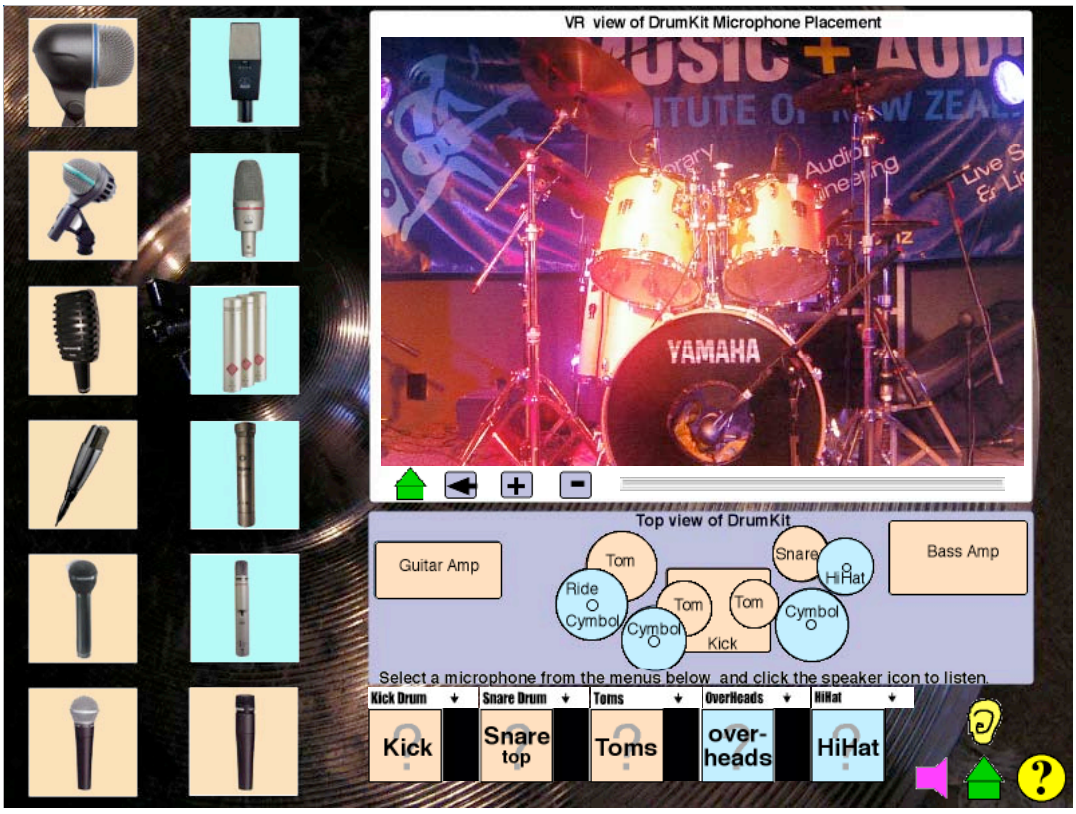

Fig 14. Screenshot of the main window of Learning Object 2 – an interactive microphone chooser.

The main section of the Learning Object includes the virtual tour of a live stage microphone setup, and links to studio microphone placement shots. The virtual tour can be navigated by either; clicking and dragging within the VR window, or clicking on an item in the 'map' below it. The user can listen to an audio example by clicking on the speaker icon. Selecting a microphone type from the drop down menus enables and disables the appropriate audio tracks so the user can hear the difference in the audio response of each microphone. The 'ear' icon takes the user to the formative assessment section, where they can select an audio mix example, and attempt to identify the microphones that were used in the different recordings.

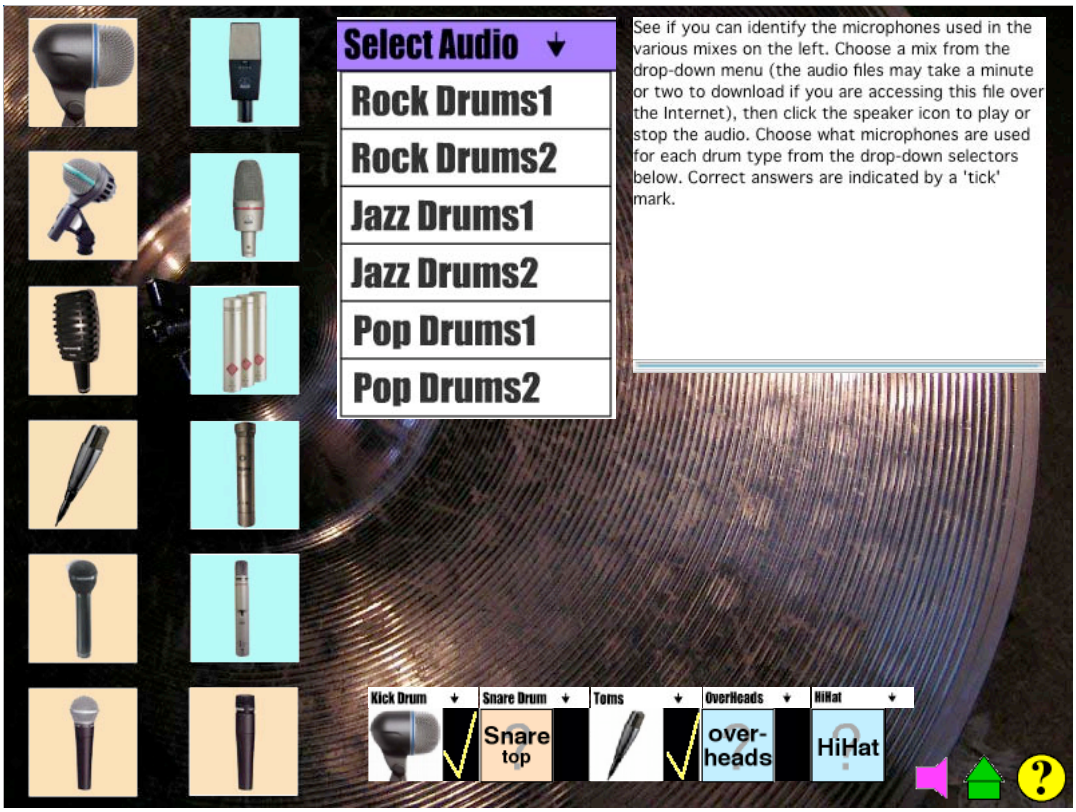

Fig 15. Screenshot of the quiz window of Learning Object 2 – an interactive microphone chooser.

4.5. Learning Object 2 Evaluation

4.5.1. Diploma Student Pre-evaluation

Below are the summary evaluation results from the researchers class of Diploma of Audio Engineering students. This was once again a pre-release evaluation before making the Learning Object available to the two main groups of evaluators.

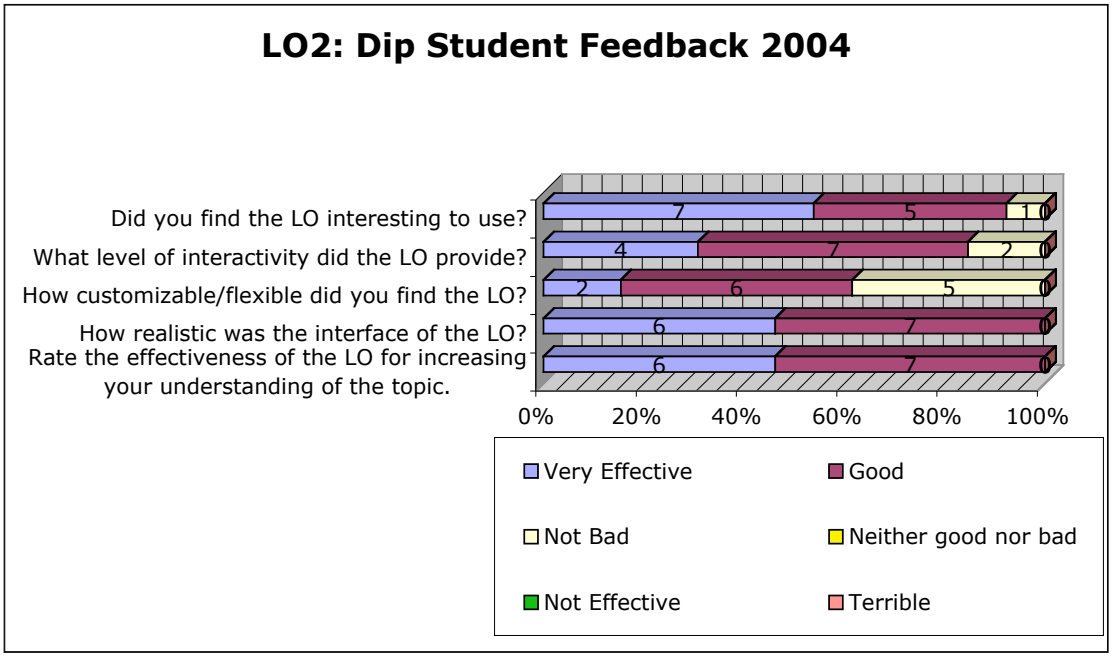

Fig 16. Summary of MAINZ Diploma Audio student's evaluation questions for Learning Object 2.

Learning Object 2 stimulated a lot of response from the researcher's students. The virtual environment achieved using QuickTime VR and the high level of user interaction within the Learning Object produced high ratings for realism and effectiveness. Their comments indicated a preference for a more involved formative assessment to be included within the Learning Object. Although there was a lot of user choice built into the Learning Object students still requested more. A trade-off between choice/coverage and Learning Object size was seen as more important to the developer, as more choice could also be achieved by linking to other Learning Objects instead. Students saw a wide range of instructional contexts for the Learning Object to be used within.

The Diploma Students were asked to describe how the Learning Objects might be improved. Their comments were mostly focused on providing a wider choice of microphone examples, i.e. increased functionality.

Students were also asked to describe what situations the Learning Objects would be most effective in. Their comments were much more adventurous than those given for Learning Object 1. They were also more discerning in their responses, e.g. "Encouraging critical listening and experimentation with mic techniques outside of a pressure environment (studio)". They indicated that there would be benefits in using the Learning Object across all of the MAINZ courses and levels. Their responses were encouraging.

4.5.2. MAINZ and Church sound operator evaluations for Learning Object 2:

Average MERLOT equivalent rating = 4.20

Feedback from Learning Object 1 indicated most users wanted more embedded pedagogy in the Learning Objects. Therefore, this was made more explicit in Learning Object 2.

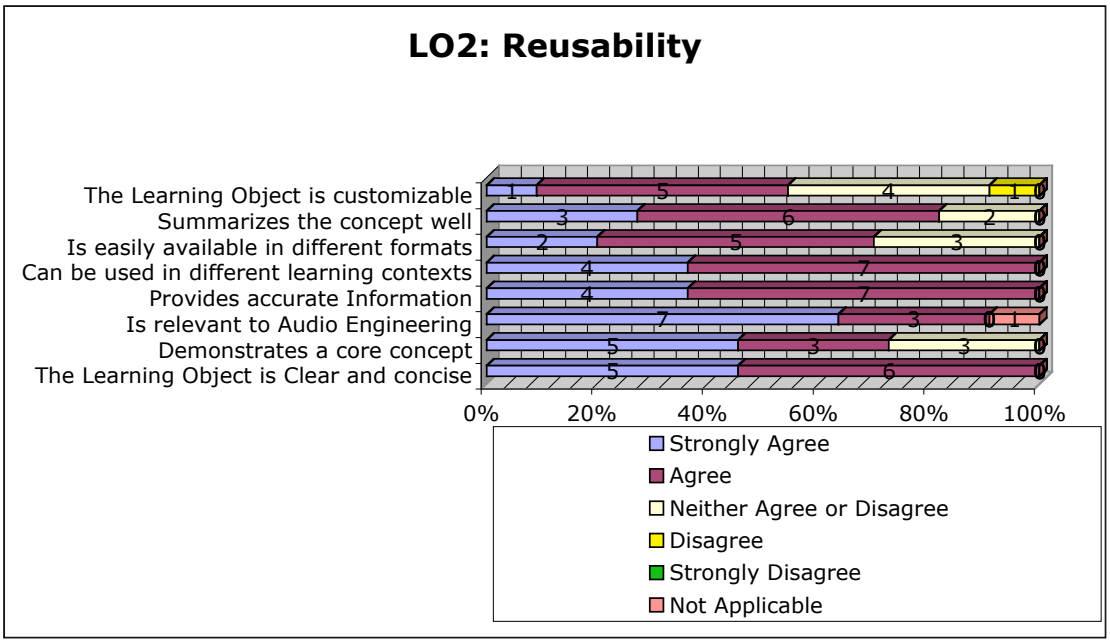

Fig 17. Summary of responses to evaluation questions relating to reusability for Learning Object 2.

The Learning Object received good ratings for reusability within the broader Audio Engineering context. The ratings were better than those received for Learning Object 1. The area of lowest rating was in customizability. This was due to the Learning Object being supplied with only one set of audio examples. While the Learning Object could be modified to allow selection of a wider range of audio this would increase the size of the Learning Object, and would limit its distribution over low bandwidth environments such as the Internet.

MAINZ tutors recognized the potential of the Learning Object when coupled with their role in embedding it within a particular pedagogical context.

Church sound operator comments were minimal. They appeared to be happy with the Learning Object, and found it interesting.

MAINZ Student found the Learning Object engaging.

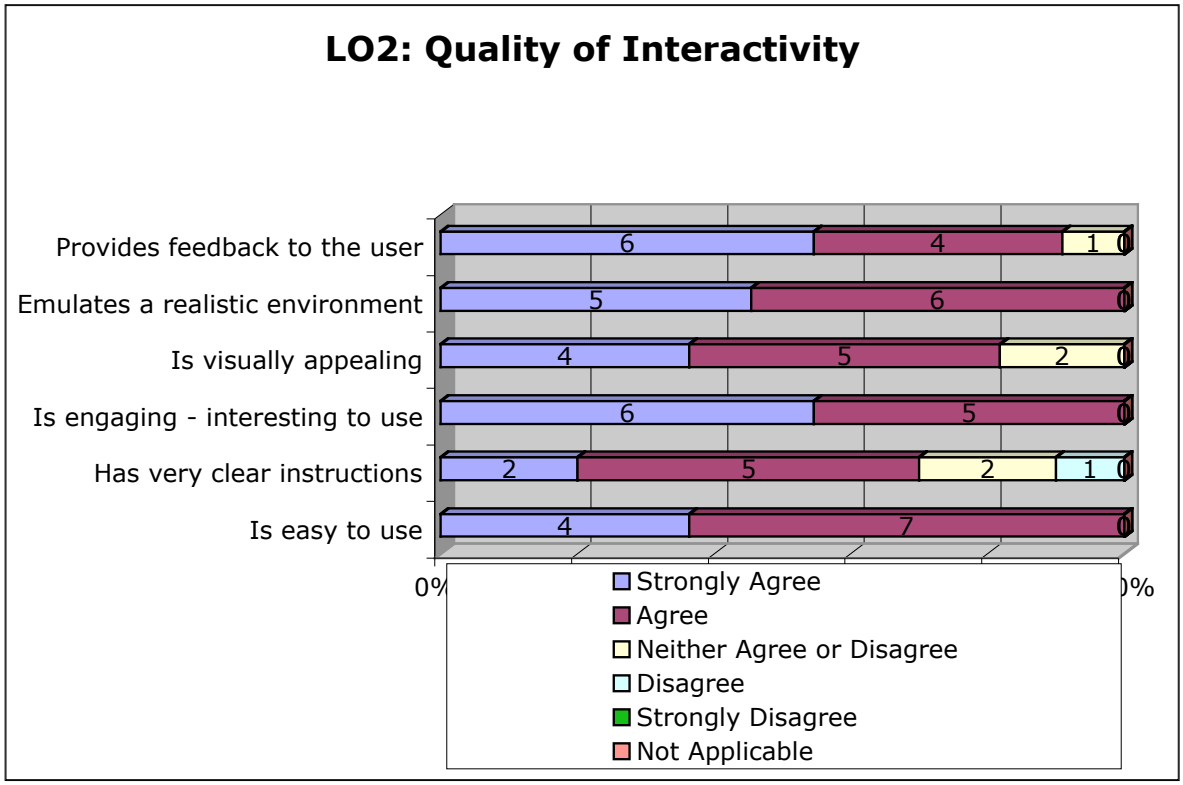

Fig 18. Summary of responses to evaluation questions relating to interactivity for Learning Object 2.

All questions regarding interactivity, with the exception of ease of use, were given higher ratings than those given to Learning Object 1. This was an encouraging progression. The bulk of comments came form MAINZ Tutors. Feedback indicated users found the Learning Object interesting and highly interactive. Some of the interactivity of the Learning Object was not explored/discovered by some users, as some of the features requested are actually possible already. Some useful suggestions were made for enhancing the formative test embedded in the Learning Object. The main area for improvement was indicated as an improvement to the instructions for using the Learning Object and the test.

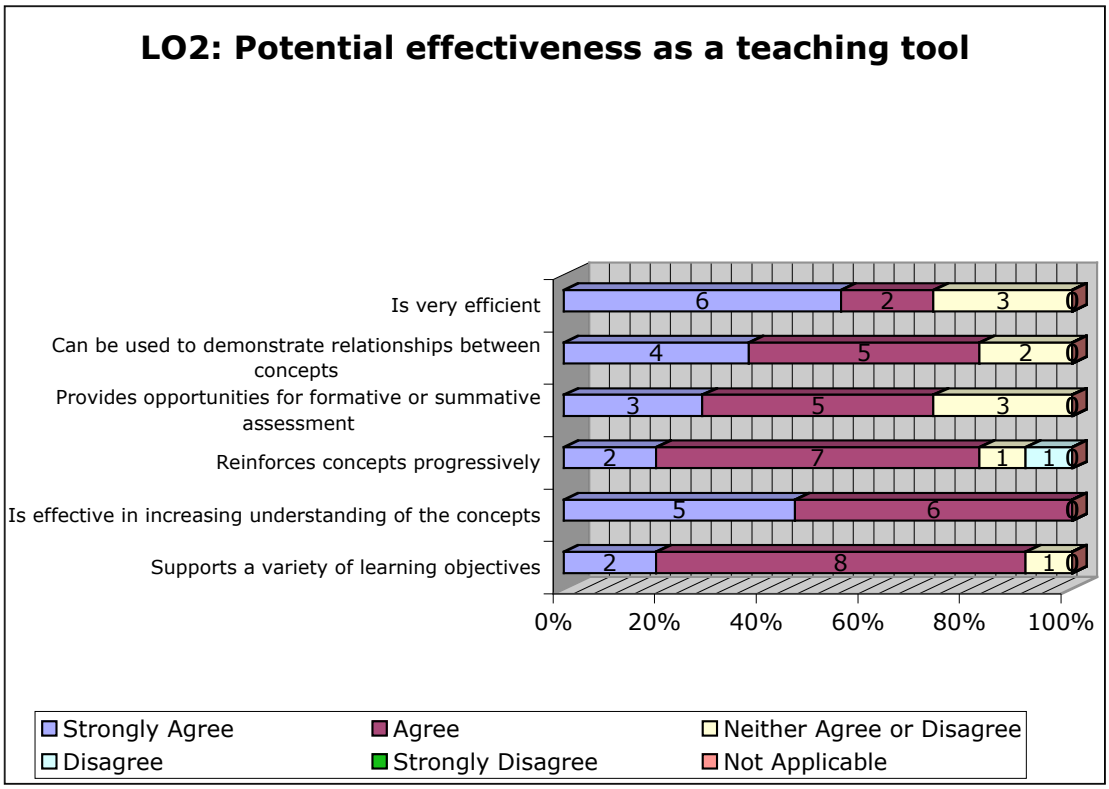

Fig 19. Summary of responses to evaluation questions relating to pedagogy for Learning Object 2.

The Learning Object was more highly rated as a teaching tool than the first Learning Object. Again users tended to request more involved assessment. Once again the MAINZ tutors recognized the role of the tutor in embedding the Learning Object into a wider instructional context. It was felt that the request for more content regarding basic microphone concepts would be better covered within a separate Learning Object, as this really wasn't the goal of the Learning Object. Interestingly no one indicated that they felt the Learning Object was too large or covered too many concepts. This was an area of concern for the developer who

thought the Learning Object was almost at the point of becoming too large and could have been split into a couple of smaller Learning Objects. However, the context of the Learning Object was quite specific so this was not perceived as a problem by evaluators.

MAINZ Tutor saw Learning Object 2 as a good progression and improvement over Learning Object 1. They were enthusiastic about the pedagogical usefulness of the Learning Object.

The church sound operators were more reserved in their comments, indicating that they believed the Learning Object required prior knowledge of the learner context.

MAINZ Students were enthusiastic about the usefulness of the Learning Object, e.g. "I learnt a lot of useful information in a short space of time".

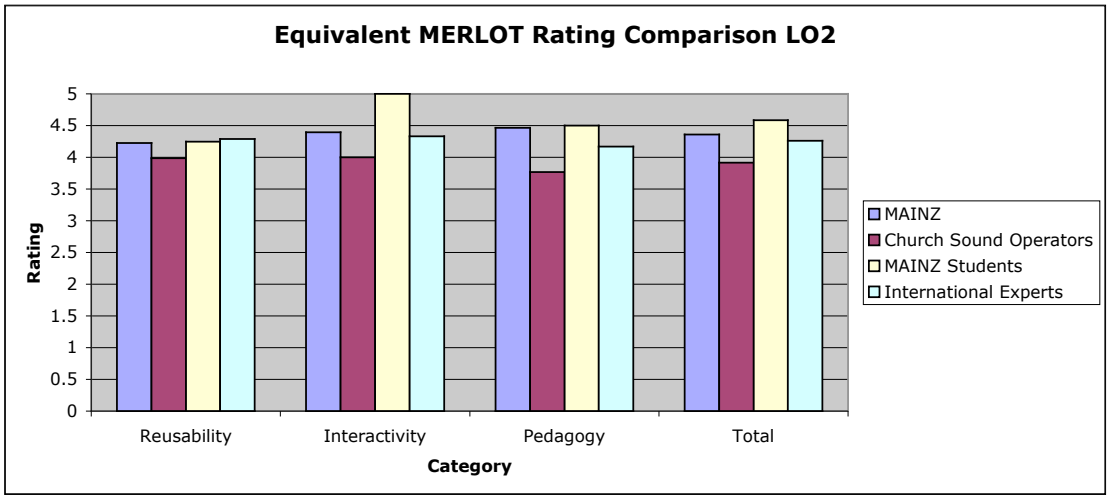

Fig 20. Summary of equivalent MERLOT Ratings for Learning Object 2.

Overall Learning Object 2 scored highly for interactivity and pedagogy. The greatest increase in rating over Learning Object 1 was in interactivity. The Church sound engineers lack of teaching experience was reflected in their relative lack of grasp of the pedagogical possibilities of the Learning Object. MAINZ tutors and international evaluators rated the Learning Object very similarly. Comments indicated that a more highly developed assessment that included the ability to record user results (and thus be used as a summative assessment) would enhance the Learning Object. The assessment was more explicit than that embedded in Learning Object 1, but still wanted more explicit assessment. This was addressed in Learning Object 3 and 4.

4.5.3. International expert evaluations:

MERLOT equivalent rating = 4.264

> This was very interesting. It had images of various microphones and allowed me to look at them, and determine the characteristics of each. The only problem that I had was that all of the tools were not available to me so I was not able to hear the differences that would have really driven the lesson home. It was very interactive and I think it could be used in many different levels of classes and used to instruct multiple objectives (L. Young, 2004).

The International experts liked this Learning Object, highlighting the large amount of interactivity available and the formative test. Suggestions included providing the ability to select different audio examples and including a scoring tool with the formative test.

4.5.4. Modifying Learning Object 2

The following modifications were made to the Learning Object as a result of feedback and evaluations:

- Instructions were modified to include graphical icons

4.5.5. Lessons Learnt from Learning Object 2

- Make pedagogy more explicit
    - Provide more extensive formative assessment with some form of scoring tool
- The Flash menus provided useful interactive navigation
- Users highly valued the interactive features of the Learning Object and the variety of media elements.
- Include a wider variety of audio examples, allowing use within a wider range of audio engineering contexts.

4.6. Learning Object 3 Design

4.6.1. Description

Learning Object 3 is an interactive demonstration of the use of parametric equalization, including several audio examples of a variety of different instruments and vocal examples, and a short formative test.

4.6.2. Learning Outcomes/Objectives

At the completion of using the Learning Object, students should be able to:
(1). Describe the three main parameters of a parametric EQ and how they affect the sound file.
(2). Demonstrate appropriate parametric EQ settings for various instruments.
(3). Evaluate how EQ can enhance the sound of an instrument.

4.6.3. Assessment Activities

Evaluations of Learning Object 2 indicated that even more explicit assessment be embedded in the Learning Object. Ways of doing this in Learning Object 3 were experimented with. As an interactive simulation, user choices provide feedback visually and audibly. However, real-time control of parametric EQ is not currently possible within QuickTime (or Director or Flash) at the moment, so formative assessment activities were limited to more descriptive type activities in Learning Object 3. To keep development time down, the learning component additions to Flash MX were used to create a simple short formative test. As QuickTime supports Flash tracks, it was hoped that the Flash test could simply be embedded within the main QuickTime movie, however, QuickTime version 6 does not yet support the learning additions of Flash MX. Therefore the formative assessment was simply linked to the main Learning Object movie. This does have the advantage of allowing a tutor to modify the assessment without needing to modify the main Learning Object itself, or possibly even provide multiple or alternate assessments.

4.6.4. Initial Concept

Equalization is a core audio engineering process to enhance, correct problems, and make an instrument stand out in a mix. Learning what frequencies affects what characteristics of an instrument, and how to achieve certain styles of sound is a very important skill. A good audio mixing desk will have several bands of parametric EQ available per channel. Parametric EQ is the most flexible type of EQ, but as such has the most parameters to adjust. Learning Object three is designed to give users an idea of how parametric EQ works and sounds on a variety of different instruments, and suggested 'standard' settings. Audio examples with and without EQ applied can be compared. As QuickTime does not support real-time parametric EQ parameters, the parameters and results will need to be simulated. To add a realistic interface to the Learning Object, audio level meters, and audio waveforms for each example were simulated, providing visual feedback to the user. Snapshots of typical parametric EQ settings were created, based upon the Sony Oxford parametric EQ software plug-in for ProTools. This is a high quality professional EQ with a well laid out graphical interface. The Learning Object was also intended to include a brief overview of graphic equalization, and a short formative test.

4.6.5. Technical requirements/Delivery formats

The Learning Object was required to be delivered via Internet, CD-ROM, and directly off of a user's hard drive.

Functionality that was required included:

- User selection of typical parametric EQ settings for various instruments.
- User selection of typical parametric EQ audio examples.
- Demonstration of parametric EQ parameters.
- Formative assessment of principles of parametric EQ.

4.6.6. System requirements

The goal was to produce a Learning Object that would run on most recent computers (cross-platform, Mac OS9 and OS X, Windows 98 and XP).

A PPC (PowerPC) Macintosh or Pentium Windows computer, with a CD quality sound card, 1024 by 768 colour monitor, and QuickTime 6 installed. A CD-ROM drive and Internet connection is also required.

4.6.7. Development Steps

To begin with the interface and media elements required to meet the Learning Objectives were brainstormed and roughly sketched out. To create an immersive virtual environment, required a different approach than the first two Learning Objects, as the real time digital signal processing required for parametric EQ is beyond the capability of QuickTime, Flash or Macromedia Director. To save development time, a simulated environment was modeled on the familiar software processing plug-ins available from ProTools audio editing systems, in particular the Sony Oxford EQ plug-in. This plug-in's graphical interface is more analogue in style than most plug-ins, making it suitable for the Learning Object without too much modification. Snapshots of plug-in settings were taken, and example audio files (of several different instruments) were processed using the actual software plug-in within ProTools. The graphical interface elements for the Learning Object were once again created using Macromedia Freehand, and then imported into LiveStage Pro for interactive scripting. Flash was used to create interactive menus for selecting different examples. Flash was also used to create an animated simulation of the audio waveforms for each example. These Flash elements were then integrated as QuickTime tracks, interacting with the main movie via Qscript added within LiveStage Pro.

The Learning Object was subjected to pre-release testing and cross-platform compatibility checks, and MAINZ Diploma Student feedback before being sent to the two main groups of evaluators.

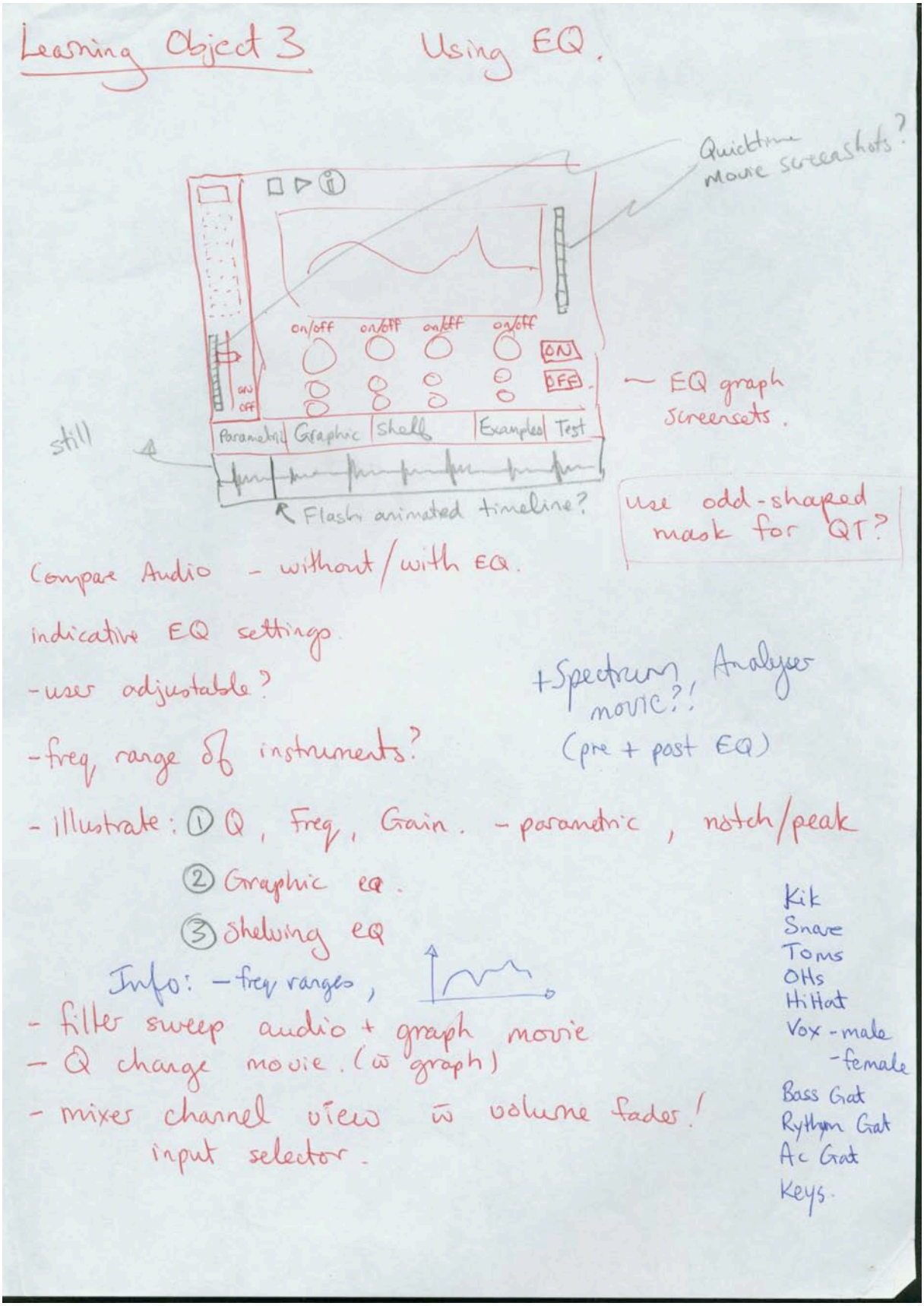

Fig 21. Initial brainstorm for Learning Object 3.

4.6.8. Interface/Overview

One of the design goals was to keep the user interface the same throughout each 'section' of the Learning Object. To achieve this the navigation was kept the same for each section of the Learning Object. As Flash tracks were used successfully as the basis for navigation in Learning Object 2, they were again utilized in Learning Object 3. The Graphical elements are a collage of elements from the Sony Oxford EQ plug-in for ProTools, a navigation menu, and a 'master' control section (right hand side). Instead of an 'instructions' page as per Learning Objects 1 and 2, the instructions are embedded into an interactive mouse over of each control on the first page. As the user mouse's around the screen information is displayed in the top right text field describing each element. The top graph is a frequency response graph, indicating the effect of the selected EQ settings. The bottom 'graph' is a simulated waveform/time display that is synchronized to each audio example while being played back. There are five main sections of the Learning Object. These are navigated by clicking on the menu titles (e.g. 'Start', 'Parametric' etc…). The play, stop, fader and pan elements control playback of the selected audio example. The EQ settings are non-user adjustable, and are snapshots of typical EQ settings for selected instrument examples.

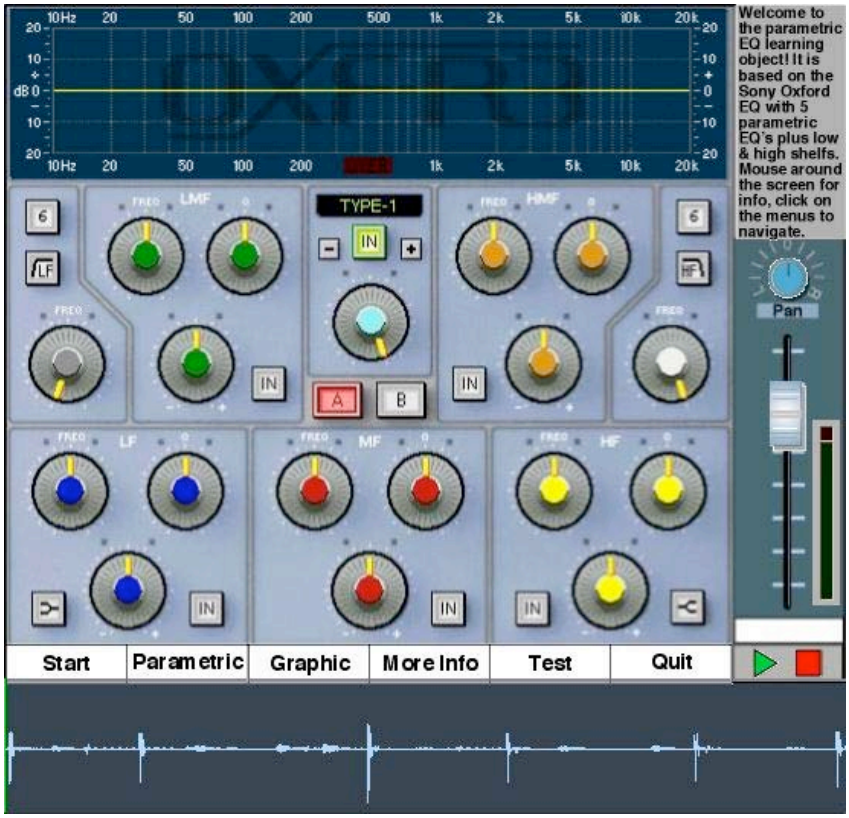

Fig 22. Screenshot of opening page of Learning Object 3.

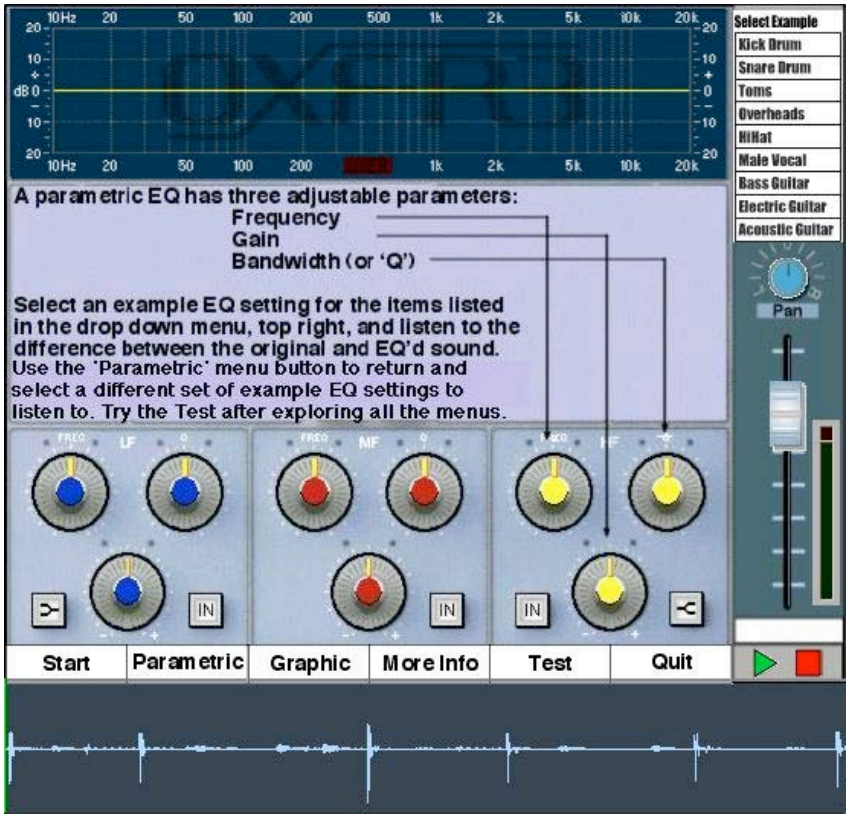

Fig 23. Screenshot of Parametric EQ section of Learning Object 3.

The first page view of the 'Parametric' section briefly explains the interface controls. The interactive Flash menu on the top right provides navigation within each section, and selection of example settings and audio files. There is also an audio level meter next to the master fader.

Fig 24. Screenshot of Example Parametric EQ selection for Learning Object 3.

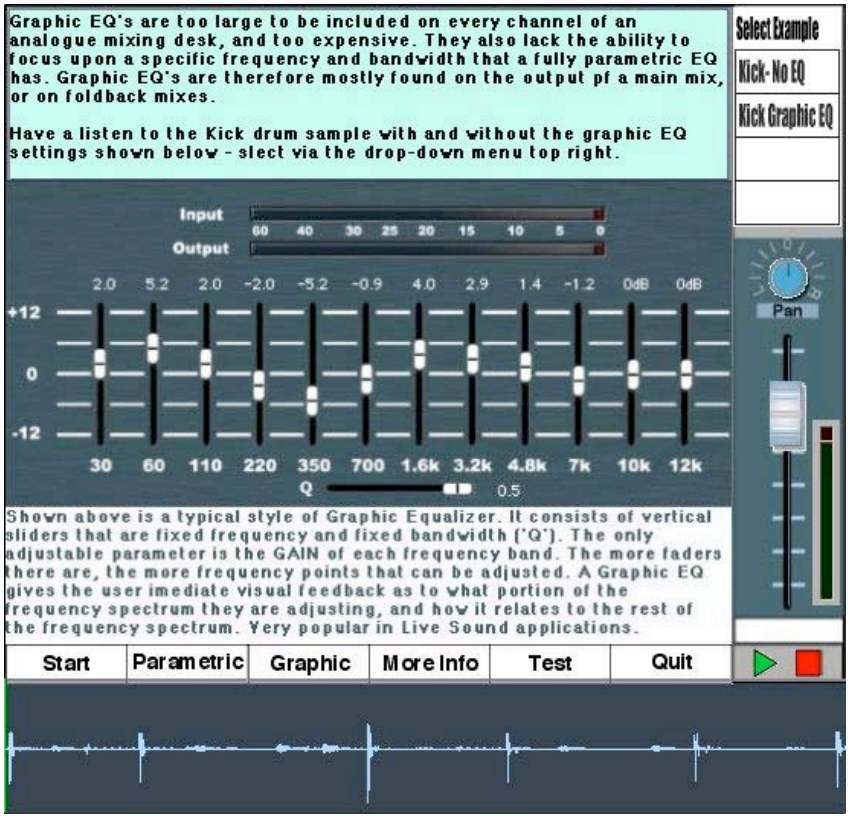

Fig 25. Screenshot of Graphic EQ section of Learning Object 3.

The Graphic section of the Learning Object displays information about graphic EQ's, and a snapshot of a graphic EQ setting. The user can select an audio example with and without the graphic EQ setting shown.

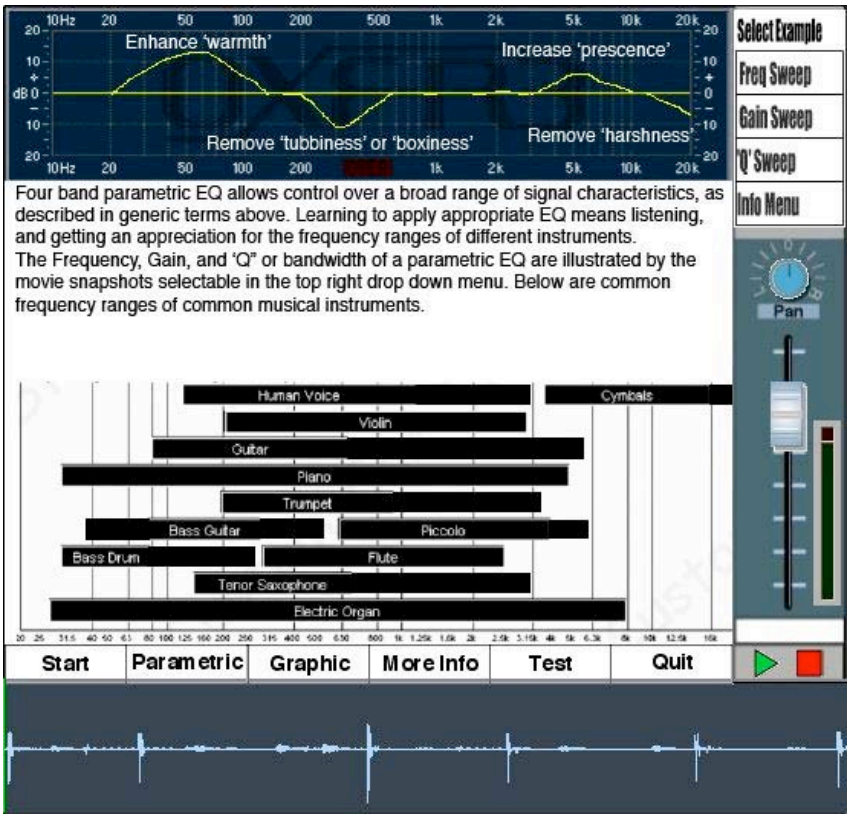

Fig 26. Screenshot of More Info section of Learning Object 3.

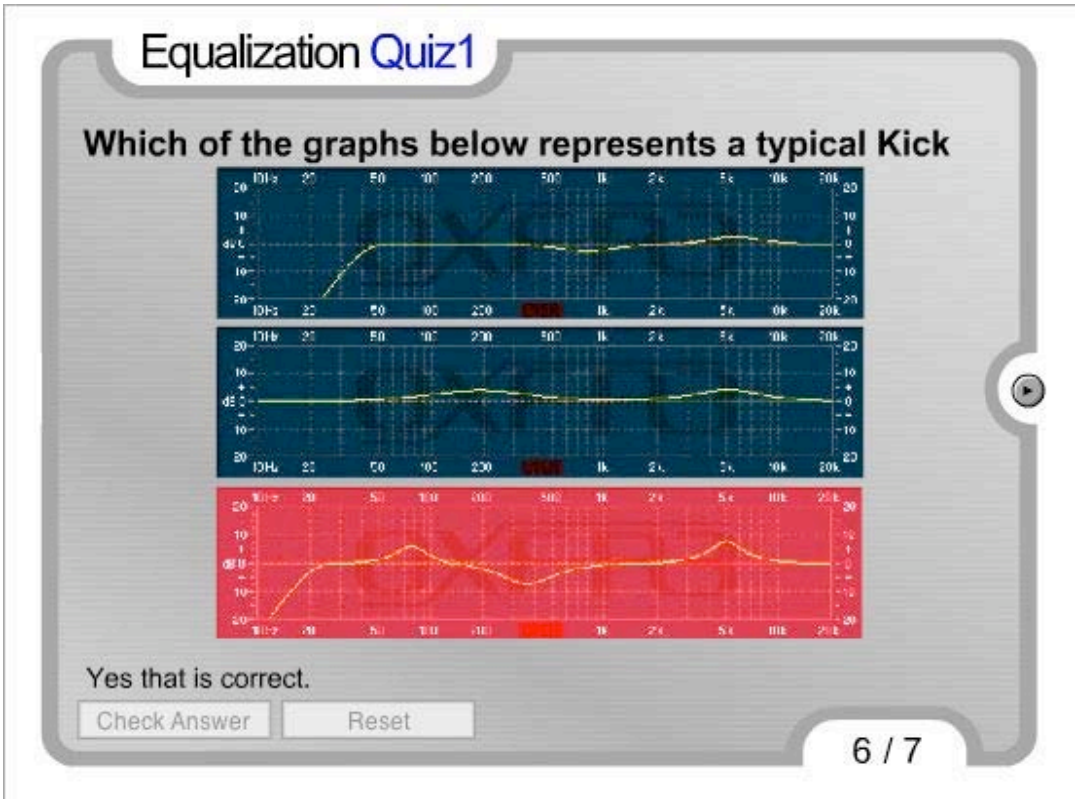

Fig 27. Screenshot of Flash formative Quiz for Learning Object 3.

The linked Flash formative test contains seven different types of questions regarding EQ that can be answered after experimenting with the Learning Object.

4.7. Learning Object 3 Evaluation

4.7.1. Diploma Student Pre-evaluation

Below are the summary evaluation results from the researchers class of Diploma of Audio Engineering students. This was once again a pre-release evaluation before making the Learning Object available to the two main groups of evaluators.

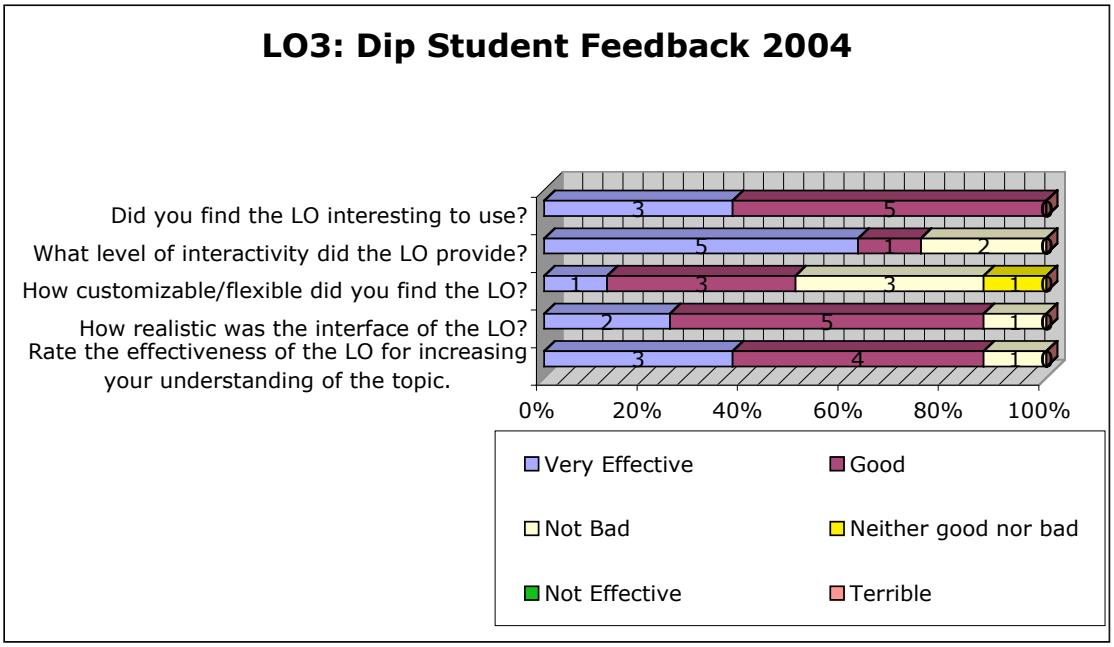

Fig 28. Summary of Diploma Student evaluations of Learning Object 3.

Ratings given were slightly lower than those given to Learning Object 2, but higher than those given to Learning Object one. Diploma students found the Learning Object interesting to use and effective in conveying concepts of equalization. The Learning Object provided less user control of parameters than the previous two Learning Objects and students missed this aspect. Students liked the linked Flash formative assessment, but wanted the assessment to include feedback on correct answers to questions when they got them wrong. Students indicated that the Learning Object was best suited to be used within a wider pedagogical context in a supported reinforcing role – for example as revision after a lecture covering the concepts of parametric equalization.

Suggestions for improvement included allowing more user control of parameters, some improvements to the quiz, and improvements to the graphics quality, which received some criticism. The graphics quality was affected by the moderate jpeg compression used to keep the file size of the Learning Object down. Because the Learning Object contained a large number of screenshots, the graphics quality contributed significantly to the overall file size. The developer had traded off graphics quality to keep the audio quality as high as practically possible while keeping the total file size down.

4.7.2. MAINZ and Church sound operator evaluations for Learning Object 3:

Average MERLOT equivalent rating = 4.12

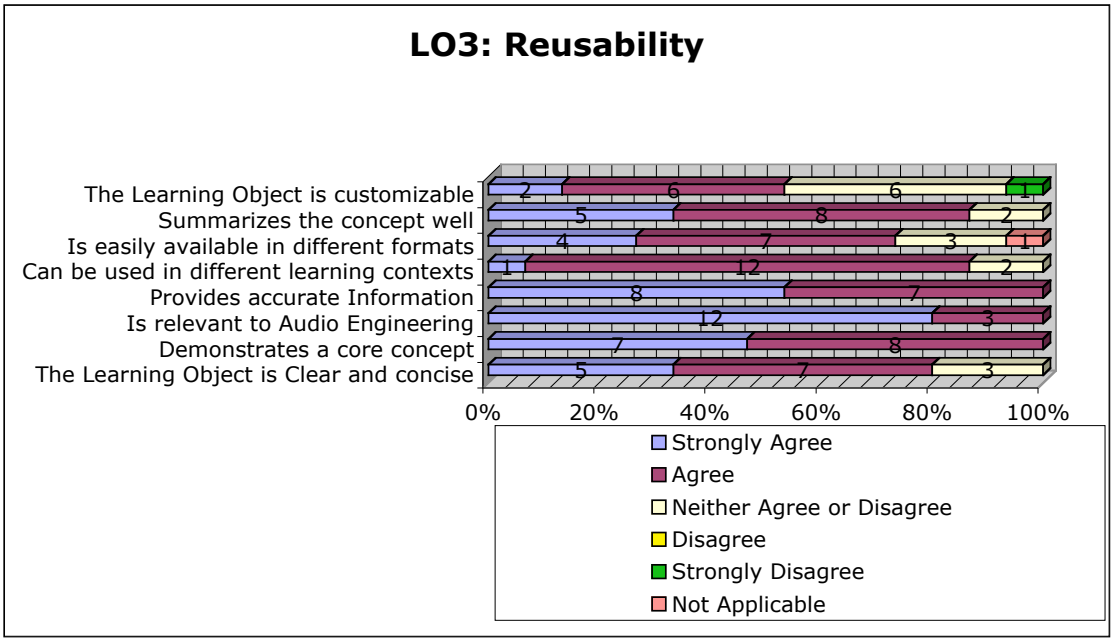

Fig 29. Summary of responses to evaluation questions relating to reusability for Learning Object 3.

Learning Object 3 was rated highly for reusability, higher than both previous Learning Objects. The customizability of the Learning Object was debated. The included audio examples cannot be changed for different examples, but there are a variety of examples included within the Learning Object that enable it to be used in a relatively wide number of audio engineering contexts. Learning Object 2 had been limited by using only drum recordings as the examples, whereas Learning Object three included examples from most common instruments and vocal examples as well. The bulk of the comments on reusability

came from MAINZ tutors, whereas the other evaluators made little comment in this area, presumably being satisfied with the Learning Object's performance.

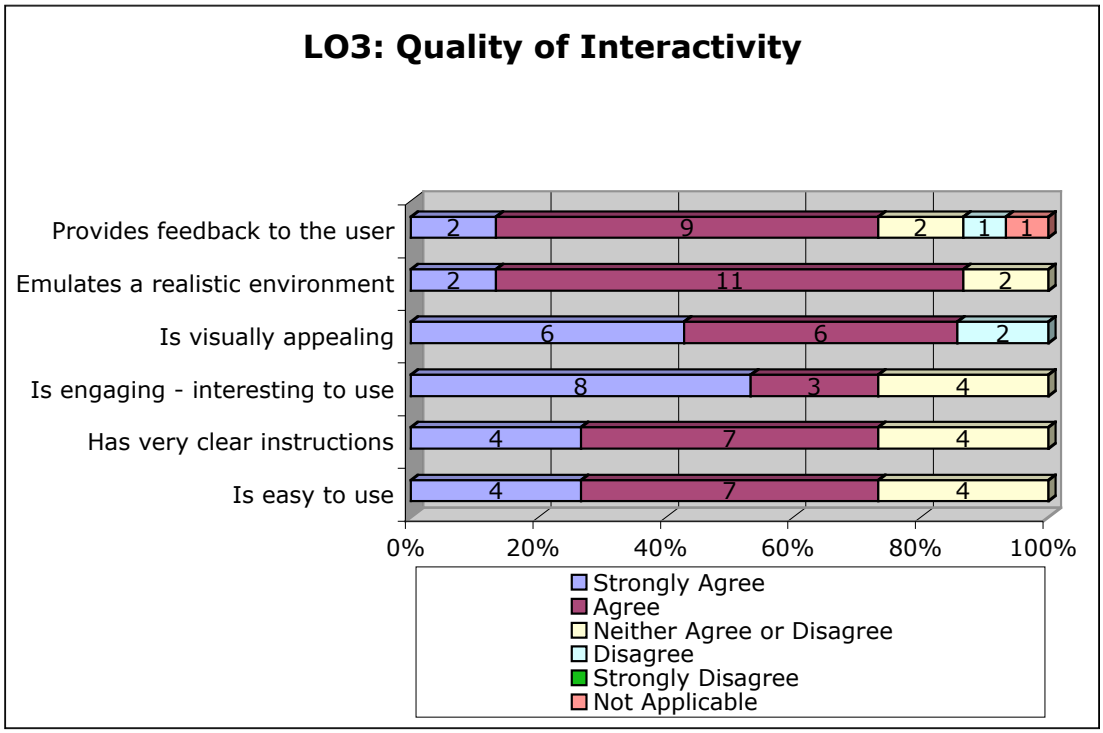

Fig 30. Summary of responses to evaluation questions relating to interactivity for Learning Object 3.

The level of user interactivity with the simulated environment parameters was the main area of comment and concern. In comparison to the previous Learning Objects there was less user control of parameters. Although users could choose from a variety of examples, the static snapshot graphics were not as appealing as interactive buttons and knobs. Users also experienced some apparent bugs in the selection interface, where some examples apparently did not work. The Learning Object did undergo extensive pre-release testing on different computers and platforms, so this was unexpected. As the interactive menus were implemented using Flash tracks embedded within the QuickTime movie, it is possible that certain users may not have the latest version of the Flash plug-in installed on their computer. One church sound engineer who could not view the Flash test indicated this. Instructions for downloading the latest version of Flash should have accompanied the Learning Object, similar to those provided for downloading QuickTime. A lot of feedback was generated from the church sound engineers regarding the lack of interactivity, navigational structure, and the graphics quality. These issues did not appear to be as important to the MAINZ tutors, possibly because

the Learning Object was modeled upon a professional software plug-in that most of the tutors were familiar with.

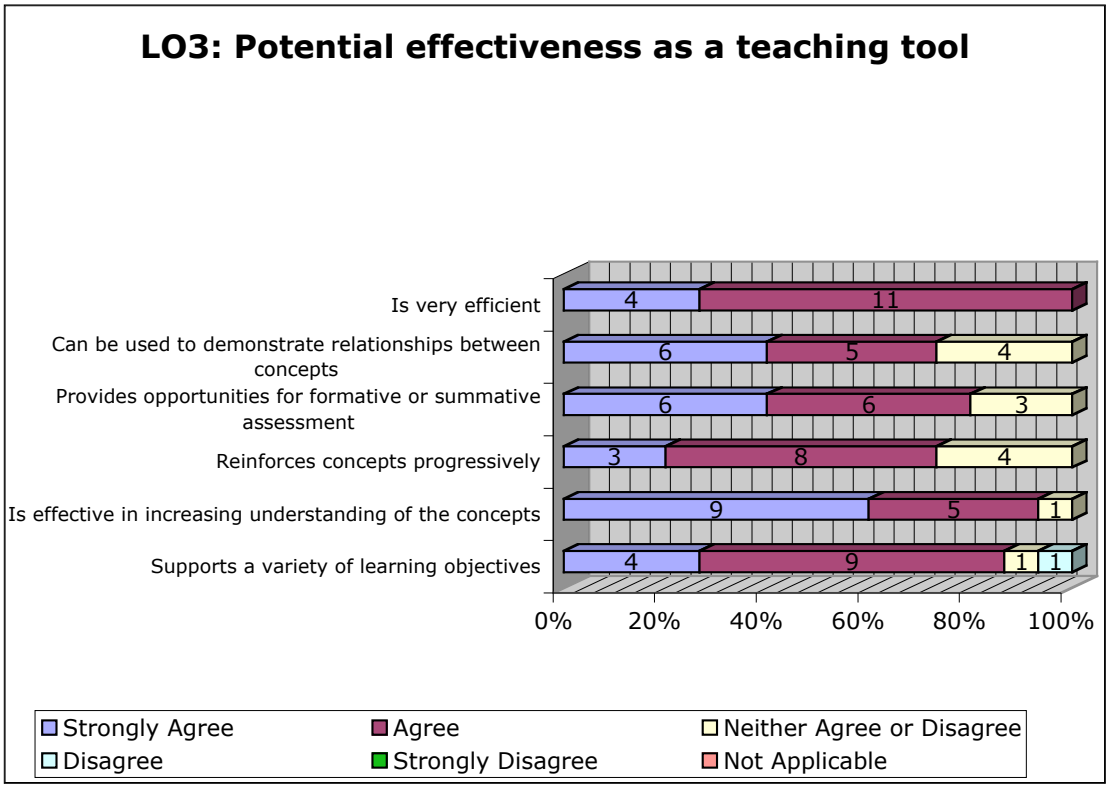

Fig 31. Summary of responses to evaluation questions relating to pedagogy for Learning Object 3.

The Learning Object was rated highly for increasing understanding of the concepts of parametric equalization, and for being an efficient way of learning these concepts. The ratings for pedagogical usefulness were higher than the previous two Learning Objects. The bulk of comments regarding pedagogy came from the MAIN tutors. MAINZ tutors liked the focus on specific learning outcomes, therefore keeping students on track. Tutors liked the linked Flash assessment. The level of tutor/expert input required to guide a learner using the Learning Object was raised. A defining statement (that could almost be described as an epiphany) by one of the MAINZ tutors illustrates the understanding of the importance of the educator to embed the Learning Objects within the wider learning environment.

> Clearly, the extent to which these are met will depend upon the pedagogies employed. More specifically, it could be said that the effectiveness of this tool in a teaching/learning situation has far more to do with the teacher/pedagogue than

the tool itself. This is particularly the case given the standard of this teaching tool, which is very high. It is, therefore, over to the teacher to maximize the learning potential of this tool (MAINZ Tutor).

This was an understanding of the nature of Learning Objects that the church sound engineers took a lot longer to grasp. As fig 32 illustrates, the non-expert church sound engineers did rate the Learning Object lower than MAINZ tutors for potential effectiveness as a teaching tool – suggesting it does presuppose some expert knowledge, either of the audio context, or of teaching skills. The church sound engineers also appear to lack a clear understanding of the terms formative and summative assessment.

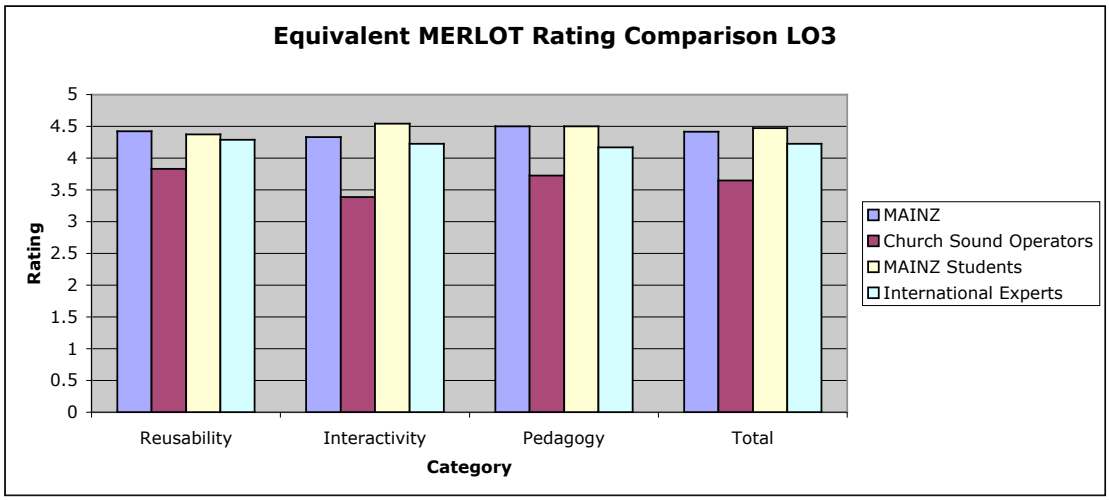

Fig 32. Summary of equivalent MERLOT Ratings for Learning Object 3.

In comparison to Learning Object 2, Learning Object 3 received similar ratings except for a significant dip in the ratings for interactivity. Generally people expected more interface interactivity, especially after experiencing Learning Object 1 and Learning Object 2 where the user has interactive control over most parameters. More detailed user instructions for navigation were also requested.

There were some issues with installing QuickTime on Windows PCs that had been upgraded to the Windows XP operating system – some PC users got stuck at registering QuickTime Pro and did not complete the QuickTime installation without help. Administrator rights are also required to install QuickTime, and some users did not have administrator access to PCs at work.

Text rendered better within QuickTime on the Macintosh computer platform than the PC platform. The initial colour scheme of the Learning Object did not provide a high contrast between the background and the text. This was changed before the Learning Objects were made available to the international evaluators.

4.7.3. International expert evaluations:

MERLOT equivalent rating = 4.227

International evaluators without audio expertise struggled with the audio engineering context of this Learning Object. They were not familiar with this type of equipment or processing that was simulated. They did like the variety of examples provided, and the test. “This one is nicely done as perhaps a review module for music engineering students. One absolutely needs prior knowledge to understand the terminology and purpose”.

4.7.4 Modifying Learning Object 3

The following modifications were made to the Learning Object as a result of feedback and evaluations:

- Background screenshots were recompressed as jpeg graphics instead of using the png format, as smaller file sizes were achieved.
- Instruction text was exported as graphics files to keep the text looking identical on both Macintosh and Windows platforms.

4.7.5 Lessons Learnt from Learning Object 3

- Provide as high a level of user interactivity as possible.
- User control of the Learning Object interface is highly valued.

- The Flash learning interactions provided a quick and effective way to create interactive formative assessments to be linked to Learning Objects. MAINZ tutors particularly appreciated the short test.
- Provide detailed instructions for Windows users to install QuickTime on their systems and to upgrade the Flash plug-in to the latest version (Several PC users had upgraded to Windows XP between evaluating Learning Object 2 and Learning Object 3 and needed to reinstall QuickTime).

4.8. Learning Object 4 Design

4.8.1. Description

Learning Object 4 is an interactive demonstration of using compression and gating, including several audio examples, and a short formative test.

4.8.2. Learning Outcomes/Objectives

At the completion of using the Learning Object, students should be able to:
(1). Describe the main parameters of an audio compressor and gate, and how they affect the sound file.
(2). Demonstrate appropriate compression and gating settings for various instruments.
(3). Evaluate how compression and gating can enhance the sound of an instrument.

4.8.3. Assessment Activities

The positive response from evaluators to the attached Flash assessments in Learning Object 3 led to utilizing this format again in Learning Object 4. Real-time control of compression and gating is not currently possible within QuickTime (or Director or Flash) at the moment, so, formative assessment activities were limited to more descriptive type activities in Learning Object 4 as in Learning Object 3. As with Learning Object 3 the formative assessment was simply linked to the main Learning Object movie. This does have the advantage of allowing a tutor to modify the assessment without needing to modify the main Learning Object itself, or possibly even provide multiple or alternate assessments.

4.8.4. Initial Concept

Dynamics control and manipulation is another core aspect of audio engineering, and an area where users generally need significant training. The goal was to produce a virtual environment to model appropriate use of compression and gating settings for various instruments. The design started with a brainstorm of capability and interface ideas, based upon actual studio dynamics processing equipment. To illustrate the concepts, interface elements from both traditional analogue equipment, and the more conceptual elements from

software plug-ins were chosen. These included standard controls, level meters, simulated waveforms, and input/output graphs. Audio examples with and without compression or gating applied were to be included to provide audible comparisons.

User feedback from Learning Object 3 indicated that the users wanted more interactive control over the Learning Object parameters than was provided. The limitation is the lack of real-time digital signal processing capability of QuickTime. To address this in Learning Object 4, a similar design approach (simulation) was taken as in Learning Object 3, but the interface knobs were made to move between selected settings, rather than selecting complete snapshots of the Learning Objects, and the comparison between unaffected and effected audio examples is selected by turning the effect 'on' (clicking on the 'on' button). This added dynamic visual element proved worthwhile in conveying a more immersive virtual environment that operates similar to real world equipment.

4.8.5. Technical requirements/Delivery formats

The Learning Object was required to be delivered via Internet, CD-ROM, and directly off of a user's hard drive.
Functionality that was required included:

- User selection of typical compression and gating settings for various instruments.
- User selection of typical compression and gating audio examples.
- Links to further background information provided.
- Formative assessment of principles of compression and gating.

4.8.6. System requirements

The goal was to produce a Learning Object that would run on most recent computers (cross-platform, Mac OS9 and OS X, Windows 98 and XP).
A PPC (PowerPC) Macintosh or Pentium Windows computer, with a CD quality sound card, 1024 by 768 colour monitor, and QuickTime 6 installed. A CD-ROM drive and Internet connection is also required.

4.8.7. Development Steps

A similar approach was taken to the development of Learning Object 4 compared to Learning Object 3.

To begin with the interface and media elements required to meet the Learning Objectives were brainstormed and roughly sketched out.

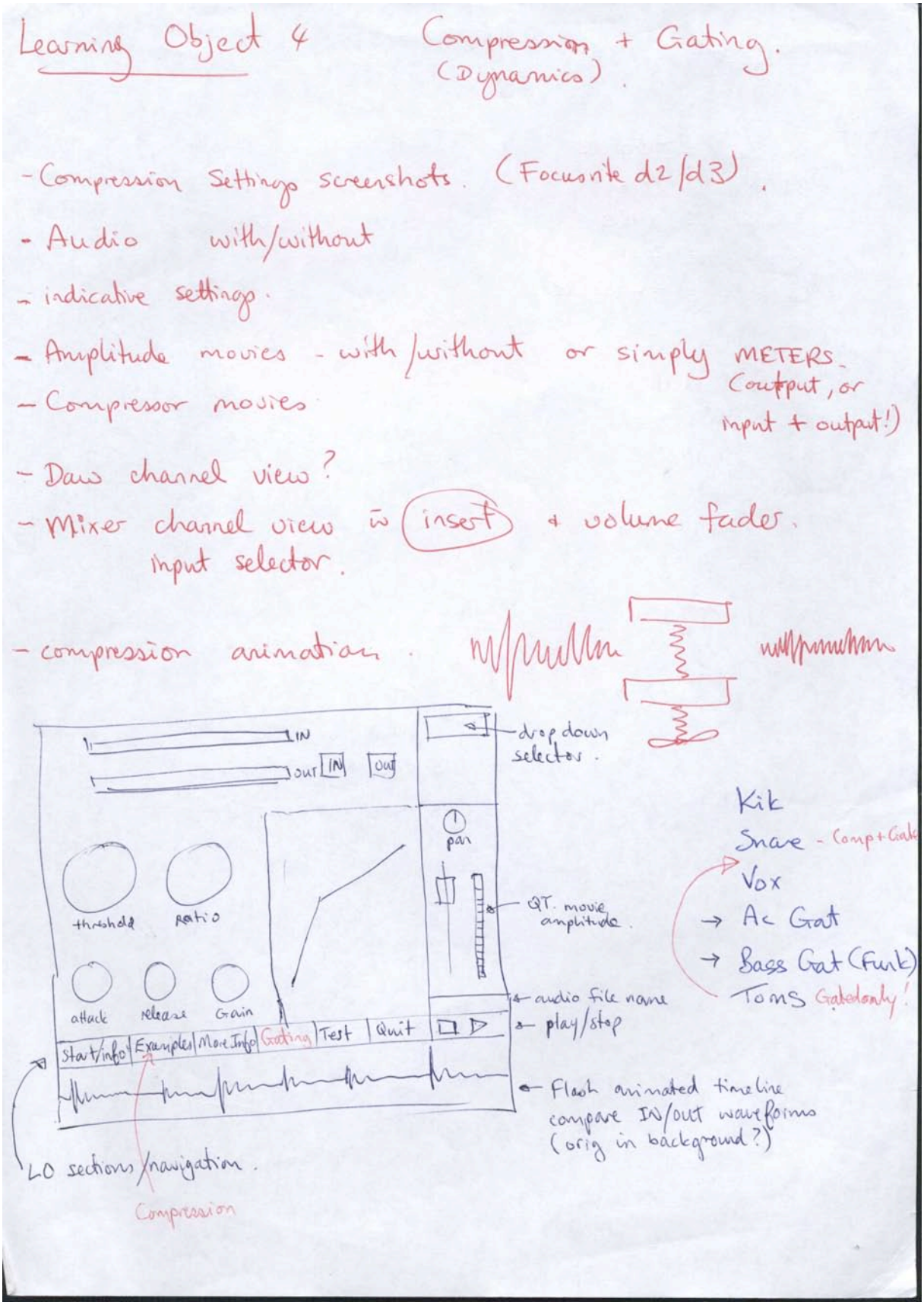

Fig 33. Initial brainstorm for Learning Object 4.

To create an immersive virtual environment required a different approach than the first two Learning Objects, as the real time digital signal processing required for compression and gating is beyond the capability of QuickTime, Flash or Macromedia Director. To save development time, a simulated environment was modeled on a combination of the familiar software processing plug-ins available from ProTools audio editing systems, in particular the Sony Oxford Dynamics plug-in (Sony Broadcast & Professional Europe, 2002), and the dBX 160 SL hardware compressor. Snapshots of plug-in settings were taken, and example audio files (of several different instruments) were processed using the actual software plug-in within ProTools. The graphical interface elements for the Learning Object were once again created using Macromedia Freehand, and then imported into LiveStage Pro for interactive scripting. Flash was used to create interactive menus for selecting different examples. Flash was also used to create an animated simulation of the audio waveforms for each example. These Flash elements were then integrated as QuickTime tracks, interacting with the main movie via Qscript added within LiveStage Pro.
The Learning Object was subjected to pre-release testing and cross-platform compatibility checks, and MAINZ Diploma Student feedback before being sent to the two main groups of evaluators.

4.8.8. Interface/Overview

As the embedding of user instructions within a user discoverable first page proved popular with Learning Object three, this approach was again taken in Learning Object 4. As the user moves around the elements in the first page of the Learning Object, explanatory notes are displayed. The interface displays input and output level meters, the main adjustable parameters of compression and gating are represented by moving knobs, an input/output function graph, a waveform time display, and user adjustable transport and volume controls for the audio examples. The initial colour scheme was modified after feedback from users that the contrast between the text and the background was not clear enough. A similar menu navigation structure to that used in Learning Object 3 was used, and Flash tracks were used for selecting the various audio examples.

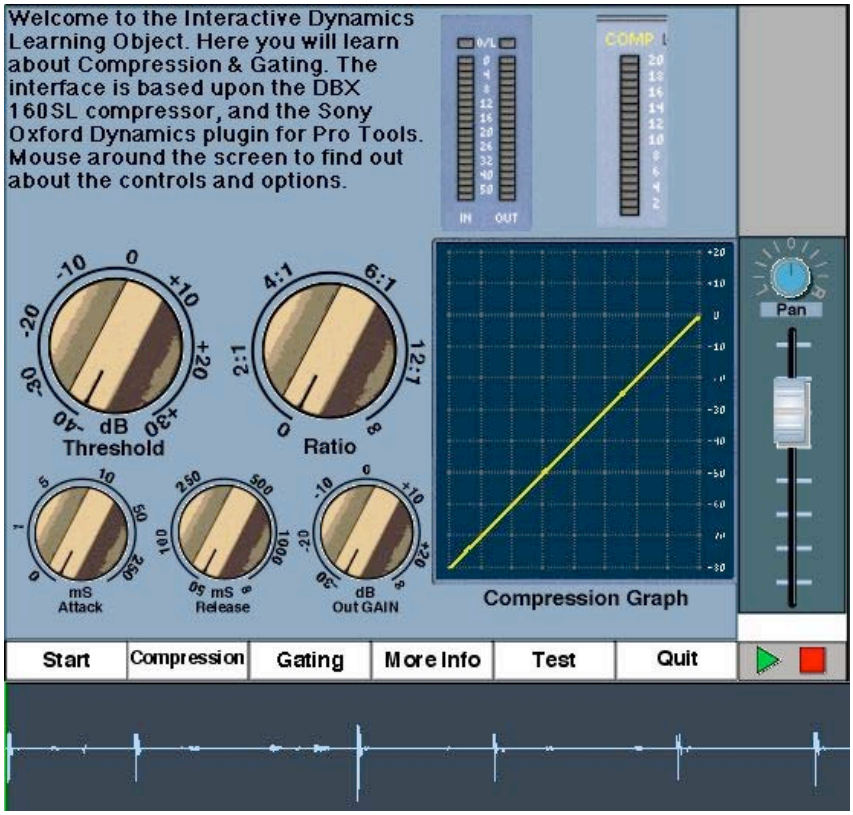

Fig 34. Screenshot of opening page of Learning Object 4.

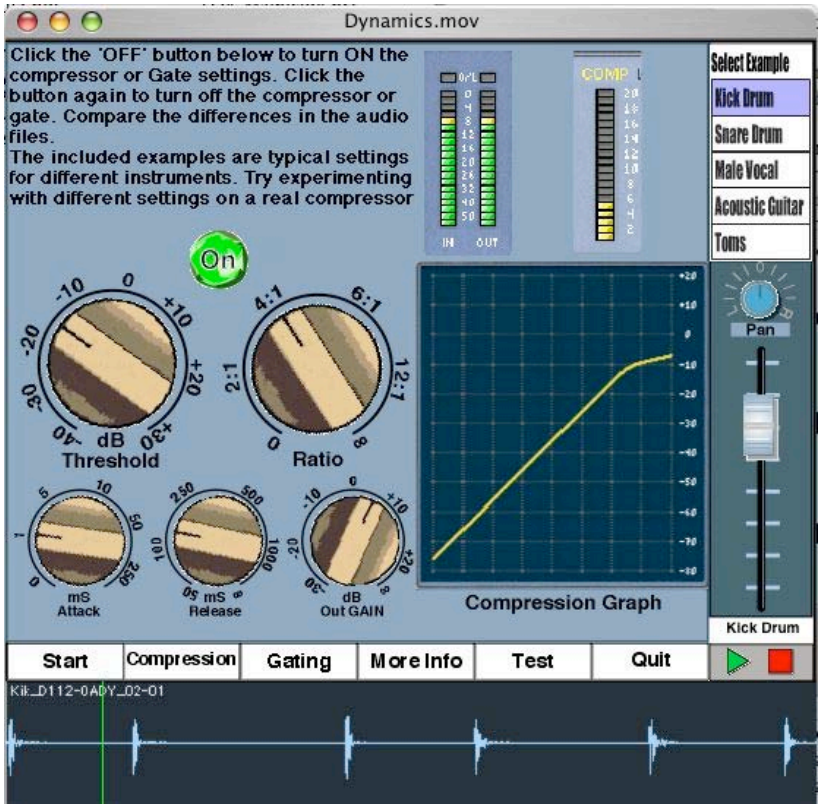

Fig 35. Screenshot of Compression section of Learning Object 4.

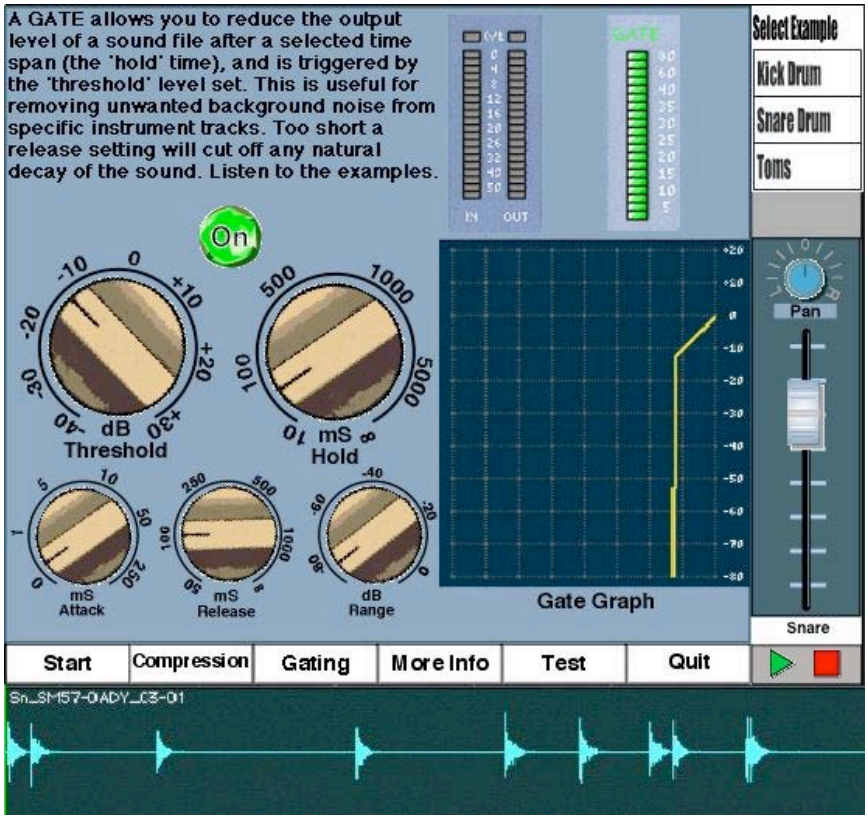

Fig 36. Screenshot of Gating section of Learning Object 4.

The following is a list of urls with information on compression and gating. Click on a link, and your web browser will open the url. (you will need an active Internet connection for this to work).

The Compressor, Ed Rei.

COMPRESSOR/EXPANDERS, LIMITERS and GATES. SAE.

Dynamics Processing, Rip Rowan.

Answers to common questions about dynamics processing. (Courtesy of Presonus)

Compressors And How To Use Them - Paul White, Sound On Sound

Advanced Compression Techniques: Part 1 - Paul White, Sound On Sound

Advanced Compression Techniques: Part 2

Advanced Gating Techniques Part 1 - Paul White, Sound On Sound

Advanced Gating Techniques: Part 2

Fig 37. Screenshot of More Info section of Learning Object 4.

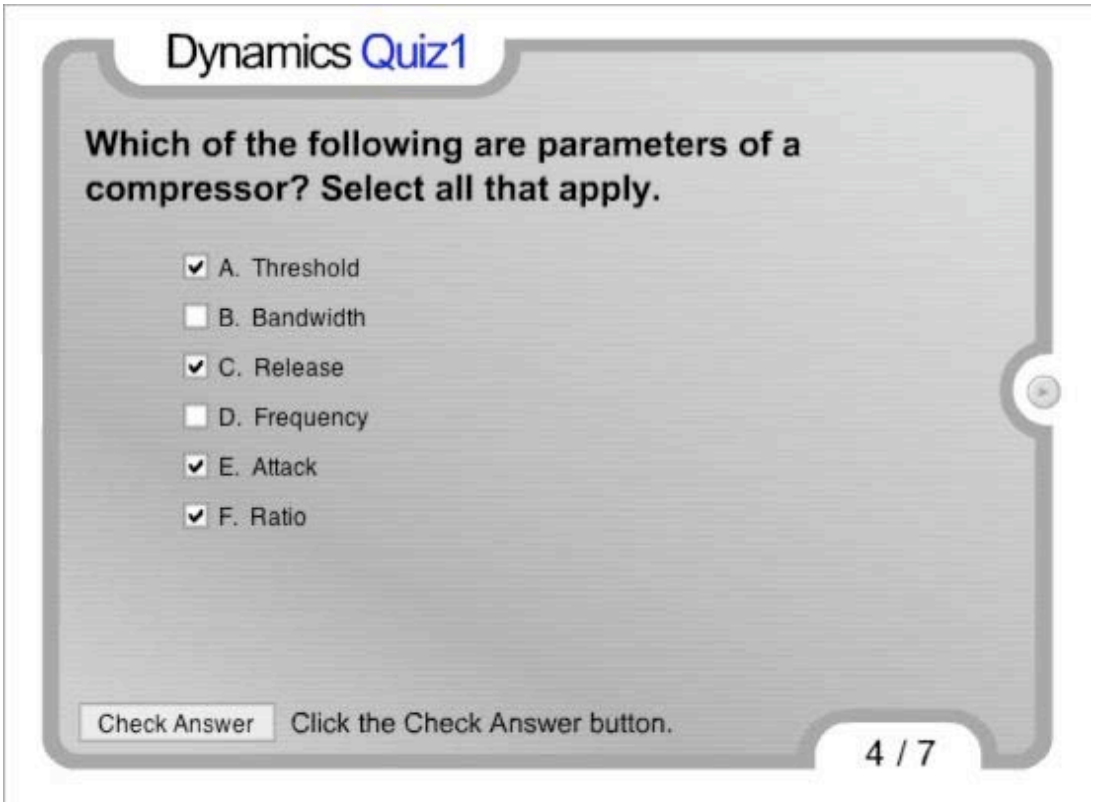

Fig 38. Screenshot of Flash formative Quiz for Learning Object 4.

The formative quiz was again created using Flash, and linked to the main QuickTime movie of the Learning Object. Seven different types of questions are used to cover aspects of the information contained in the Learning Object.

4.9. Learning Object 4 Evaluation

4.9.1. Diploma Student Pre-evaluation

Below are the summary evaluation results from the researcher's class of Diploma of Audio Engineering students. This was once again a pre-release evaluation before making the Learning Object available to the two main groups of evaluators.

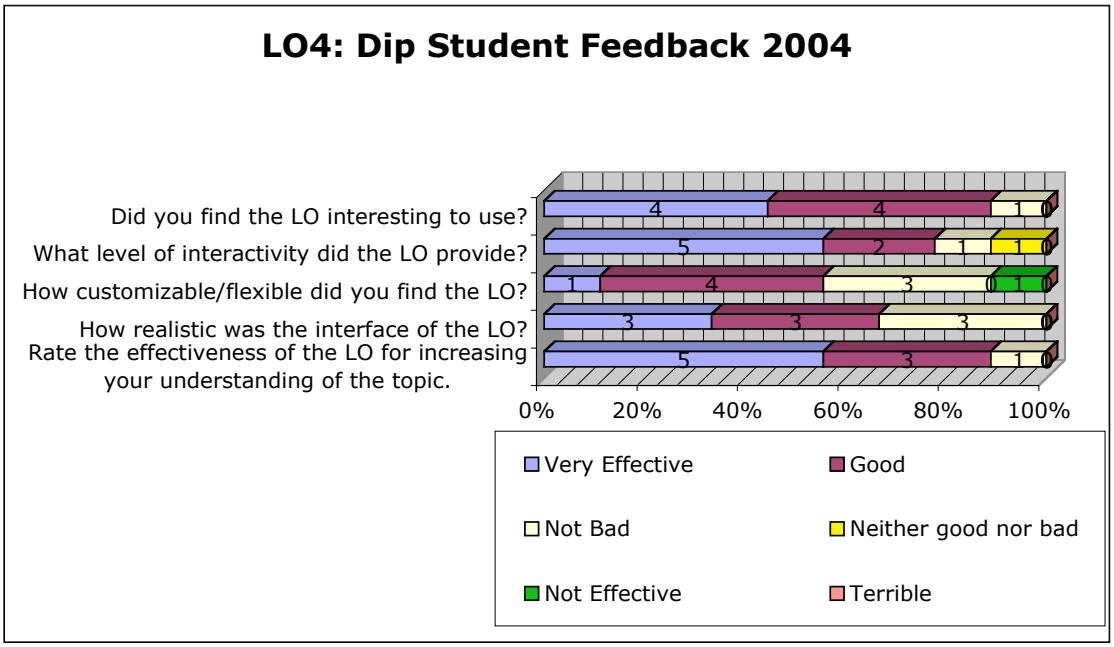

Fig 39. Summary of Diploma Student evaluations of Learning Object 4.

Diploma students rated Learning Object 4 very similarly to Learning Object 3. This was expected as a simulated approach similar to that used in Learning Object 3 was used. The Learning Object gained a higher rating for effectiveness than Learning Object 3. Students liked the linked formative test, and made several useful suggestions for improving it including an option to display correct answers at the end of the test. The students liked the graphics better than Learning Object 3, but commented that the graphics could still do with improvement in quality. The navigational interface was also easier for students to follow. Students described a wide range of contexts within which the Learning Object could potentially be used, but commented that some level of prior knowledge was required to understand the terms and concepts used. This could be a future project – an introduction into audio engineering terms.

4.9.2. MAINZ and Church sound operator evaluations for Learning Object 4:

Average MERLOT equivalent rating = 4.24

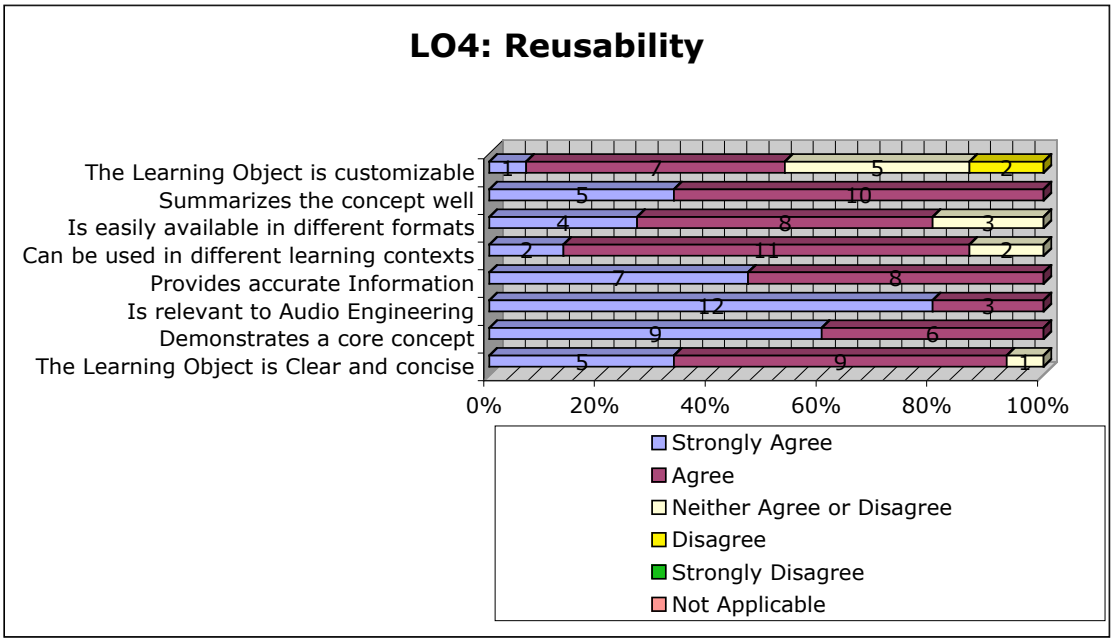

Fig 40. Summary of responses to evaluation questions relating to reusability for Learning Object 4.

The Learning Object received the highest rating for reusability of all the Learning Objects. The interface was simplified from that of LO3, less cluttered and more focused on the topic. "Presents core concepts well – easy to learn the principles of compression and gating" (comment from MAINZ tutor). As with Learning Object three, the colour scheme of the Learning Object was criticized for lack of contrast between the background colour and the text instructions. This was later changed in response to user feedback, and the modified Learning Object was then made available via the website. One MAINZ tutor noted that a certain amount of prior knowledge was needed to get the most out of the Learning Object. Although the Learning Object was available via the website and CD-ROM some users accessed the Learning Object solely from the supplied CD-ROM and did not access the website. Those who did access the website gained a more integrated view of the Learning Objects.

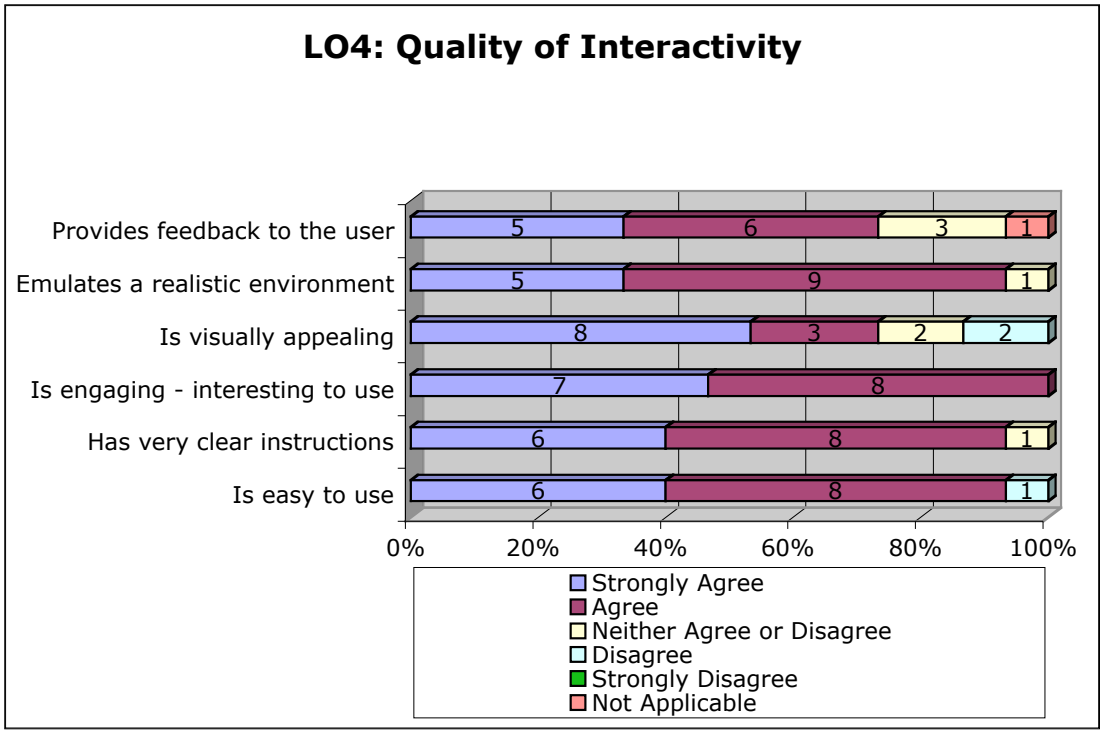

Fig 41. Summary of responses to evaluation questions relating to interactivity for Learning Object 4.

Learning Object 4 received the second highest rating for interactivity of all the Learning Objects, second only to Learning Object 2. Interestingly the Learning Object received much better ratings for interactivity than Learning Object three, even though the actual level of user control of parameters was equivalent. The difference was in the perceived interactivity, as instead of static screenshots of example parameter settings, the knobs on Learning Object four were made to move to preset values as users selected different examples. Selection of audio examples was linked to an ON/OFF button – giving the users the illusion that they were actually operating the compressor. This gave the users a more interactive visual experience that they appreciated. Users did note that they would prefer control of the Learning Object settings by being able to actually move the knobs. This could have been achieved by limiting the positions to which the knobs could move, but was not implemented due to the additional development time that this would have required.

A couple of church sound engineers experienced problems installing QuickTime on new PCs to evaluate the Learning Object. The problem was traced to users attempting to enter the Macintosh version of the registration code instead of the Windows one. More explicit instructions for installing QuickTime for PCs should have accompanied the Learning Object.

MAINZ tutors liked the Learning Object, but suggested additional information was probably needed to accompany the Learning Object to help explain terminology and the concepts of compression. It was also suggested that the examples could be exaggerated to make the effect more obvious to beginners.

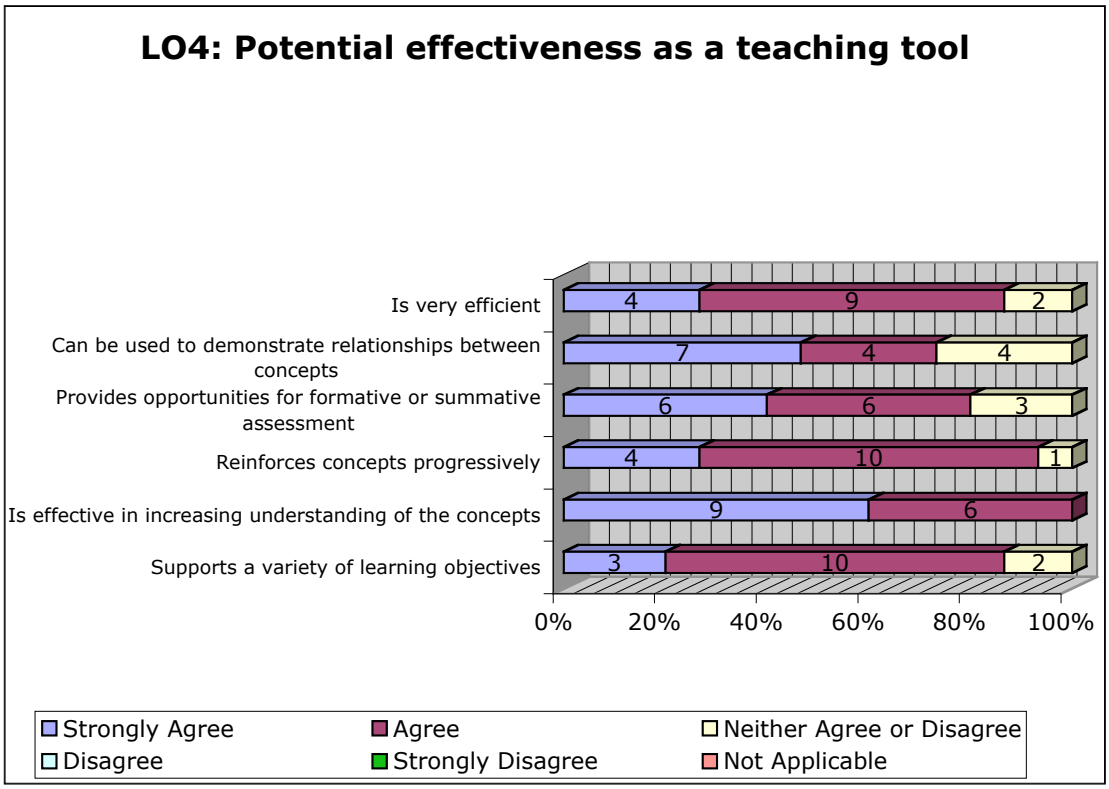

Fig 42. Summary of responses to evaluation questions relating to pedagogy for Learning Object 4.

The Learning Object received the highest rating for pedagogical usefulness of all the Learning Objects. Comments were all very positive. One MAINZ tutor noted that including options for progression modes through the Learning Object would suit a wider range of learner levels. Another recommended including additional supporting information on the concepts covered. However, this could easily be provided by tutors supplying their own additional instructions and supporting information alongside the Learning Object, rather than including these options within the Learning Object itself.

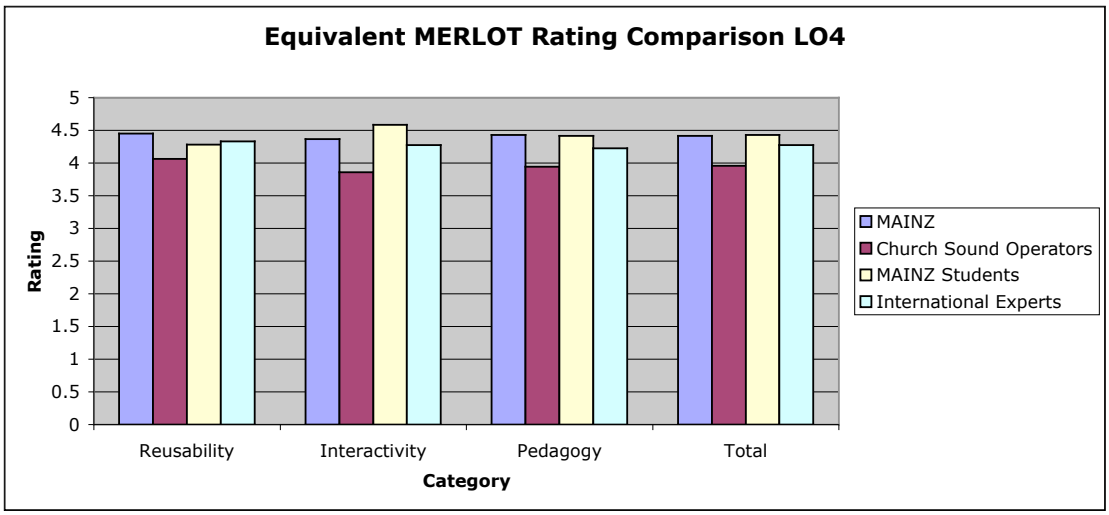

Fig 43. Summary of equivalent MERLOT Ratings for Learning Object 4.

The most significant rating difference between Learning Object 3 and 4 was the increase in the rating for interactivity. Learning Object 4 received the highest overall ratings of all four Learning Objects from all groups of evaluators. The Learning Object was focused on a specific learning outcome, provided an interactive simulated environment, and included a short formative assessment that was more developed than earlier Learning Objects. MAINZ tutors considered it to be a useful overview of the main concepts of compression and gating. Users voiced their desire for more interactive control of actual parameters within the simulated environment, but were happy that the Learning Object succeeded in its goal of allowing users to discover the principles of compression and gating.

4.9.3. International expert evaluations:

MERLOT equivalent rating = 4.278

International experts rated Learning Object 4 very similarly to MAINZ tutors. Their comments focused on the pedagogical usefulness of the Learning Object, and also noted that the level of user interactivity was not as high as the first two Learning Objects. They concluded that the Learning Object was successful in meeting its learning goals.

> This RLO was not as interactive as the others but was very useful in providing me with knowledge about dynamics, compressors and the characteristics of them. It was very informative. The only drawback was that after I had intacted with the

other RLOs I was trying to turn knobs to test the equipment but this was not a feature of this object (L. Young, 2004).

4.9.4. Modifying Learning Object 4

The following modifications were made to the Learning Object as a result of feedback and evaluations:

- Background colour was modified to provide better contrast between text and background.

4.9.5. Lessons Learnt from Learning Object 4

- Provide as high a level of user interactivity as possible, even if this is simulated.
- Be careful not to assume prior knowledge within the Learning Objects, particularly in terminology used.
- Provide multiple options for formative and summative assessment that can be attached to the Learning Object.

4.10. Learning Object Website Design

The Learning Objects were made available both on CD-ROM and via the Internet. The website was progressively updated to include all of the Learning Objects over the period of the study. Below is a screenshot showing the layout of the Learning Object website. As discussed earlier, this was created to test the Internet delivery of the Learning Objects, and also to provide access to the Learning Objects for the international evaluators and the MERLOT database. When the thumbnail icon of each Learning Object is clicked on, the Learning Object is opened in a new browser window. The user must first have QuickTime installed on their computer, and a web browser that supports the QuickTime plug-in (virtually all web browsers on both Macintosh and Windows computers). Because it is impossible to determine what download speeds a user will achieve, and the fact that the Learning Objects contain many linked media elements, loading bars were incorporated into the Learning Objects to indicate when they were fully downloaded and ready to be used. Once downloaded, the Learning Objects functioned exactly as the CD-ROM versions. The smallest Learning Object contained 2.4MB of data, while the largest contained 20MB of data. The main limitation of the web delivery of the Learning Objects was the bandwidth of the Unitec web server. Because the Internet connection is shared by several thousand students and staff the Internet connection can slow down to a crawl and international evaluators used to fast download speeds could get frustrated. Hosting the Learning Objects on a fast overseas server would solve this problem, but also costs money. International evaluators were sent CD-ROM copies of the Learning Objects to overcome the Internet download speeds, but this added to the time delay in receiving evaluations back.

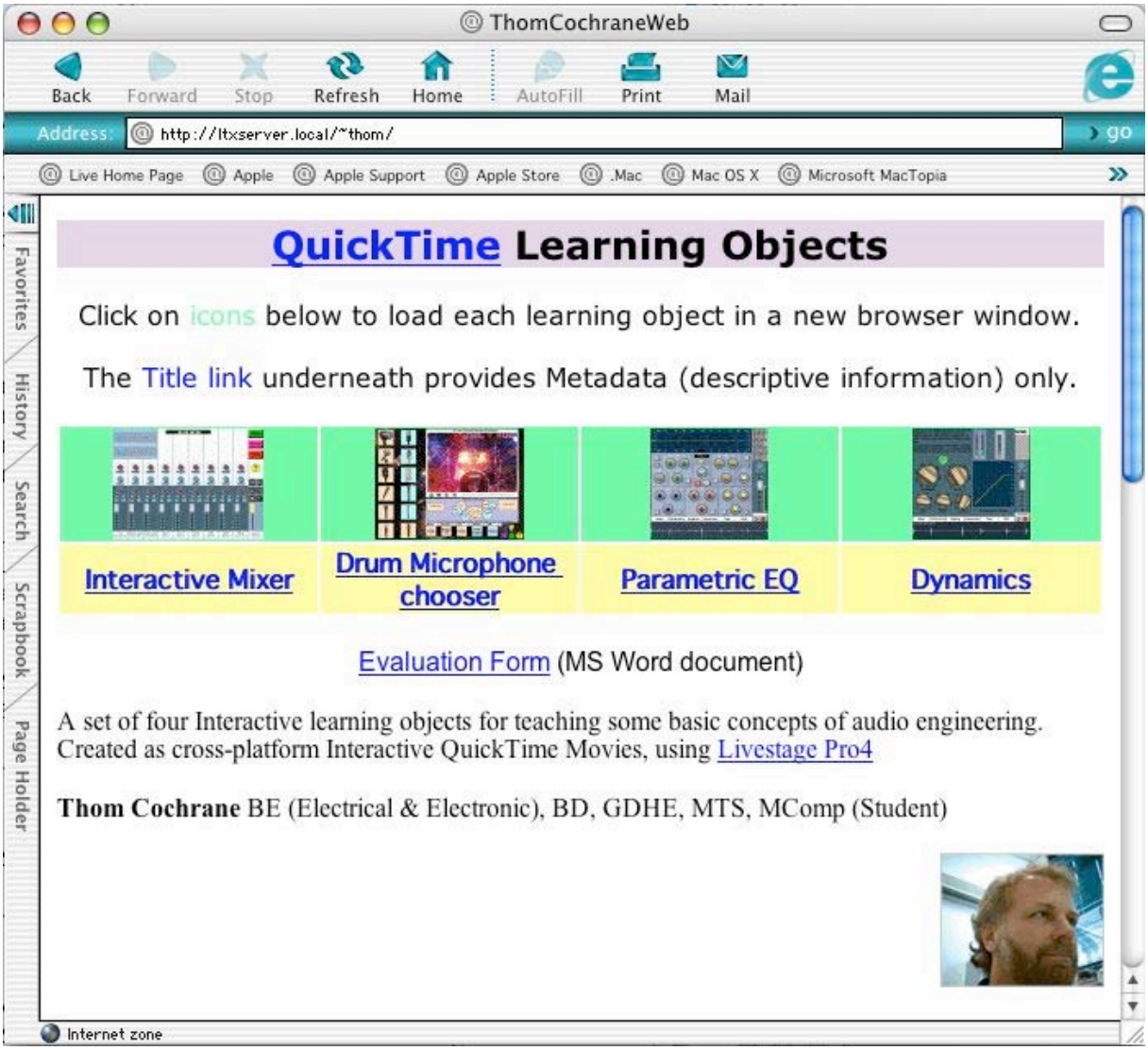

Fig 44. Screenshot of Learning Object Website.

The online Dublin Core metadata form (Koch & Borell, 1997) was used to generate metadata for each of the Learning Objects. An example of the generated metadata for Learning Object 2 is shown below.

Table 3. Example Dublin Core attributes

Dublin Core attribute	Scheme (if any)	Value
DC.Title		Microphone Chooser
DC.Creator		Thomas Cochrane
DC.Creator.Address		thom.c@xtra.co.nz
DC.Subject		Audio
DC.Subject		Microphones
DC.Subject		Drumkit
DC.Subject		QuickTime
DC.Description		An interactive microphone chooser for learning basic principles of microphone choice, including audio examples
DC.Date	ISO8601	August 2004
DC.Type		Interactive.Multimedia
DC.Format	IMT	text/html
DC.Identifier		http://203.167.245.43/~thom/
DC.Language	ISO639-1	en
DC.Date.X-MetadataLastModified	ISO8601	2004-08-26

The form generated html code for pasting into the head of the html page in which the Learning Object was to be embedded, as illustrated below for Learning Object 2.

```
<head>
<META NAME="DC.Title" CONTENT="Microphone Chooser">
<LINK REL=SCHEMA.dc HREF="http://purl.org/metadata/dublin_core_elements#title">

<META NAME="DC.Creator" CONTENT="Thomas Cochrane">
<LINK REL=SCHEMA.dc HREF="http://purl.org/metadata/dublin_core_elements#creator">

<META NAME="DC.Creator.Address" CONTENT="thom.c@xtra.co.nz">
<LINK REL=SCHEMA.dc HREF="http://purl.org/metadata/dublin_core_elements#creator">

<META NAME="DC.Subject" CONTENT="Audio">
```

<LINK REL=SCHEMA.dc HREF="http://purl.org/metadata/dublin_core_elements#subject">

<META NAME="DC.Subject" CONTENT="Microphones">
<LINK REL=SCHEMA.dc HREF="http://purl.org/metadata/dublin_core_elements#subject">

<META NAME="DC.Subject" CONTENT="Drumkit">
<LINK REL=SCHEMA.dc HREF="http://purl.org/metadata/dublin_core_elements#subject">

<META NAME="DC.Subject" CONTENT="QuickTime">
<LINK REL=SCHEMA.dc HREF="http://purl.org/metadata/dublin_core_elements#subject">

<META NAME="DC.Description" CONTENT="An interactive microphone chooser for learning basic principles of microphone choice, including audio examples">
<LINK REL=SCHEMA.dc
HREF="http://purl.org/metadata/dublin_core_elements#description">

<META NAME="DC.Date" SCHEME="ISO8601" CONTENT="August 2004">
<LINK REL=SCHEMA.dc HREF="http://purl.org/metadata/dublin_core_elements#date">

<META NAME="DC.Type" CONTENT="Interactive.Multimedia">
<LINK REL=SCHEMA.dc HREF="http://purl.org/metadata/dublin_core_elements#type">

<META NAME="DC.Format" SCHEME="IMT" CONTENT="text/html">
<LINK REL=SCHEMA.dc HREF="http://purl.org/metadata/dublin_core_elements#format">
<LINK REL=SCHEMA.imt HREF="http://sunsite.auc.dk/RFC/rfc/rfc2046.html">

<META NAME="DC.Identifier"
CONTENT="http://203.167.245.43/~thom/LO2_final/Drum_Miking.html">
<LINK REL=SCHEMA.dc
HREF="http://purl.org/metadata/dublin_core_elements#identifier">

<META NAME="DC.Language" SCHEME="ISO639-1" CONTENT="en">
<LINK REL=SCHEMA.dc
HREF="http://purl.org/metadata/dublin_core_elements#language">

<META NAME="DC.Date.X-MetadataLastModified" SCHEME="ISO8601" CONTENT="2004-08-26">
<LINK REL=SCHEMA.dc HREF="http://purl.org/metadata/dublin_core_elements#date">
</head>

The metadata for each Learning Object is provided on the Learning Object website and accessed by clicking on the title link for each Learning Object. The actual Learning Objects are accessed by clicking on the icon of each Learning Object. This convention led to some confusion for a couple of the international evaluators who attempted to access the Learning Objects by clicking on the metadata text link.

> The convention of icon for the Learning Object itself and the name for metadata for the object itself perhaps needs additional visual reinforcement. I read the explanation without really thinking too much – but then had to go back and re-read the instructions after which there was no problem. (Comment from one international evaluator)

More detailed instructions were therefore added to the Learning Object website to make the navigation clearer.

4.11. Focus Group Feedback

4.11.1. Focus Group Feedback Summary

The focus groups gave an opportunity to gather overall evaluation of the Learning Objects from representatives within the two main contexts that they were used – MAINZ Tutors and church sound engineers. The questions and summaries of the resulting discussion are included below.

1. How would you rate the effectiveness of the Learning Object for increasing your/your students understanding of the topic?

MAINZ:

The Learning Objects were rated highly effective within the MAINZ context. The interactivity and ability for students to take their time and explore and develop their understanding of the concepts presented was valuable. Discussion focused on the Learning Objects providing the opportunity for students to 'put it all together'. The limitation would be the student's ability to exercise a reasonable level of self directed learning.

Church sound engineers:

The Learning Objects were described as good. The Learning Objects provided an easy way to check out the audio engineering concepts. Interactivity is the key, and the 'excitement' factor of the user being able to fiddle with the knobs and parameters to see what happens.

2. How realistic was the interface of the Learning Object?

MAINZ:

Good, very visual and realistic interface. Although a greater degree of interactivity within Learning Object 3 and 4 would have improved them. Learning Object 3 would benefit from making the knobs move and using in/out buttons for selecting the various equalization sections (more like the control available to the user in Learning Object four).

Church sound engineers:

The interface was true to life, but people's expectations are coloured by the flashy graphics of today's software plug-ins, and this was seen as an important motivational factor for younger users. It was considered that the Learning Objects would benefit from better graphics design.

3. How customizable/flexible did you find the Learning Object?

MAINZ:

An interesting discussion around the customizability of the Learning Objects and their pedagogical focus developed out of this question. Tutors decided that the Learning Objects were not highly customizable (users cannot choose examples other than those already included within each Learning Object) but this was regarded as a good way to keep students on track and focused on the concepts that each Learning Object presented. The Learning Objects thus provided the opportunity for depth of learning rather than breadth. The MAINZ tutors agreed that the Learning Objects were therefore ideal as a teaching tool for specific concepts.

Church sound engineers:

It was felt that the Learning Objects were flexible from the aspect of providing multiple options to explore within each Learning Object itself.

4. How context specific did you find the Learning Objects?

MAINZ:

The discussion from question three above flowed into this question. The Learning Objects were viewed as being context specific, but in a good way. The presentation of specific tasks and Learning Objectives keeps students focused on the issues rather than providing opportunities for distraction.

Church sound engineers:

The Learning Objects were described as relevant to the topic covered by each.

5. Describe how the Learning Objects may be improved.

MAINZ:

Discussion focused on providing more interactivity (user control of simulation parameters) and providing a wider range of audio examples. A brief discussion regarding how much prior knowledge was assumed by the Learning Objects instructions followed.

Church sound engineers:

Similar thoughts were expressed to those of MAINZ tutors. Learning Objects 3 and 4 particularly could be improved by providing interactive control of knobs and buttons to select example parameters. The possibility of having selectable settings rather than the technically impossible freely rotating knobs was discussed. Another idea included providing examples of the illustrated effects (dynamics and EQ) applied over an entire mix (as a mastering example) rather than just examples of applications to individual instruments. This would give users a concept of how applying this effect achieves a specific result. It was also felt that the Learning Objects would benefit from better graphics design.

6. How would you rate the usefulness of the Learning Objects for your own teaching?

MAINZ:

The Learning Objects were described as very useful. Most commonly they are used alongside other methods of teaching a particular concept, then the Learning Objects are demonstrated to students, who then use the Learning Objects as self-directed tasks. The Learning Objects provide non-threatening environments in which to learn concepts.

Church sound engineers:

While this question was more relevant to MAINZ tutors, the church sound engineers are each in charge of small teams that they are training. The Learning Objects were considered useful for introducing learner church sound operators to concepts before hands on training sessions.

7. What level of interactivity did the Learning Objects provide?

MAINZ:

The level of interactivity was described as good for the task, although more control within Learning Object 3 and 4 would be appreciated. The interactivity is significantly narrow enough to allow specific learning outcomes to be met.

Church sound engineers:

The first two Learning Objects appeared more interactive than the last two, as users expected to be able to move the knobs and press buttons as in the first Learning Objects.

8. What was your experience of utilizing QuickTime as the Learning Object format?

MAINZ:

Overall there were no real problems encountered. There were a few glitches on the PCs. System administrator access was required to install QuickTime on the PCs in the computer labs.

Church sound engineers:

There were some issues with users installing QuickTime on PC systems, and differences in the way text and graphics rendered on PC systems compared to the Macintoshes. PCs were considered to be the main platform that learners would use due to their perceived cheaper cost. It was discussed that it was a good idea not to use commercial software (e.g. ProTools) as the delivery medium for the Learning Objects, as this adds a layer of complexity (the user would first need to learn how to use the host software), and added cost. It was discussed that use of coding in software to create stand alone applications or plug ins to create Learning Objects would give users more control of parameters.

9. Were the system requirements for the Learning Objects easily met?

MAINZ:

There were no difficulties with the system requirements, although some older PCs used early in the project (now replaced) did struggle with the audio requirements.

Church sound engineers:

Some PC users experienced audio synchronization problems (tracks getting out of time). The web interface for the completed four Learning Objects was popular, as it provided integrated access to all four Learning Objects.

10. How easy to understand was the language used in the Learning Objects?

MAINZ:

Tutors found the language good, following industry standards, but wondered about presupposing prior knowledge. It was felt some explanation for new and beginning students would be required.

Church sound engineers:

The language used was considered very appropriate and simple enough.

11. How could the description (metadata) of the Learning Objects be improved?

MAINZ:

MAINZ tutors were happy with the brief descriptions of the Learning Object supplied.

Church sound engineers:

The Learning Object descriptions should explicitly state if the knobs and buttons are moveable by the user or not. The learning outcomes should also be stated explicitly and measured by the test.

12. In what situations would the Learning Objects be most effective?

MAINZ:

Student computer access was seen as a determining factor in the use of the Learning Objects. The optimum scenario is for class presentation of the Learning Objects followed by student self-directed use.

Church sound engineers:

The Learning Objects were considered most effective in entry-level applications.

13. What opportunities exist for using the Learning Objects to provide formative assessment?

MAINZ:

The included quizzes (especially those for Learning Object three and four) were considered good ideas. Tutors wanted these to be developed into options for summative assessment, including facility for students to enter their names. Tutors were not confident enough to produce their own Flash summative assessment, but wanted the option of choosing a pre built Flash assessment to link or attach to each Learning Object.

Church sound engineers:

More in-depth assessment options were requested to be included with the Learning Objects, plus the ability to re-sit and reset the tests.

4.11.2. Analysis of Focus Group Feedback

The focus groups identified several key aspects of the Learning Objects that made them successful:

- An emphasis on user interactivity and the creation of a constructivist learning environment. (A caution being that this relied on the level of student self-directed learning skills)
- The interactivity motivated users to explore and experiment, which is why the decreased interactivity of Learning Object 3 was disappointing
- The simulation of a real environment – i.e. simulating actual audio equipment
- The importance of the role of the educator to embed the Learning Objects within the wider learning environment

Areas for improvement included:

- The quality of the graphics is important in gaining the attention of users
- Increased level of assessment and addition of assessment options requested
- More guidance for installation of QuickTime on Windows XP PC systems needed

The Learning Objects were seen as pedagogically useful in both audio engineering contexts and have found a place particularly within the Foundation and Certificate courses at MAINZ. Depth of learning was seen as more important than breadth of learning in the MAINZ context. The Learning Objects were valued for facilitating this and focusing students on core concepts.

Contexts in which the Learning Objects could be most effectively used were regarded as:

MAINZ:
Used alongside other methods of teaching a particular concept, then the Learning Objects are demonstrated to students, who then use the Learning Objects as self-directed tasks. The Learning Objects provide non-threatening environments in which to learn concepts.

Church sound engineers:
Useful for introducing learner church sound operators to concepts before hands on training sessions.

5. Discussion

5.1. MERLOT Ratings

Below are the average equivalent MERLOT ratings for each Learning Object from all evaluators (MAINZ tutors, Church sound engineers, and MAINZ Students).

Learning Object 1 Evaluation, MERLOT equivalent rating = 3.95
Learning Object 2 Evaluation, MERLOT equivalent rating = 4.20
Learning Object 3 Evaluation, MERLOT equivalent rating = 4.12
Learning Object 4 Evaluation, MERLOT equivalent rating = 4.24

These results indicate that the Learning Objects were generally highly rated by all users. On the MERLOT rating criteria the results of evaluation of all four Learning Objects indicates "materials are very good overall but there are a few minor concerns" (MERLOT, 2000). By investigating and implementing constructivist design strategies for Learning Objects before developing the Learning Objects the project produced quality Learning Objects that did not require radical changes, but rather optimizing and polishing. The design and development processes were informed by current educational technology research.

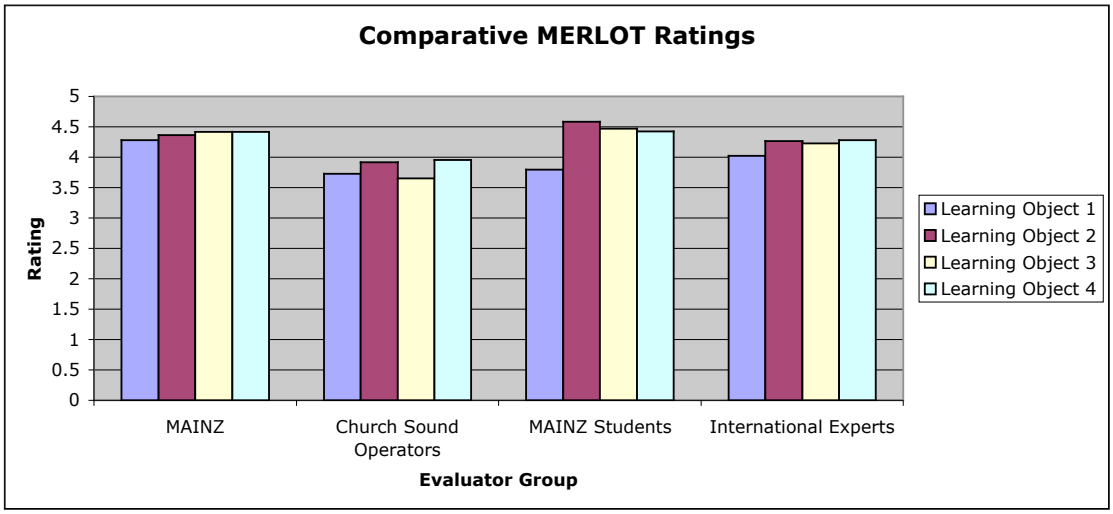

Fig 45. Comparison of equivalent MERLOT Ratings for all Learning Objects.

The Learning Objects did achieve a progression of increasing quality in terms of users evaluation, even though the last two Learning Objects pushed the boundaries of the

interactive possibilities within the QuickTime environment. The developer learnt valuable lessons from the design of each consecutive Learning Object. The 'dip' in evaluations ratings for Learning Object three reflected the expectation of a higher level of user control and interaction with the virtual environment that had been built up by the first two Learning Objects. The technical limitations of the QuickTime authoring environment meant that this interaction had to be simulated. This was achieved more successfully in Learning Object four. More time available for development would allow a higher level of user control of parameters to be simulated within the Learning Objects.

The least experienced evaluators (church sound engineers and MAINZ students) ratings varied more significantly between the four Learning Objects than those of the 'experts' (MAINZ tutors and international experts). This indicates that these users value different aspects of the Learning Objects. The less experienced users were more concerned with the interface and graphics, while the MAINZ tutors and international experts were more focused on the pedagogy of the Learning Objects.

The adoption of the MERLOT criteria for evaluating Learning Objects provided a tried and tested starting point for the Learning Object evaluation instrument. Rather than re-inventing the wheel, the MERLOT criteria check list was modified for the context of this study. The three MERLOT evaluation categories: quality of reusability, quality of interactivity, and effectiveness as a teaching tool, aligned perfectly with the research project. The peer review process also ensured a scholarly approach to the evaluations. However, as Nesbit at al (2002) pointed out, the main problem with peer review processes, such as the MERLOT evaluation process, is the time involved in waiting for the reviews to be returned. This time lag limited the number of Learning Objects that could be evaluated over the time span of the project. One evaluation per semester was all evaluators were willing to undertake. In selecting reviewers, some form of mutual contact with the researcher needed to be established for reviewers to agree to participate. This was not a problem for this study, as the researcher was a colleague of the MAINZ reviewers, and had established relationships with most of the church sound engineers, but it could present a problem for other projects where there was not this initial contact.

The actual MERLOT repository review of the Learning Objects for this project appears to be a case in point, as nothing has been heard from the MERLOT editors, several weeks after

referring the finished Learning Objects to the MERLOT repository, and two direct emails to request review. The theory behind the process is good, it's the implementation that is lacking. There are definite benefits to placing the results of the peer reviews alongside the Learning Objects in a digital repository. As Stiles (2003) points out, this will allow the Learning Objects to be more readily reused. "The effective reuse of content depends on educators being able to find items of content, ascertain their quality and availability and then repurpose these things to contribute to enable their learners to meet the goals the educator wishes to set them" (Stiles, 2003, pg. 1). To decrease the time taken for the peer review process, MERLOT needs to create a larger base of expert reviewers. This will be possible as MERLOT becomes better known through integration with Blackboard and other Learning Management Systems.

While the equivalent MERLOT rating is a useful guide for rating the usefulness/quality of the Learning Objects, the qualitative data gained from the various groups of evaluators provides rich data for improving the process. The MERLOT evaluation process formed the springboard for gathering richer data. By itself the MERLOT peer review process presents only one stakeholder view of the Learning Objects. "The MERLOT peer review process needs to be extended to match the conditions under which Learning Objects are developed and used, and to better meet the needs of students" (Nesbit et al., 2002, pg. 4). Involving representatives from all stakeholders in the evaluation process gave a richer view of Learning Objects. A recent study by CLOE (Howard-Rose & Harrigan, 2004) utilized a participant-oriented evaluation process similar to that used by this project. The authors emphasize the critical nature of evaluation of Learning Objects and the appropriateness of the participant-oriented evaluation approach. This agrees with the findings of this project. In contrast to the approach taken in this project Cisco's (Cisco Systems, 2001) four step evaluation process is targeted at workplace training situations, especially phases three and four: phase three evaluates the transfer of skill back to the job (are the learners using the Learning Object?), phase four evaluates the impact on the business (return on investment model).

5.2. Learning Object Design

As Wiley (2000a) has pointed out, there is a lack of instructional design principles specifically for Learning Object development. There is also a lack of academic case studies on Learning Object design and implementation. Of fifty one papers submitted for last year's

Ed-Media Learning Object Symposium, very few dealt with design, development and evaluation.

> Many groups seem to be grappling with issues that relate to the pedagogically sound use of Learning Objects. Few papers included clear guidelines or methodologies, or analyzed in any detail what had worked, how or why. It seems like there is more agreement on the nature and relevance of the questions than on approaches to try and make progress with answering the questions (Duval, Hodgins, Rehak, & Robson, 2003, pg. 2).

Established instructional design principles for interactive multimedia were therefore utilized, interlaced with ideas recently proposed from Boyle (2002a). Baruque and Melo (2003) emphasize that Learning Object design should be informed by established learning theory. They propose the adoption of an eclectic approach to learning theory in the design of Learning Objects, using principles form different learning theories. This supports the approach taken by the research project.

In contrast to the predominantly constructivist pedagogy employed by the research project, industry examples of Learning Object development tend to utilize instructivist pedagogies. E.g. Cisco's design approach (Cisco Systems, 2001) leans heavily towards an instructivist pedagogy, illustrated by their heavy use of Merrill as a key reference.

The design process used by this project provides a template for other developers to use. Embedding a participation oriented evaluation process within the familiar ADDIE instructional design process matched the action research methodology of the project well. The development and evaluation of each Learning Object formed a cycle within the action research process. The ability to progressively improve the Learning Objects within the design and evaluation cycle produces a higher quality product. This approach has also provided suggestions for the potential redevelopment of the Learning Objects at a later stage. The design process is similar to that used by other Learning Object developers. An example is the template used at the Northwest Missouri State University Center for Information Technology in Education, described by Runyon and Von Holzen (2004 , pg. 2) that defines steps in the design process very similar to those used in this project with an emphasis on firstly defining Learning Objectives. This design process is also advocated by Smith (2004).

5.3. Learning Object Effectiveness

All users rated the Learning Objects as being highly effective in improving the learning environment. Other recent studies have also demonstrated the effectiveness of quality, pedagogically rich Learning Objects. Howard-Rose and Harrigan (2004) study showed users indicated Learning Objects significantly added value to the learning environment. A study by Bradley and Boyle (2003) showed 86% of students found Learning Objects to be helpful or very helpful to their learning. Metros and Bennett's study also showed a high level of faculty agreement that "Learning Objects are being used in instruction to improve the quality of the learning experience" (Metros & Bennett, 2002 , pg. 6).

Feedback indicated that the more experienced user and people with teaching experience can see the potential in the Learning Objects more than the first time user or inexperienced teacher. Overall, MAINZ tutors (and the international experts) consistently rated the Learning Objects higher in all categories than the other users, particularly with regards to their pedagogical potential. This possibly reflects a more developed understanding of pedagogy, and a higher level of understanding of background audio engineering concepts and terminology. Although the learning outcomes may have been implicitly obvious to MAINZ tutors, the learning outcomes needed to be made explicit for the church sound engineers. Interestingly MAINZ students also rated the Learning Objects higher than the church sound engineers. The main difference in the learning context is the access to expert tutors and immersion in the terminology and actual studio equipment. This point was highlighted by some of the feedback received from international evaluators, who are experts in elearning but not the field of Audio Engineering.

> For the audio engineering students the Learning Objects assume they can hear the difference between the various settings and know how to make meaningful adjustments to the various controls. This is probably the case. For those who have more modest prerequisites it could be useful to suggest some examples that highlight the differences, again for the Mixer where I spent more than 10 minutes trying various permutations in order to hear versions which differed perceptively from each other. Again this boils down to how explicit you want to make the

prerequisites for deriving benefit from each of the Learning Objects (International Expert 4).

Knowledge of the Audio Engineering context of the Learning Objects is needed in order to effectively reuse them within a related learning environment. The project illustrated that Learning Objects are designed to be part of a wider educational environment, where other sources of information and communication are available to the student/user. This agrees with Wiley's caution: "We must be extremely careful that our learning environments based on reusable resources contain opportunities for meaningful discourse" (Wiley, 2003a, pg. 2). Educators must develop the skills to embed Learning Objects within the wider learning environment and thus maximize the learning potential of Learning Objects.

While the church sound engineers gave the Learning Objects lower ratings than the MAINZ tutors, their ratings and evaluation comments were very good. Feedback from the group of church sound engineers was positive, but they tended to struggle with the computer system requirements more than the MAINZ users. This was a barrier to their use. The church sound operators all used PC computer systems for their evaluations, while fifty percent of the MAINZ tutors used Macintosh computers. The church sound operators PC systems were not as optimized for audio as those used by the MAINZ tutors.

The evaluations highlighted that the key ingredient in Learning Object success is user interactivity. This agrees with Smith (2004, pg. 13) who emphasizes interactivity in creating effective Learning Objects and Bradley and Boyle (2003) also saw interactivity (pedagogical richness) as a key in their successful Learning Objects. The importance of interactivity was illustrated by the drop in evaluation ratings from Learning Object 2 to Learning Object 3, and then the increase in ratings with Learning Object 4. The main difference was the lessoning of user interactive control in Learning Object 3.

Key feedback on the functionality and interface focused upon extending the functionality of each Learning Object, adding a wider choice of included audio tracks, and 'modernizing' their appearance. However, Learning Object features must be traded off against the development time involved in implementing them.

5.4. Improving the Learning Objects

There were several recurring comments regarding future improvements to the Learning Objects. A common theme that arose was – make instructions or 'help' much more obvious – as it appears several people did not discover the built in 'help' page in the first Learning Object. For example, the following is a comment on Learning Object 1 from one of the MAINZ foundation studies students, "I found it fairly easy to use. I found no instruction on how to use it if I had no idea of what was what I would not know what to do. I can see how later version of this would emulate a real environment. Should include a brief explanation of what does what". This was addressed in later Learning Objects by turning the first 'page' of the Learning Objects into an interactive help/overview of the interface. Providing more detailed metadata with the Learning Objects could also solve this problem. Including: interface descriptions, learning outcomes, and system requirements. The most appropriate medium for this metadata would be on a website with links to the Learning Objects, or within whatever content repository the Learning Objects are stored in.

Evaluators made several comments regarding the graphics quality of the Learning Objects. To keep file sizes down most graphics files were exported as medium compressed JPEGs. To increase the quality of the graphics without increasing file size of the Learning Objects vector graphics formats could be used. The downside of this is the increased development time involved. Several screenshots of software plug-ins were used as quick sources for backgrounds and layout of the Learning Objects. There were differences in the rendering of text and different graphics formats between Macintosh and Windows systems. Text rendered much clearer on the Macintosh platform, and Mac OS X provided system level integration of the PDF format while Mac OS9 and Windows systems required an extra plug-in for QuickTime to view PDF graphics directly within QuickTime. Compatible graphics formats and fonts had to be experimented with and tested on all platforms. Polsani notes that "Appearance and style are extremely important for an effective presentation of Los" (Polsani, 2003 , pg. 5), unfortunately this can be very subjective. It is the end-users preference that must be taken into account.

Evaluation feedback consistently asked for more formative assessment and the possibility of incorporating summative assessment linked to the Learning Objects. This surprised the researcher, as it was believed that this would actually limit the pedagogical contexts of the

Learning Objects and make them less reusable. As Littlejohn notes, "In terms of resource size, there is often a tension between increasing educational value and maximizing reusability" (Littlejohn, 2003a, pg. 4). However, the feedback given from tutors does agree with Wiley's (2003a) pragmatic approach to the optimum size of a Learning Object being dependent on what best meets the needs of the learners in the context. The first Learning Object developed incorporated the least explicit embedded pedagogy and assessment, thus representing the broader definitions of Learning Objects that do not necessarily focus upon learning and pedagogy. It appears that most educators do not want to be required to make the effort to embed the Learning Objects within a wider instructional context themselves. The implication for Learning Object design is that there should be a simple option for linking Learning Objects to pre-developed formative and summative assessments that can be chosen by the educator.

The Flash MX learning additions and quiz templates provided a quick way to develop interactive tests that could be either formative or summative. The developer needed minimal understanding of Flash to modify these templates and link them to the main QuickTime Learning Objects. Future updates to QuickTime will probably include support for the Flash learning additions, but currently QuickTime version 6.4 supports Flash 6 tracks only and therefore Flash MX tracks do not currently function currently as embedded tracks within a QuickTime movie. Linking the Flash tracks to the Learning Object movies provided a simple way around this.

Overall there has been a very positive response from users to the Learning Objects developed so far. Some MAINZ tutors have even begun to see the possibility of teaching audio egineering principles on-line using interactive Learning Objects to fill the gap of lack of off-campus student access to traditional equipment. Studio experience could then be gained through these distance students attending campus-based block course type scenarios.

5.5. Reusability

The developed Learning Objects demonstrated the ability to be reused within different learning contexts related to Audio Engineering. Within the MAINZ context there were different curriculum and levels for each of the courses that the Learning Objects were tested in. The re-usability of the Learning Objects is important in light of the amount of time

involved in developing such highly interactive multimedia Learning Objects. After spending many long hours developing the four Learning Objects for this project the researcher agrees that "The embracing of the 'digital agenda' by an individual educational institution is an expensive proposition and it is important to leverage as far as possible through re-purposing and re-use the learning resources" (Ip & Morrison, 2001, pg. 296).

The focus groups produced discussions that highlighted the difference between customizability of the Learning Objects and context specificity. The fact that the Learning Objects were not highly customizable was seen as a good way to keep students focused on the learning outcomes of the Learning Object and thus not to be distracted by customizable interface features. Focus group discussion called this 'depth' of learning rather than 'breadth'. Rather than cover too much content, Learning Objects should focus the users attention on one main concept. Although there were many requests for more content within the Learning Objects, these requests would be better met by developing additional Learning Objects that covered the requested concepts/details. The Learning Objects are unashamedly focused on specific concepts within the context of Audio Engineering, as Wiley (2003b, pg. 2) cautions, "While economically sensible, the drive toward decontextualization may actually be counterproductive from the standpoint of student learning".

5.6. QuickTime

The project highlighted the appropriateness of QuickTime as an authoring and distribution environment for Learning Objects. In contrast to the level of interactivity utilized within the QuickTime architecture by this project, most other examples of QuickTime Learning Object development barely scratch the surface of QuickTime's capability e.g. (Cameron, 2003; Dantas et al., 2003; Fardon & Henderson, 2003; Mellow et al., 2003).

QuickTime provided better audio features than either Macromedia Director or Flash. This was particularly important for the audio engineering context of the project. Most users were satisfied with the level of interactivity available within the QuickTime architecture. Future additions to QScript and custom components for QuickTime will allow higher degrees of interactive control of audio parameters, and real-time feedback. The cross-platform compatibility and delivery medium scalability of QuickTime minimised development time. QuickTime is also supported by most (if not all) online learning management systems.

The level of multimedia authoring experience and scripting required to develop interactive QuickTime is similar to that required for either Macromedia Director or Flash. For educators not wanting to delve into QScript, less detailed interactive QuickTime Learning Objects can be created using the simpler object oriented QuickTime authoring applications available. While several PC users had unforseen difficulties during the installation process for QuickTime, this could be eased by providing PC users with a detailed description of the installation and registration process. Initially the developer had thought the process to be straight forward, but this had presupposed a certain level of computer literacy that some users did not have. User access to the Learning Objects must be kept as simple a process as possible.

5.7. International Feedback

The international expert evaluators had the advantage of receiving the Learning Objects after some of the modifications suggested by the earlier groups of evaluators had been implemented, and most of the identified interface bugs had been sorted out. Several of these evaluators were experts in educational technology, but were not familiar with the field of audio engineering. Therefore the terminology of the Learning Objects was considered a barrier for them. A possibility for a future Learning Object to accompany those already developed may be an interactive glossary of audio engineering terms and descriptions of standard equipment. Comments from international expert evaluators tended to focus on interface details and pedagogical issues. Many of their pedagogical comments were similar to those expressed by MAINZ tutors. Some example comments are discussed below:

> The user needs to be able to distinguish between the simulator and the meta-cognitive layer that contains information to do with learning and the use of the Learning Object. It is not always easy to see what is what, i.e. what is the interactive mixer and what are the visual accoutrements to enable the learner to pick up knowledge and skills.

Unfamiliarity with the audio equipment being simulated meant there was some confusion between the navigational and instructional elements and the simulation elements. One possible solution could be to have instructions and navigational elements in a separate

floating window to that of the main Learning Object. This is technically feasible as multiple QuickTime movies can effectively share information and 'communicate'.

> A second difficulty is that the user is thrown in at the deep end with the need to explore to find out what the Learning Objectives and goals are and what then needs to be done. For an audience under 30, the Learning Objects as they stand are probably fine for the experienced user of rich media on PCs. For those who are not, it might be an idea to have an opening screen with the goals and instructions, i.e. a clearer differentiation between the activities: BEFORE using the simulator, DURING the use of the simulator, and AFTER the use of the simulator.

The goal of the Learning Objects was to create a constructivist learning environment, therefore user exploration is expected and encouraged. The comment assumes that the Learning Objects are 'stand-alone' Learning Objects – without tutor or expert help available. This was not the design intention of the Learning Objects. They should be used to help illustrate concepts that either a tutor or other expert utilizes within a wider learning environment that they design as appropriate for their students. The Learning Objects will most effectively be utilized within a dynamic collaborative learning community.

> There is no means of pacing yourself, knowing what the likely demands on your time and other resources until you get stuck in. Some kind of feedback on progress could be of help in order to plan autonomous learning. As a minimum it would be a good idea to give some approximate average (max/min) times for each activity with the Learning Object, the option to see whether you had completed the various activities in the Learning Objects and some sort of feedback on the desired and actual learning outcomes of each of these.

Again this comment assumes that the Learning Objects will be used 'stand-alone', which was never the intention. Such information should be added to the Learning Object by the educators using it within their own learning context. This type of information can be included as metadata associated with the Learning Object. Nichol (2003) describes this type of metadata as 'educational metadata'.

In general the feedback from the International experts was very positive. Including international evaluators within the evaluation cycle would be beneficial in future studies.

5.8. Answering the Research Questions

The research project intended to address two research questions.

(1). What are the key factors in designing Learning Objects that are reusable for learning concepts in Audio Engineering - a discipline that traditionally teaches these concepts in a 'face-to-face' 'hands-on' mode?

The research project has demonstrated the development and evaluation of four Learning Objects that have covered four key concepts within Audio Engineering that are usually taught 'hands-on'. These Learning Objects received very positive evaluations from tutors of five different audio engineering courses, as well as church sound operators from five different churches in Auckland. The Learning Objects were demonstrated to be effective in these different learning contexts. Representative Audio Engineering students, and international experts also gave the Learning Objects good evaluations. The potential for the Learning Objects to be used within other learning contexts has been expressed by the evaluators. The optimum scenario for the use of the Learning Objects is complimenting other methods of learning rather than a complete replacement of face-to-face teaching. The key factors in the design of these Learning Objects were found to be: clearly defining the Learning Objectives, choosing an appropriate multimedia architecture, simulating real world activities/equipment, providing high levels of user interactivity, embedding formative assessment into the Learning Objects, and utilizing a participant-oriented evaluation within the design cycle.

(2). To what extent can these Learning Objects support learner interactivity and interest, and thus provide pedagogically rich learning environments that engage and motivate the learner?

Using the QuickTime architecture, a high level of interactivity within the Learning Objects was possible, including real-time control of many audio parameters. Audio parameters that were inaccessible directly via QuickTime were simulated within the QuickTime environment. The user evaluations emphasized the high value that interactivity and user control within the Learning Objects is given. Emulating a real world environment and Audio Engineering

equipment was highly valued. The ability to experiment and learn within a safe simulated environment was also highly valued. All the evaluators agreed that the Learning Objects were successful in enhancing the users ability to learn the Audio Engineering concepts covered. The inclusion of formative assessment provided opportunities for users to test their understanding of the concepts. The level of assessment could be increased for future Learning Objects or added to the current Learning Objects. The Learning Objects successfully augmented traditional methods of learning audio engineering concepts.

6. Conclusions

Development of the Learning Objects took a lot longer than initially anticipated. Features and interactivity were constrained by the available development time. However, the choice of QuickTime as architecture, and the implementation of instructional design principles provided the basis for developing interactive Learning Objects that successfully enhanced the learning of a wide range of users at different levels and in different contexts. The QuickTime environment allowed a high level of user interaction without requiring high level programming knowledge from the developer, thus keeping the development at a more creative rather than technical level.

Implementing a participant-oriented evaluation process within the design cycle of the Learning Objects provided useful feedback on their effectiveness and areas for modification and improvement. Interactivity and learner control of the Learning Objects were highly valued by evaluators.

Trained educators managed to see the pedagogical possibilities of the Learning Objects better than the Church sound operators. This is expected, as modifying an educational context does require expertise (Otherwise Learning Objects could replace tutors). Thus the role of educators to embed the Learning Objects within a larger learning context is crucial. “To be useful, Learning Objects will require the mediation of human (teacher) judgment, even though these judgments can operate in a very distributed way” (Mayes, 2003, pg. 2).

The utilization of action research produced a research project that has real world tangible results that will benefit the researcher’s educational practice, and the wider field of Audio Engineering within New Zealand. Future recommendations for the study include building into the design and evaluation process evaluations of the Learning Objects from a wider range of users e.g. from international audio courses right from the beginning of the project.

Recommendations for interactive multimedia Learning Object development are:

- Make operator instructions and learning outcomes clear and explicit
- Provide multiple assessment options that educators can choose to link to each Learning Object.

- Provide as high a level of user interactivity as possible
- Include participant-oriented evaluation as an integral part of the design process
- Emulate real world environments as closely as possible
- Choose a multimedia architecture that meets the key project requirements
- Allow plenty of time for development and evaluation
- Provide training for educators to develop the skills to embed the Learning Objects within the wider learning environment and thus maximize the learning potential of Learning Objects

Learning Objects have the potential to enhance learning, but what is needed is a commitment from tertiary institutions to not only research this field, but to also develop and share quality Learning Objects for the Learning Object economy to become a reality.

> Learning Objects are at a turning point. There is an opportunity to create a diverse, global network of Learning Object developers, repositories, and users who, if they can effectively organize and coordinate their activities, will be able to produce a library of high-quality, pedagogically sound, free (or inexpensive) materials that will make all of the investments in infrastructure pay off in the educational experience for students (Roy, 2004a, pg. 82).

Author Contact details

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7. Appendices

7.1. LEARNING OBJECT/MODULE NEED ANALYSIS

The information gathered from this questionnaire will be confidential and anonymous, and will be used solely for the purposes of a research Thesis for the MComp at Unitec.

Participant Details:		
Position: (Circle one) MAINZ Student, MAINZ Tutor, Sound Operator		
Course:		
Location:		
Contact info (optional) Email:	Name:	Phone:

Please answer the following questions.

1. In your opinion, is there a need for interactive teaching material for audio engineering concepts?

2. What would a useful Learning Object for audio engineering look like?

3. What system requirements (computer platform, minimum computer specifications, delivery format – CD, DVD, Internet…) would be most suitable for these Learning Objects?

4. What concepts do learners in your situation need help with: (tick appropriate column, and state areas not covered).

Concept	**Y/N**	**Comment**
• Principles of Acoustics		
• Response of different instruments		
• Behaviour of sound in rooms		

• Sound Pressure Level		
• Principles of Sound Reproduction		
• Microphones – o Types, o Use, o Appropriate choice		
• Loudspeakers and Amplifiers – o Specifications and ratings		
• Mixing Desk operation		
• Signal Flow		
• Signal Processing		
• Ear Training – o Achieving a good mix, o Recognizing audio frequencies		
• OTHER		

5. Have you ever used multimedia Learning Objects to teach or learn audio engineering concepts? (If yes, please state what these were, and whether they were effective or not).

6. What level of computer literacy do your students/personnel currently have?

7. How would you benefit from having access to a 'library' of interactive multimedia Learning Objects that covered a wide range of concepts in Audio Engineering?
8. What would you consider to be the most important design factors in creating useful Learning Objects for audio engineering?
9. What questions do you have regarding this study?
Thanks for your time and feedback.

Thom Cochrane

thomc@tpp.ac.nz

MAINZ (Music & Audio Institute of New Zealand)

Tutor Diploma of Audio Engineering.

Ph. 09 3793819-x210 wk.

Home:

181a Sturges Rd, Henderson, Auckland.

Ph. 09 8360042 hm.

7.2. **Learning Object Evaluation (Diploma Audio Engineering Students):**

QUESTION:	**Your Answer: tick or circle most applicable answer/s, or write your answer in the space provided below.**					
1. How would you rate the effectiveness of this Learning Object for increasing your understanding of the topic?	Very effective	Good	Not Bad	Neither good nor bad	Not effective	Confusing – hinders learning
2. How realistic was the interface of the Learning Object?	Very Good	Good	Not Bad	Neither Good nor Bad	Not Good	Totally unrealistic
3. How customizable/flexible did you find the Learning Object?	Very Good	Good	Not Bad	Neither Good nor Bad	Not Good	Totally inflexible
4. What level of interactivity did the Learning Objects provide?	Very Good	Good	Not Bad	Neither Good nor Bad	Not Good	Terrible
5. Did you find the Learning Object interesting to use?	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	
6. Describe how the Learning Objects may be improved.						
7. In what situations would the Learning Objects be most effective?						
8. What questions do you think would be useful to add in evaluating similar Learning Objects?						

7.3.

Learning Object Design Project

Consent Form

This research project examines the design of multimedia Learning Objects for teaching principles of Audio Engineering. The research is being done by Thomas Cochrane from UNITEC Institute of Technology, and will be supervised by Chris Manford and Stuart Young.

Name of Participant:…….

I have seen the Information Sheet dated 3 March 2003 for people taking part in the Learning Object Design Project. I have had the opportunity to read the contents of the information sheet and to discuss the project with the Learning Object Design team and I am satisfied with the explanations I have been given. I understand that taking part in this project is voluntary (my choice) and that I may withdraw from the project at any time and this will in no way affect my access to the services provided by MAINZ.

I understand that I can withdraw from the questionnaire, observation or focus group if, for any reason, I want this.

I understand that my participation in this project is confidential and that no material that could identify me will be used in any reports on this project.

I have had enough time to consider whether I want to take part.

I know whom to contact if I have any questions or concerns about the project.

The Learning Object Design **principal researcher** for this project is Thomas Cochrane, 181a Sturges Rd, Henderson Heights, Auckland, 09 8360042, thom.c@xtra.co.nz

Signature…….participant …….(date)

Project explained by……

Signature……. ……...(date)

The participant should retain a copy of this consent form.

This study has been approved by the UNITEC Research Ethics Committee from (March 2003) to (December 2004). If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the Secretary (ph: 09 815-4321 ext 8041). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

7.4.

Learning Object Design Information sheet

About this research

You are invited to take part in research being undertaken on behalf of the Unitec Master of Computing programme.

This research survey looks at the design and evaluation of Learning Objects for audio engineering principles.

The research project will involve you in three or four aspects:

- You will be given several multimedia Learning Objects that cover some principles of audio engineering, We would like you to use and evaluate these. The evaluation feedback includes:
- A questionnaire for evaluating each Learning Object – please see attached sheet "Learning Object/Module Evaluation".
- **An observation of you using the Learning Object by the researcher.**
- And finally involvement in a focus group at the end of the semester, where you can add any reflections or questions that you have on the use and design of the Learning Objects.

Your involvement in this research will help Thomas Cochrane in the development of pedagogically rich,interactive learning resources for audio engineering, and will hopefully be of benefit to you in this field also.

The Researchers

Thomas Cochrane.

This project is being supervised by Chris Manford and Stuart Young.

Selection of Participants

You were purposely chosen for this research because of your involvement and interest in learning about audio engineering. Twenty people involved in audio engineering have been asked to participate.

Returning the Questionnaire

We would greatly appreciate you returning your questionnaire as quickly as possible. Please post the completed form Thom Cochrane - a stamped and addressed envelope is enclosed.

About a week after you have received this pack, we will contact people who have not sent the questionnaires back to see if we can help you in any way to complete them.

You have the right to not participate, or withdraw from this research survey at any time. This can be done by posting back a blank questionnaire, by phoning Thom Cochrane (09 8154321 x7747 wk, or 09 8360042 hm), or by telling us when we contact you that you do not want to participate.

It is very important that we get as many completed questionnaires as we can. The questionnaire will take about 20 minutes to complete.

Getting help

Please contact me should you require help with the questionnnaire.

Thom Cochrane 09 8360042 hm, 09 8154321 x7747 wk.

thom.c@xtra.co.nz

Information and concerns

If you want further information about the project you can write, fax or email the above address.

At anytime if you are concerned or confused about the research project you may contact the Unitec School of Information Systems and Computing and speak to Donald Joyce:

MComp programme Director, djoyce@unitec.ac.nz, 09 8494180.

Confidentiality

Confidentiality and your anonymity will be protected in the following ways:

- The questions are not of a personal nature, but we ask that you do not write your name *anywhere* on the questionnaire. This is important to protect your anonymity.
- You will notice that there are numbers on the questionnaires. This is *only* so that we can contact you if we have not received your questionnaire back by the due date.
- Once we have received your completed questionnaire your name and your questionnaire number will be deleted from all records so that you cannot be identified. All computer records will only accessible by passwords held only by the researchers.
- The completed questionnaires will be seen *only* by the researchers. The Unitec School of Information Services and Computing will only receive summaries and reports in which all personally identifying features are removed.

A copy of the final report will be available at the Unitec Library. All participants are welcome to view this. Summaries and recommendations may be published in appropriate journals.

Finally, we would like to thank you for your valuable contribution to this research.

Kia Ora.

This study has been approved by the UNITEC Research Ethics Committee from March 2003 to December 2004. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Committee through the Secretary (ph: 09 815-4321 ext 8041). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome

7.5. LEARNING OBJECT/MODULE EVALUATION

(Adapted from the MERLOT Module Review Form (MERLOT, 2000) and (Bennett & Metros, 2001)) The information gathered from this questionnaire will be confidential and anonymous, and will be used solely for the purposes of a research Thesis for the MComp at Unitec.

Learning Object/Module Title:
Brief description:
Location/URL:
Learning Goal:
Target audience:

Reviewer Details:		
Circle one: MAINZ Student, MAINZ Tutor, Sound Operator		
Course:		
Location:		
Contact (optional) Email:	Name:	Phone:

Some Definitions:

Learning Object: "Any digital resource that can be reused to support learning. The term "Learning Objects" generally applies to educational materials designed and created in small chunks for the purpose of maximizing the number of learning situations in which the resource can be utilized." (Wiley, 2002)

Reusability: The ability to use a Learning Object within different learning contexts.

Pedagogy: "the activities of educating or instructing or teaching ;activities that impart knowledge or skill" (HyperDictionary, 2003)

System Requirements: You will need a PPC Macintosh OR Pentium Windows computer, with a CD quality sound card, 1024 by 768 colour monitor, and QuickTime 6 installed (http://www.apple.com/quicktime).

Tick the appropriate column for each statement.

	Reusability	**Strongly Agree**	**Agree**	**Neither Agree or Disagree**	**Disagree**	**Strongly Disagree**	**N/A**
		5	4	3	2	1	
A	The Learning Object is clear and concise						
B	Demonstrates a core concept						
C	Is relevant to Audio Engineering						
D	Provides accurate information						
E	Can be used in different learning contexts						
F	Is easily available in different formats (e.g. web, CD, HD, Windows, Mac)						
G	Summarizes the concept well						
H	The Learning Object is customizable						
I	Comments/Improvements:						

	Quality of Interactivity	**Strongly Agree**	**Agree**	**Neither Agree or Disagree**	**Disagree**	**Strongly Disagree**	**N/A**
		5	4	3	2	1	
A	Is easy to use						
B	Has very clear instructions						
C	Is engaging – interesting to use						
D	Is visually appealing						
E	Emulates a realistic environment						
F	Provides feedback to the user						
G	Comments/Improvements:						

	Potential effectiveness as a teaching tool	**Strongly Agree**	**Agree**	**Neutral Agree or Disagree**	**Disagree**	**Strongly Disagree**	**N/A**
		5	4	3	2	1	
A	Supports a variety of Learning Objectives						
B	Is effective in increasing understanding of the concepts						
C	Reinforces concepts progressively						
D	Provides opportunities for formative or summative assessment						
E	Can be used to demonstrate relationships between concepts						
F	Is very efficient (one can learn a lot in a short period of time)						
G	Comments/Improvements:						

Thanks for your time and feedback.

Thom Cochrane
tcochrane@unitec.ac.nz
181a Sturges Rd, Henderson Heights, Auckland.
Ph. 09 8360042hm.

References:

Bennett, K., & Metros, S. (2001, 10/21/01). *Learning Object/Module Checklist*. Retrieved 23 February, 2003, from http://itc.utk.edu/educause2001/checklist.htm

HyperDictionary. (2003). *Pedagogy*. Retrieved 8 October, 2003, from http://www.hyperdictionary.com/dictionary/pedagogy

MERLOT. (2000, 11-27-0). *Evaluation Standards for Learning Materials in MERLOT*. Retrieved 23 February, 2003, from http://taste.merlot.org/eval.html

Wiley, D. (2002). Learning Objects - a definition. In A. Kovalchick & K. Dawson (Eds.), *Educational Technology: An Encyclopedia*. Santa Barbara: ABC-CLIO.

7.6. **Focus Group Questions:**

13. How would you rate the effectiveness of the Learning Object for increasing your/your students understanding of the topic?

14. How realistic was the interface of the Learning Object?

15. How customizable/flexible did you find the Learning Object?

16. How context specific did you find the Learning Objects?

17. Describe how the Learning Objects may be improved.

18. (For Tutors) How would you rate the usefulness of the Learning Objects for your own teaching?

19. What level of interactivity did the Learning Objects provide?

20. What was your experience of utilizing QuickTime as the Learning Object format?

21. Were the system requirements for the Learning Objects easily met?

22. How easy to understand was the language used in the Learning Objects?

23. How could the description (metadata) of the Learning Objects be improved?

24. In what situations would the Learning Objects be most effective?

13. What opportunities exist for using the Learning Objects to provide formative assessment?

7.7. **Reflective Journal:**
Having never been a 'dear diary' type person, rather, goal and event driven, my reflective journal will take shape around key reflective events (experiences/moments/events).

The 'structure' of my reflective journal we be:

Date:	
REFLECTIVE EVENT	
Description	
Pedagogical Implications/Outcomes	
Change	
Reinforcement	
Development (growth)	
Relevance/LINKS	
To the Research Project	
To my Teaching Practice	
REFERENCES	

7.8. Diploma Student LO Evaluation Comments: LO1

QUESTION:	Your Answer: write your answer in the space provided below.
6. Describe how the Learning Objects may be improved.	• Could be more realistic looking? (use photo of an actual mixer) • There seems to be a bit of a time lag when changing parameters that can lead to a bit of confusion • Following mouse movement not so smooth • More information on how to mix • Fix all the bugs • Better EQ, Solo 2 things at a time • Maybe include other mixer controllers, even if they are not controllable – eg aux groups. Global reverb switch? On off to see what reverb does •
7. In what situations would the Learning Objects be most effective?	• Absolute beginner level • For beginners to Audio, New cert students, secondary school studios • First users • Start of Cert/Foundation/Star Course • When students are by themselves, as they are able to work it by themselves • For learners just to have a look and fiddle • For a beginner looking to get into audio mixing, possible Mainz student • Entry level students
8. What questions do you think would be useful to add in evaluating similar Learning Objects?	• How easy is the Learning Object to figure out/use? •

7.9. Diploma Student LO Evaluation Comments: LO2

QUESTION:	Your Answer: write your answer in the space provided below.
6. Describe how the Learning Objects may be improved.	• Being able to position mics myself. Being able to do single hits with the mouse like a drum pad. • So far, so good • Wider choice of mics, variable placement of mics, ability to switch off kick drum in listening mode. • More variety • Having more questions to answer • Possibly more microphones to choose from, mic positions. • Instead of web based, maybe window based application would be easier. So people can download & install on their system once and can use it again & again without logging on the net & downloading huge files each time. • A larger variety of microphones • Load times could be faster • Add more instruments, especially rare instruments e.g. brass • Faster load times. Use different instruments, more types of mics. • More instruments would be cool
7. In what situations would the Learning Objects be most effective?	• Learning sounds of microphones, learning mic placement, mic choice • Certificate year would benefit, as well as Diploma. Working out exact mics to use is easier for a beginner. • Encouraging critical listening and experimentation with mic techniques outside of a pressure environment (studio). • Comparison & practical session • Recognizing/understanding the use of different microphones on types of instruments to enable optimum audio results. Also improving ones ear for recognizing characteristics of certain microphones. • Quick revisions before exams • Helping first timers understand microphones etc. • Aural test? Miking techniques! • Helping choose appropriate mics for certain styles of music • Comparing mics, deciding what mic suits what music. • When trying to produce a certain sound • Comparing different microphones when preparing

	for a recording session. • Trying to learn what mics would be useful when aiming for a particular sound.
8. What questions do you think would be useful to add in evaluating similar Learning Objects?	• Any errors/bugs you found or hard to use buttons etc… • What are the best features of the Learning Object? • Question on sound behaviour & quality • Ease of use? • How easy was it to navigate? • Will this change the way you mic drums? •

7.10. Diploma Student LO Evaluation Comments: LO3

QUESTION:	Your Answer: write your answer in the space provided below.
6. Describe how the Learning Objects may be improved.	• Free for individual users to adjust the actual knobs for the parameters. • More control of EQ settings. The examples menu was hard to find and use. • Interactivity with buttons & knobs, could be a little slicker. Be good if the window could be bigger. • The drag section of the test is unclear if you wish to 'check answer' after each drag. Even if you place the correct answer on top, it will say you are wrong cos you havn't finished the whole drag thing. • Better quality graphics • On the quiz if you could not have the movements locked in (more flexible) But it is good. •
7. In what situations would the Learning Objects be most effective?	• Best for revision – so after a 'learner' has been told/shown things. They can use this to explore. • When used alongside a lecture • Classes or courses to do with Audio, especially EQ topics & modules • Certificate year or below in audio engineering and live sound • Schools, High Schools. •
8. What questions do you think would be useful to add in evaluating similar Learning Objects?	• How user friendly is the navigation between menus? • Maybe to illustrate exactly what frequency 'means'. Could have some sine waves like 100, 1000, 6000 and 12000Hz tones. Just to confirm 'frequency'. •

7.11. Diploma Student LO Evaluation Comments: LO4

QUESTION:	Your Answer: write your answer in the space provided below.
6. Describe how the Learning Objects may be improved.	• Better visual design. Being able to modify the compressor. Better audio examples. • Better flexibility in Quiz. Answers lock in too easily. • Better graphics • Should have correct answers displayed at the end of the quiz. Improve graphics – too chunky. Use a different font – looks too old school. • Very good job. The DBX compressor needs to be a lot clearer (resolution). • Very cool, not much to improve in my opinion. Very user friendly. • Control over compressor. Better examples menu. Ability to check answers. • Liked the layout better than LO3 (EQ). Screen not so cluttered as EQ even though its still good – Initial reaction is more user friendly. • How does the teacher adjust to the students needs?
7. In what situations would the Learning Objects be most effective?	• Cert Audio. I feel someone would have to come into this with some knowledge of compression. • High Schools • People who want to learn the basics • Cert Audio • Live sound • In Audio courses dealing with Dynamics and the finer points of Audio. • After the student had an understanding' • Revision
8. What questions do you think would be useful to add in evaluating similar Learning Objects?	•

7.12. Compiled LO1 Evaluation Comments

User	Reusability	Quality of Interactivity	Potential Effectiveness as a teaching tool - Pedagogy
MAINZ Livesound Tutor1	Timing moved substantially, sometimes as samples looped	Could have more features on mixer without being seen as being more complicated to operate	Functions could be increased without level (i.e. basic) rising.
MAINZ Livesound Tutor2	At times the various tracks appeared to get out of sync		Mid/Sweepable EQ & a basic reverb
MAINZ Contemporary Music Tutor	Excellent for a basic understanding of audio engineering – easily understood and functional	Sometimes hard to set knobs – they don't always respond well. After soloing a channel, sometimes the mix you come back to sounds different and nothing has been tweaked! (It seems that some faders stop responding and need to be moved again)	Good having example mixes both sonically & visually. Perhaps more of these demos & more capability of mixing a variety of sources would enhance the idea.
MAINZ Tutor Foundation Studies	It's a good concept. Also good to see the microphones that our students have had experience in the past with, named on the mixer	Some buttons a bit 'sticky' – e.g. solo button for Kik wasn't working properly – Was a little unsure of the 'listen to example mix' and 'view example mix' ports – then I clicked on the ? button. At the start when first loaded, maybe this screen could 'popup' before the user starts playing.	Question F – with the right instructions, I think one could learn a lot in a short space of time, but it's a bit harder when you're not quite sure of what to actually do. E.g. were we meant to just play the piece & mess with faders and parts – storing our adjustments or just press play example?
MAINZ Tutor Certificate Audio	EQ controls not noticeable. I suggest a full mix band i.e Kik/SNR/Drum mix/Bass/Gat/Vocal/BV/ Keys		Great Fun

	would be more fun/educational. Example mix knobs should be buttons. Good clear layout. Audio loop seems short, could possibly include a file browser so say four different examples could be selected		
MAINZ Tutor Diploma Audio			
MAINZ Student Contemporary Music		The mixer environment looks a bit old and budget and could maybe be improved	
MAINZ Student Foundation Studies		I found it fairly easy to use. I found no instruction on how to use it if I had no idea of what was what I would not know what to do. I can see how later version of this would emulate a real environment. What feed back. Should include a brief explanation of what does what	There are no explanations of what is what, solo button dosen't work very well.
Church Sound Engineer 1	Took me a while to get going on my computer – good idea though.		
Church Sound Engineer 2	Would not run well on older PCs, even with dual 500Mhz chips & 384MB Ram. Only relevant to mixing	A 'full' band with Vox, Gat, Bass, Reverbs etc would be better in terms of learning to mix a complete range of sounds.	See previous comment. The concept is great but a little simple still. As per previous comment, more instruments/vox & perhaps reverb, compression, EQ on main mix. This way someone can be taught 99% of mixing theory.
Church Sound Engineer 3	Users would need to be directed as to what to do with	Only simulates a very small portion	With appropriate exercises or a range

	the program unless they were somewhat experienced with mixers. Not customizable in current form, but has potential.	of desk operation, but for basic work – excellent. Has huge potential if taken further.	of multitrack options, this tool would be fantastic!
Church Sound Engineer 4	Some drum parts didn't match up almost like they had a delay on them	Maybe some more EQ possibilities	
Church Sound Engineer 5	It would be nice to have a full range of instruments all playing a song together and to be able to mix this. I think that would allow the simulation to be used in more contexts	One thing I did notice was that the instructions are in very small print. When I enlarged the view it became so big – I had to drag the window around the screen in order to read it.	Is this going to be used by a student in an environment where there is no teacher. If so may be you could have more instructions and examples of what would sound good or not. Although having the freedom to try what you like. I think a bit more instruction would be beneficial.
International Expert 1	It is not clear at all what one is to do in this object, especially for someone not familiar with the equipment or audio engineering. It would help to have some more upfront instructions or more than one example.	The interactivity level is high as one has many controls to manipulate and the ability to save and restore sessions. It very effectively simulates an analog piece of equipment (knobs, sliders, and dials). Without experience in this sort of equipment, one is left to more or less click every button or twirl dials. It is not clear if I can do this while the track is playing or not, and sometimes adjusting a setting causes the audio to cease.	I am not sure I can judge this well not being familiar with audio engineering, so the concepts one could learn are an open judgment. I would like to see it embedded in an instructional context to be able to better respond
International Expert 2	The first one that I accessed was the Interactive Mixer. It was fantastic. I was able to		

	manipulate the music by using the different features of the virtual mixer. I really enjoyed using it - I found it to be fun - it was extremely interactive - I could turn the knobs and slide the bars and hear the difference that it made. I could also imagine the possibilities for use of this RLO to demonstrate musical principles in an audio engineering class		
International Expert 3	The user needs to be able to distinguish between the simulator and the meta-cognitive layer that contains information to do with learning and the use of the Learning Object. It is not always easy to see what is what, i.e. what is the interactive mixer and what are the visual accoutrements to enable the learner to pick up knowledge and skills.		

7.13. Compiled LO2 Evaluation Comments

User	Reusability	Quality of Interactivity	Potential Effectiveness as a teaching tool - Pedagogy
MAINZ Tutor Foundation Studies	Lots of possibilities with teaching, understanding of sound in each	Brilliant, navigation easy, well produced	Great teaching tool
MAINZ Tutor Certificate Audio		Instructions/Help a bit 'wordy' initially. GUI could be dressed up more. Needs feedback when eartraining section is completed correctly. Perhaps roles of object could be clearer at start: 'Compare Drum Mics"' "Mic Specs", "How good is your ear"? Drum loops could be more defined – i.e. simpler (& shorter?) with choice of styles for the mic comparison section.	Could be setup to test ears more progressively. Overall a great idea.
MAINZ Tutor Contemporary Music	Focused, clear intention of Learning Object. Useful for a wide range of students, not just Audio Engineers	When using the interactive listening test, it would be nice, once clicking on mic while trying to guess; to have a 'back' button to go straight back to the test	Excellent, interactive resource. I learned a great deal about drum miking in a very short space of time!
MAINZ Student Contemporary Music	Really interesting even for a non-drummer. It would be good to see more examples of the sounds – maybe associate a band with each mic.		Really good I learnt a lot of useful information in a short space of time.
MAINZ Livesound Tutor 2			It's a good progression from the 1st drum sound check one.
MAINZ Tutor Diploma Audio	Depending upon pedagogies utilized	Depends how audio/computer literate you are	Depending upon how it is used
Church Sound Engineer 2			Demands prior knowledge in microphone fundamentals. Perhaps

			some basic microphone concepts would be a nice touch for the beginner.
Church Sound Engineer 5	Although I don't think there is much other use for this exercise, other than its intended purpose, I found it did offer a lot of options and therefore was interesting. Drum solo was cool too.	The guessing thing was cool although it wasn't that hard, never the less again it is very interesting – again I had problems with the window. This time it was a fraction too large and made completing the activity quite difficult.	Great!
International Expert 1	This object is well defined and includes a good mix of content information and interactivity. It does require a fair bit of familiarity with audio equipment, so as someone without that background, I can only play around ;-) This would be highly reusable if there is a way to attach other sounds files without having to re-program the software (?)	It is good that the microphone icons are lit up on the left when selected from the drop down menus. I did not try it, but would hope the data from each mike is available during the "VR" selection process. The purpose of the "zooming" is not clear, perhaps I missed something. The interactivity level is good even for the presentation of information about the microphones. This object allows one to try out various setups and then take a small test to check your knowledge.	It might be better to indicate correct choices more clearly (I was not sure at first what a "tick" mark was. Some sort of scoring tool could be included. It might also be useful to have an option to present the correct responses. This one is nicely done as perhaps a review module for music engineering students. Some sort of scoring tool would add to the level of potential use for assessment.
International Expert 2	This was very interesting. It had images of various microphones and allowed me to look at them, and determine the characteristics of each. The only problem that I had was that all of the tools were not available to me so I was not able to hear the differences that would have really		

	driven the lesson home. It was very interactive and I think it could be used in many different levels of classes and used to instruct multiple objectives		
International Expert 3			A second difficulty is that the user is thrown in at the deep end with the need to explore to find out what the Learning Objectives and goals are and what then needs to be done. For an audience under 30, the Learning Objects as they stand are probably fine for the experienced user of rich media on PCs. For those who are not, it might be an idea to have an opening screen with the goals and instructions, i.e. a clearer differentiation between the activities: BEFORE using the simulator, DURING the use of the simulator, and AFTER the use of the simulator.

Reflection: LO2 comments
It appears that the more experienced user and people with teaching experience can see the potential in the Learning Object more than the first time user or inexperienced teacher. Common theme – make instructions or 'help' much more obvious – as it appears several people did not discover the builtin 'help' page.

Key feedback on the functionality and interface focused upon extending the level of EQ control, adding a wider variety of audio tracks, and 'modernizing' the 'look'.

Overall – very positive response from users.

7.14. Compiled LO3 Evaluation Comments

User	Reusability	Quality of Interactivity	Potential Effectiveness as a teaching tool - Pedagogy
MAINZ Tutor Foundation Studies	Maybe an instruction panel at the very beginning to allow the user to begin with purpose	I wasn't sure about where I was initially meant to focus first	Great teaching tool!
MAINZ Tutor Certificate Audio	Much better than first object	Some buttons didn't work on my version – e.g. selecting between some different EQ examples. Would have been good to switch 'panel' EQ graphics in and out as they were selected/deselected in the wave examples window (rather than have the total 'final' EQ showing). Still a few minor interface issues – placement of buttons etc…	Could be perhaps more progressive – option of easy to hard EQ's? or more bands added? Graphics much better on these ones Thom – but still a bit clunky looking – mainly text and variable graphics. Would be better to incorporate test into main object if possible.
MAINZ Tutor Contemporary Music	Some of the examples don't actually make any sound: (last two for male vocal, last 4 bass guitar, last 3 acoustic gat)	It would be nice to implement the actual parametric controls to be varied as per the graph – both in direct user interaction as well as having the controls vary for each example setting.	I like the quiz aspect & it's a good teaching aid – especially the 'more info' section. More visuals like that for the other examples would be even better.
MAINZ Student Contemporary Music		Some of the examples didn't work, e.g. male vocal 182Hz boost, 5kHz boost, bass guitar 785 kHz, plus some others.	
MAINZ Tutor 2 Livesound			
MAINZ Tutor Diploma Audio			
MAINZ Student Foundation Studies	You really have to take in what you are reading and what sounds you are hearing, otherwise you don't really understand the	Maybe make the buttons a bit clearer. It looks a bit fuzzy (hard on the eyes).	

	test questions		
MAINZ Student Foundation Studies			
Church Sound Engineer 1		Could look a bit flasher – e.g. modern audio plugins – better graphics.	Could use better demo sounds. Maybe could choose between different loop sounds.
Church Sound Engineer 2			
Church Sound Engineer 4		It would be good if you could move the knobs so you could change EQ, etc… if people hear what something does when the knob moved was changed it would be more helpful.	
Church Sound Engineer 3	Learning Object is generally good! – very detailed.	Interface Issues: Menu buttons along bottom & then you have to go up top right to select options within each section. Not good connection between the two. None of the knobs or sliders actually work. Once mouse is over, hand disappears immediately, allowing no adjustment. Parametric page good examples, allowing a good range of band instruments to choose form. However, having to go back to "Parametric" button to choose different instruments not user friendly. Needs interactive menu navigation panel with "back" buttons & sub-menus etc… Suggest combining menu with top right. Graphic page serves little use but as a picture of a slider EQ. The difference between the channel EQ settings has already been learnt in the	More info page is fantastic! – Great live demos of sweep knobs. Quiz good.

		previous page. Slidersare not adjustable & don't change when "kick – no EQ" or "Kick graphic EQ" is selected.	
Church Sound Engineer 5		Again I struggle with the size/clarity of the emulation. When viewing the "More info" page the words on the diagram of the parametric EQ are very hard to make out. It would be interesting to know if other people are having similar troubles.	I don't know why but the test did not load. The browser opened and the progress indicator got to half way, but after waiting 10 min I figured it would probably not load.
International Expert 1		There is a lot of information and content included here; I had some trouble with navigation and knowing what I needed to be doing (there was about 10 words on instruction squeezed in the top right). It was not fully clear at first that all of the controls in the middle are presented depending on the instrument selections. Could have used a bit more detailed instructions or a map of where I needed to move through this object. There is a high degree of choices when exploring the object, which I like.	The test was a bit unresponsive, and I would have expected the feedback to be generated when I tried to move on rather than having to click a check answers button. Also, it appeared sometimes I could move on after a wrong answer and other times not (?). I was pretty bad, scoring only a 17% ;-) It might be good to have a way to print or email results. This one is nicely done as perhaps a review module for music engineering students. One absolutely needs prior knowledge to understand the terminology and purpose.
International Expert 3			There is no means of pacing yourself, knowing what the likely demands on your time and other resources until you get stuck in. Some kind of feedback on progress could be of help in order to plan autonomous learning.

			As a minimum it would be a good idea to give some approximate average (max/min) times for each activity with the Learning Object, the option to see whether you had completed the various activities in the Learning Objects and some sort of feedback on the desired and actual learning outcomes of each of these.

Reflection:
LO3
Generally people expected more interface interactivity, especially after experiencing LO1 & LO2 where user has interactive control over most parameters.

Some issues with installing QuickTime on PCs – some PC users got stuck at registering QuickTime Pro and did not complete QuickTime download without help.

Text rendered better on Macs.

7.15. Compiled LO4 Evaluation Comments

User	Reusability	Quality of Interactivity	Potential Effectiveness as a teaching tool - Pedagogy
MAINZ Tutor Foundation Studies	Very enjoyable – can I just mention that the colours aren't the best for reading – white writing on dark surfaces work!	Good to use although I would have liked to be able to turn the dials and stuff.	Awesome work Thom!
MAINZ Tutor Certificate Audio		Compression examples might need to be exaggerated – (perhaps progressively – easier to hear on first examples?). Graphics clunky, text hard to read. "off" button should be "on/off". Terminology – e.g. "hotter' signal – might need to be clarified for beginners.	More progression needed (perhaps as another option). I.e. "modes" – freeform, linear progressive, tests - easy (what you've got now, but within the object), listening (harder).
MAINZ Tutor Contemporary Music	Presents core concepts well – easy to learn the principles of compression and gating.	Good – I like how the controls do move for each example. Some examples perhaps a little hard to hear subtle differences.	Very good. Possibly some more actual control interactivity would be good, but may mean more advanced application needed.
MAINZ Tutor 2 Livesound			
MAINZ Tutor Diploma Audio			
MAINZ Student Contemporary Music			
MAINZ Student Foundation Studies	Make the writing in a brighter colour. Hard to read against the dark background		Shorter summaries of what the different controls do.
Church Sound Engineer 4		Would be good if you could play around with the knobs to experiment with the sound.	
Church Sound Engineer 1		Found it hard to set up. Should be very easy to set	

		up on all computers. *(problems installing QuickTime on PC! – entering Mac registration code by mistake!)*	
Church Sound Engineer 3	Excellent – only improvement would be to have all parameters adjustable!	Excellent	Excellent.
Church Sound Engineer 5		Again I had trouble loading the test.	
Church Sound Engineer 2			
International Expert 1	This object clearly presents and demonstrates two related concepts, is well framed, and provides a nice series of steps through the material.	It might help to have some examples to hear of what happens when the settings are not made correctly. Or to hear the samples played in the context of the whole music piece (e.g. hi-hat with this Gate setting versus this one that is not optimal??)	I was pretty bad again, scoring only a 17% (one lucky guess) ;-) It might be good to have a way to print or email results. This one is nicely done as perhaps a review module for music engineering students. One absolutely needs prior knowledge to understand the terminology and purpose.
International Expert 2		This RLO was not as interactive as the others but was very useful in providing me with knowledge about dynamics, compressors and the characteristics of them. It was very informative. The only drawback was that after I had intacted with the other RLOs I was trying to turn knobs to test the equipment but this was not a feature of this object	
International Expert 3			For the audio engineering students the Learning Objects assume they can hear the difference between the various settings and know how to make meaningful adjustments to the various controls. This is probably

			the case. For those who have more modest prerequisites it could be useful to suggest some examples that highlight the differences, again for the Mixer where I spent more than 10 minutes trying various permutations in order to hear versions which differed perceptively from each other. Again this boils down to how explicit you want to make the prerequisites for deriving benefit from each of the Learning Objects.

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