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Exploring learning design in tertiary mathematics

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Exploring learning design in tertiary mathematics

This research is motivated by challenges in the design of learning materials and their delivery through a blend of traditional and e-learning environments. The initial focus addresses the question "what is learning design?" Definitions of learning design have changed in response to educator's attempts to implement learning designs in their subjects and in response to their attempts to articulate how to design for better learning. Building on Herrington & Oliver's (2002) model which directs attention to resources, tasks and supports in designing online learning environments, this study applies a learning design model to an introductory subject (MATH151). The underlying question asked is "how can resources and tasks best be combined in e-learning to support students in learning?" This has led to the creation of a learning design for MATH 151 with emphasis on visual components rather than written descriptions. One question addressed in the design process is "how can the temporal aspects of the subject be linked to resources?" The design process has generated questions about the nature and potential benefits of using designs to improve clarify concepts and to understand the learning process. An extension of these questions involves asking "how can students be better engaged in the learning process?"

Keywords: Visual learning design, pedagogical, resource based learning, e-learning, blended learning.

Introduction

The development of technology has changed pedagogical approaches to teaching and learning at the tertiary level. This change has come with the use of information and communications to achieve desired learning outcomes (Boud & Prosser, 2001). The emergence of new learning technologies has coincided with a growing awareness and recognition of learning theories that suggest there are many problems and inefficiencies with conventional forms of teaching (Oliver & Herrington, 2003). Universities have welcomed the capability of online systems to promote access to information and services for students irrespective of location, or computing skills. Whether e-learning in itself provides a solution for many of the problems facing institutions of higher education is debatable (Oliver, 2001). This research was prompted by the challenges posed by an increased demand for information and interaction in university subject websites including, ensuring high quality resources are provided. It also addresses the challenge of increasing lecturers' knowledge and awareness as to how to best make resources available to support university students in mathematics courses. The background for this paper is the area of e-learning and specifically e-learning of mathematics.

In the search for answers to the questions "how can resources and tasks best be combined in e-learning to support students in learning?", and "how can students be better engaged in the learning process?" our initial focus is to understand what constitutes the elements of a good learning design. Definitions of learning design, their purpose and components have changed in response to educators implementing learning designs in their subjects and attempts to articulate how to design for better learning.

Definitions of learning design

The term "learning design" is used in different ways. According to Oliver (1999)

learning design should focus on tasks, supports and resources. These "provide a strong framework for instructional design, and highlight the importance of planning specific roles for learners, the teacher and the technology in the learning environment" (p. 343). With this framework it is possible for students to access resources in a multiplicity of ways, choosing which materials to use and how to use them. Oliver (2001) and Oliver and Herrington (2003, p. 13) suggest the following design stages as the basis of effective and efficient approaches to design:

- ***Design of learning activities.*** Design the activities and interactions for engaging and directing the learner in the process of knowledge acquisition and development of understanding.
- ***Provision of learning resources***. Develop and provide the content, information and resources upon which learning is based given learner interaction. Resources are needed by the learner to successfully complete the set tasks and to facilitate the scaffolding and guidance.
- ***Design of learning supports***. Learning supports are the strategies planned to engage learners with the tasks and to enable them to complete tasks. This includes scaffolds, encouragements, assistance and connections used to support learning by providing guidance and feedback in the learning process. There three stages overlap and intersect as represented in Figure 1.

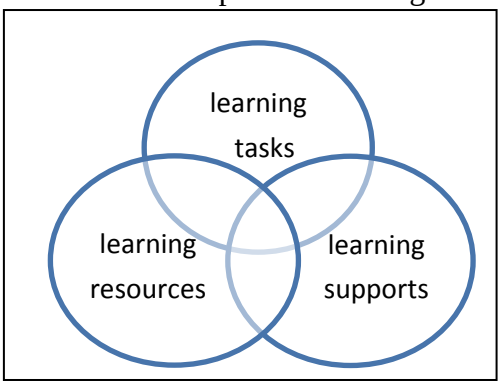

Figure 1: Element of learning design (REF) Oliver and Herrington (2001), Agostinho, S, et al 2002

To facilitate sharing of designs Oliver (1999, 2001) and Oliver and Herrington (2001) formalized the learning design sequence through the use of graphical notation (Figure 2): squares to symbolize tasks, triangles to symbolize resources, and circles to symbolize supports. Activities may differ for different learners; the activity sequence may be represented by parallel or concurrent activity components for that section of the sequence. Similarly, resources and supports can be specific to one task or may be available for entire duration of learning experience (Agostinho et al, 2008). These authors emphasise the significance of planning specific roles for students, the teacher and the technology in the learning environment (Oliver, 1999).

Koper & Olivie (2004) define learning design as the 'application of a pedagogical model for a specific learning objective, target group and a specific context or knowledge domain' (p. 98). It can encompass both the students' and instructors' activities and may involve the use of physical resources or the steps of the teaching and learning process. Koper (2006) and Dalziel (2007) describe learning design as a simplification process, or educational modelling, by teachers of a sequence of learning activities within a unit of learning which support students in the classroom. In the e-learning environment learning design can provide scaffolding which supports students. Teachers can provides strategies, resources and links that the students are able to access

to complete tasks and to develop their knowledge (Oliver, Herrington, & Omari 1996, p2).

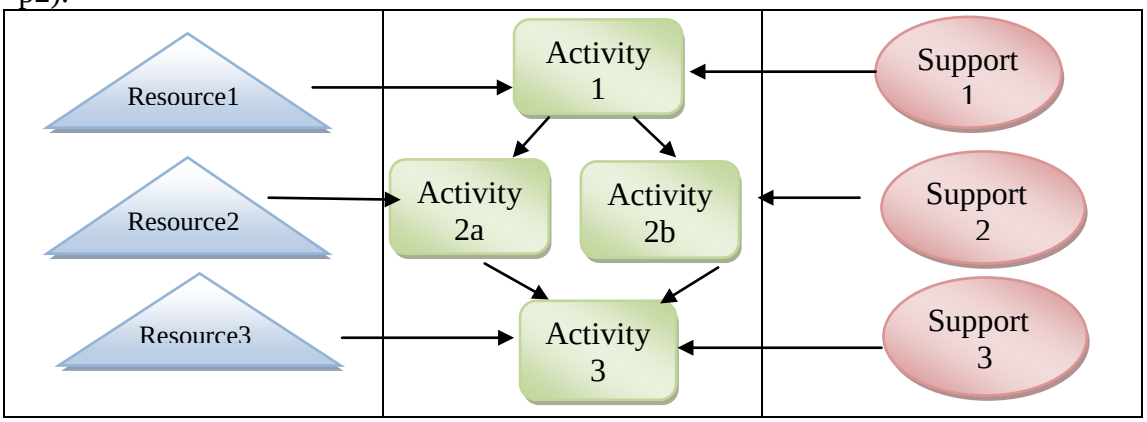

Figure 2: Example of concurrent activities in a learning design (LDVS) adopted from (Agostinho et al, 2008

Agostinho (2009), Oliver (2007) and Conole & Fill (2005) discuss representations of learning designs, which they describe as the outcome of the process of designing and planning a sequence of interactive learning activities. The creation of learning designs, representing the process of learning, leads to the possibility of them being shared, adapted and reused by other teachers. Building on others' designs might assist lecturers to design high quality learning environments. As such learning design is "a formalism for documenting teaching and learning practice to facilitate sharing and reuse by teachers" (Agostinho, et al 2009, p. 11). Agostinho, et al 2009 identified six approaches to representing learning designs: Educational Environment Modeling Language, computer readable format, the software application Learning Activity Management System, Learning Design Visual Sequence (LDVS), a lesson plan and Patterns. According to Agostinho (2006) and Agostinho et al (2009) a graphical representation, such as LDVS, can help teachers in understanding a learning design. The LDVS they illustrate uses maps to distinguish resources, tasks and supports in a subject.

Level of learning design

Masterman, Jameson & Walker (2009, p. 3) believe that learning design has three levels: as a technological infrastructure, as a framework for practice, and as a way to model and share practice through appropriate representations. Technological infrastructure is the development of an infrastructure of authoring applications to apply to a model of teaching and learning, such as the Learning Activity Management System (LAMS). In the second level the learning design is seen as a conceptual framework for practice. It includes designing, planning and orchestrating learning activities as part of a learning session or programme. The third level is sharing the outcomes of the first two levels. This means learning designs can involve technical approaches with the use of any technology or software and be integrated with the activities designed to support learning. Boyle (2010, p. 662) argues that learning design has four levels: course design, designing or planning sessions, designing activities and designing learning objects.

Issues in learning design: Academic staff

The spread of ICT has resulted in university staff changing the way they teach. Examples of ICT use include internet based activities, blogs, LAMS and the use of

digital media for presentation, interaction, and communication in teaching. Learning experiences are enhanced when ICT is used to build interactive learning environments for users to share and to collaborate (O'Sullivan and Samarawickrema, 2008). ICT can provide an environment with structure to guide the activities and roles of the learners and teachers (Oliver, 2007). The ability of ICT to provide communication channels between students allows them to be more active in collaborative learning. Combining ICT with learning design produces enhanced opportunities for sharing and re-using effective learning design. Waterhouse (2005) pointed out that e-learning can bring powerful changes in the way staff interact with students including the distribution of course information, the provision of web links, electronic communications, online testing and grading and how students interact with course content. In the mathematics education context, the requirement of effective online learning information and services can have a substantial benefit in enabling learners to access resources in variety of ways to decide which material to use and how to use it (Oliver 1999). However, conventional instructional design approaches tends to focus on online learning from the perspective of content delivery and produce learning settings whose main organsing element is the course content (Oliver & Herrington, 2003).

There are a variety of issues and challenges facing teachers in using learning designs, particularly regarding the use of technology. Many university teachers have little expertise in the development of online learning environments. For example, the effective use of a learning design can help students to undertake complex activities by giving them an idea about the way to engage in the activity sequence. However, "teachers who expect students to work individually on online units are not only denying them the benefits of collaboration, but also the benefits of expert assistance providing hints, suggestions, critical questions, and the 'scaffolding' to enable them to solve more complex problems" Oliver (2001). To use learning design effectively requires staff to be familiar with new approaches to teaching. Many teachers are concerned with how to engage students and to have students active in learning processes: "educators find themselves challenged to plan engaging and effective learning experiences for students" (Agostinho, at el, 2009, p11).

Due to a combination of factors such as research, professional engagement and teaching commitments, academics often lack the chance to participate in workshops relating to the implementation of modern pedagogies in their educational setting (Agostinho, at el 2009). In addition, the skills and understandings of learning that many teachers develop through their face-to-face teaching are often insufficient to support their needs in online learning settings (Oliver, Herrington 2001). The challenge for lecturers is identifying how to provide an environment that can accommodate individual students' needs, promote deeper approaches to learning and engage students as active participants in learning experiences with use of ICT.

Benefits of learning design

One advantage of learning design is that it allows teachers to move away from a focus on content to better describe and share the teaching process (Dalziel, 2007, p1). The use of learning design can improve the student use of ICT by placing students into an environment where they can better relate them to context and practice (Oliver, 1999). Students are more likely to use their knowledge and skills to connect new learning with previous and related learning if they are able to share and discuss ideas in an interactive learning environment. Good learning designs engage learners in building on their expectations and provide students with the confidence to be critical of both themselves

and their peers in a supportive environment (Oliver, 2007). Therefore, learning design involves identifying strategies for teachers to encourage students to share their thinking with others and reflect upon their learning. This encourages self awareness in the knowledge creation process (Oliver, et al, 2002), promoting creativity from students who are involved in the educational process. Although using technology in teaching can be effective, the key points to consider are: whether or not this tool adds value to education, how to engage students to use it and what strategies staff should use to create a balance between teaching and learning.

This Study

This aim of study is to examine the application of learning design principles to the redevelopment of an introductory mathematics subject. This study builds upon Oliver's (1999, 2001) and Herrington & Oliver's (2002) model which directs attention to resources, tasks and supports in designing the online learning environment. Learning design is defined as a structural model of the educational process which includes support of students in learning, understanding, and performing in their subject of study and to assist teachers in the design of their subject. The focus in this study is on the redesign of the subject home page and the use of learning design as an interaction map to reveal the structure of the educational process and the impact of communicating this to students. Through this students should be enabled to understand the learning and teaching process as they engage with their discipline. The interaction map maps resources, the sequence of student activities and learning support.

Re-design of the Home Page

This redesign involved changes to both the home page and the secondary level of pages. Both the original and redesigned E-Learning subject site contained tasks or learning activities, such as online quizzes and tutorial sheets; the learning resources, including solutions to mathematics questions covered in lectures, collections of worked examples and supports such as access to the E-Learning discussion forum. The structure of the original website did not convey the temporal sequencing of activities, including the appropriate time to access resources and to complete tasks (Refer Figure 3).

The need to organize resources in an e-learning environment to help students study effectively by providing good support and appropriate ``scaffolding'' has been emphasised by Xiaozhen & Yun (2002) and Hua Kuo (2008). Furthermore, the e-learning environment can provide ``enhanced input and abundant learning resources and aids'' Hua Kuo (2008, p. 297) .

Oliver & Herrington (2003) argue there is a "need to plan learning settings based on meaningful and relevant activities and tasks which are supported in deliberate and proactive ways''. There are many ways to improve teaching and learning by organizing the structure of e-learning sites and providing appropriate online learning strategies. The learning activities, learning resources and learning supports suggest an organizational framework for the e-learning setting (Oliver and Herrington, 2003).

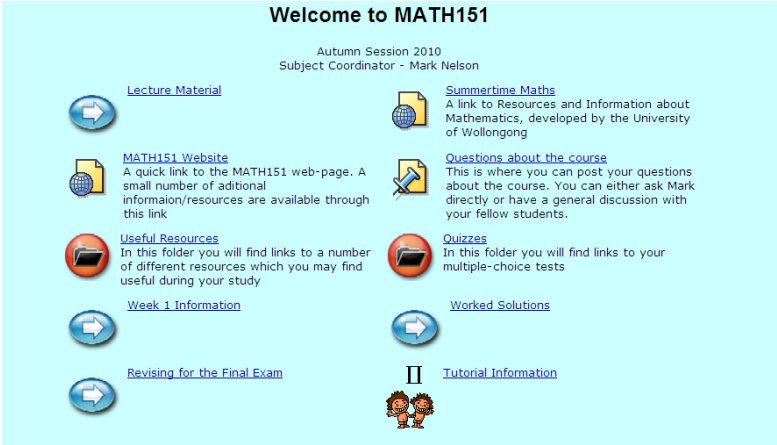

Figure 3: The original e-Learning website for math 151

In the redesign, with a focus on resources, tasks and supports and the temporal requirements associated with their use, additional learning supports and resources were deemed desirable. The redesign at the home page level (compare Figure 3 and Figure 4) associated tasks, assessment, tutorial and projects with the resources or units to be learned and provided a link to general support. It also provided links to useful resources, past examination papers and solutions, and this has not changed in the initial re-design. However, the location of the introduction link was moved to the first position reflecting the temporal order of requiring information and it included a one page assessment diary.

Figure 4: the redesign at the home page level

Redesign/ Design of second level of pages

Introduction

In the original design the week 1 link provided students with access to subject information (subject outline, details of who is lecturing, assessment, details on tutorials and other policy information). In the redesign with an emphasis on student support a video presentation was added which provided an overview of the units and advice on how to effectively complete the subject. An assessment schedule providing a map of temporal aspects of the subject was also added.

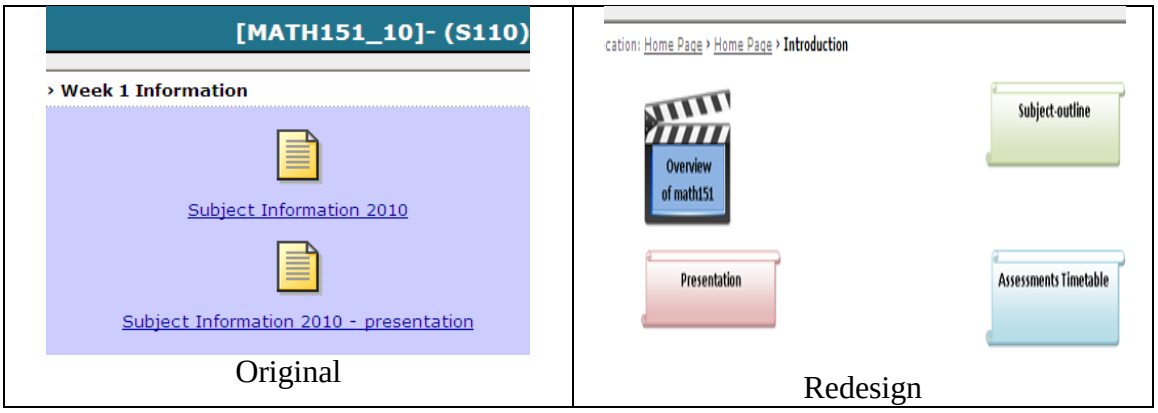

Figure 5: week 1 information and introduction

Unit pages

In the original design "lecture material" referred to self-test and solutions, worked examples and solutions, practice online quizzes and solutions for all topics. There was much debate amongst the design team regarding the classification of tasks, resources and supports. In the first stage of redesign the topics were placed into three unit links which provided worked examples and solutions. This was primarily because there were three assessment tasks for each unit of work, although at this stage assessment was in a separate link. The remaining resources, categorised by topic, were moved to the assessment links associated with each of the three units. Additional resources were moved to the resources link. A major change is that each chapter (reading material and lecture material) previously given only in print and face-to-face format is now included in the units along with a video providing an overview of each chapter.

The next stage of the mapping process should be holistic, as suggested in the LDVS (Refer Figure 2). This suggests that the tutorials, assessments and additional resources, currently separate links should be included in the LDVS map. While the first redesign moved the e-learning page structure closer to the LDVS it has not associated each task or class of tasks to specific support and specific resources. To obtain such a map involves skills such as the use of image maps, icon creation, and PDF creation from Math type programs. The implementation of the map is also far more time-consuming that simply uploading the content. Perhaps this explains why the design of many subjects has remained content oriented. Casey and Dyson (2009, p.176) emphasize that "the implementation of any new pedagogical approach is time-consuming and highly labour intensive". The inclusion of assessment into the map on the left to the homepage is a particular instance for debate: the lecturer wanting to promote the ease of being able to place changing assessment components into the website over the desire to include them in the holistic map. (Refer Figure 6)

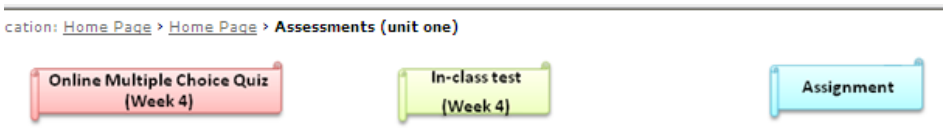

Figure 6: assessment in the homepage

Learning support

At the homepage level the previous link to the "questions about the course", a discussion forum where students and lecturer provided feedback or answered questions, was expanded to become a link to Support. This linked to a more general list of support, including the discussion forum, including links to other sources of help such as a formal peer support program (PASS), the consultation hours of the subject lecturers and contact details for a newly employed mathematics learning developer.

There is a second type of support that may be provided through resources. Video clips, self-tests, worked examples and solutions can be used to support the learning of specific mathematics skill required. In the desired LDVS design these would be associated with each task or class of tasks (Bukhatwa et all, 2011).

Resources added to the sites include orientation videos, videos of worked examples and web links; and, learning support, such as schedules, self tests. The structure proposed by implementing the LDVS in this work highlights to the designer when new supports or resources are required, for example in this subject there are video resources for seven topics but not yet for the three modelling, differentiation and integration.

The aim of this work has not been as an aid to the designer, rather the ultimate aim has been to communicate to students, the objectives of the chapters, the activities they must perform and the support that is available to help them to both complete the activities and to learn. "In this way the definition of learning design has been extended from guiding the lecturer in the design of learning through a learning design map to using a map to improve student's awareness of what they have to do, when it has to be completed and the resources available"(Bukhatowa et al, 2011). At this stage it would be possible to evaluate the impact of the LDVS on student learning.

Analysis of the Evaluation

MATH151 was the subject that was redesigned in this study. The students were drawn from different disciplines and were lectured by one of two lecturers; one taking the first seven weeks of the subject with the second lecturing the last six weeks. In addition students had small group tutorials of about 15 students for 1 hour per week. The evaluation was conducted in during the last lecture of the autumn session 2010 and after implementation of the redesigned eLearning pages in 2011.

The subject had 130 students enrolled this during the autumn term of the 2010 academic year 101 students responded to the survey. During the autumn term of the 2011 there were 146 students enrolled but with fewer students attending the final lecture there were only 49 students responded to the survey. "While a large percentage of students (79.3%) in 2010 indicated that E-Learning was useful in helping them learn and understand, it was clear from the ranking of different features of the E-Learning site such as the clarity, structure and student comments that the E-Learning could be better designed." (Bukhatwa et al 2011) and this was confirmed when a greater proportion of students found the pages better in a variety of ways (Refer Table 1).

Several significant differences were observed when comparing the value of design of e-learning in 2010 and 2011. These include: better; access material (χ^2=26.4, df=1, p-value=.000); understanding (χ^2=28.4, df=1, p-value=.000); identification of resources to support through difficulties in learning (χ^2=37.4, df=1, p-value=.000);

clarity as to what the lecturer wants (χ^2=36.9, df=1, p-value=.000). Knowledge of the required assessment (χ^2=31.3, df=1, p-value=.000)

What did you gain from the design of e-learning E-learning pages structured to be helpful for students - How useful E-learning page in helping you understand in this subject	**Agree & Strongly Agree**	
	% 2010	% 2011
The E-learning page better organize work and better access learning material	79.3	83.6
The structured of E-learning pages are to help me understand objectives of the subject	76.3	83.6
The E-learning page helps me identify resources to support me through difficulties in my learning	74.3	79.5
The E-learning pages are structured in such a way that "what the lecturers wants from me is clear"	64.4	73.1
The E-learning pages are structured to help me know what is required in terms of assessment	75.3	79.6

Table 1: Useful of E-learning page

The comments in 2010 suggested improvements could be made. Many students indicated that the e-learning was messy and difficult to find worked solutions to revise and further that they needed more examples that were better structured and accessible for revision (Bukhatwa et al, 2011, p. 4). However in 2011, students indicated that E-Learning "Very well organized easy to find things" ," It is better customized", "It is easier to find what is needed", "Very different-clear", "Easy to see what part of course we are up to", "Very easy to navigate and user friendly" .

The evaluation questionnaire also involved evaluation of the usefulness all resources identified by the lecturer and used in a subject (lecturers, notes, assessment…) but no differences were found between the two cohorts. Similarly no significant differences were found in perceived competency in mathematics topics.

Conclusions

Tertiary education has benefited from advances in technology, especially in the area of e-learning support for student learning. E-learning in mathematics is an area that requires further research in terms of applying different learning designs and pedagogical practices. The initial redesign has led to improvements in students perceptions as to the functionality of the E-Learning site. While undertaking a website redesign many issues are illuminated for example, how to best show the interrelationship between resources, activities and support. From the perspective of team development: multiple people lead to multiple perspectives giving rise to questions as to whether or not materials should be mapped as resources or as a learning support. These issues complicate the design process. The learning design needs to take into account operational difficulties where for example to place frequently changing items such as assessment. Although there is a huge demand in terms of redesigning, it is anticipated that the benefit to students would out-way the costs and that after the first redesign subsequent changes would be less complicated, certainly it has allowed the design team to identify missing support and resources.

References

Agostinho S, Bennett, S, Lockyer, L, Kosta, L, Jones, J and Harper, B 2009, "An examination of learning design descriptions in an existing learning design repository". In Same Places, Different Spaces. Proceedings ascilite Auckland 2009, pp.11-19. http://www.ascilite.org.au/conferences/auckland09/procs/agostinho.pdf

Agostinho, S 2006, “The use of a visual learning design representation to document and communicate teaching ideas”. In *Who's Learning? Whose Technology? Proceedings ASCILITE Sydney 2006* (pp. 3-7). http://www.ascilite.org.au/conferences/sydney06/proceeding/pdf_papers/p173.pdf

Agostinho S, Harper, B , Oliver, R , Hedberg ,J and Wills, S 2008, “a visual learning design representation to facilitate dissemination and reuse of innovative pedagogical strategies in university teaching”, IGI, pp380-393.

Agostinho, S 2009, Learning Design representations to document, model and share teaching practice. InL. Lockyer, S. Bennett, S. Agostinho, & B. Harper (Eds.), Handbook of Research on Learning Design and Learning Objects: Issues, Applications and Technologies Information Science Reference, Hershey, New York, vol, pp. 1-19.

Boud,D & Prosser, M(2001) ‘ appraising new technologies for learning: A framework for development’, educational media international, 39:3, 237-245

Boyle, T 2010, ‘Layered learning design: Towards an integration of learning design and learning object perspectives’, Computers & Education, vol.54, pp 661–668.

Bukhatwa, B., Porter, A. & Nelson, M. (2011). Experience with Change Evaluations suggests the need for better learning designs: one possibility for mathematics. In S. Barton et al. (Eds.), *Proceedings of Global Learn Asia Pacific 2011* (pp. 875-884). AACE.

Conole, G. and Fill, K. (2005).A learning design toolkit to create pedagogically effective learning activities. *Journal of Interactive Media in Education* (08).pp 1-16.

Casey, A. and Dyson, B. (2009). The implementation of a models-based practice in physical education through action research**.** *European Physical Education Review 15*, no. 2: 175-199.

Hua Kuo C, 2008, “ Designing an Online Writing System Learning with Support “RELC Journal , vol. 39 no. 3 285-299 http://rel.sagepub.com/content/39/3/285.full.pdf+html

Dalziel, J 2007, Learning design and open source teaching, 19/01/2010, http://blog.worldcampus.psu.edu/index.php/2007/05/16/learning-design-and-open-source-teaching/

Koper, R (2006), Current Research in Learning Design. Educational Technology & Society, vol .9, no.1, pp 13-22.

Koper, R. and Olivier, B. (2004), Representing the learning design of units of learning', Education, technology and society, 7(3), 97-111.

Masterman, E, Jameson, J & Walker, S 2009, ‘Capturing teachers' experience of learning design through case studies, Distance Education, vol.30, no.2, pp223-238.

O’Sullivan, M & Samarawickrema, G (eds) 2008, Changing learning and teaching relationships in the educational technology landscape*: Proceedings of the 2008 Annual International Conference of the* Australian Society for Computers in Learning in Tertiary Education */ (*ascilite), Melbourne , Australia, 711-714, 2008.

Oliver, R 1999, “Exploring strategies for on-line teaching and learning”, Distance Education, vol .20, no.2, p240-254.

Oliver, R., Herrington, J. & Omari, A. (1996). Creating Effective Instructional Materials for the World Wide Web, In R. Debreceny & A. Ellis (Eds) Proceedings of AusWeb 96: The Second Australian World Wide Web Conference, (pp 485-492). Lismore, NSW: Southern Cross University Press.

Oliver, R 2001, “Seeking best practice in online learning: Flexible Learning Toolboxes in the Australian VET sector”. Australian Journal of Educational Technology, vol.17, no.2, pp 204-222.

Oliver, R & Herrington, J 2001, “Online learning design for dummies: professional development strategies for beginning online designers”, In P, Barker & S, Rebelsky (Eds.), Proceedings of EDMEDIA 2002, World Conference on Educational Multimedia, Hypermedia and Telecommunications. Norfolk, VA: AACE, pp 1500-1505.

Oliver, R & Herrington, J 2001, Teaching and learning online: A beginner’s guide to e-learning and eteaching in higher education. Edith Cowan University: Western Australia.

Oliver, R & Herrington, J 2003, “Exploring technology-mediated learning from a pedagogical perspective”, Journal of Interactive Learning Environments, vol.11, no.2, pp111-126.

Oliver, R. 2007, Reusing and sharing learning designs in higher education, in Enhancing Higher Education, Theory and Scholarship, Proceedings of the 30th HERDSA Annual Conference.

Oliver, R, Harper, B, Hedberg, J, Wills, S & Agostinhol 2002, Formalizing the description of learning designs, 19/01/2010, http://elrond.scam.ecu.edu.au/oliver/2002/herdsa.pdf

Xiaozhen , Yun B 2002, “Role-based Resource Organization in E-learning Environment”, IEEE, pp273-277. http://lttf.ieee.org/icalt2002/proceedings/t701_icalt060_End.pdf

Waterhouse, S 2005,” The power of e-learning : the essential guide for teaching in the digital age “

Boston : Pearson/Allyn & Bacon Wright, R 2008, “Can 20th Century Minds Design Interactive Multimedia for 21st Century Learning?” Can 20th Century Minds Design Interactive Multimedia for 21st . ACSSESS 6/2/2011.