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Bothaina Bukhatowa, Anne Porter and Mark Nelson

Centre for Statistical & Survey Methodology, University of Wollongong, Wollongong NSW 2522. Phone +61 2 4221 5435, Fax +61 2 4221 4845. Email: anica@uow.edu.au

Experience with Change Evaluations suggests the need for better learning designs: one possibility for mathematics

Bothaina Bukhatowa
School of Mathematics and Applied Statistics
University of Wollongong
bfab852@uow.edu.au

Anne Porter
School of Mathematics and Applied Statistics
University of Wollongong
alp@uow.edu.au

Mark Nelson
School of Mathematics and Applied Statistics
University of Wollongong
nelsonm@member.ams.org

Abstract: A Change Evaluation was conducted in the School of Mathematics and Applied Statistics, at the University of Wollongong (UOW) with a view to identifying which resources to improve in order to facilitate better student learning outcomes. One hundred and thirty students took the subject MATH151 during the autumn term of the 2010 academic year with 101 students responding to the evaluation questionnaire. Data collection was used to discover which resources had the greatest potential for improvement or replacement and to examine if the structure of the subject could be improved for better student understanding and learning. The survey was also employed to evaluate the effectiveness of the e-learning page, and this led to an emphasis on finding an alternative learning design. Several possible approaches to learning designs are discussed.

Keywords: *higher education, pedagogy, e-learning, technology, learning design.*

Introduction

E-learning has already influenced the field of teaching, training and development (Manochehr, 2006) with many universities using systems such as WebCT to provide communication and additional resources for students. There are claims that E-learning, or online learning as it is also known, can improve student learning, if this is purposely planned (Oliver, 1999, p241). However, there are concerns that there is insufficient evidence to show that e-learning is an effective delivery mechanism (Manochehr, 2006). A key issue is understanding how lecturers can engage students as active participants with these resources and how they can help students to learn in effective and interesting ways. Typically, for many students, the first year is a challenge in university-style learning. It is well known that many students struggle to understand and learn many subjects, and in particular mathematics. These difficulties may be due to poor subject design. Hanson and Heller (2007) argue that the design of academic programs typically focus "on the disciplinary content of what should be taught" while other issues important for success in courses, such as, "how students learn most effectively, how essential learning process skills can be nurtured, and, for first-year students, how the difficult transition from high school to college can be facilitated" are overlooked. The primary functions of models of e-learning that have been developed to date are to support course development as well as to support the design of teaching and learning processes (Franklin et al., 2004).

Exploration of issues important for success requires appropriate evaluation. However, there are different perspectives depending in part on the purpose of the evaluation as to what evaluation should focus on and how it should be undertaken. Evaluation can provide feedback and motivation for continued improvement for learners, faculty, and innovative curriculum developers (Wojtczak, 2001). Hay and Hatzipanagos state that "measures of

student learning are the only valid indicators of the quality of teaching" (2009, p. 1). Evaluation of program efficiency involves identifying the areas in which a program is most successful in order to capitalize upon them as well as identifying areas of weaknesses in order to make improvements (Muraskin, 1993). One significant reason to evaluate should be continual program improvement. Using evaluation results program administrators can better understand how their program is working and where it is headed. The use of evaluation results enables them to make better decisions that will improve the program in the long run (Quiñones & Kirshstein, 1998). "When we implement changes in learning, such as blended learning, we wish to judge the impact of the reform. Therefore, evaluation is a process by which we make judgments about the worth of an educational development" (Harding et al., 2005).

The development of effective online learning environments that meet pedagogical needs requires the application of appropriate instructional design principles (Siragusa et al., 2007). In order to improve learning experiences and learning outcomes, lecturers need to understand how learning design can best deliver the learning support students need and how to make effective use of the available resources to improve student learning. Only research and evaluation can confirm how best to use new technologies and to identify technological and other problems than need to be addressed (Lewis et al., 2001).

There are many suggested pedagogical approaches. For example, it has been suggested that to improve their learning experience students should have the opportunity to revisit material independently with guidance from the lecturer (Barrett at el., 2009). Allowing students to have independent access to resources enables them to develop their own preference for learning styles and if the resources are well-designed and student-focused this can lead to increased academic achievement and improved student attitudes toward learning (Coffield et al., 2004).

The starting point for design can vary from lecturers who wish to develop a course related to their interests to a department reviewing its portfolio of courses in an attempt to identify areas which requiring strengthening (Franklin et al., 2004). Planning and understanding the demands in course provision will always be the first concrete phase of any new course but will typically build on the reviews of previous courses as well (Franklin et al., 2004). Pressure from students is a frequent motivating force!

Definitions of learning design

In the educational literature the term "learning design" is used in a variety of ways. Agostinho (2009) identified six different approaches to learning design representations which include Educational Environment Modeling Language (EML), computer readable format (IMS LD), the software application Learning Activity Management System (LAMS), Learning Design Visual Sequence (LDVS), a lesson plan (LDLite) and Patterns as a way of capturing knowledge from designer and sharing them with practitioners.

Agostinho and Oliver (2002) recommend a learning design that involves three principle elements: learning resources, such as, lectures, books and web links; learning activities, such as problems, tasks and assessments; and, learning support, such as e-learning, schedules and consultations. Oliver (1999, p. 343) argues that tasks, supports and resources "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". These elements can be illustrated as a map. For instructors the map can prompt thinking about design activities and learning and in so doing lead to better learning of experiences for students.

In this study the learning design builds on the work of Agostinho and Oliver (2002) but the focus of the structure assumes another role, that of communicating to students' objectives of the course, the activities that the students must perform and the support that is available to help students to both complete the activities and 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.

Agostinho et al. (2002) propose the use of a "Learning Design Evaluation form" (ERF) to review learning designs prior to implementation. The focus of the evaluation of the learning design is to guide lecturers through the process of designing and planning learning to produce an effective learning design. Alexander (1999, p182) states that "Evaluation needs to be part of all stages of the development and use of CIT… Without effective, scholarly evaluation, even well designed innovations are unlikely to achieve wider dissemination, and the potential benefits of CIT for learning in higher education are unlikely to be realised"

Porter (2007) describes a change evaluation process for continuous improvement of subjects, identifying areas of strength and weakness and thus targeting areas of the subject where resources can be improved or replaced. Through baseline and follow-up evaluations the process provides a means of measuring the impact of

innovations or modifications made to improve learning outcomes. The process involves *Next Step* interviews with lecturers and a *Change Evaluation* questionnaire for students. The *Next Step* interview is used to identify the resources used in subjects for example, lectures, tutors, laboratory tasks, video clips, assessment, the structure of the subject, the major topics taught, the learning outcomes desired together with the lecturers perspective as to what needs to be changed in order to improve the subject. The *Change Evaluation* "was designed to elicit student perspectives' on how to improve the subject". "The core components of the questionnaire included questions about: how students undertook their study; ratings on how valuable the learning resources were in terms of helping them learn and understand; ratings of their perceived competence in the major topic areas; student perspectives on how to best improve the subject; either student marks on some assessment or a question on the expected grade for the subject; and demographic information to allow comparison of student preferences for resources". The questions can be adapted to gauge the impact on different outcomes such as student anxiety (Baharun & Porter 2009; Baharun, 2009).

Project aims:

1) To identify potential strategies for improving resources in e-learning so as to enable students to better learn and understand as well as to improve learning outcomes;
2) To identify and develop ways to support students in developing learning strategies that allow them to learn more efficiently, provide them a better learning experience, to motivate them to learn more enjoyably, increased learner preparation and contribution and opportunity to successfully complete the chosen subject;
3) To evaluate the effectiveness of e-learning pages so as to provide a baseline for evaluating future improvements;
4) Explore the implementation of changes identified by the Change Evaluation Process; and
5) Explore the role of learning design evaluations.

Research Method

This study reports on the first two steps of a three step process for improving subjects, refer Figure 1. The first step involves the implementation of a change evaluation process, with the lecturer suggesting the next steps for improvement and a change evaluation questionnaire collecting student perspectives as to the need for change. In the second step the subject is redesigned and evaluated using a modified Learning Design Evaluation Form (ERF) (Agostinho et al., 2002). The final step will continue the process through the evaluation of the impact of the changed design and identifying potential areas for future improvement.

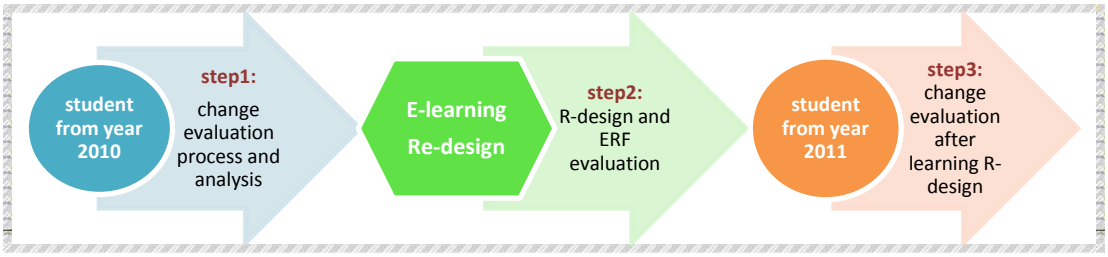

Figure 1: procedure of research method

Step 1: Change Evaluation Process and Analysis

Identifying Context and lecturer's Next Steps

MATH151 is a mathematics subject designed for students who lack the pre-requisite level of Mathematics for undertaking a Science degree. Key resources available for students included lectures, 11 printed chapters of lecture notes, e-Learning and summertime math which are a DVD of mathematics learning resources. this DVD for students who wish to identify what specific skills are required for their first session of studies and to review their Mathematics skills before starting at Uni (http://www.math.uow.edu.au/subjects/summer/topics/logs.html). The chapters include an introduction and cover the topics, indices: logarithms, function notation, straight lines, trigonometry, exponential growth and decay, data modeling, limits, differentiation and integration. The subject MATH 151 had 130 students enrolled

this during the autumn term of the 2010 academic year. Students from different disciplines were put into a large group with two lecturers; one taking the first seven weeks of the subject with the second lecturing the last six weeks. At this stage there was a suspicion by the teacher and researcher that the online component of the subject needed to be better designed, and this included the possibility of using video learning support resources. Questions were developed to assess this in the Change Evaluation Questionnaire.

The Change Evaluation Questionnaire

In this study the change evaluation was conducted in the School of Mathematics and Applied Statistics, during the last lecture of the autumn session 2010. Students were asked to complete a paper version of the change evaluation survey. The change evaluation questionnaire involved evaluation of all resources identified by the lecturer and used in a subject (lecturers, notes, assessment…) in terms of how those resources help students learn and understand (Refer Table 1). Similarly students were asked about perceived competency in mathematics topics and in the use of E-Learning. The questionnaire also includes questions to determine the profile of students completing the evaluation, the student's pattern of study and this allows comparisons of the usefulness of resources for international and domestic students, males and female students. Open-ended question also asked students "how best can MATH151 be improved?" and if changes to the assessment system were warranted and specific questions asked about various aspects of the E-Learning home page.

Usefulness of Learning Resources How useful are the existing resources in helping you understand in this subject	Rarely used this resource	Little use	Moderately useful	Extremely useful
Lectures	1	2	3	4
Work in Practical classes	1	2	3	4
Tutor in Practical classes	1	2	3	4
Assignments	1	2	3	4
etc	1	2	3	4

Table 1: Usefulness of Learning Resources

Analysis of the Change Evaluation

Fifty-seven percent of respondents (n=58) were male and forty-three per cent were females (n=43) allowing a comparison of preferences for different resources and confidence in completing different mathematics topics. Twenty percent of students (n=20) were international and eighty percent were domestic students (n=81).

The subject outlines state the time for an average student to complete a six-credit point subject is 12 hours of work per week. Notable is that in this subject only 10% of students report completing nine or more hours per week. Fifty per cent of students report doing 0-5 hours per week work.

The feedback received from students allows the ranking of the usefulness of the learning resources provided to students, refer Figure 2. The modification of some resources is not possible as they are externally developed, for example the Summertime Maths resource and the Peer Assisted Support Group (PASS) sessions (Miller et al., 2006; Ladyshewsky and Gardner., 2008). While there is scope to improve the higher ranked resources such as lectures, assessments there is greater scope to improve the resources that are currently less useful. Time constraints limit what can be done in improving the subject. What seemed feasible was a redesign of the E-Learning site was possible with only 50.5 per cent to 79.3 per cent citing the elements of the E-Learning system were useful. This also included restructuring how students accessed the self tests as it some students did not complete them. The redesign of the site and subject is subject to evaluation prior to and after implementation and this may lead to another cycle of change.

While a large percentage of students (n=79.3) 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. Some students observed in an open-ended question asking how the subject can best be improved that "e-learning messy/difficult to find worked solutions to revise/need more examples that are easy structured and accessible for revision". Specifically students cited a need for:

- Better online design, better access to learning material, site clarity, better structure, clear folder files, easier location of assessment and which week in which it is due and reminders;

- More online documentation, relevant problems, resources, worked solutions;
- Fewer links to materials, clearer links, all links to work;
- Improved resources e.g. materials needs to be explained more clearly; and, that
- All information for the course is available in e-learning.

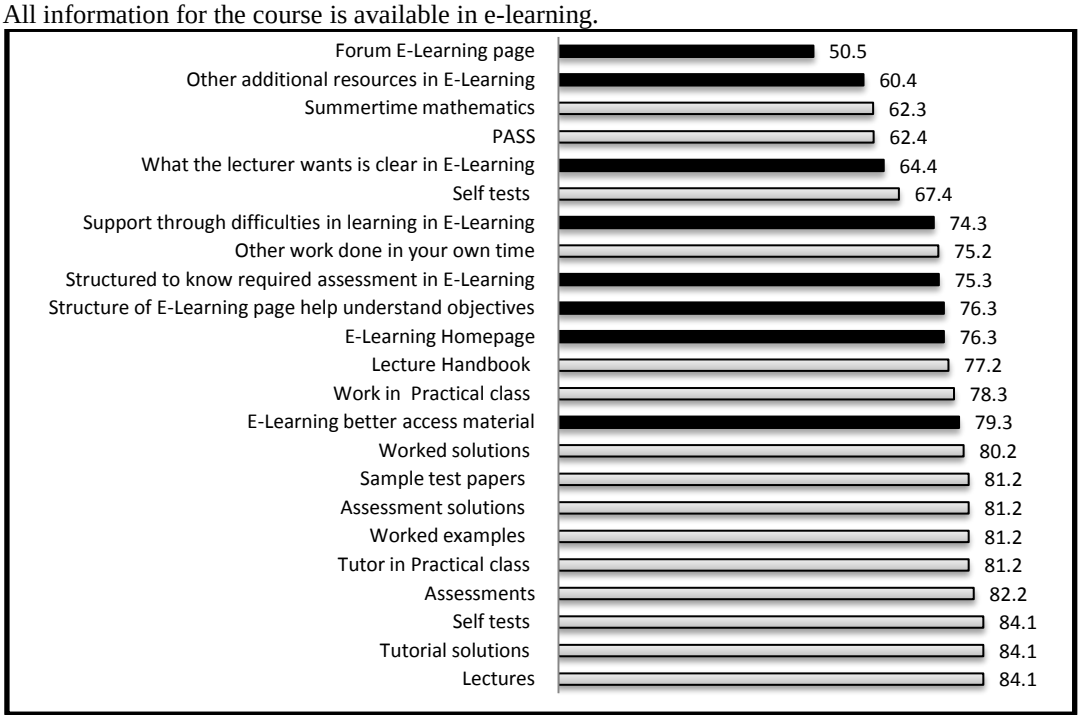

Figure 2: Per cent of students finding resources extremely, moderately useful in helping them learn and understand mathematics

Step 2: Learning Re-design and evaluation

The original E-Learning site consisted of a series of links to lectures, tutorials, assessment and solutions, worked solutions, summertime math and web links to useful resources, past exams online practice and assessment quizzes, solutions. The layout was as in Figure 3.

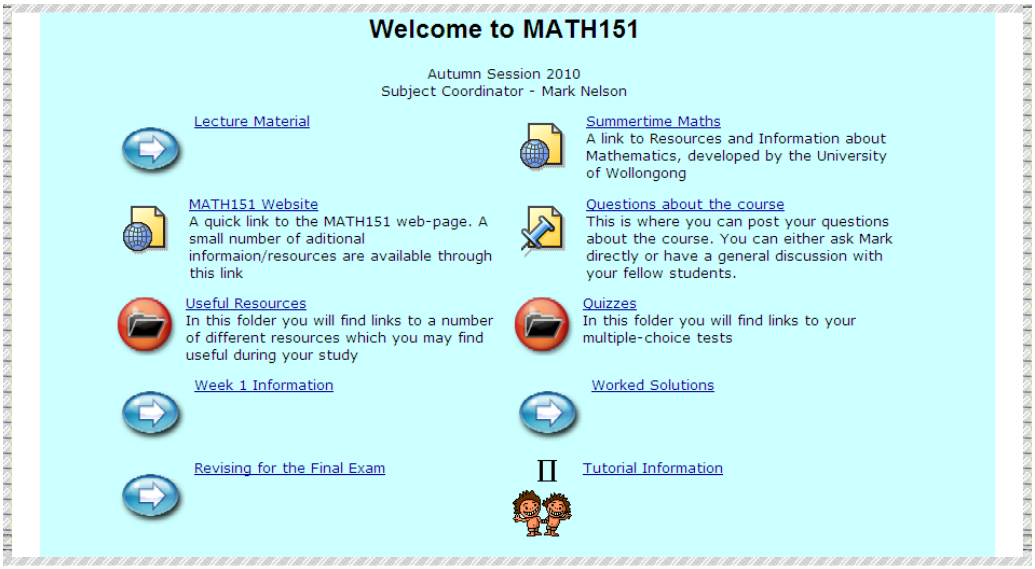

Figure 3: The original E-Learning site

The first step in the learning redesign focussed on assessment design (Refer Figure 4), the assessment schedule of learning outcomes and upon the supports that students required to achieve the outcomes. The second step involved the design of a learning design visual sequence (Agostinho 2009) that reveals the structuring of the educational process to enable students to understand the learning and teaching process. In this way with a modified purpose of supporting students learning, learning design is seen as a model which communicates the structure of the plan for the delivery of educational processes such as, tasks, supports, resources and timing, to both teachers and to students. In this implementation the learning design includes a structural plan for each level of the education process; the subject, the sub- unit or chapters, the activities, the assessment and the support.

1) **Designing assessment**

Porter et al. (2003, p. 70) argue that "The assessment system is a powerful learning tool and is also useful for examining the nature of students' thinking". In this subject the assessment focuses on the skills and knowledge of the student. In addition to a final examination three types of assessment are used: in-class tests, multiple choice quizzes and tutorial assessments. Reflecting current teachers' exploration new ways to engage learners through collaborative learning activities in active and meaningful learning environments (Oliver & Herrington 2001, p. 11) students are able to supplement this traditional assessment by collaborating on a project to investigate the importance of mathematics in science. In the redesign students are provided with an on-line assessment schedule, Figure 4, rather than information provided only in a subject outline as in previous years.

WEEKS	In Class Test	Online Quizzes	Tutorial Assignment	Research Assignment	Final exam
Week 1					
Week 2					
Week 3			Tutorial Assignment **(1)** 2.5		
Week 4	**(1) practical class** Test paper 10%	**(1)** Multiple-choice e-learning page 3 1/3 From 8 am on Monday to 17:30 pm on Saturday			
Week 5					
Week 6	**(Repeat) [In Tutorial** class] Test paper 10%		Tutorial Assignment **(2)** 2.5		
Week 7					
Week 8	**(2) practical class** Test paper 10%	**(2)** Multiple-choice e-learning page 3 1/3 From 8 am on Monday to 17:30 pm on Saturday			
Week 9			Tutorial Assignment **(3)** 2.5		
Week 10	**(Repeat) [In Tutorial class]** Test paper 10%				
Week 11					
Week 12	**(3) practical class** Test paper 10%		Tutorial Assignment **(4)** 2.5		
Week 13		**(3)** Multiple-choice e-learning page 3 1/3 From 8 am on Monday to 17:30 pm on Saturday		**Presentation** group component 7.5 individual component 2.5	
Exam period					**Final exam** 50% 40%
%	**30%**	**10%**	**10%**	**0 / 10%**	**50 / 40%**

Figure 4: The assessment table

2) **Mapping the overall subject**

The front page for MATH151 allows student to gain an overall perspective on the subject and its requirements (Figure 5).

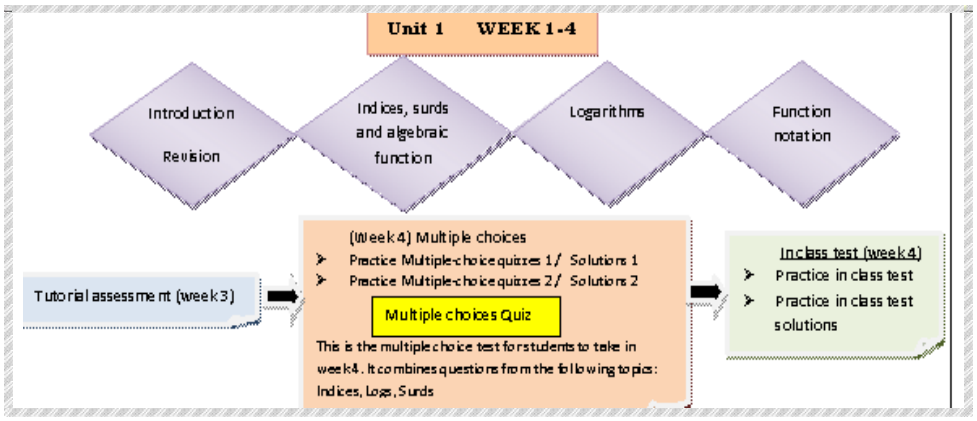

Figure 5: Extract from learning design map of the overall educational process

The map reveals topic names which link students to another map of the activities, resources and supports for use when completing topics. The subject map also provides links to tutorial assessment, practice test examples and in class tests. The timing of work is also conveyed.

a) Mapping the activities, resources and supports

The elements of this map, activities, resources and supports, are the key attributes of learning design according to (Oliver, 2001; Oliver& Herrington, 2001). (Refer Figure 6).

Learning Activities

The objectives of the subject are aligned with the learning activities. These activities define from a content perspective what it is the students need to be able to do when they have learned the topic. To help the student learn, so that they can complete these activities and thus meet the objectives, the teacher provides both learning resources and learning supports. In addition to discipline objectives there may also be objectives in relation to graduate attributes.

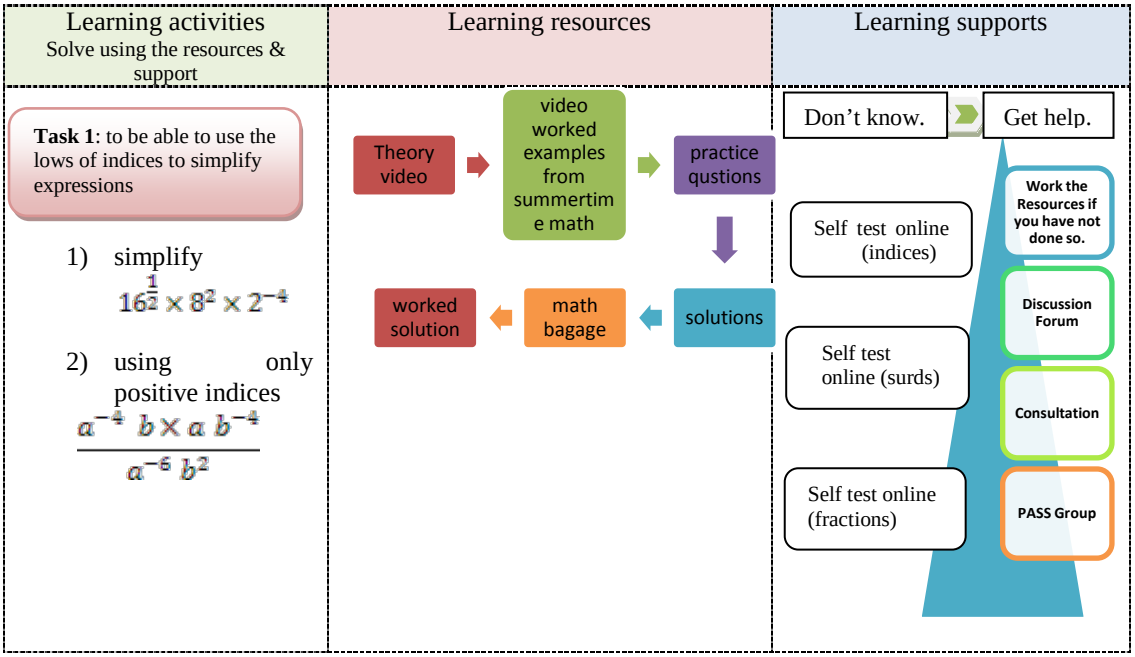

Figure 6: Extract of learning design map for chapter 1

Learning resources

Learning resources designed, chosen and developed for flexible technology-based learning for students, are essential in creating on-line learning environments (Oliver & Herrington 2001, p18). Learners need to have a variety of resources and to have choices in the resources that they use and how they are used (Oliver & Herrington, 2003, p15). This variety of material is made accessible to learners to help them understand and complete tasks. In MATH151 E-Learning resources include the chapters which provide theory and printed worked examples for each topic, relevant websites and practice examples. As one of many innovations in design Green, et al (2003) argue that streaming video can support the learning of first year students. Students in MATH151 have access to videos orientating them to the subject, discussing theory and showing the working of examples.

Learning support

Support is necessary to guide learners and to provide a feedback mechanism which is responsive to students (Oliver & Herrington, 2003, p. 14). In this subject learning supports are the strategies planned to facilitate learners experiencing difficulties to effectively achieve completion of the learning process. These supports include self tests so that students can identify what it is they know and do not know. This then facilitates their seeking of help. The initial suggestion is that they review the resources if they have not done so. The next support is the student forum where students are encouraged to post academic questions for other students to answer. Students may also seek private assistance through consultations with the lecturer or support through additional group work in PASS groups (Miller, et al., 2006). Beginning in week 2, the PASS academic mentoring program is run by an experienced senior student who helps students to learn strategies and concepts that will save students many hours struggling at home alone.

Step3. Learning Design Evaluation Form

The third step, following the creation of a new design involves evaluation of that design before implementation. In this instance the *ERF: Learning Design Evaluation Form* (Agostinho et al 2002) was used as a formative evaluation tool. The five areas examined included: 1) Whether the learning design supports Learner Engagement; 2) How well the learning design acknowledges the learning context; 3) Whether the learning design challenges learners; 4) Whether the learning design provides practice; and 5) Whether the technologies employed, their supportive systems and particular implementation facilitate the learning design. In this study the application is to Mathematics subject design and some aspects are easier to address than others. For example evaluating how the learning design provides for practice, as can be seen in Figure 7, it is relatively easy to align the goals, tasks and assessment, provide feedback at key points, and encouragement for students to communicate with others through the forum or via consultation, encouraging learner practice in this instance through the provision of a variety of formats (multiple choice, problem solving, quizzes). It is more difficult to assess whether the design encourages student confidence although the provision of video resources has been found to increased confidence (Baharun & Porter, 2009). Access to the PASS program, the focus on continued practice addresses issues in equipping students to learn appropriately as does the location of sources of timely help when needed. In Mathematics continuous practice is important (Coyne et al., 2009). Similarly the provision of lots of worked examples models the expected performance required.

It is more difficult to address issues such as whether or not the design supports learner engagement. Engaging students in Mathematics and the practice of mathematics is problematic. How do you get students to complete worked examples and practice? It is what inspires reviews and revisions of subjects. Mathematics as a core course attracts many students from different disciplines and many of these do not see the relevance of mathematics to their chosen career so identifying and responding to learners' goals, intentions and expectations is difficult as is using student prior experience. Enabling access to key concepts in many ways is possible, with different mediums, video, lecture & text, different types of problems on the one topic is a possibility so that the concepts need to be used in a variety of situations and building in real world illustration of concepts. At this stage peer interaction is not high, supplementary projects provide for teamwork but not all students complete these, most assessment is completed in isolation, student use of the forum to ask questions and answer them, but this is a proportion of the students not the whole. Opportunities for feedback regarding work are high as there are many practice examples and self tests with solutions for self-checking. While students may be allowed control of learning in being able to complete from home with the use of E-Learning rather than attending lecturers, there is

no control over the pace at which work needs to be learned, with assessment closely following topics presentation. With session begin and end dates formalized and Higher Education Contributions (HECs) payments due, actual structures of subjects would need to change to allow the type of control that permitted students to complete at their own pace. That a review pre-implementation reveals for example that there are no intentional activities to engage students in reflection about their learning or engaging students affectively raises issues in mathematics. To what extent should these indices of quality teaching pertain to mathematics and how do we build subjects which address them. In terms of review they pose the challenges still to be met.

Conclusion

The final step of this research will examine the effectiveness of the learning design map for supporting student learning in math 151. The effectiveness of the re-design will be evaluated by a further Change Evaluation after students have completed the redesigned subject and an examination of student assessment outcomes. The focus on learning design raised questions as to how best to combine resources and what resources to supply. The intent in learning design in this case study is to support the students' learning in mathematics. The module is designed to encourage students independently. It is not ultimately necessary or expected, that all students would find the time to access all the learning resources made available. However when students struggle to learn mathematics it is important that they know there are useful resources and that they use them. Re-design of the E-Learning system was to improve students' knowledge of what is expected, what is available and when resources are of most use. Whether students engage will be determined with further evaluations after implementation.

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