E-Learning and E-Systems to Facilitate Learning from Marked Student Work

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Abstract

Heinrich (2004a) first introduced the concept of 'electronic repositories of marked student work' and suggested an innovative approach of learning from marked student work. This research project further develops this e-learning approach.

The learning approach was analyzed in the framework of modern educational theories, especially those relevant to formative assessment. Learning activities that mostly suit this new approach were identified. These activities show a large degree of variation in cognitive complexity and learning effectiveness, and according to their characteristics, can be associated with various learning styles. A range of factors that need to be considered in constructing learning processes based on these learning activities were investigated.

The conceptualization of an e-learning environment to support the approach of learning from marked student work was developed. Three major objectives of developing such an e-learning environment were identified. Based on these objectives the general framework of e-learning from marked student work was outlined.

There were very few applications of this approach in teaching practice and no study has been done on its effectiveness in the practical teaching before this research. An initial learning experiment using this approach was carried out. The effectiveness of this approach was evaluated and various aspects associated with this approach were investigated. To fully support this new learning approach, a web-based prototype system named *E-Repositories of Marked Student Work*, was developed.

This research project developed opportunities for student learning and provided guidelines for teaching staff on how to reuse valuable learning resources in their teaching practice in the e-learning context.

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Publications

Publications related to this research are:

Heinrich, E. & Lu, J.Y. (2005). Opportunities in Learning from Marked Student Work. Paper presented at the Ed-Media2005 World Conference on Educational Multimedia, Hypermedia & Telecommunication, Montreal, Canada.

Lu, J.Y, Heinrich, E. & Fung, I. (2005). An Initial Survey on Student Attitudes toward Working with Marked Examples in the E-learning Context. Paper presented at the International Conference on Computers in Education (ICCE2005), Singapore.

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Chapter 1   Introduction

1.1   Research background

Assessment is highly instrumental in improving student learning. This is strongly supported by modern educational theories and teaching practice (see, e.g., Black & Wiliam, 1998; Crooks, 1998; Leach, Neutze & Zepke 2000; Nicol & Macfarlane-Dick, 2006). Crooks (2001) defined assessment as any process that provides information about the thinking, achievement or progress of students. Two categories of assessment are usually included in a comprehensive assessment plan: formative assessment and summative assessment. Assessment used to judge the performance of learners is defined as summative assessment and assessment used to improve learning and teaching achievements is defined as formative assessment.

Summative assessment provides grades and classifications about learners that can be treated as a performance indicator for students, departments, institutions, employers, funding bodies, and quality agencies (Knight, 2002). The majority of summative assessments are conducted formally (e.g., mid-semester test and final examination). It is a test or examination that is conducted at the end of a learning period (term, semester or year) (Black & Wiliam, 1998). Summative assessment shows results of previous learning. To fulfil the purpose of a performance indicator, summative assessment must be robust and reliable.

Formative assessment involves teachers' or markers' feedback on students' work and it is usually private and focuses on the weaknesses and strengths of the learners. The main goal of formative assessment is to encourage students to develop knowledge at a deeper level. It helps learners to close the gap between their current status of learning and the desired learning achievements (Black & Wiliam, 1998). It influences student learning by contributing to raising levels of students' motivation, their decisions and evaluation regarding their learning (Lambert & Lines, 2000). Formative assessment is essential in helping students to gain deeper understanding of their subject areas. Teachers have to be involved in both summative assessment

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(assessment of learning) and formative assessment (assessment for learning) (Black & Wiliam, 1998).

Recently there has been great interest in the role played by formative assessment in higher education (see e.g., Zimmerman & Schunk, 2001; Higgins, Hartley & Skelton, 2002; Nicol & Macfarlane-Dick, 2006). Formative assessment provides valuable feedback to both students and teachers. This point of view is strongly supported by many studies. For example, a research project carried out by Higgins, Hartley and Skelton (2002) in the United Kingdom (UK) revealed that formative assessment is essential for encouraging students to adopt deep learning approaches and that students have complex perceptions of feedback. Black and Wiliam (1998) discussed the theoretical foundations of formative assessment and classroom learning. Their comprehensive review set up an initial framework for learning from formative assessment. Yorke (2003) pointed out that, although there is a general acceptance of the importance of formative assessment, formative assessment is not well understood across higher education. There is a need for further theoretical development of formative assessment.

Nowadays e-learning (or online learning) is part of the agenda of most universities and other organizations concerned with education and training and there has been much research on various issues around e-learning. However, how to implement formative assessment in the e-learning context is an area that has not been fully explored. Brown and Knight (1994) suggested that feedback must be rapid in order to be effective. Using the pen and paper method of giving feedback can sometimes result in delayed feedback, especially if classes are big. Furthermore, late feedback on assignment has less positive impact on learning. Web-based computer environments can effectively support formative assessment, e.g. providing prompt feedback. However the extent to which formative assessment can be supported depends largely on the nature of the tasks. For example, essay-type open-ended assessment (which is able to reveal much more information on student learning than multiple-choice style assessment) is not well supported by current e-learning technologies.

Heinrich (2004a) first introduced the concept of 'electronic repositories of marked student work' and suggested an innovative learning approach (hereafter referred as "learning from marked student work") that utilizes these repositories. The repositories consist of written, essay-type work that is submitted by students and marked by human markers. It was pointed out by Heinrich (2004a) that students' essays and markers' feedback provide valuable learning resources that may be used not only by the students who have submitted the work but also by future students studying the same concepts. Students' work can serve as samples for the solutions of the task. Both weak and strong solutions are valuable resources. Furthermore, the feedback provided by the marker gives guidelines for future students on how to solve similar problems.

Issues on transferring paper-based assessment skills into an e-learning environment have been investigated (Heinrich & Lawn, 2004; Zhang & Heinrich, 2005). An on-screen marking tool named MarkTool, which supports teaching staff to mark student submissions in PDF format, has been developed.

1.2 Motivation and research goals

The primary aim of this research is to develop e-learning opportunities where the approach of learning from marked student work can be applied in tertiary education. The research presented in this thesis continues the work started by Heinrich (2004a & 2004b). It is motivated by the following considerations.

1. In order to apply the method of learning from marked student work in teaching practice, learning resources, learning activities and important issues in designing the related learning processes must be identified and investigated.

2. Learning from marked student work in an e-learning context is an innovative approach which is endorsed by many educational theories. However there are very limited applications of this approach in current teaching practice. An initial learning experiment using this approach provides an opportunity to evaluate its effectiveness and to explore various aspects associated with this approach.

3. This learning approach is not well supported by the current e-learning environment – there are few suitable applications and none of them is specially designed for this approach. For example, current course management systems (e.g. WebCT [2005]), which are widely used in higher education institutions, are developed mainly for supporting course management, publishing course content and doing summative assessment. They do not offer functions to substantially support learning from marked student work. An e-learning system specially designed for this learning approach is urgently needed.

The research goals are set up as follows.

1. To investigate how to integrate repositories of marked student work into student learning in an e-learning context.

2. To evaluate the effectiveness of learning from marked student work.

3. To conceptualize, design and implement a prototype of a web-based system to support learning from marked student work.

1.3   Research steps

To satisfy the above research goals, the following research steps are to be carried out.

1. Literature review

   The educational theories on learning and formative assessment set up strong foundations for this research. It is important to review these theories at the beginning of this research. Also one of the research goals is to conceptualize a web-based learning environment. To achieve this goal currently available software or learning systems which support assessment in learning need to be reviewed.

2. Conceptualizing e-learning from marked student work

   Based on Heinrich's work (2004a) and the results of a wider literature review, the conceptual development of e-learning from marked student work is carried out.

Important learning components such as learning resources and learning activities, and critical factors in designing learning processes, are identified. This part of the research brings the concept of e-learning from marked student work one step closer to teaching practice.

The conceptualization of an e-learning environment that fully supports learning from marked student work is developed. How to employ IT technologies to support learning from marked student work is explored. The software requirements of this system are analyzed and the architecture of this e-learning environment is proposed.

3. Evaluating the method of e-learning from marked student work

Yorke (2003) pointed out that there are many complex factors that influence student learning and it is very difficult to measure the effectiveness of learning from formative assessment. He suggested establishing quantitative inquiries on students' reactions to the learning approach and their expectation for further improvement. As an initial step to evaluate the effectiveness of learning from marked student work, a simple learning exercise is conducted which requires limited IT support. It reveals information on the level of student participation, perceptions on contribution to student learning and attitudes towards more interactive learning processes.

4. Prototyping a web-based learning system

A prototype of an e-learning system that fully supports the approach of learning from marked student work is designed and implemented. It involves populating the repositories of marked student work using available learning resources and demonstrating how teaching staff and students may use the web-based system.

1.4 Structure of the thesis

The above research plan lays the outline for the structure of this thesis.

Chapter 1 introduces the research background, motivation and objectives of this research project. The research plan is also included.

Chapter 2 reviews educational theories on formative assessment and learning.

Chapter 3 reviews currently available computer systems used in assessment practice.

Chapter 4 develops the opportunities in e-learning from marked student work. Learning resources, learning activities and important issues of designing the learning processes are investigated. The conceptualization of an e-learning environment which supports learning from marked student work is described.

Chapter 5 presents a learning experiment with second year software engineering students at Massey University. The design of this experiment and the results of an anonymous survey are discussed.

Chapter 6 discusses technical aspects of developing a prototype of web-based learning system and reports an informal evaluation of the prototype system.

Chapter 7 provides conclusions of this research and discusses of future work.

Chapter 2 Assessment and Learning in Higher Education

Assessment is fundamental to education. It connects learning and teaching. While evaluating educational achievements has been the primary purpose of assessment, another important role of assessment is to improve learning and teaching. In this chapter the general issues in assessment and learning in higher education are reviewed in Section 2.1. Formative assessment and its contributions to learning are discussed in Section 2.2. The last section is the summary for this chapter.

2.1 Assessment in higher education

Assessment plays an important role in higher education. Lambert and Lines (2000) identified the purposes of assessment in education as follows:

- to provide feedback to teachers and students about progress in order to support future learning, i.e. to play a formative role,

- to provide information about the level of students' achievements, i.e. to play a summative role, and

- to contribute to the information on which judgments are made concerning the effectiveness of individuals and institutions in the system as a whole, i.e. to play an evaluation role.

All these purposes inextricably affect student learning, and it is very hard to separate them in the teaching practice (Boud, 2000).

Considering the culture of adult learning in higher education, Leach, Neutze, and Zepke (2000) emphasized that assessment is part of learning, not apart from it. This means that "assessment occurs while learning is taking place, involves dialogue between learner and teacher, and includes the student in decision making" (Leach, Neutze & Zepke, 2000, p107). They also suggested issuing students with some power in assessing their own learning. Students could "propose assessment, decide what evidence they will present and the form of presentation, negotiate the criteria by which the work will be judged and be involved in making the assessment judgment" (Leach, Neutze & Zepke, 2000, p108). Students may also negotiate themselves from

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these processes and position themselves in the traditional teacher-learner power relationship. This philosophy also reflects the paradigm of learner-centred learning. Huba and Freed (2000) discussed issues regarding learner-centred assessment in higher education, which will be briefly reviewed in subsection 2.2.1.

Knowledge and understanding are two important aspects of assessment (Brown, Bull & Pendlebury, 1997) as well. Boud (2000) pointed out that assessment practice in higher education should be sustainable i.e. assessment should not only be equipped for the evaluation purpose but also performs an important role in student lifelong learning.

In order to fully satisfy the purpose of assessment, good practices for assessing student learning need to be adopted. The following 10 principles, proposed by the American Association for Higher Education (AAHE, 1996) and Banta et al. (1996), provide guidelines for the development of good assessment practice.

1. The assessment of student learning begins with educational values.

2. Assessment is most effective when it reflects an understanding of learning as multidimensional, integrated, and revealed in performance over time.

3. Assessment works best when the programs it seeks to improve have clear, explicitly stated purposes.

4. Assessment requires attention to outcomes and (equally) to the experiences that lead to those outcomes.

5. Assessment works best when it is ongoing, not episodic.

6. Assessment fosters wider improvement when representatives from across the educational community are involved.

7. Assessment makes a difference when it begins with issues of use and illuminates questions that people really care about.

8. Assessment is most likely to lead to improvement when it is part of a larger set of conditions that promote change.

9. Through assessment educators meet responsibilities to students.

10. Assessment is most effective when undertaken in an environment that is receptive, supportive and enabling.

Assessments are carried out in higher education in various forms depending on their primary goals and the teaching and learning context. In the following subsections, forms of assessment, which are widely used in higher education practice are introduced and analyzed.

2.1.1   Learner-centred and teacher-centred assessment

Assessments can be designed as learner-centred or teacher-centred depending on the party that is put in the focal point of the teaching and learning process. Research shows that learner-centred assessments have advantages over teacher-centred assessments for most teaching-learning tasks. Also learner-centred assessments can support and improve the quality of higher education to a larger extent than the teacher-centred assessments. (Huba and Freed, 2000) Thus learner-centred assessments are discussed below.

Huba and Freed (2000) identified the hallmarks of learner-centred assessment. Learner-centred assessment:

- promotes high expectations,

- respects diverse talents and learning styles,

- enhances the early years of study,

- promotes coherence in learning,

- synthesizes experiences, fosters ongoing practice of learned skills, and integrates education and experience,

- actively involves students in learning and promotes adequate time on task,

- provides prompt feedback,

- fosters collaboration, and

- depends on increased student-faculty contact.

Figure 2.1 shows the four basic elements in the learner-centered assessment process discussed by Huba and Freed (2000).
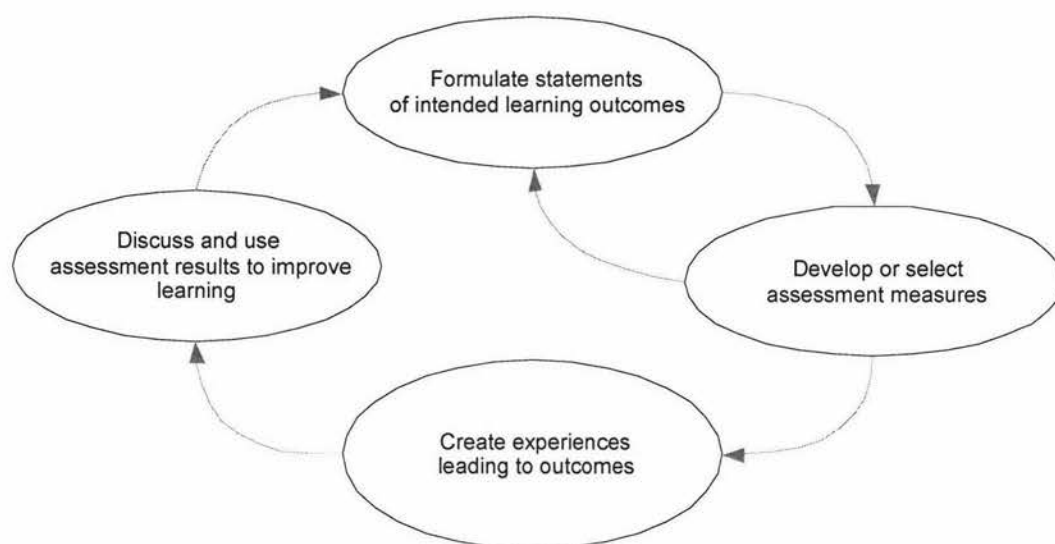
Figure 2.1 Learner-centred assessment process

Formulating statements of intended learning outcomes

The first element to consider is to formulate the intended learning outcomes. Learning outcomes provide teaching staff with clarity on what will be evaluated and help students to get information on what they should know and will be able to do after studying in the course.

Developing or selecting assessment measures

The second element is to develop data or techniques to measure whether the intended learning outcomes have been achieved. This should include both direct assessment measurement (examinations, quizzes, projects, papers/essays and case studies etc.) and indirect assessment measurement (e.g. teaching evaluation surveys).

Creating experiences leading to outcomes

The third element is to ensure that students have experiences both in and outside the courses, which help them to achieve the intended learning outcomes.

Discussing and using assessment results to improve learning

The final element is to discuss the assessment results among the teaching staff and students to find out what changes are required in the intended learning outcomes, in the curriculum, in teaching strategies and in assessment techniques, in order to improve student learning.

2.1.2   Self- and peer-assessment

Apart from the traditional assessment that is performed by teaching staff (lecturers, tutors and graduate assistants), self-assessment and peer-assessment are two other methods to assess student work. Self- and peer-assessment offer more possibilities and opportunities in learner-centred learning. Self- and peer-assessment "promote lifelong learning, by helping students to evaluate their own and their peers achievements realistically, not just encouraging them always to rely on (tutor) evaluation from on high" (Brown, 1996)

Student work can be assessed by students themselves. This encourages students not only to reflect on their own learning of a topic but also improves their learning skills. Peer-assessment is a form of innovative assessment (Mowl, 1996; McDowell & Mowl, 1996), which aims to improve student learning and motivate learners. It was found in an experiment carried out by Bostock (200) that peer-assessment was more useful than peer grading. Peer-assessment can be defined as students assessing work by other students. Peer-assessment can be conducted formatively (peer-review) or summatively (grading). Students can also participate in the activities associated with setting marking criteria and the selection of achievement evidence (Brown, Rust & Gibbs, 1994).

Compared with other forms of assessment, peer-assessment has the following advantages (Brown, Rust & Gibbs 1994; Zariski, 1996).

- Peer-assessment gives a sense of ownership of the assessment process and improves motivation.

- Peer-assessment encourages students to take responsibility for their own learning, and develops them as autonomous learners.

- Peer-assessment treats assessment as a part of learning, so that mistakes are opportunities rather than failures.

- Peer-assessment practises the transferable skills needed for life-long learning, especially evaluation skills.

- Peer-assessment uses external evaluation to provide a model for the internal self-assessment of a student's own learning.

- Peer-assessment encourages deep rather than surface learning.

Self- and peer-assessment have many advantages in common and are therefore often utilized together in teaching practice. Peer-assessment can enhance self-assessment by evaluating peer work – students think back to their own work. Peer- and self-assessments help students develop the ability to make judgments, which is necessary for study and professional life (Brown, Rust & Gibbs, 1994).

Some issues regarding validity and reliability can be encountered in student self- and peer-assessment.   One issue is whether the feedback provided by the students is valuable and accurate, and another is whether the grades provided are accurate (Brown, Rust & Gibbs, 1994). Setting clearly detailed criteria for self- and peer-assessment is one way to tackle these problems. The involvement of teaching staff in monitoring student learning is also helpful. Attention should also be paid to provide students with training or experience in developing their abilities in assessing self- or peer- work (Mcdonald & Boud, 2003).

2.1.3   Summative and formative assessment

According to the role it plays, assessment can be classified as summative or formative. The difference between the two types of assessment is nicely described by Robert Stakes using an analogy: "When the cook tastes the soup, that's formative assessment; when the guests taste the soup, that's summative assessment" (Frechtling, 2002, p8). Summative assessment gives an overview of previous learning either by accumulating evidence over time or by testing at end-phase or other transition times. Summative assessment is a response to external pressures and constraints, and the need for accountability. Formative assessment is personal and

focuses on the individual needs of learners. Black and Wiliam (1998) pointed out that teachers have to be involved in both formative and summative assessment, and must keep the two in tension.

Formative assessment can lead to significant learning improvements. In the next section formative assessment and its contribution to learning are discussed.

2.2 Formative assessment and its contribution to learning

A large number of articles on formative assessment have accumulated in the past few decades. There have been several attempts to summarize these research findings by various authors. Natriello (1987) and Crooks (1988) published two review articles on the subject. Black and Wiliam (1998) published a substantial article reviewing progress made during the period 1988-1998. Since then a lot of research has been conducted on the subject (see, e.g., Lambert & Lines, 2000; Yorke, 2003; Nicol and Macfarlane-Dick, 2006; Pintrich & Zusho, 2004; Zimmerman & Schunk; 2001).

2.2.1 What is formative assessment

In the extensive review on classroom formative assessment by Black and Wiliam (1998), formative assessment was defined as "all those activities undertaken by teachers, and/or their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged" (Black & Wiliam 1998, p7). Black and William further defined the core of formative assessment as two actions: the student must recognize that there is a gap between his or her current understanding or skill level and the desired understanding or skill level; and the student must take effective action to close the gap.

Formative assessments can be formal or informal (Yorke, 2003). Formal formative assessment is usually well defined in the course curriculum. Students need to perform specially designed tasks and teachers need to assess students' work and provide feedback. Informal formative assessment occurs more often in the learning and teaching process and includes activities such as in-class discussions between students and teachers. Another example of informal formative assessment is that students learn from the comments on peer students' work.

2.2.2   Effectiveness of formative feedback

There is a general belief that formative assessment plays a critical role in improving student learning. This is emphasized in Black and William's review article: "The research reported here shows conclusively that formative assessment does improve learning" (Black & William 1998, p36). Feedback on student work presents and explains the right answers to students – this is the basic function of feedback. Furthermore, the feedback should be constructed and presented in such a way that deep learning is encouraged (Boud, 1995a & 1995b). Lambert and Lines (2000) highlighted the benefits on student learning from formative assessment as (a) raising levels of motivation to learn, (b) deciding what to learn, and (c) evaluating learning.

There are many factors that may limit the use of formative assessment. Yorke (2003) identified and discusseed the following factors:

- an increasing concern with attainment standards which leads to greater emphasis on the summative assessment of outcomes;

- increasing student/staff ratios which lead to a decrease in the attention being given to individuals;

- curricular structures changing in the direction of greater unitization, which results in more frequent assessments of outcomes and less opportunity for formative assessment; and

- the demands placed on academic staff in addition to teaching, including the need to be seen as research active, the generation of funding, public service, and intra-institutional administration.

Those factors exist in most higher education institutions worldwide. Currently the most severe pressure on the use of formative assessment in New Zealand universities could come from the change on the research funding management system – the introduction of Performance Based Research Fund (PBRF, 2006), which greatly emphasizes the research aspect of higher education.

2.2.3 Theory of formative assessment

Recent research has highlighted the importance of a sophisticated theory of assessment that can provide a framework for the construction of assessment (Yorke, 2003; Nicol & Macfarlane-Dick, 2006). Although assessment has been widely used in higher education for a long time, very little attention has been paid to the development of theory of assessment. Without a theory, many aspects of assessment cannot be fully investigated, thus constraining the use of assessment. Both summative and formative assessment are under-theorized. The theory for formative assessment differs significantly from that for summative assessment due to the different nature of the two types of assessments. Formative assessment is a highly two-directional communication process – teachers provide feedback on students' work and students usually, e.g. during class discussions, can engage in further discussions with teachers. On the other hand, students have hardly any opportunity to follow up on final examinations, which are the typical form of summative assessment.

A theory of formative assessment should include (Yorke 2003, p486):

- the epistemological structure of the relevant subject discipline(s),

- the ontology of students (subsuming both psychopathology and development),

- theoretical constructs relating to learning and assessment,

- the professional knowledge of the educator/assessor, which includes knowledge of student development at generic and specific levels, and knowledge of assessment methodology and of the psychology of giving and receiving feedback, and

- theory relating to communication and interpretation.

2.2.4 Formative assessment in learner-centred learning

Self-regulated learning was defined by Pintrich and Zusho (2002, p64) as

"self-regulated learning is an active constructive process whereby learners set goals for their learning and monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features of the environment".

There is strong evidence to show that self-regulated learning can lead to effective learning (Pintrich 1995; Zimmerman & Schunk, 2001). Students who are more self-regulated are "more persistent, resourceful, confident and higher achievers" (Pintrich 1995; Zimmerman & Schunk, 2001). Thus the learning environment should provide enough opportunities for students to practise self-regulation.

Sadler (1998) describes three conditions under which students can benefit from formative assessments and feedback.

1. Students know what good performance is (i.e. they possess a concept of the goal or standard being aimed for).

2. Students know how current performance relates to good performance (for this, students must be able to compare current and good performance).

3. Students know how to act to close the gap between current and good performance.

Basing on the work of Barr and Tagg (1995), De Corte (1996) and Nicol (1997), Nicol and Macfarlane-Dick (2006) discusses formative assessment in a learner-centred theory of teaching and learning that describes learning as a process in which students actively construct their own knowledge and skills. It was argued that students must be provided with opportunities to develop the ability to regulate their own learning so that they can face the challenge of life-long learning after higher education. Using a model suggested by Nicol (1997), Nicol and Macfarlane-Dick (2006) build a conceptual model of the process of self-regulation and internal feedback. This model is summarized in Figure 2.2. The shaded areas describe processes internal to the learner.
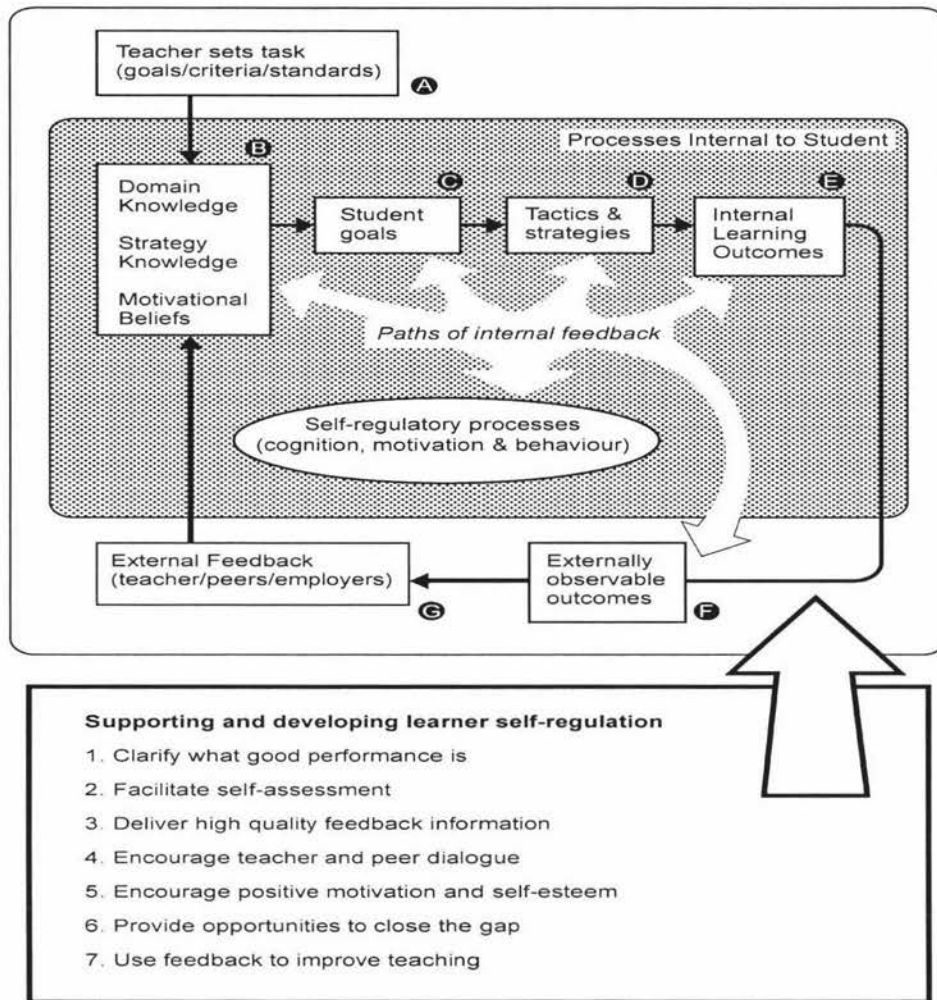
Figure 2.2 A model of self-regulated learning and the feedback principles that support and develop self-regulation in students (Nicol & Macfarlane-Dick, 2006)

The process can be summarized as follows:

A The teacher sets an academic task that initiates students' self-regulation process;

B Using their own prior knowledge and motivational beliefs, students interpret the task and its requirements;

C Students formulate their own goals, which will overlap with the teacher's goals to a certain extent;

D Students decide on strategies and tactics that they will adopt in order to achieve these goals;

E Internal learning outcomes such as changes in self-perceptions of ability and motivation are produced;

F Externally observable outcomes measurable by tests and exams are generated;

G The external outcomes are assessed and feedback can be provided by the teacher, by a peer or by other means.

Students compare the learning outcomes and their goals formulated at step (C), and thus generate internal feedback. Depending on the level of agreement between the learning outcomes and study goals, students will make changes to different components and steps in the learning process. This could involve an improvement in the tactics and strategies and/or an adjustment to the study goals. The internal feedback may occur at various levels, such as cognitive, motivational and behavioral.

External feedback is not always consistent with internal feedback. The effect of external feedback is determined by two factors: the quality of the external feedback and students' attitude to the feedback. Poor external feedback is very unlikely to have a positive impact on student learning. Students must actively engage with these external inputs in order for them to have a significant impact on the learning process.

Nicol and Macfarlane-Dick (2006) suggest seven principles of good feedback practice that can strengthen students' capacity to self-regulate their own performance and described strategies that can be used to develop good feedback. Good feedback practice:

1. helps clarify what good performance is (goals, criteria, expected standards),

2. facilitates the development of self-assessment (reflection) in learning,

3. delivers high quality information to students about their learning,

4. encourages teacher and peer dialogue around learning,

5. encourages positive motivational beliefs and self-esteem,

6. provides opportunities to close the gap between current and desired performance, and

7. provides information to teachers that can be used to help shape future teaching.

2.3 Summary

In this chapter the theories of assessment and learning in higher education were reviewed. The focus was on how formative assessment can contribute to student learning. By doing so, the essential theoretical foundations for the approach of learning from marked student work in an e-learning context were set up. Information technologies (IT), which can be used to develop good formative assessments and feedback are discussed in Chapter 3.

Chapter 3 IT Systems Enhancing Assessment and Learning

It is generally agreed that modern information and communication software as well as computer assisted instruction applications can influence student learning processes and outcomes positively. Carefully selected IT systems that support curricula can improve student learning in many subject areas (e.g. Mathematics, Languages, Sciences and Social Sciences). IT systems can help students to develop their higher order thinking skills and improve their problem solving skills. IT systems also link work experience and academic subjects together, and hence enhance career preparation (Cradler et al., 2002).

Electronic learning (e-learning) is well accepted as an efficient knowledge-transfer medium and is seen as a future application worldwide (Iahad & Dafoulas, 2004). E-learning has undeniable advantages over traditional learning (see e.g., Joliffe, Ritter & Stevens, 2000). It is cost effective and enables learners to learn anytime, anywhere and at their own pace to support life-long learning. Its value is recognized both as an approach for complete courses and as a supplement to the face-to-face form of teaching. There are various definitions of e-learning in the literature. Butterfield et al. (2002, p11) defined e-learning as "learning that takes place in the context of using the Internet and associated web-based applications as the delivery medium for the learning experience".

Currently there are many assessment management and marking tools available on the market to help teaching staff mark student submissions (for more recent work done in New Zealand, see Hamer, Kell & Spence, 2007; Plimmer & Mason, 2006). Generally these systems can be classified according to the functionalities they provide – managing student submissions, assessing student work, facilitating communication between students and teaching staff, and conducting self- and peer-assessment. In this chapter some typical systems including web-based systems and stand-alone software are reviewed.

3.1   Assessment management systems

There are many computer-based systems that can assist teaching staff to manage student submissions. Compared with labour-intensive, non-automated management of student assessments, a computer-assisted management system can provide efficient and effective help with aspects such as collecting and storing electronic-form submissions, recording student marks, and returning marked student work with feedback. Two typical management systems, EAST (Edwards et al., 2002) and WATA (Wang et al., 2004), are reviewed below.

EAST (Electronic Assessment and Storage Tool) (Edwards et al., 2002) is a web-based system for managing assessment submissions. It solves some significant problems in the assessment process of person-to-person delivery and paper-pencil marking. Using EAST to manage electronic submissions can reduce the labour involved in delivering and collection. It also provides long-term electronic storage for student and marker's work. This system focuses on the acquisition, storage and tracking of student submissions along with the assessment criteria and the assessment results (Edwards et al.,, 2002).

WATA (Web-based Assessment and Test Analyses System) (Wang et al., 2004) utilized the Triple-A model (assembling, administering and appraising) developed by Wang et al. (2002). It can help teaching staff to administer and manage testing. Each teaching staff member using the system can have a personalized interface. Students can use it to do tests and get feedback. The assembling functions include 'expert item pool', 'property serial number', 'constructing test with two way chart', 'set-up' and 'arrangement of multi-exam items'. WATA can grade students' work and collect the students' performance data for further analysis. It informs students of their marks on each item and sends a grade report to student and teacher by email. Students can discuss questions with their teachers through email. WATA can appraise and analyze student grades in a short time. A report of the test analyses can be generated in HTML format, and the report content includes standard statistical descriptors. The

system automatically creates a pie chart or a bar chart for teachers to understand scores distribution.

3.2 Systems supporting student work assessing – marking tools

Marking tools support teaching staff to assess student work. The level of support varies to a large extent depending on the nature of the assessment. Some tools can mark student work automatically; some systems employ a semi-automated approach to assess student work; some systems help teaching staff to manually annotate students' open-ended submissions.

Automated and semi-automated marking tools

If the assessment tasks are in the form of multi-choice, true/false question or fill-in-the-blank so that answers' syntax can be specified as regular expressions, there are many tools available to automated grade these types of tasks and provide marking report automatically. The quiz components of some popular e-learning systems such as WebCT (WebCT, 2005), Blackboard (Blackboard, 2005) and Moodle (Moodle, 2005) are common examples. Two other typical representatives are PEG (Project Essay Grade; Shermis et al., 2001) and PILOT (Bridgeman et al., 2000). PEG was designed to automatically grade written work. Its focus is on the assessment of general writing ability. It can automatically analyze the text and make comparison with a statistical model and give a score to it. PILOT is a web-based interactive system for testing algorithmic concepts in computer science. It can automatically grade and offer feedback to the student in graph format.

A semi-automated approach has been developed to assess student programming assignments by Jackson (2000), arguing that although computers can assess some aspects of submissions efficiently and accurately, it is not possible to replace human markers. Computers are used to assess the mechanical aspects of the programming source code (style analysis, compilation, testing, and report generation) and the human makers make judgments at a higher level such as documentation, more testing and source code checking.

Annotating tools

Essay is the major type of assessment task in the higher education context. This type of student work contains a mixture of formats including text, diagrams, graphs and pictures (Heinrich & Wang, 2003; Heinrich & Lawn, 2004), which are difficult to mark using computers. However, computers can be used to assist in annotating essays to save time and effort. Annotations can help students to understand feedback more easily. An annotation tool offers students a chance to discuss the context. Such a feature also supports learner-centred collaborative learning (Nokelainen et al., 2003).

EDUCOSM (Nokelainen et al., 2003) and CoNote (Davis & Huttenlocher, 1995) are document-based annotating/commenting tools, which allow annotations to be embedded in a text file. In the EDUCOSM system, annotations can be embedded at any position in the document by selecting a desired text area and right clicking the mouse. When the user clicks on a piece of commented text, annotations are shown in small tool tips that pop up above the annotated area. CoNote was developed at Cornell. It is a computer-supported cooperative work system designed to facilitate communication within a group via the use of shared annotations on a document. Using CoNote annotations are displayed at the nearby position that they were made.

EDUCOSM and CoNote can also be used as web-based peer-assessment systems and have been employed as such in teaching practice (Nokelainen et al., 2003; Davis & Huttenlocher, 1995; Gay et al. 1999). Research results show that the majority of students felt that these systems helped them to learn and made them think. Students strongly agreed that the system added value to the learning process and changed their studying habits favourably. Students made a very positive assessment of the value of these systems for developing relationships that were helpful to others. It has also been pointed out that annotation software can be particularly helpful for less self-confident students in a course (Nokelainen et al., 2003).

MarkTool (Heirnrich & Lawn, 2004) (see Figure 3.1) was designed as an onscreen marking tool that a human marker can use to annotate essay-type student work and provide formative feedback. MarkTool can be used to mark any essay-type artefacts in the PDF format. Marking data and annotations are stored separately in XML files. Some management functions are available to assist teaching staff, e.g. loading class

lists and creating the required entries. The teaching staff can also set up and update the assessment component for a certain paper, and set up marking schemes using this tool. Further functions of MarkTool include selecting and opening students' work for assessment, viewing PDF files, assigning marking status for a submission, annotating student work, grading assignments, and saving markers' work (Heinrich, 2004b).
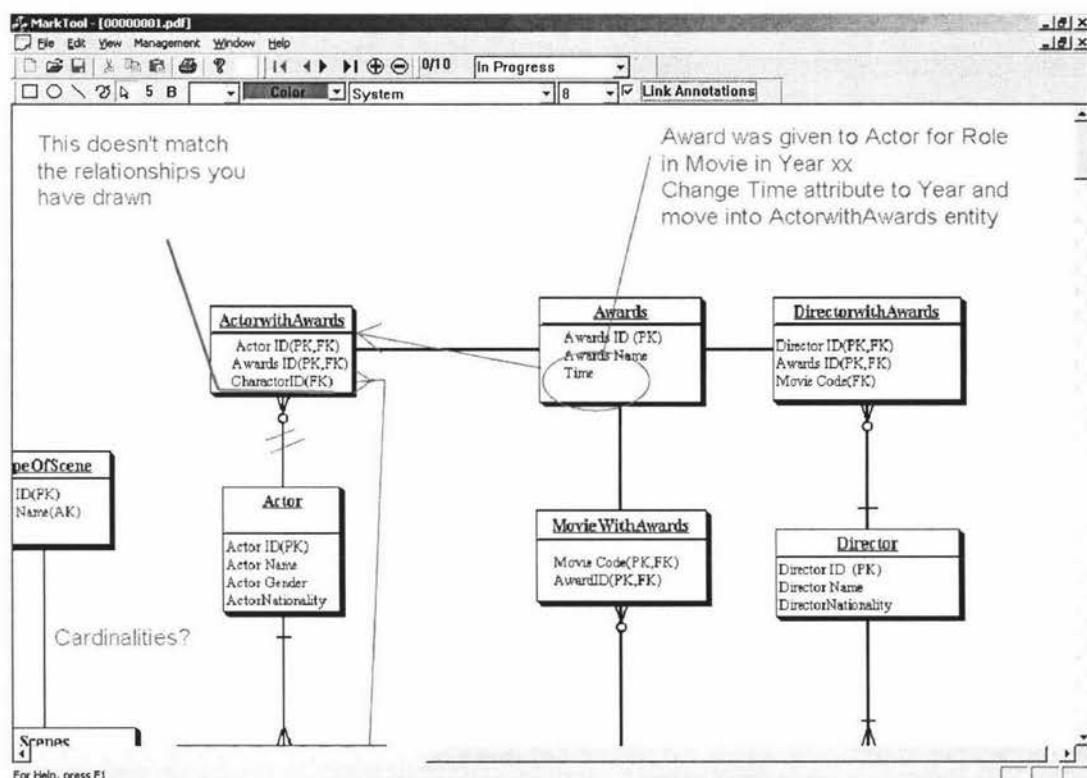
Figure 3.1 Screenshot of MarkTool showing the onscreen marking of assignments (Heinrich & Lawn, 2004)

In Chapter 5, a simple learning exercise will be introduced. In the exercise MarkTool was utilized as a student learning tool. A survey was conducted at the end of the learning exercise. In the survey (see Appendices A and B) some questions relating to MarkTool were asked. It was found that most students were satisfied with using this tool in the learning exercise and that installing and working with MarkTool was easy.

3.3 Course management systems with assessment management components and communication facilities

Course management systems provide a variety of efficient and economical tools for supporting student management, course content delivery, communication and collaborative learning, and assessment management. Among these systems three well-known course management systems which have components to support assessment and student collaborative learning are significant: WebCT (2005), Blackboard (2005) and Moodle (2005).

All three systems have the ability to mange assessment, including automated tests/quizzes and open-ended student submissions. For the open-ended student submissions, teaching staff can set up the assignment task, and students can upload any type of digital content. Teaching staff can download submissions for marking off-line and upload student marks and formative feedback which can be in the form of simple messages or files addressed to individual students. These systems provide functions for assessment management such as file submission, progress tracking and grade distributing.

These systems all provide communication tools such as private email and discussion boards. They also provide tools for virtual collaboration, and group and peer learning facilities to support collaboration among students. All these tools can also be used to communicate assessment related issues. Teaching staff can send emails to individual students, to groups of users or to all users within the course via the private email tool. Discussion boards support threaded or asynchronous discussions. Virtual collaboration tools, including Chat Room, White Board, Bulletin Board and Conferencing Tool, support live, synchronous interactions. WebCT, Blackboard and Moodle also provide tools to support group and peer learning. Students can be divided into groups. Students in the same group can upload and exchange files in order to create group projects. Teaching staff can watch the progress of any group work and offer advice to the students. Moodle has the ability to utilize peer assessment as a method to assess student work. "Workshop activity" is the tool provided in Moodle to support peer assessment for open-ended assignments.

3.4 Web-based systems linking e-learning with self- and peer-assessment

There are web-based systems which are specially designed to support self- and peer-assessment. In this section, several such systems are reviewed (see Table 3.1).

	Type of assessment involved	Evaluation Participants	Assessment tasks	Resources used	Marking outputs
NetPeas	Peer-assessment	Pre-service teachers and university computer science students	Science activities	Marking scheme	Scores; Comments
Web-SPA	Self- and peer-assessment	High school students	Web page design	Scales for marking	Rating scores
WBPAS	Peer-assessment	University students	Programming assignments	Marking criteria	Marking report; Comments on peers' marking
OASYS	Peer-assessment	University computer science students	MCQs; Open-ended questions	Example answers Marking scheme	Formative feedback
RRAS	Peer-assessment	University computer science students	Programming assignments	Sample rubric	Grades; Comments

Table 3.1 Summary of the web based systems that support self- and peer-assessment

Networked peer assessment system

NetPeas (Networked peer assessment system) (Lin, Liu & Yuan, 2001a & 2001b) was designed to support peer assessment. Options on the student interface include assignment uploading, assignment modifying, peer assessment, and complaint filing. The teacher interface offers three options: assignment assessment, feedback assessment and complaint review. Work by Tsai, Lin and Yuan (2002) provided initial evidence that a web-based environment provide a potential avenue for students to share ideas with peers, comment on the work of peers and then effectively achieve the goal of peer assessment. In Tsai, Lin and Yuan's work peer assessment was viewed as a form of collaboration for pre-service teachers. It was found that peer assessment might help pre-service teachers enhance their work according to peers' comments and constructive suggestions. It was also revealed that students could improve their own work by offering detailed and constructive comments on peers' work. Participating students generally agreed that peer-assessment was an effective learning strategy and NetPeas was a satisfactory system.

Web based self- and peer-assessment system

Web-SPA (Web based self- and peer-assessment system) (Sung et al., 2003) adopts the procedures of progressively focused self- and peer-assessment (PFSPA). It breaks through the restriction of conventional classroom self- and peer-assessment and offers various functions for teachers to design flexible self- and peer-assessment procedures without the constraints of time and space.

There are three main characteristics of the PFSPA procedures. 1) Emphasis is put on the integrated and recurring nature of the activities of self-assessments, the observation of work, peer-assessments and peer interactions. 2) Focus is on the increasingly sharp contrast in the quality of work during the process of undertaking activities as this makes learners' sense of judgement increasingly better tuned. 3) It seeks a balance between the thoroughness of evaluation work and the economy of time allocation.

An evaluation of Web-SPA showed that the students demonstrated greater objectivity in their self-assessment scores (Sung et al., 2003). Significant consistency was found between student self- and peer-assessment results and the assessment results of the teacher. Furthermore, the quality of students' work improved after the assessment activities.

Web-based peer assessment system

WPAS (Web-based peer assessment) (Sitthiworachart & Joy, 2003) is a web-based system involving students marking and providing feedback on their peers' work. After logging in, students can view three steps of marking assignment, marking quality of marking, and marks which were designed by the teaching staff for students to follow. Students can view the assigned scripts for marking, view the automated test results for the scripts and access the making scheme (see Figure 3.2). Students can revise their marks until the marking deadline is reached. Anonymity is provided for all users.

In an application of WPAS, participants were students from the University of Warwick majoring in computer science. Students were asked to do the assignment task then submitted the assignments via an online submission system. Before peer-assessment started, these programming assignments were automatically tested. During the peer-assessment stage, students marked other students' assignments and discussed their marking with peers. The evaluation results show that it is possible to apply peer-assessment in a programming course and that the system contributes positively to students' learning experience (Sitthiworachart & Joy, 2003).
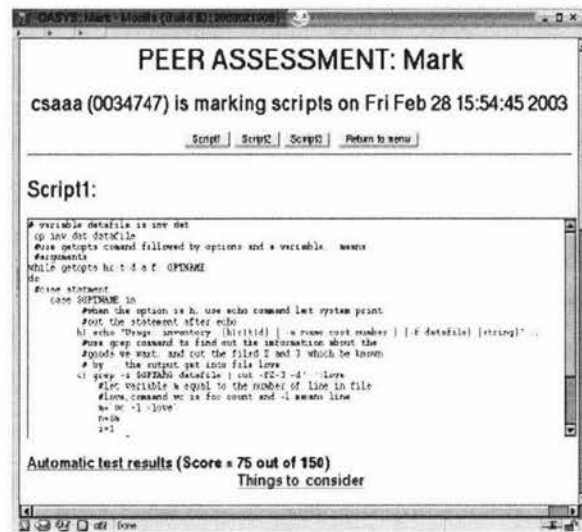
Figure 3.2 Assignment script on the 'Mark' web page of WPAS

On-line assessment system

OASYS (On-line assessment system) (Bhalerao & Ward, 2001) is an assessment system that automatically assesses the multiple-choice questions part of an assignment, and distributes the scripts to students to do peer-assessment for the open-ended questions. It provides functionalities of testing, marking, and viewing results to students, and interfaces of authoring, moderation and administration to teaching staff.

OASYS has been used for students taking a programming class at University of Warwick (Bhalerao & Ward, 2001). The evaluation results showed that there was a correlation between the final results and the efforts students put in peer-assessment: the more marking they did, the better their own results, and anonymity was important in the process of peer-assessment (Bhalerao & Ward, 2001).

Read, Review and Assess System

RRAS (Read, Review and Assess System) (Trivedi & Kar, 2003) is a web based assignment submission and assessment system that supports anonymous peer-assessment. This system includes an assignment submission tool, and an interface for students to read, review and assess others' assignments. Students can check the

evaluation of their assignments. The system also includes some tools for instructors and system administrator to administer the system. RRAS would perform well for introductory programming courses, in which programming solutions are small.

3.5 Discussion

Marking tools are an important component in formative assessment. Apart from supporting teaching staff to assess student submission, marking tools provide new possibilities and better efficiencies in student learning. Marking tools can also be valuable formative learning tools during student learning. Dalziel (2001) suggested combining these tools with useful feedback and integrating them within the learning processes, as more educational value would be added to the online courses when marking tools were integrated into a web-based learning environment (Dalziel 2001). It was also pointed out that marking tools could be adopted as a student learning tool to support self- and peer-assessment. Regular self-testing and feedback during student learning may substantially enhance student learning regardless of whether the learning applications are stand-alone or web-based (Davies, 1999 & 2003; Baggott & Rayne, 2001; Dalziel, 2001).

Document-based marking tools like EDUCOSM (Nokelainen et al., 2003), CoNote (Davis & Huttenlocher, 1995) and MarkTool (Heirnrich & Lawn, 2004), which support marking essay types of student work have been reviewed in this chapter. EDUCOSM (Nokelainen et al., 2003) and CoNote (Davis & Huttenlocher, 1995) have also been used as web-based peer-assessment systems in teaching practice and positive learning results were received. It is proposed in the discussion that MarkTool can also be chosen as a teaching tool – to support teaching staff to assess student work and provide formative feedback, and as a learning tool – to support student learning through formative assessment.

The course management systems and learning systems reviewed in section 3.3 and 3.4 have their merits in supporting student learning. However a common weakness of these systems is that they have very limited ability to manage learning from formative feedback. The benefits of learning from marked student work cannot be maximized using these systems.

A feature of learning from marked student work is that the learning activities need to be conducted in a sequence (see Chapter 4 for details). Some activities have to be undertaken earlier than others. This puts some special requirements on the IT system. For example, in order to do peer-assessment, students first need do and submit their solutions. Current course management systems which have assessment components (e.g. WebCT, Blackboard and Moodle) provide facilities like assignment tools to publish tasks, collect student submissions and offer feedback. However, in these systems student marks have to be returned together with the feedback, which does not fit with the purpose of learning from formative feedback. The communication tools in these course management systems can be adopted as platforms to support assessment related discussions. However, there is no facility in the current systems which can be used to link these activities together, organize the learning resources for each activity and operate them in sequence.

NetPeas, Web-SPA, WPALCP, OASYS and RRAS are web-based systems specially designed for e-learning with self- and peer-assessment. These systems have been employed in teaching practice and it has been proven that learning activities like self- and peer-assessment enhance student learning and improve student learning outcomes. Learning options are provided on the student interface. However, none of the above systems provides interfaces to support teaching staff to manage the learning resources and design learning processes for the students. The systems cannot be directly used in e-learning from marked student work either.

3.6 Summary

In this chapter, currently available IT systems supporting assessment and learning were reviewed. The focus was on the systems that support assessment management, tools for marking and commenting student submissions, and systems that have been specially designed to facilitate self- and peer-assessment. The use of marking tools as student learning tools has been discussed. It can be concluded that there is no IT system available that can fully support the approach of learning from marked student work.

Chapter 4 Conceptualization of E-Learning from Marked Student Work

The educational theories relating to assessment and learning which form the theoretical foundation for the method of e-learning from marked student work have been reviewed in Chapter 2. IT systems supporting assessment and their contributions to learning have been discussed in Chapter 3. In this chapter the approach of learning from marked student work is systematically analyzed and the conceptual development of e-learning from marked student work is reported. Appropriate learning processes are suggested after the approach of learning from marked student work is analyzed in the context of learner-centred educational theories. To utilize this learning approach, a learning environment is needed. The objectives and technical requirements of such a learning environment are investigated. The framework to construct the learning environment is suggested at the end.

4.1 Opportunities in learning from marked student work

In many courses taught at universities the core content remains very similar from year to year. Based on the fundamental concepts of the course, teachers set different examples to help students develop the knowledge and provide different tasks to assess students' learning. While the examples or tasks may vary from year to year, the methods needed to complete the tasks remain largely unchanged. Heinrich (2004a) suggested the concept of electronic repositories of marked student work and proposed the approach of learning from marked student work. The main idea was to make effective use of the resources available and to enhance student learning.

In this section the whole procedure of learning from marked student work is described. The learning resources and learning activities are identified. Important issues in designing the learning processes endorsed by learner-centred educational theories are investigated. Some examples of learning processes are suggested.

4.1.1   Overview of procedure of learning from marked student work

Figure 4.1 shows the actions relating to learning from marked student work from both a teaching and a learning perspective. One of the possible learning processes – the example learning process 3 introduced in Section 4.1.5 was used here. The procedure involving other learning processes is very similar. The actions which are presented in a time sequence. They can be fitted into two main phases: the preparation phase and the learning phase.
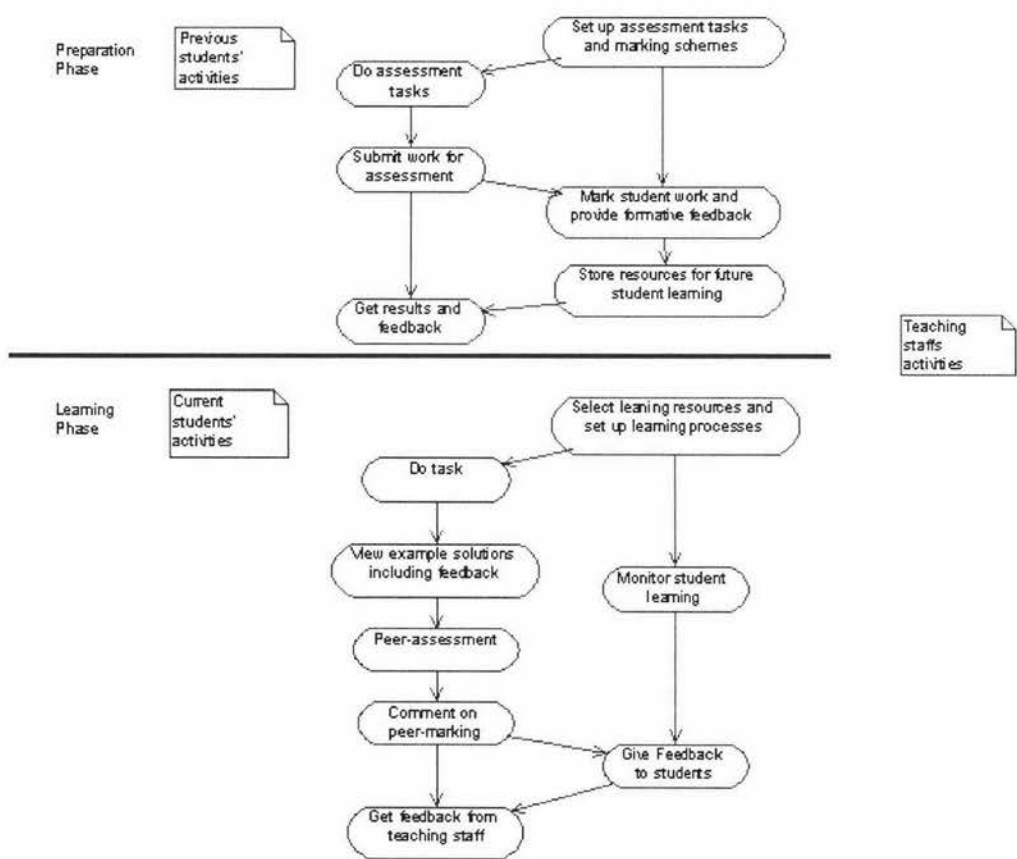
Figure 4.1 Overview of all actions relating to learning from marked student work

I. Preparation phase

In order to make learning from marked student work an effective educational practice, a number of actions must be performed in advance.

1. Teaching staff set up assessment tasks and marking schemes

The first action in the preparation phase is that the teaching staff set up assessment tasks and marking schemes. The marking schemes provide not only guidelines for markers on how to mark student work but also provide students with the instructor's expectations. The assessment tasks and marking schemes are made available to the students.

2. Students do the assessment tasks

After getting the assessment task from the teaching staff, students apply the knowledge they have learnt to complete the assessment task.

3. Students submit their work for assessment

It is becoming common practice for students to submit their work in the form of electronic files and/or via online submission facility. Depending on the subject and software the students use, the submitted files may be in different formats (e.g. word documents, video clips, graphic files, etc).

4. Teaching staff mark student work and provide formative feedback

After collecting the students' work the teaching staff (the instructor and/or teaching assistants) mark the student submissions according to the marking scheme. They need to provide summative information and most importantly formative feedback which should target students' individual weaknesses and strengths (Black & Wiliam, 1998).

5. Teaching staff store the learning resources for future student learning

This is another important activity in the preparation phase. Before marked student submissions are returned to the students, teaching staff need to select representative

samples and store the materials including assessment tasks, the marking scheme, student work and formative feedback, which could become learning resources for future students. For the purpose of using student work and formative feedback in the future, consents from the authors of the submissions are required.

6. Students get the assessment results and feedback

Marked student work is returned to the students who have done the work. While marks show the numeric results of the assessment, formative feedback helps students to understand the subject knowledge at a deeper level and gets them closer to the desired learning achievements (Black & Wiliam, 1998). At this stage some communication and discussion among students and teaching staff may take place.

It is also necessary to point out that although these actions are normal activities in an assessment life cycle, to make learning from marked student work possible all of these actions must be carried out properly by taking student learning from formative assessment in mind, especially the actions of marking and providing formative feedback which is crucial to student learning. These are the preconditions for further learning from marked student work.

II. Learning phase

After the preparation phase the learning resources are collected by the teaching staff. The following actions are involved:

1. Teaching staff select the learning resources and design the learning processes for the current students.

The learning resources from previous years include the task specifications and the marking schemes for the assignments or tests, sample student solutions, and teaching staff's formative feedback for the sample solutions. Teaching staff must review the learning resources and make sure those materials fit the current teaching requirements. The next step is that the teaching staff design a suitable learning process for the current students using the selected learning resources. This is a very challenging task. There are many educational issues that must be considered:

cognitive complexity and learning effectiveness, students' learning styles, and teaching staff's time and workload. After setting up a suitable learning process, teaching staff publish the process with the learning materials for the students.

2. Students learn by following the learning activities in the learning process that the teaching staff have prepared.

The following are activities that could be used by the teaching staff to design the learning process: doing tasks; viewing sample solutions; marking sample solutions; viewing sample solutions with feedback; self-assessment; peer-assessment; commenting on peer-marking; commenting on the marking scheme or creating a new marking scheme; setting a new task. Detailed discussions of the above learning activities and their contributions to student learning are presented in Section 4.1.3.

3. Teaching staff manage and monitor student learning.

The teaching staff manage and monitor student discussion postings, keep the discussions on track, and remove misleading or offensive messages if necessary. Also, teaching staff may track student learning records and collect student data to analyze individual or class performance and student learning patterns for each activity.

4. Teaching staff provide feedback or comments on student learning progress.

Feedback may be given to individuals or to the whole class by the teaching staff during or after the learning process. This will help students to reflect on their performances and learning experience for the whole learning process and improve not only their learning results for the current concept or learning topic but also their learning skills for their future learning.

5. Students receive feedback or comments from the teaching staff.

At this stage, further communication between the teaching staff and students will follow.

4.1.2   Learning resources

The contents stored in learning repositories include task specifications, marking schemes, samples of student submissions, and markers' feedback for sample solutions (see Figure 4.2). Task specifications could include previously used assignment tasks or examinations (test) questions. Marking schemes are the criteria used by the teaching staff to mark student work. Sample solutions are selected work from previous student submissions, usually showing different ways of solving the specified tasks or showing mistakes frequently made by the students. A marker's feedback should be formative feedback for the example solutions made by the marker. It identifies good points and shortcomings, and provides guidance for further improvements. Teaching staff can utilise all these valuable learning resources to create suitable learning processes for the students.
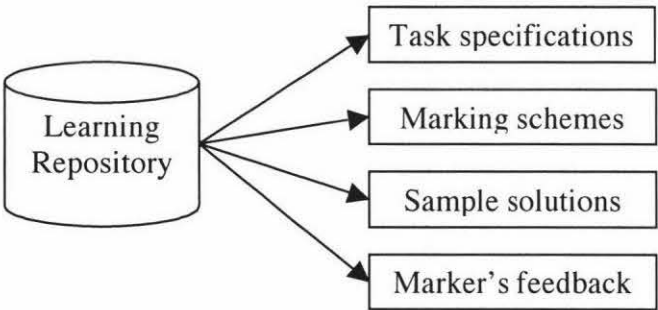
Figure 4.2 Learning resources stored in the repositories

4.1.3   Learning activities

Many learning activities can be designed in the learning context utilizing the learning resources identified above. These learning activities, as the building blocks of a learning process, should encourage the development of a deep learning approach and need to be constructed under the guidelines of learner-centred learning theories. Based on the educational literature and the scenarios presented in Heinrich's work (2004a) the following learning activities have been identified as appropriate.

1. Doing tasks

Students apply the knowledge they have acquired and learn more by solving problems. Students learn a great deal when attempting to find solutions for problems. Black and Wiliam (1998) also pointed out that students should attempt a task before feedback or solutions are provided. Students need to try solving the problem by themselves before moving to other learning activities such as self- or peer-assessment.

2. Viewing sample solutions

The sample solutions for the task's problem are made available to students. Research has shown that worked-out examples are "the key to initial cognitive skill acquisition and, therefore, critical to lifelong learning" (Renkl & Atkinson, 2002, p105). Renkl (1997) proposed two successful approaches to learning from worked-out examples: one is to concentrate on self-explanation and the other is to focus on frequently anticipating solution steps. Viewing sample solutions is an effective mode of learning, especially for novice learners. Sample solutions should be made available to students so they can analyze these and try to understand the work done by previous students. This will encourage students to think in detail about their own work and will benefit their own learning. The sample solutions can be chosen from a wide spectrum of quality – from the poorest to the best, so when students view the samples they can learn not only from good work which provides possible solutions to the task but also from poor work which shows the common mistakes.

3. Marking sample solutions

Literally, marking is critical reading of students' work involving the annotation of scripts. In this learning activity students take the marker role and mark the work, which they do not usually get to do. This learning activity is harder than the activity of doing tasks. Students can learn deeply by acting as a marker (Joyce & Weil, 1992) since it requires students to think from peers' perspectives to understand different ways of solving the same problems and importantly to make judgments on other students' work. This activity can also let students understand the marking scheme

better and can provide a stepping stone to perform other learning activities including discussing marking schemes and setting up new marking schemes. In this research we concentrate on formative assessment, so it is suggested that students annotate peers' week by giving formative feedback instead of simply giving marks.

4. Viewing sample solutions with feedback

Not only the sample solutions but also the teaching staff's formative feedback is made available to the students. Students learn by studying the formative feedback for the sample solutions. Good formative feedback from teaching staff facilitates deep-level learning (Higgins, Hartley & Skelton, 2002). Using the repositories, students have the opportunity to view and study their teaching staff's formative feedback on student work. Following the procedure of attempting a task before looking at a solution, students could mark some sample work by themselves (activity No. 3) before comparing their own marking with that provided by the teaching staff.

5. Self- and peer-assessment

Students learn by assessing their own or their peers' work according to a marking scheme. The benefits of self- and peer-assessment in student learning are discussed extensively in literature (see e.g., Black & Wiliam, 1998; Topping, 1998). Students benefit from analyzing solutions suggested by others and they need to clarify their understanding in order to be able to give constructive feedback. Moreover, good quality peer-feedback provides new insights into students' own work; being involved in self- and peer-marking allows students to reflect on their own solution attempts. Distinct from commenting on peers' marking (below, activity No. 6), students would in this case not share their marking with their peers.

6. Commenting on peers' marking

Students learn by providing feedback on their peers' marking of the sample solutions. Student may also comment on each other's feedback which can be used as a starting point to facilitate discussion among students. This process can be enabled by the use of a marking tool which allows shared annotation on the work of peers. This type of interaction is also known as context discussion (Brush et al., 2002a &

2002b). One particular advantage of this interaction is that it focuses on specific points that directly link to the materials and therefore makes the discussions more efficient.

7. Commenting on a marking scheme or creating a new marking scheme

This is an advanced learning activity, which involves student learning by providing feedback on an existing marking scheme and/or creating a new marking scheme for the task. After students have marked sample solutions using the marking scheme provided by the teaching staff, students could embark on an even deeper level of analysis by commenting on the criteria given in the marking scheme. As before, this could be done in the form of a targeted discussion. As an advanced task, students could be asked to propose their own marking schemes. Other researchers (see, e.g., Sivan, 2000) have also suggested similar approaches involving student work around marking criteria.

8. Setting a new task

This is also an advanced learning activity where students learn by setting a new task for a particular concept. Formulating their own new questions encourages students to learn and think more (Black & Wiliam, 1998). Developing good task specifications is very difficult and students can learn even more deeply from attempting to do so.

4.1.4 Designing learning processes

The learning activities discussed in Section 4.1.3 can be combined to form different sequences. Each sequence can potentially become a learning process. However, to choose an appropriate learning process is not an easy task for teaching staff. Many educational issues are still open and need to be explored and evaluated in educational practice. Issues discussed in this section include the cognitive complexity and learning effectiveness of various learning activities, the diversity of students and learning activities, the two ways for students to participate in the learning activities – being identified or remaining anonymous, and the role of teaching staff in the learning process.

I. Cognitive complexity and learning effectiveness

Cognitive complexity and learning effectiveness are important aspects in designing learning processes. The relationships among these factors still need to be fully evaluated and analyzed. Baxter's (1997) approach of analyzing the cognitive complexity of science performance assessments suggested that more complex learning activities usually lead to higher learning effectiveness (see Table 4.1). For example, self- and peer-assessments are more complex than studying example solutions. The former, which involve students marking a piece of work, require more knowledge than the latter. Therefore, performing self- and peer-assessment is a more effective way of learning than studying example solutions.

Cognitive Complexity	Learning Activities	Learning Effectiveness
easier	View sample solutions	lower
	View sample solutions with feedback	
	Doing tasks	
	Marking sample solutions	
	Self-assessment	
	Peer-assessment	
	Commenting on peers' marking	
more complex	Commenting on a marking scheme	higher
	Creating a new marking scheme	
	Setting a new task	

Table 4.1 Cognitive complexity and learning effectiveness of various learning activities

II. Characteristics of learners

Learners in higher education are usually much more mature than students at other levels. There have been many studies describing the profiles of these adult learners (Boud, 1995b; Candy, 1991; Knowles, 1990; Leach, Neutze & Zepke, 2000). Adult

learners vary in their desire and are usually very confident to make a judgment about their own work. Adult learners can develop a critical attitude through a reflective process. An approach suggested by Leach, Neutze & Zepke (2000) is to encourage learners to consider alternative perspectives, or to develop their own new perspectives, and position themselves accordingly.

Also, every individual has his/her preferred learning style. Discovering the learning styles of learners and then designing suitable learning processes for them will help students to learn more effectively. To meet the diversity of student learning styles, a multi-style teaching approach involving a range of activities is desirable. According to their learning styles, students can classified as follows: (Felder, 1993; Felder & Silverman, 1988)

- Sensing or intuitive learners,

- Visual or verbal learners,

- Inductive or deductive learners,

- Active or reflective learners, and

- Sequential or global learners.

When a learning process is designed using marked student work, the learning activities identified in Section 4.13 need to be chosen according to the learning styles that students are likely to adopt. The relationships between learning activities and related learning styles are described in Table 4.2. The learning activity of *viewing sample solutions* with or without feedback suits sensing, verbal and inductive learners since they like facts and observations. Intuitive and deductive students would prefer activities like *doing tasks, making sample solutions, making a new marking scheme* or *setting a new task. Self- and peer-assessment* are suitable for reflective learners who do not mind working alone or in pairs and like to think in analytical ways. Active learners who enjoy working in groups probably would choose activities like *commenting on peers' marking* and *commenting on a marking scheme.*

By analyzing the characteristics of adult learners and the learning styles that they are more likely to adopt, it can be concluded that the learning activities identified for learning from marked student work in Section 4.1.3 suit students with a wide variety of learning styles in the context of higher education.

Learning activities	Related learning styles
Viewing sample solutions; Viewing sample solution with feedback	Sensing, inductive learners
Doing tasks; Marking sample solutions	Intuitive, deductive learners
Self- and peer-assessment	Reflective learners
Commenting on peers' marking; Commenting on a marking scheme	Active learners
Creating a new marking scheme; Setting a new task	Intuitive, deductive and reflective learners

Table 4.2 The relationships between earning activities and learning styles

III. Tracking participation vs. anonymity

Anonymous discussions can be easily set up in an e-learning environment. It has been pointed out, however, that anonymity is a "double-edged sword" in student learning (Zhao, 1998). Being anonymous, students feel freer to criticize their peers' work, but they may also care less about the consequences of their comments and be less motivated to participate. Apart from being totally anonymous or being totally identified, a semi-anonymous approach could be adopted in which students need to register in the system before they can submit their work but can participate in peer-assessment anonymously. Such an approach gives teaching staff a large degree of control, as they can track the real identities of students at any stage.

IV. Role of teaching staff in an e-learning environment

It is common practice in today's higher education to share work and discuss in the e-learning environment. In a learner-centred learning approach (Genang & Santema,

2001), discussions and interaction among students are greatly encouraged. Queiroz and Mustraro (2003) pointed out that in the e-learning environment teaching staff must take the role of manager and facilitator of the learning process. The extent to which teaching staff need to be involved depends on the characteristics of the learning activities set. Among the activities identified in Table 4.2, *viewing sample solutions*, *doing tasks*, *making sample solutions* and performing *self-assessment* require little involvement of teaching staff, while performing *peer-assessment* and *commenting on peers' marking* need teacher involvement to keep discussions moving in the right direction. *Creating a new marking scheme*, and *setting a new task* requires a lot of assistance from the teacher.

The roles of teaching staff in an e-learning environment are manifold and varied. Staff might be involved in setting up and managing learning resources, controlling student access rights, choosing learning processes, setting up incentive schemes to attract student interest, regularly accessing student marking comments to keep discussion on track, assessing student submissions and providing feedback, and removing misleading or offensive submissions.

4.1.5 Some example learning processes designed for learner-centred learning

After analyzing the important issues of learning from marked student work, some learning processes utilizing the repositories of marked student work under different learning conditions can be designed. These processes have the following common characteristics:

- The learning processes are designed for learner-centred learning.

- The learning processes are not too long or too short (4-6 learning activities in each learning process are appropriate).

- The multiple learning styles are included in each learning process.

- The learning activities included in each learning process have a wide spectrum of difficulty.

- The workload of each learning activity is reasonable i.e. not too little or too much (using 2-5 pieces of learning resource in each activity is suitable).

Example learning process 1:

1. Solve an assignment task from previous years.

2. View and study some sample solutions.

3. Mark the sample solutions.

4. View marker's feedback for the sample solutions.

Example learning process 2:

1. Solve an assignment task from previous years.

2. Mark some sample solutions.

3. View and study marker's feedback for the sample solutions.

4. Mark own solution from step 1 (self-assessment).

5. Discuss the original marking scheme.

Example learning process 3:

1. Solve an assignment task from previous years.

2. View marker's feedback for the sample solutions.

3. Mark peers' solutions from step 1 (peer-assessment).

4. Discuss peers' marking.

Example learning process 4:

1. Solve an assignment task from previous years.

2. Mark peer's solutions from step 1 (peer-assessment).

3. Mark own solution from step 1 (self-assessment).

4. Discuss the original task problem.

5. Set a new task for the same learning concept and set a new marking scheme.

Among the above examples, learning process 1 can be conducted in a "simple" way such that no student submission is required and no teacher involvement is needed. Apart from requiring a marking tool for the students (client side), the server side requirements for such a learning process are minimal – a webpage displaying the learning processes and learning resources is suitable. Current web-based course management systems (e.g. WebCT) can fulfil these basic technical requirements. In Chapter 5, a simple learning experiment based on the example learning process 1 discussed above is presented and discussed.

For more complicated learning processes that involve student submissions from previous steps, in order to use the method of teaching and learning from marked student work in an "interactive way", a web-based system which supports teaching staff in the design of learning processes and supports all designed learning activities is required. A prototype system is presented in Chapter 7 and example learning processes 2 and 3 are used to show the implementation results of this web-based learning system.

4.2 Developing an e-learning environment to support learning from marked student work

In this section the conceptual development of an e-learning environment which supports learning from marked student work, is presented. The objectives of developing this e-learning environment are identified. The technical requirements of such an e-learning environment are discussed and a framework of the e-learning environment is presented.

4.2.1 Objectives of developing an e-learning environment

In Section 4.1 the activities for both teaching and learning relating to learning from marked student work were reviewed. To make this learning approach achievable in the e-learning context, an e-learning environment is required. It has been pointed out

in Chapter 1 that this project is to investigate how to learn from marked student work, and the research focus is on the learning phase. The objectives for developing such an e-learning environment are as follows:

- establishing electronic repositories of marked student work,

- helping teaching staff to design learning processes and monitor student learning, and

- supporting student learning from marked student work.

These objectives are discussed in detail in this section.

I. Establishing electronic repositories of marked student work

One of the motivations for this research project is to reuse previous assessment materials (which include task specifications, marking schemes, sample solutions and marker's feedback) for future students. Setting up electronic repositories for storing and maintaining the learning resources in electronic form is the foundation work to make e-learning from marked student work possible.

Setting and publishing the task specifications and the marking schemes in the electronic form is becoming a common teaching practice. Also in some institutions students are asked to hand in electronic submissions (disks/CDs) and there are more and more institutions that collect assessment submissions via stand alone systems for uploading or the upload tool in learning management systems (LMS). Storing the task specifications, marking schemes and student submissions electronically are not very difficult tasks.

Formative feedback provided by teaching staff may be in different forms (see Table 4.3). The submissions could be marked by adding handwriting feedback on the hard copies, by filling in the feedback on marking sheets (using a marking scheme). However, to have student learn from formative feedback in an e-learning context, it is required that teaching staff mark student work electronically. The electronic feedback could be in the form of electronic marking sheets or comments written into the assignments. To write comments into student assignments, on-screen marking (commenting) tools are needed.

As has been discussed, for the learning activities involving viewing the sample solutions with or without marking, separating the sample solutions and the formative feedback are necessary. Thus the formative feedback needs to be stored in separated files. Maintaining the learning resources (the basic ingredients for designing successful learning exercises for students) in the repositories is another important activity for the teaching staff. The learning resources must be added to, updated regularly to suit the need of student learning.

Paper-based	Handwriting feedback on hardcopies
	Handwriting feedback on marking sheets
Electronic-based	Filling in electronic marking sheets
	Writing comments into assignments

Table 4.3 Forms of formative feedback

II. Helping teaching staff to design learning processes and monitor student learning

Designing learning processes

An e-learning environment should provide appropriate support for teaching staff to design the learning processes for students. A learning process is a sequence of learning activities that the teaching staff select for their students. It should suit both the subject matter and students' need. The educational issues in designing learning processes which have been investigated in Section 4.1.4 have to be taken into account.

Monitoring student learning

Teaching staff need technical support to manage and control the learning processes to keep student learning on the right track. Attention should also be paid to individual learning differences relating to experience, gender, ethnicity and cultural background. This will improve not only the teaching staff's ability to teach but also the students' ability to learn.

III. Supporting student learning from marked student work

The e-learning environment should support student learning as well. While they are learning by following the learning processes designed by the teaching staff, students need to access the published learning processes and the learning resources. Software should be made available to them to perform the learning activities.

4.2.2 Technical requirement analysis

This section discusses the technical requirements of the e-learning environment, which fully supports learning from marked student work. The requirement in the preparation phase is briefly described and then attention is paid to the technical requirements in the learning phase.

I. Requirements in the preparation phase

The requirements in the preparation phase include the following.

1. The teaching staff need software to set up assessment tasks and marking schemes. Depending on the subject, different software packages may be required. Document processing tools (e.g., Word) are the most commonly used software. Drawing packages (e.g., Visio), programming tools (e.g., Delphi and JBuilder), image processing tools (e.g., Photoshop) and data analyzing tools (e.g. Excel and Access) could also be used. When students do the assessment tasks, depending on the subjects they are learning use of one or more of the software packages mentioned above may be required.

2. Students need to submit their work in electronic format for assessment. An on-line assessment management system with an uploading and student-record management facility is required.

3. Teaching staff need a marking tool to mark student work and provide formative feedback. Among the available tools for commenting on work, MarkTool is recommended.

4. After marking students' work, teaching staff need to upload the feedback and marks into the online assessment system, so students can access their assessment results and formative feedback in electronic format.

II. Requirements in the learning phase

1. It is very important that at the end of a semester, teaching staff save the task specifications, marking scheme, samples of student solutions and teaching staff feedback for future student learning. At this stage electronic repositories of marked student work are required for storing and maintaining the learning resources.

2. The teaching staff must design, manage, and control the learning processes. To select the learning resources and design the learning processes for current students, the electronic repositories should be accessed to fulfil this requirement. An upload tool and a web page to display the learning process and the instructions are required to support the teaching staff in publishing the learning process with the learning materials and instructions.

3. The teaching staff need to monitor student learning. At this stage a student record management tool is required for teaching staff to control access right and track student learning records.

4. The teaching staff require a web based communication tool (e.g. Discussion Forum in WebCT) to communicate with the whole class, a group of students or individual students, to provide feedback, and to comment on student learning progress.

5. The functional requirements to support the learning activities for both student users and teaching staff need to be identified. These requirements involved in various learning activities are described in Table 4.4.

| Learning activities | Technical requirements | |
	Supporting teachers	Supporting learners
Viewing sample solutions with or without feedback	Select and upload sample solution files and marking comments to server	Download and display files
Doing tasks; Marking sample solutions	Upload task file and marking scheme file, and set due date	Download and display files; Use suitable software to do the task, and submit solution files
Self-assessment	Make marking scheme available	Download and display the files; Use an annotation tool to add comments and submit marking comments
Peer-assessment	Make marking scheme available and allocate peers' work to students	Download and display peers' work; Use an annotation tool to add comments and submit the marking comments
Commenting on peers' marking	Allocate peers' marking to students	Download and display peer's marking data; Use an annotation tool to add comments and submit discussion data
Commenting on a marking scheme	Upload instructions, marking scheme file	Download and display files; Use an annotation tool to add comments and submit comment
Creating a new marking scheme	Upload instructions	Download and display files; Create and submit new scheme
Setting a new task	Upload instructions	Download and display files; Create and submit the new task

Table 4.4 Technical requirements for different learning activities

4.3   The framework of the e-learning environment

Computers and networks are necessary in the approach of learning from marked student work. Based on the requirements analyzed in Section 4.2, an e-learning framework has been developed.

Client/server architecture is chosen to design the e-learning environment. While a 'client' is a requester of services (documents, data, etc.), a 'server' interprets the message and fulfils the client's requests. This approach reduces the limitations of file sharing architectures by introducing a database server. Using a relational database management system (DBMS), client requests can be answered directly and network traffic is reduced. Multi-user updating is also improved via graphical user interfaces (GUIs) to a shared database (Schuusel, 1996; Edelstein, 1994).

Figure 4.3 shows the framework of the e-learning environment from marked student. The server is an e-learning system which stores the learning materials and provides management functionalities to support learning and teaching. Apart from the functionalities to support the learning activities for both students and teaching staff, some management functionalities are required for the teaching staff to maintain the learning resources, to set up learning processes and to access user information. The detailed functionalities for such a system are presented in Chapter 6.

On the client side, there are local computers for teaching staff and students. Students will download the learning resources from the server and perform the required learning activities. A commenting tool which can be used not only as a marking tool by the teaching staff but also as a learning tool by the students must be installed. A web browser is required as well.
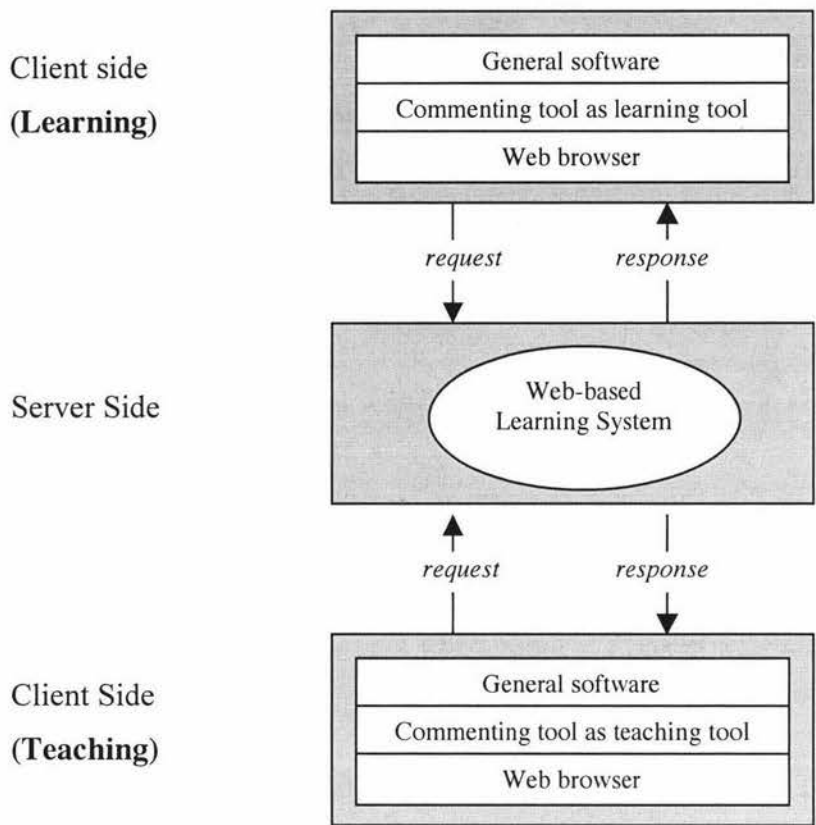
Figure 4.3 Framework of the e-learning environment

4.4 Summary

In this chapter the concept of implementing formative assessment in an e-learning environment by working with marked student work was investigated. The actions for both learning and teaching in the preparation and learning phases were reviewed. In this context learning activities like doing tasks, analyzing marked sample solutions, providing feedback, and developing a marking scheme were identified. A range of factors that need to be considered in designing a learning process were discussed. Learning activities were shown to vary to a large degree in terms of cognitive complexity and learning effectiveness and to have different characteristics that can be associated with various learning styles. Teaching staff can and must fulfil a variety of roles to support the learning activities. The right technical environment needs to be available. Some examples of learning processes were presented. The conceptualization of an e-learning environment to support learning from marked

student work was presented. Three major objectives of developing such an e-learning environment were pointed out: establishing electronic repositories of marked student work, helping teaching staff to design learning processes and monitor student learning, and supporting student learning from marked student work. Based on these objectives the general framework of e-learning from marked student work was proposed. The architecture chosen for this e-learning environment is the client-server architecture. The general tools required for client side and server side were identified.

Chapter 5　A Learning Experiment

Measuring the effectiveness of a learning approach is a key aspect in the development of any new method of learning. It is difficult to measure the effectiveness of learning approaches developed using formative assessment in the e-learning environment due to the complexity and sophistication of such an approach. Yorke (2003) proposed the use of quantitative enquiry to establish students' perceptions of a formative assessment approach and their expectations and recommendations for future improvements. As an initial research to evaluate the effectiveness of learning from marked student work, this study followed York's suggestions.

A simple learning exercise in which students followed the designed learning process was conducted at Massey University with second year software engineering students. An anonymous survey was carried out at the end of the learning exercise. In this chapter, the learning exercise and the survey are described and the survey results are discussed.

5.1　The learning exercise

5.1.1　Aims of the learning exercise

The main focus of this learning exercise was to investigate how a learning process which is designed using student work marked by teaching staff may help university students learn a concept within their area. In this exercise the task for students in a software engineering class was to master the concept of data modelling. A simple learning process was designed (see Section 5.1.4) and to evaluate the effectiveness of the learning approach using marked student work and to discover student attitudes towards this learning approach, an anonymous survey was conducted at the end of the process.

5.1.2   Participants

The participants in this exercise were students of a 2004 second year software engineering course at Massey University, Palmerston North. Most students in the course were studying towards a Bachelor of Science or a Bachelor of Information Science degree. Participation was voluntarily and students received no marks or credits towards their final grades. This learning experiment was judged to be low risk, and approved by the Massey University Human Ethics Committee (see Appendix A).

5.1.3   Learning topic and resources

The topic chosen for this learning experiment was data modelling which is one of the hardest, yet one of the most important, concepts in software engineering. Data modelling is "a technique for organizing and documenting a system's data" (Whitten, Bentley & Dittman, 2004, p294) which involves eliciting and understanding user requirements. To model and express these requirements in diagram format, Entity-Relation Diagrams (ERDs) are commonly used.

Lectures, tutorials and an assignment contributed to the learning of this topic in the course referred to. For the learning exercise, students had to provide a final entity relationship diagram showing all entities, relationships and cardinalities. The task specification was taken from the assignment set for the students of the previous year (2003) (see Appendix B). While applied to a different domain, this task was structurally similar to the assignment that was set for the 2004 students. The assignment task for 2003 was based around a business called 'Snippets' and focused on modelling information around movies, actors and awards. The assignment task for 2004 was to model an information system for a local high school that monitors allocation of teachers to classes and subjects. Therefore, participating in the learning experiment was directly relevant to students' learning in 2004.

The students were provided with the task specification (the assignment questions for 2003 students), student sample solutions (the assignments submitted by 2003

students, given in anonymous form), the marking scheme of 2003, and the lecturer's formative marking feedback as provided in 2003.

5.1.4 The learning process

The example learning process 1 discussed in Section 4.1.5 was recommended to the students:

1. Solve the data modelling task (the 2003 assignment).

2. Study the sample solutions (the 2003 student work).

3. Annotate these solutions with marking comments, and

4. Study the marker's comments from 2003 and compare these comments to students' own marking comments made in Step 3.

This learning process involves the following learning activities: *doing tasks* (Step 1), *viewing sample solutions without marking* (Step 2), *marking sample solutions* (Step 3), and *viewing sample solutions with feedback* (Step 4). It includes learning activities in the range of easy (*view sample solutions*) to modest complex (*Marking sample solutions*). To make the students' learning more effective, they were asked to attempt the task themselves (Step 1) before doing the marking (Step 3) and viewing the lecturer's formative feedback (Step 4). After Step 4 they were asked to reflect on their own solution constructed in Step 1 and to refine the solution if necessary. The learning process included multiple learning styles for different types of learners (sensing, inductive, deductive and reflective). This process was learner-centred with teaching staff involved only in the provision of the material according to a time schedule.

5.1.5 Setting up an e-learning environment for the exercise

Learning activities that did not require students to upload their solutions were involved in the learning exercise. More advanced activities such as self- and peer-assessment and discussions were not included. The technical requirements for setting up this learning process were not high level. A webpage for publishing the learning

process by the lecturer, and for downloading the learning resources by the students was sufficient.

The course management system WebCT (2005) and the marking application MarkTool (Heinrich & Lawn, 2004) were used to provide the e-learning environment (see Figure 5.1). WebCT is used in most papers taught at Massey University, so the learning resources (task specification, sample solutions, marking scheme, and lecturer's feedback) were made accessible to students via the content module of WebCT. The resources were released by the lecture at different dates so that only information required at a certain point of time was available.

MarkTool (Heinrich & Lawn, 2004) is an application tailored towards the formative assessment of essay-type assignments. With MarkTool it is possible to annotate assignments with feedback comments and to link these comments to the marking scheme. Students used MarkTool to view the sample solutions, to comment on the sample solutions using the marking scheme provided, and to view the marker's formative feedback. Students had easy access to MarkTool which was installed on computer in a computer laboratory. They were also given opportunities to install this software to their own personal computers.
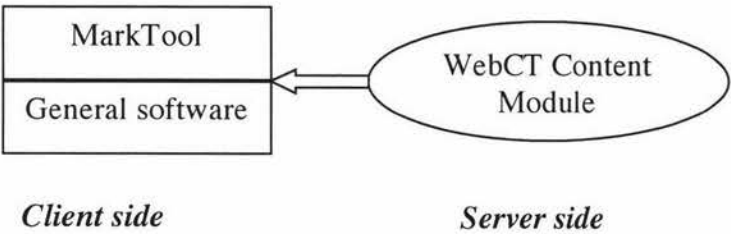

Figure 5.1 The e-learning environment chosen for the learning exercise

5.2 The survey

To evaluate the effectiveness of learning from marked student work and to get feedback from the student participants, an anonymous survey was conducted at the end of the exercise (see Appendices A and C for the information sheet and the survey document). The survey was conducted after the students had submitted their assignments following on from the exercise but before they had received the results

for these assignments. The survey aimed at collecting information about the level of participation; students' perceptions of the contribution of the exercise towards learning and their own abilities; and students' attitudes towards a more extended, interactive learning process involving marked student work. The survey contained 22 questions, 19 of which were in multiple-choice format and the rest of which were in short-answer format (NZSA, 1988).

5.3   The results

In this section important findings from the survey are reported and discussed. The data collected is presented in Appendix D.

Level of Participation

There were 61 students in the lecture theatre when the survey was carried out and 58 students returned valid surveys. Of these 58 students who participated in the survey, 34 (59 per cent) students stated that they had taken part in the overall learning process in some form (see Figure 5.2).

Interestingly, students who expected to do very well in the assignment following this exercise were the ones who participated to the highest degree. Nearly everyone who stated the expectation of receiving a very high mark for his or her assignment (22 per cent) had participated. Of the students who expected medium or high marks (76 per cent) about 50 per cent had participated, and of the students who expected very low or low marks no-one had participated. The anonymous nature of the survey makes it difficult to verify students' expectations. Assuming students were able to judge their performances correctly, two not necessarily conflicting interpretations of these numbers seem possible: (a) students who receive higher grades are the ones who are willing to put extra effort into their studies; (b) students who had participated had gained from the exercise and were expecting higher grades.

Of the 34 students who had taken part in the overall learning process:

- 32 (94 per cent) had looked at the sample solutions without accessing lecturer's marking comments;

- 17 (50 per cent) had attempted to do some commenting themselves;

- 24 (71 per cent) had looked at sample solutions annotated by lecturer's marking comments.
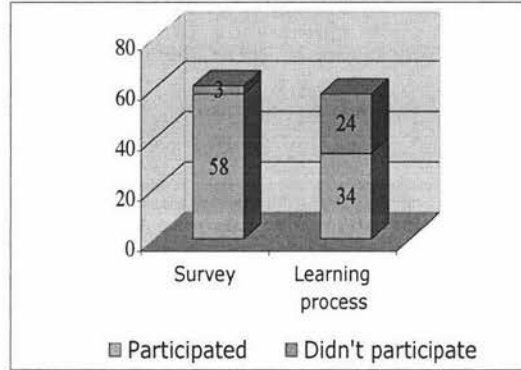

Figure 5.2 Participation level in the survey and learning process

The level of participation was encouraging, especially as the participation was completely voluntary and no rewards through credits towards passing the 2004 course were given. 42 per cent of the 24 students who filled out the survey but stated that they had not taken part in the exercise gave 'being too busy' as the reason for not doing so. Other reasons mentioned were being too lazy, not knowing about it or not receiving any course credit for it. Not surprisingly, less participation was evident for the more challenging and time-consuming task of commenting on the work of others.

Perception of contribution to learning and own abilities

Of the 34 students who looked at the sample solutions without accessing marker's comments, 35 per cent stated that they had learnt a lot from the exercise, 41 per cent stated that they had learnt something, and 24 per cent saw no or little learning effect (see Figure 5.3). Asked about the benefits of looking at the marking comments, 12 per cent felt they had learnt a lot, 52 per cent had learnt something, 30 per cent saw no or little benefit and 6 per cent did not respond (see Figure 5.4). More than half of the students (55 per cent) agreed that commenting on the work of others made them reflect on their own solution attempts. Obviously these data have to be treated cautiously as it is very difficult to judge one's learning progress and to attribute this

progress to a specific intervention. Still, it is very encouraging to see that a strong majority of the students felt that the exercise has benefited their learning.
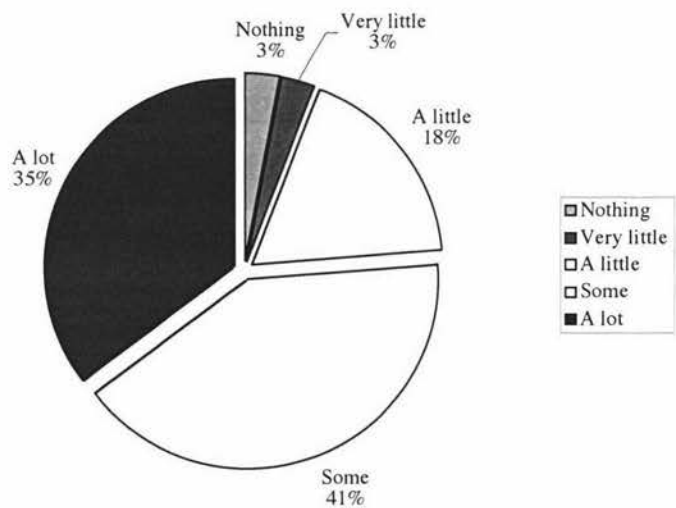

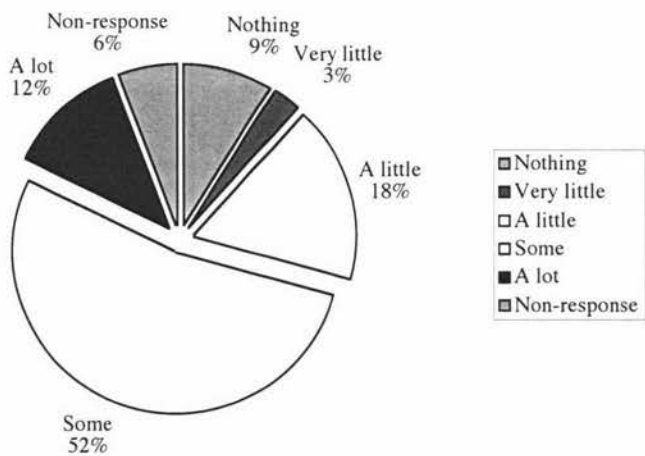**Figure 5.3 Effects of learning from sample solutions**

Figure 5.4 Effects of learning from formative feedback

Asked about their level of confidence (whether they have adequate knowledge) to comment on the work of others, 31 per cent of the students felt confident, 50 per cent were neutral and 19 per cent were not confident. These numbers allow a range of

interpretations and comments. Considering that the students were asked to comment on subject materials they had only just learnt and there had been no previous requirement to provide feedback (at least not in any computer science papers), the level of student confidence was fairly high. It can be speculated that this confidence was linked to the students' expectations of marks for their assignment. The students who felt comfortable offering comments would have expected high to very high marks. For the other students, mechanisms would have to be put into place to create a safe and comfortable environment. This might include discussing comments in a supportive atmosphere where they could learn how to provide feedback and are 'free' to make mistakes and see how to learn from these mistakes. Providing constructive feedback certainly is a higher level skill that needs to be developed over time.

Attitudes towards an interactive learning process involving marked student work

The questions in the survey regarding attitudes towards a more interactive learning process were directed to all students, regardless of whether they had participated in the exercise or not. The learning process in this exercise encouraged students to work on their own solutions for the task and to write comments on the work of others. Yet, the learning process did not provide students with a mechanism for submitting their solutions or comments to the class or to receive feedback on their work. One section of the survey asked students about their attitudes towards a more interactive learning process. Most students (81 per cent) would have liked to receive feedback on their own solution attempts. More than half of the students (57 per cent) would have like to receive feedback on their own marking attempts. These figures clearly indicate that the learning process towards more interactivity should be extended. There are two ways of doing this, both valuable. Firstly, the comments that current students write for the sample solutions from previous students could be made available for discussion. Secondly, the solution attempts of current students could be made available to the class for peer-feedback. The focus of the first approach is on learning 'how to comment' in a polite and constructive way, and the aim of the second approach is to provide feedback on the actual subject matter.

As an issue related to introducing a more interactive learning process, student attitudes towards anonymous participation were explored (see Figure 5.5). About half of the students (47 per cent) said they would feel confident to share their marking with others if this was anonymous. About one quarter (22 per cent) did not feel comfortable with the remainder being neutral. Asked if they would feel confident to share even if they could be identified resulted only in a slightly lower level of confidence (36 per cent), yet with consistent changes throughout all response categories. The idea of offering anonymity was to facilitate exchange between people who would not normally approach each other (the course is taught in face-to-face mode). While the data did not contradict this idea, there was no strong support for it either. Based on this and considering the positive effects that have been reported on creating trust by building online communities, one can expect that the learning processes around named participation should be designed.
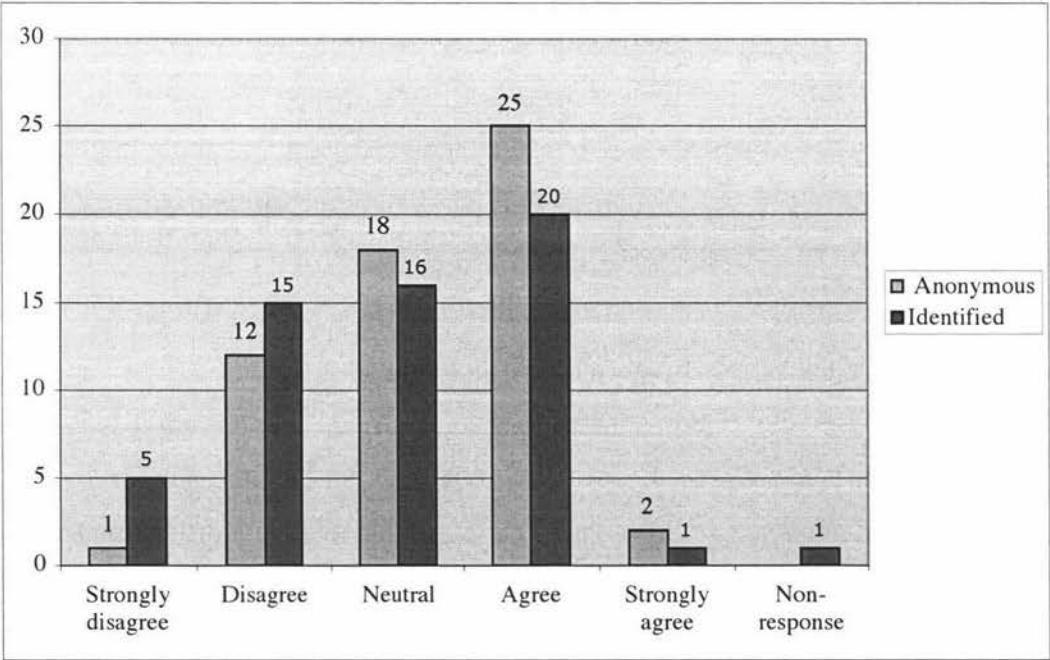

Figure 5.5 Student attitudes towards anonymous/identified participation

Summary of the Survey Results

To summarize the insights gained from the survey, the level of participation in the learning exercise and the perception of learning as reported by the students were encouraging. The data show clearly that students would like the opportunity to receive feedback on their own work. Based on these findings and supported by related educational theories it will be possible to devise very interesting interactive learning processes around samples of marked work.

However, one of the challenges lies in motivating the students to actively participate. While students have clearly stated that they would like to receive feedback on their work, what one can read from the data indicates caution should be exercised with regard to expectation around the extent of 'giving'. The data show that more students passively viewed than actively commented, that a large proportion did not feel confident to comment, and that quite a number of students did not have time or enough motivation to participate in the exercise at all.

5.4   Summary

To evaluate the effectiveness of learning from marked student work, an initial experiment was carried out with the students of a second year software engineering course (2004) at Massey University. The students were asked to performed tasks designed using examples of marked student work, by following a simple learning process. At the conclusion of the exercise a survey was conducted to obtain information related to the level of student participation, perceptions and attitudes. The survey results were an encouragement to continue the work with marked examples of student work and to proceed towards a more interactive learning process that facilitates peer-feedback and discussion.

In order to technically support learning from marked student work, an e-learning system that can fully support interactive learning processes around formative assessment is required. As shown in Chapters 3 and 4, current course management systems are not sufficient. While they support summative assessment and distribution of material from lecturer to students, they do not provide functionalities which fully

support learning from marked student work. What is envisaged is a web-based system that not only supports student learning but also guides teachers in the selection of learning resources and the designing of learning processes for students and then provides the technical assistance required to implement the processes. A prototype of such a system is presented in Chapter 6.

Chapter 6　Development of E-Repositories of Marked Student Work – a Prototype System

In Chapter 3, current software systems that support assessment and learning were investigated. It was found that there is no system that fully supports the approach of learning from marked student work. In Chapter 4, a framework of e-learning from marked student work was proposed. General software (e.g. document presentation system) and commenting tools are on the client side. A web-based learning system needs to be developed on the server side due to the limitations of current learning management systems in supporting the approach of learning from marked student work. The positive results from the initial learning experiment presented in Chapter 5 are also an encouragement to develop a web-based system which fully supports e-learning from marked student work.

This chapter presents a prototype system named *E-Repositories of Marked Student Work* that fulfils the major requirements identified in Chapter 4. The scope of this system is introduced in Section 6.1. The development technologies chosen and issues associated with implementing the system are discussed in Section 6.2. An informal evaluation with two example learning processes is presented in Section 6.3. The last section of this chapter is reserved for a summary.

6.1　The scope of the prototype system

The scope of the implemented system includes user roles and main functionalities.

6.1.1　User roles

The system is designed for the tertiary education environment since the activities of learning from marked student work suit adult learners who have already accumulated some learning experiences. The user roles in this system are tertiary teachers (teaching staff) and students in universities or other higher education institutions. Teachers play the role of a learning designer – setting learning processes for students and monitor student learning. Students are e-learners who learn by following the learning processes that have been designed by the teaching staff.

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6.1.2   Functionalities

Figure 6.1 shows the primary usecases in *E-Repository of Marked Student Work*. The "Log in" usecase which provides functionalities to ensure that only eligible users can access the system is shared by teacher and student roles. The other functionalities are designed for teaching staff and students separately.

Figure 6.1 Usecase diagram of *E-Repositories of Marked Student Work*

I. Functionalities to support teaching staff

Functionalities to support teaching staff include managing repositories, exercises and users.

Manage repositories

The learning resources including assignment problems, marking schemes, sample student solutions for the problems, and teachers' marking comments are stored in the initial repository. Teachers can set up and update the repositories. The functionalities available to them include adding, deleting and updating learning resources.

Manage exercises

By utilizing the learning resources stored in the repositories, teaching staff can set up and update exercises for students. Each exercise includes a task problem, a marking scheme and a learning process that are designed by the teacher. In the learning process, there may be several learning steps selected from the learning activities discussed in Chapter 4 (see Sections 4.1.3 and 4.1.4). Technical supports for the teaching staff to set up the attributes of the learning steps are also provided. Depending on the activities involved, the teacher distributes different learning resources to students in each step and can require students to submit their work.

Manage users

Teaching staff can manage user information. This includes issuing user access rights to the system and updating a user's records.

II. Functionalities to support students

Functionalities to support student learning include enabling students to do the exercise and view the learning record.

Do exercises

Student users can select and do the learning exercise by following the learning processes designed by the teacher. Students can upload their submissions to the system as required.

View learning record

Student users can view their learning records to review the learning activities involved and the work they have done.

Due to the time constraints placed on a master project it was impractical to implement a completed system in this research, so a prototype was developed. As the first version of a system which implements the approach of learning from marked student work, it concentrates on the main functionalities illustrated in Figure 6.1.

6.2   Prototype implementation

The technologies chosen to implement this prototype were the Java 2 Platform and Enterprise Edition (J2EE). One primary advantage of these technologies is that they support a component-based approach for software development. They are cost effective, and most importantly, platform-independent, i.e. they do not rely on any application programming interfaces (APIs) or products (Armstrong et al., 2004). The prototype system was implemented on a Macintosh computer (PowerBook G4) using JBuilder 2005 Developer. In this section the model that was adopted as the guideline to develop the prototype system and technologies and implementation issues relating to the prototype system are investigated.

6.2.1   Application model

A multi-tier distributed application model from J2EE platform (see Figure 6.2) provides a mechanism to develop web-based software (Armstrong et al., 2004). This mechanism also matches the client-server architecture designed for the e-learning environment (see Section 4.3). Generally this model is three-tier: a client machine, a J2EE sever machine and a database or legacy machine at the back (see Figure 6.2). The client-tier components run on the client machine, web-tier and business-tier components run on the J2EE server and the enterprise information system (EIS)-tier software run on the database server machine.

J2EE components are organized according to J2EE specification: Application Clients and Dynamic HTML Pages are on the client side; Java Servlet and Java Server Pages (JSPs) technology components which belong to web components, and Enterprise

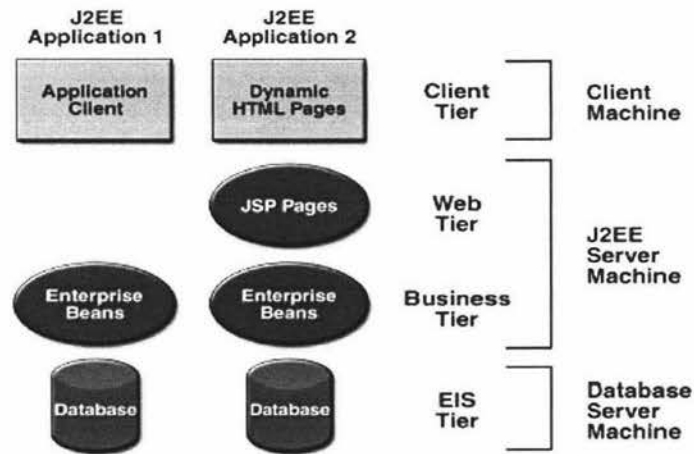JavaBeans (EJB) components which serve as business components are on the server side (Armstrong, et al. 2004).

Figure 6.2 J2EE multi-tier application model

The structure of *E-Repositories of Marked Student Work* (see Figure 6.3) is a server side application which has a simplified version of the above J2EE multi-tier application model. In this structure, JSPs have build-in support from Java Classes/Beans, so the data presentation and program implementation can be separated. Changes to the display of data (presentation) can be made without any modification to the Java Classes/Beans (implementation). Also, the underlying code can be updated or optimized without affecting the JSPs. The database server is connected to Java Beans via JDBC APIs. This component-based structure improves the reusability of system implementation.

Presentation   JSPs

Implementation   Java Class and   Server Side
                      Java Bean

Data support   Database
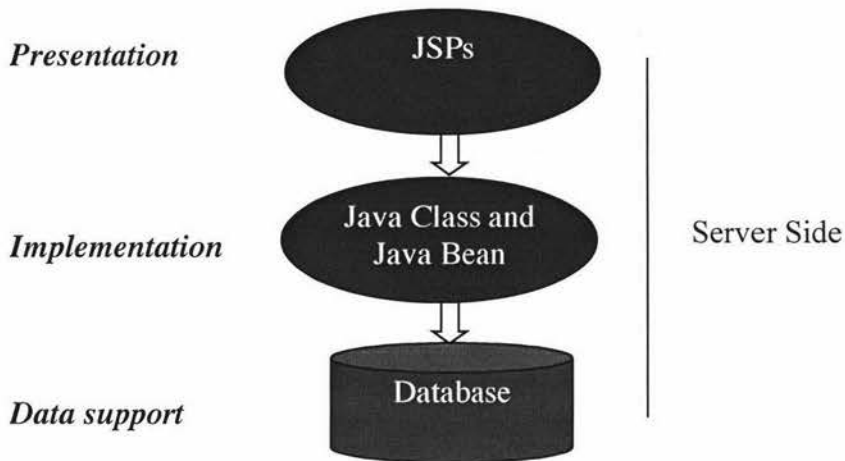
Figure 6.3 The structure of *E-Repositories of Marked Student Work*

6.2.2   Java Server Pages

JSPs serve as the server-side scripting language. It provides opportunities for software developers to create contents on the web tier easily. A JSP page contains traditional static HTML codes along with a set of HTML-like tags that interact with Java objects to determine the dynamic contents of the page (Fields & Kolb, 2000). Table 6.1 shows the main JSP pages developed in this prototype system and their functions.

JSP	Description
Login.jsp	Provides a login form to ensure that only eligible users can access the system.
Teacher_users.jsp	Displays the user list and options for the teaching staff to add new users, update current user information or delete selected users.
Teacher_newuser.jsp	Provides a form for the teaching staff to add a new user to the system.
Teacher_edituser.jsp	Provides a form for the teaching staff to edit a user's information.
Teacher_repositories.jsp	Displays the repository list and provides options to add a new repository, delete a repository or edit an existing repository.
Teacher_exercises.jsp	Displays the exercise list and provides options to add a new exercise, delete an exercise or edit an existing exercise.
Teacher_exercisedetails.jsp	Shows the details for a particular exercise.
Teacher_exerciseprocess.jsp	Helps the teaching staff to set up a learning process for an existing exercise.
Teacher_newexercise.jsp	Provides a form for the teaching staff to add a new exercise to the system.
Teacher_editexercise.jsp	Provides a form for the teaching staff to update information for an exercise.
Student_exercises.jsp	Displays the list of exercises currently available to the students who can select an exercise or view their learning records.
Student_exercisedetails.jsp	Shows the details of an exercise including the suggested steps in the learning process.
Student_upload.jsp	Provides a form for browsing and uploading files
Student_record.jsp	Provides the record of student submissions.
Header.jsp	Displays the title of this system with an image which is shared by the above JSPs.
Footer.jsp	Displays the copyright information which is shared by the above JSPs (except Header.jsp).

Table 6.1 Main JSPs in *E-Repositories of Marked Student Work*

6.2.3   Java Class and Java Bean

As shown in the structure of *E-Repositories of Marked Student Work* (Figure 6.3), Java Class and Java Bean are used to implement the logic tier on the server side. A Java Bean is basically a Java class that contains some fields and methods, and it can be used alone or with other Beans. Table 6.2 shows the Java Classes and Java Beans used in the prototype system.

Java Class/Bean	Description
Connector.java	Creates a connection for the Java Beans to access and update the database.
UserBean.java	Connects to the user table in the database and provides functions to display the user list, check user information for logging in, add a new user, delete a user, and update user information.
TaskBean.java	Connects to the task table and sample table in the database and provides functions to display the task list, add a new task, delete a task, and update task information.
ExerciseBean.java	Connects to the exercise table, task table in the database and provides functions to display the exercise list, add a new exercise, delete an exercise, and update exercise information.
StepBean.java	Connects to the step table, exercise table, task table, user table and sample table in the database, and provides functions to display the learning process for an exercise, update or delete a step in a learning process; Facilitates setting up a learning process for a new exercise.
SampleBean.java	Connects to the sample table in the database and provides functions to display the sample list with a teacher's comments for each sample, add a new sample, delete a sample, and update sample solution information.
UploadBean.Java	Provides functions for students to upload their submissions to the server, connects to the submission table in the database, and adds uploaded files to the submission table.

Table 6.2 Java Class/Beans in *E-Repositories of Marked Student Work*

6.2.4 Java Database Connectivity Application Programming Interface

Java Database Connectivity Application Programming Interface (JDBC API), developed by Sun Microsystems, includes a set of classes and interfaces that support database access functionalities. Classes that form the JDBC API are in java.sql and javax.sql packages (Reese, Yarger & King, 2002). Table 6.3 shows the classes/interfaces that have been used in implementing this system.

Class/Interface	Function
Connection	Represents a connection to a specific database.
Driver	Creates the connection and returns information about the driver version.
PreparedStatement	Runs compiled SQL statements.
ResultSet	Provides access to a table of data that is generated by running a SQL query.
Statement	Runs SQL statements and obtains the results.

Table 6.3 JDBC classes and interfaces used in the prototype system

JDBC architecture (see Figure 6.4) shows the relative location of Java Applications, JDBC API, JDBC Driver Manager, JDBC Drivers, and SQL Server (database systems). Java Applications contain Java Servlets, applets and Java classes, and manipulate the database via JDBC API, JDBC Driver Manager and JDBC Driver. The JDBC API uses a JDBC Driver Manager to support a JDBC Driver which is linked to a database.

Figure 6.5 shows the 5-step process used to assess and manipulate the database using JDBC API (Callaway, 2001). First a JDBC Driver registers with the Driver Manager, and then a database connection is established. After an SQL statement is executed, the result is processed. Finally the database connection is closed.

```
┌─────────────────────────────┐
│      Java Applications       │
└─────────────────────────────┘
               │
┌─────────────────────────────┐
│          JDBC API            │
└─────────────────────────────┘
               │
┌─────────────────────────────┐
│      JDBC Driver Manger      │
└─────────────────────────────┘
               │
┌─────────────────────────────┐
│         JDBC Driver          │
└─────────────────────────────┘
               │
          ╭─────────╮
          │ SQL Server │
          ╰─────────╯
```
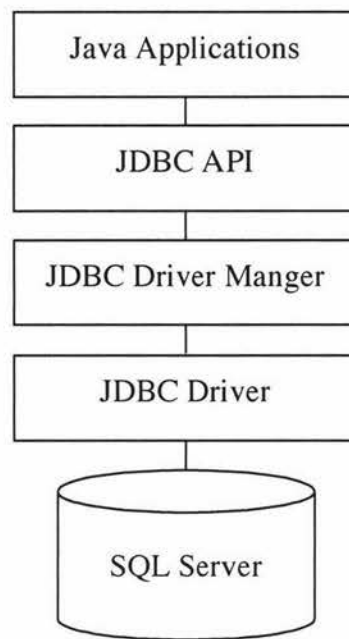
Figure 6.4 JDBC architecture

```
┌─────────────────────────────────────────────────┐
│  Register the JDBC Driver with the Driver Manger  │
└─────────────────────────────────────────────────┘
                         │
                         ▼
┌─────────────────────────────────────────────────┐
│            Establish a database connection        │
└─────────────────────────────────────────────────┘
                         │
                         ▼
┌─────────────────────────────────────────────────┐
│              Execute a SQL statement              │
└─────────────────────────────────────────────────┘
                         │
                         ▼
┌─────────────────────────────────────────────────┐
│                 Process the result                │
└─────────────────────────────────────────────────┘
                         │
                         ▼
┌─────────────────────────────────────────────────┐
│             Close the database connection         │
└─────────────────────────────────────────────────┘
```
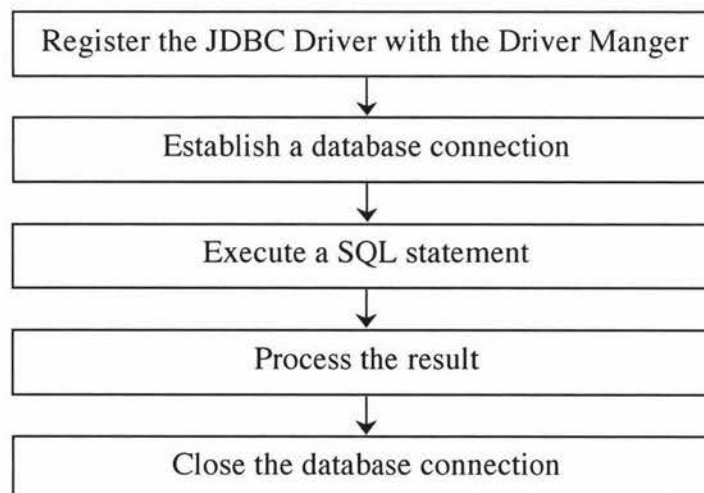
Figure 6.5 Using JDBC to assess databases

6.2.5   MySQL database server

MySQL was chosen as the database server in this system. It is cost-effective, reliable and high-performance, and one of the most popular database servers (Reese, Yarger

& King, 2002). Compared with other database systems, MySQL database server has the following advantages (Matthews, Cole & Gradecki, 2003):

- Portability: MySQL runs on almost any operating system.

- Speed: MySQL is faster than almost any other database system when executing queries.

- Scalability: MySQL can run on different sized systems and efficiently utilize data for multiple users.

- Flexibility: MySQL provides different table types to suit users' requirements.

- Ease of use: MySQL is easy to install and administer.

- Fine-grained security model: MySQL provides access rights at different levels to users to prevent unauthorized updating or retrieving of data from the database.

The information stored in the database comprises: the learning resources, exercise information, learning processes for each exercise, student submissions and user information. Table 6.4 shows the details of the database tables.

Table	Data field
users	`Id` int(6) unsigned NOT NULL auto_increment `UserId` varchar(20); `LastName` varchar(50) `FirstName` varchar(50); `pseudonym` varchar(50) `Password` varchar(50) default NULL `Role` char(1) NOT NULL default 's' PRIMARY KEY (`Id`)
tasks	`Id` int(6) unsigned NOT NULL auto_increment `Title` varchar(40) NOT NULL default '' `Topic` varchar(40) NOT NULL default '' `Year` varchar(4) NOT NULL default '' `TaskFile` varchar(90) default NULL `SchemeFile` varchar(90) NOT NULL default '' `HasSample` varchar(1) NOT NULL default 'y' PRIMARY KEY (`Id`)
samples	`Id` int(6) unsigned NOT NULL auto_increment `TaskId` int(6); `SampleFile` varchar(40) NOT NULL default '' `Marker` varchar(20) default NULL `MarkingFile` varchar(40) NOT NULL default '' PRIMARY KEY (`Id`)
exercises	`Id` int(6) unsigned NOT NULL auto_increment `ExTitle` varchar(30) NOT NULL default '' `TaskId` int(6) NOT NULL default '0' `Steps` int(1) NOT NULL default '0' `Available` varchar(1) NOT NULL default 'y' PRIMARY KEY (`Id`)
steps	`Id` int(6) unsigned NOT NULL auto_increment `ExId` int(6) NOT NULL `StepIndex` tinyint(4) NOT NULL default '0' `Activity` varchar(30) default NULL `Start` varchar(12) default NULL `Due` varchar(12) default NULL `instruction` longtext `AssignWork` varchar(3) NOT NULL default '0' `Submit` varchar(1) NOT NULL default 'n' `Assigned` varchar(1) NOT NULL default 'n' PRIMARY KEY (`Id`)
submissions	`Id` int(6) unsigned NOT NULL auto_increment `UserId` varchar(20) NOT NULL default '' `ExeId` int(6) NOT NULL default '0' `Act` varchar(40) default NULL `RelateId` int(6) NOT NULL default '0' `SubmissionFile` varchar(40) default NULL PRIMARY KEY (`Id`)

Table 6.4 Tables on the MySQL server

6.3 System evaluation

The system supports the functionalities identified in Section 6.1.2 for teaching staff and students. The three objectives of implementing this e-repository of marked student work were identified in Section 4.1.2 as follows:

- establishing electronic repositories of marked student work,

- helping teaching staff to design learning processes and monitor student learning, and

- supporting student learning from marked student work.

These objectives are also taken as guidelines to evaluate this prototype system. An informal evaluation which was carried out with two learning exercises has been conducted. The full set of screen shots are presented in Appendix E.

6.3.1 Learning exercises

Two learning exercises that include advanced learning activities such as self- and peer-assessment and peer-discussion have been implemented using this system. These learning exercises are based on example learning processes 2 and 3 designed in Chapter 4 (see Section 4.1.5 for details). It has been pointed out in Chapter 3 (see Section 3.6) that these learning processes cannot be fully supported by the current course management systems and assessment systems.

Learning Exercise 1

A 5-step learning process is designed for this exercise (see Section 4.1.5, example learning process 2). The activities are show in Table 6.5. To complete this exercise, first the students download the task problem and solve the problem using general software (Step 1). Students are required to choose at least one of the sample solutions to mark (using MarkTool) and submit the marking feedback (in xml format) (Step 2). The sample solutions together with marker's feedback of previous year are made available to students after they have submitted their solutions so that the students can view the marker's feedback (Step 3) and add their comments for discussion (Step 4).

The last step is to discuss the marking scheme and submit any comments. In this exercise each step is a prerequisite of its following step.

Step	Activity	Start date	Due date	Submission required?
1	Solve a problem	2006-11-11	2006-11-14	Yes
2	Mark the sample solutions	2006-11-15	2006-11-17	Yes
3	View marker's feedback for the sample solutions	2006-11-18	2006-11-20	No
4	Self-assessment	2006-11-21	2006-11-23	Yes
5	Discuss the marking scheme	2006-11-24	2006-11-26	Yes

Table 6.5 The learning process for Data Modelling Exercise 1

Learning Exercise 2

In Exercise 2, a 4-step learning process is adopted (see Section 4.1.5, sample learning process 3). The activities involved in this learning exercise are shown in Table 6.6. The sequence of these activities is as follows: 1) Students download and solve the task problem. 2) Students submit their solutions and view the sample solutions with marker's feedback of the previous year. 3) Students are required to mark at least one of their peers' submissions from step 1. 4) Students discuss the peer marking feedback and submit their comments.

Step	Activity	Start date	Due date	Submission required?
1	Solve a problem	2006-12-12	2006-12-13	Yes
2	View marker's feedback for the sample solutions	2006-12-14	2006-12-15	No
3	Peer-assessment	2006-12-17	2006-12-19	Yes
4	Discuss peers' marking	2006-12-20	2006-12-21	Yes

Table 6.6 The learning process for Data Modelling Exercise 2

6.3.2 Establishing electronoic repositories of marked student work

The first learning repository was set up using learning resources provided by Eva Heinrich, a lecturer in computer science at Massey University. The task set for the 2003 data modelling assignment, the marking scheme for this task, ten examples of student work (with consents given by the authors for their use) and feedback for the example solutions were included in this repository. The details of the first repository are shown in Figure 6.6. More repositories can be constructed in a similar way and the system provides functionality to mange these repositories (see Figure 6.7).
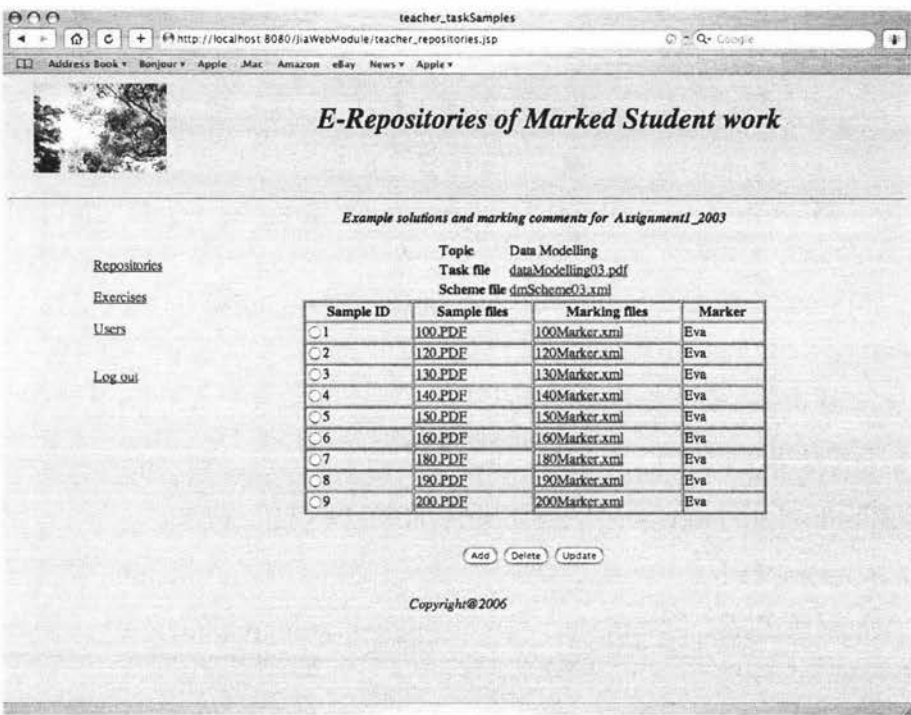
Figure 6.6 Sample files and marking files in the first repository
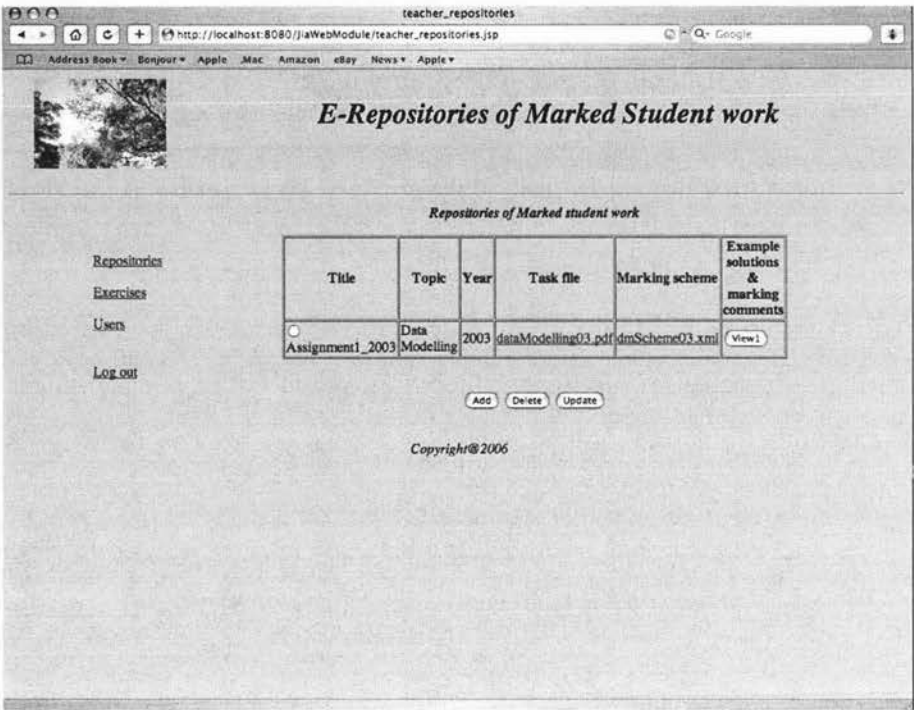
Figure 6.7 Management page for the repositories

6.3.3 Helping teaching staff to design learning processes and monitor student learning

Functionalities available to the teaching staff include managing repositories, exercises and users. The system will guide the teaching staff through the designing of the learning process. When a member of the teaching staff logs into the system, an exercise list page that displays existing exercises is shown. The teaching staff member can choose to modify the existing exercises and/or add a new exercise. The procedure for adding a new exercise is discussed as follows. Firstly, the teaching staff member needs to fill the form related to adding a new exercise (see Figure 6.8). The information that needs to be provided includes the title for the exercise, the task (selected from the repository), the number of steps in the learning process, and the availability of the exercise. Secondly, the teaching staff member sets up the learning process for the new learning exercise. For each step in the learning process, the teaching staff can choose a suitable activity from a drop-down list (see Section 4.1.3 for available learning activities). The start date and due date can be picked up from the calendar page. The detailed instruction for each step needs to be entered. The

number of samples from the repository that will be released to students and submission requirements need to be selected. Finally, the system will randomly distribute the samples to students and set up the uploading facility accordingly.

Figure 6.8 Adding a new exercise

Figure 6.9 shows the screen for setting up the first step for Learning Exercise 1. The chosen activity for this first step is *Solve a problem* which belongs to the activity of "Do task". Setting up the other steps will involve a similar procedure although the attributes of each step are different and the screen-shots will be similar to Figure 6.8. Other learning activities implemented in the system that can be chosen for setting up the learning steps for various learning processes include "viewing sample solutions", "viewing sample solutions with feedback", "marking sample solutions", "self-assessment", "peer-assessment", "commenting on peers' marking" etc (see Section 4.1.3 for a more detailed list). After setting up the learning process for the new exercise, the teaching staff can view the whole process including the details for each step (see Figure 6.10).
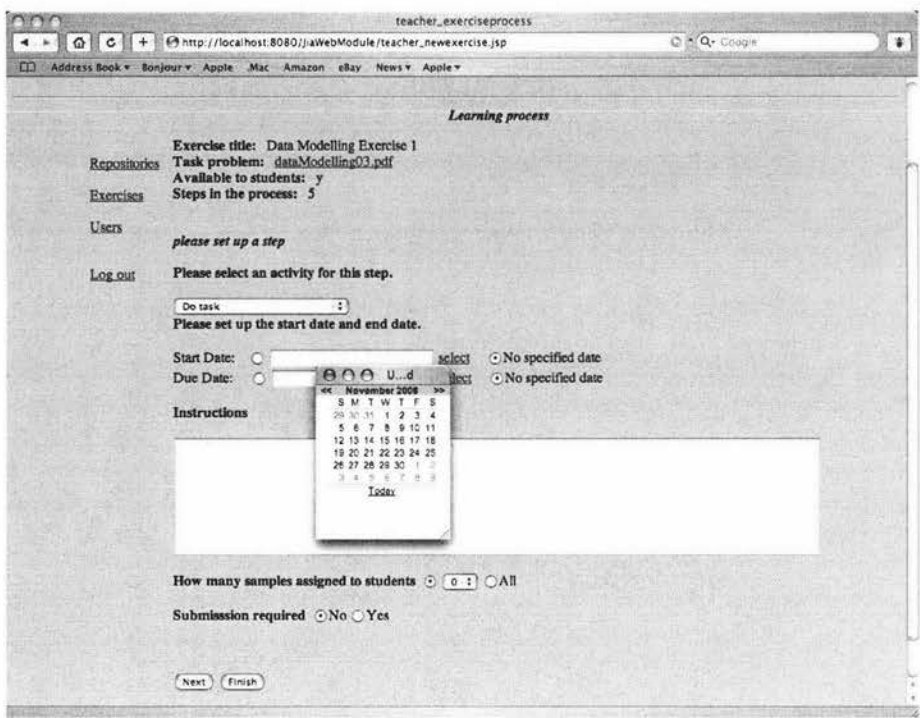
Figure 6.9 Setting up a new step page
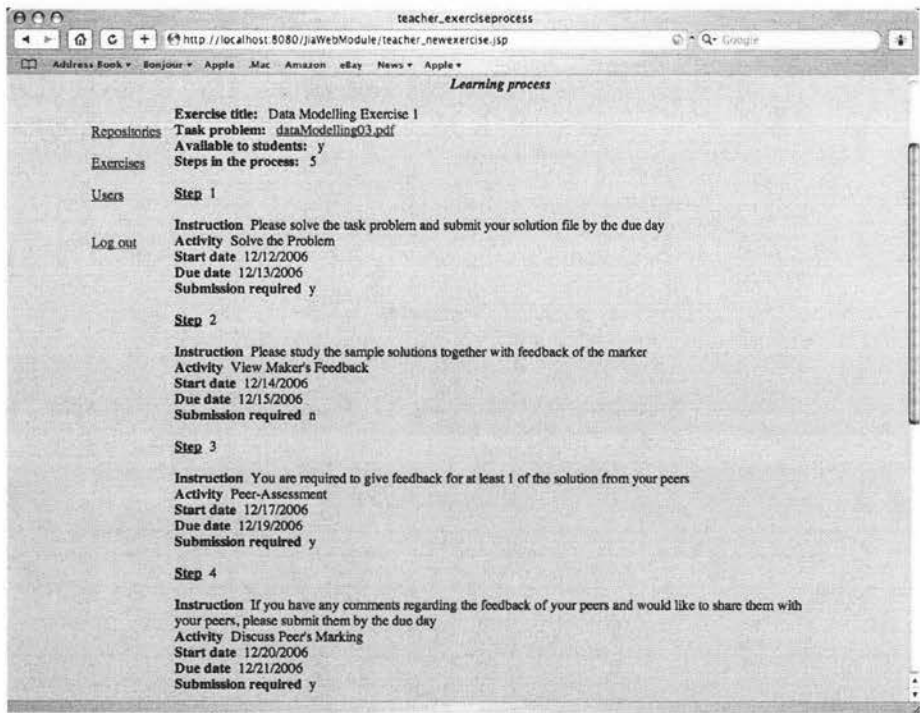
Figure 6.10 Displaying the learning process for Data Modelling Exercise 1 for
the teaching staff

6.3.4   Supporting student learning from marked student work

The system helps students to do the exercise and view the learning record. When a student logs into the system, a list of available exercises is presented and the student can select and start the exercise. Figure 6.11 shows the screen shot for Step 3 (from 11/18/2006 to 11/20/2006, the date is given in the format of month/day/year) of Learning Exercise 1. The learning activity for this step is "viewing marker's feedback". The sample solutions from the students of previous years together with the marker's feedback are made available to the student from 11/18/2006. The screen shots that show the other learning steps in the two learning exercises are presented in Appendix E.

The learning resources required for an activity will be available when the corresponding learning step starts. For example, for a learning activity requiring student submission, the submission facility will be visible to the students. Students can select and upload files to the system and view their submission record at any time.
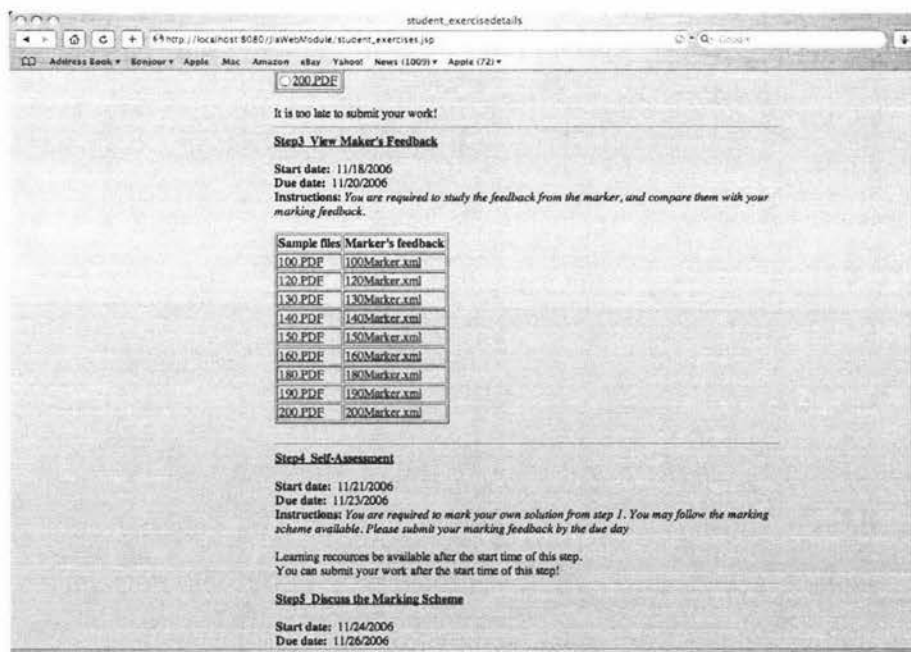
Figure 6.11 "Allan" (a dummy student) viewing the learning process during Step 3 of Learning Exercise 1

6.3.5   Other management functionalities

The repositories of marked student work can be established and managed as shown in Section 6.3.2. The other management functionalities provided by the system include:

- Logging into the system: To ensure that only authorized users can access this system a login facility is provided.

- Managing users: Functions such as adding, deleting and updating user information are provided. Figure 6.12 shows the form for adding a new user to the system. Figure 6.13 shows the user management page with a list of users. One dummy teacher and eleven dummy students were used in the system.

Figure 6.12 The page for adding a new user
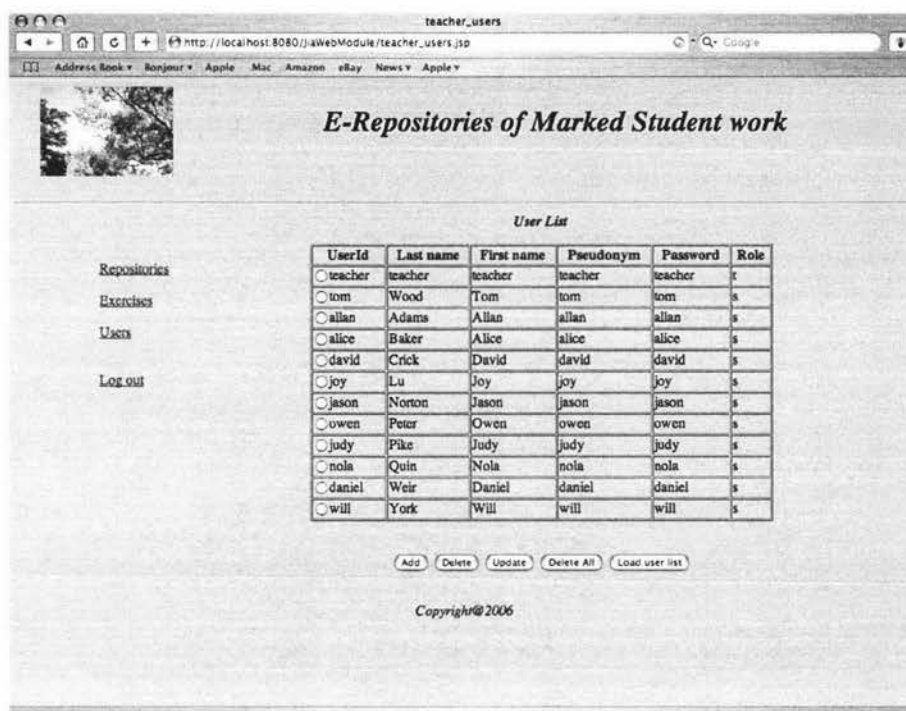
Figure 6.13 The page for managing users

6.4 Summary

In this chapter, the development of a prototype system named *E-Repositories of Marked Student Work*, which supports e-learning from marked student work, has been presented.   The scope of this system including user roles and main functionalities was described. The main technologies involved in developing this system were discussed and how these technologies were implemented was introduced.

The first learning repository was set up and two learning exercises were implemented into the system. An informal evaluation of the system was carried out in order to reveal the extent to which the objectives of implementing this prototype were achieved. These objectives included setting up electronic repositories of marked student work, helping teaching staff to design learning processes and monitor student learning, and supporting student learning from marked student work. The evaluation showed that the system was successfully.

Chapter 7 Conclusions and Future Work

In this chapter the thesis is concluded and future work that can extend this research is outlined.

7.1 Project review

The research goals of this project were:

- To investigate how to integrate repositories of marked student work into student learning in an e-learning context;

- To evaluate the effectiveness of learning from marked student work;

- To conceptualize, design and implement a prototype of a web-based system to support learning from marked student work.

A literature review was first carried out. The educational theories on assessment and learning were reviewed. Special attention was paid to the contributions of formative assessment in learner-centred theories of teaching and learning. Existing computer systems used in assessment practice and e-learning were reviewed. This review provided the essential theoretical foundation for the new learning approach of e-learning from marked student work.

The opportunities in e-learning from marked student work were developed. The important components in this learning approach including learning resources, learning activities and issues of designing the learning processes were investigated. The conceptualization of an e-learning environment was developed. The technical requirements were analyzed, and a general framework of e-learning from marked student work was proposed.

To confirm the effectiveness of this new e-learning approach, a learning experiment was conducted. In this experiment, the students followed a designed learning process utilizing marked student assignments. An anonymous survey was conducted at the end of the experiment in order to reveal students' attitudes and perceptions on this learning approach.

A prototype system named *E-Repositories of Marked Student Work* was implemented. It covers the major requirements of such a system.

7.2 Contributions

The contributions made in this research project can be summarized as follows.

1. The development of a concept of e-learning from marked student work

An innovative learning approach, which integrates formative assessment and an e-learning environment by working with marked student work, was investigated. In this context learning activities such as performing a task, analyzing marked example solutions, providing feedback, self-assessment, peer-assessment, creating a marking scheme, and setting a new task were analysed. A range of factors that need to be considered in constructing learning processes based on the above learning activities were discussed. The learning activities vary in a large degree according to their cognitive complexity and learning effectiveness and have different characteristics that can be associated with various learning styles. Teaching staff need to fulfil a variety of roles to support these learning activities and an appropriate technical environment needs to be put in place to achieve effective teaching and learning. This investigation has developed the opportunities presented by reusing marked assignments as the valuable learning resources in teaching practice.

2. The conceptualization of an e-learning environment

The conceptualization of an e-learning environment to support learning from marked student work has been developed. The actions for both teaching staff members and students in the preparation phase and teaching-learning phase have been identified. Three major objectives of developing such an e-learning environment were highlighted: establishing electronic repositories of marked student work, helping teaching staff to design learning processes and monitor student learning, and supporting student learning from marked student work.

Based on these objectives a general framework of e-learning from marked student work were proposed. The requirements on the software for the client side and server

side were analysed. On the client side, the Marking Tool can be used by teaching staff (to assess students' work) and students (to add text comment). On the server side a web-based learning system is required. It was found that a new web-based learning system is needed since the currently available course management and assessment systems have limitations in supporting e-learning from marked student work.

3. The experiment using e-learning from marked student work

To evaluate the effectiveness of this new learning approach, an initial learning experiment involving the second year students at Massey University was conducted. This experiment was based around samples of marked student work and involved a four-step learning process. At the conclusion of the learning process a survey aiming at obtaining information on the level of student participation, perceptions and attitudes was conducted. The survey results showed that the level of participation in the learning exercise and the perception of learning were encouraging. These positive results were encouragement to continue the work with marked examples of student work and to proceed towards a more interactive learning process that facilitates peer-feedback and discussion.

4. A prototype of a web-based learning system

A prototype system, *E-Repositories of Marked Student Work* – which is a web-based system supporting e-learning from marked student work has been developed using Java 2 Platform and Enterprise Edition (J2EE) technologies. The structure of the prototype system is a server side application, which has a simplified version of a J2EE multi-tier application model. JavaServer Pages, Java Classes/Beans, JDBC API were used to implement this system. MySQL database server stores the learning resources and student records, and provides data support for this web-based learning system. This prototype system was informally evaluated by setting up the first learning repository and implementing two learning exercises.

7.3   Future work

This project can be further developed in the following three directions.

1. At the conceptual level: to develop a multi-dimensional framework for e-learning
    from marked student work

This framework of e-learning from marked student work can be used to provide
teaching staff detailed guidelines in designing learning process and setting exercises
for students. The dimensions of this framework could be set around factors in
designing the learning processes that have been identified in this thesis such as
cognitive complexity, learning effectiveness, learner characteristics and the role of
teaching staff. Other issues around student skill levels, commitment and motivation
are worth further investigations as well.

Heinrich (2005) has investigated the issues around exploring the use of the IMS
learning design specification for facilitating formative assessment. It is possible to
adopt this specification to describe the learning processes of learning from marked
student work formally and to integrate them into the framework developed in this
project. This will greatly improve the reusability of this learning approach.

2. At the technical level: to fully implement and evaluate the web-base learning
    system

In this thesis a prototype of web-base learning system, *E-Repositories of Marked
Student Work*, has been developed. The framework for such a system has been built
and some important aspects in constructing this system have been explored.
However, under the time constrains of a master thesis it is impossible to fully
develop the whole system. So, fully implementing and formally evaluating the
system requires further work.

3. At practical educational level: to conduct further learning experiments which
    involve more interactive learning activities

The positive survey result from the simple learning exercise presented in this research project provide encouragement to conduct further learning experiments to investigate the effectiveness of this e-learning approach in which more interactive learning processes that facilitate peer-feedback and discussion are involved.

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Appendix A Information sheet for the survey

Learning Repository and MarkTool Survey

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This evaluation has been reviewed, judged to be low risk, and approved by the Massey University Human Ethics Committee. If you have any concern about the conduct of this research, please contact Professor Sylvia V Rumball, Chair, Massey University Campus Human Ethics Committee: Palmerston North, telephone 06 350 5249,
email humanethicspn@massey.ac.nz.

Completion and return of the questionnaire implies consent. You have the right to decline to answer any particular question.

Appendix B The task for the learning experiment

Data Modelling Task Exercise for 159.254, 2004
(Based on Assignment1 2003)

You are planning to setup a business called 'Snippets' to provide a service to movie fans. The movie fans will be able to search your movie archives and download specific scenes of movies. (You have sorted out the licensing requirements to provide this service legally.)

You plan to provide the movies in various formats (like mpeg1, mpeg2) to cater for different download speeds.

To allow your customers a range of search possibilities you plan to store information like
- Movie title, year, producer, genre, classification, …;
- Actors involved, which role/character they play in the movie, …;
- Which awards the movie or the actors involved in the movie received.

To support downloading of specific scenes you will need to store information like the type of scene ('car chase', 'romance', …), who was involved (which characters in the movie and which actors), and the start and end times of the scene.

Tasks (as given in 2003)
Produce the following diagrams/documents:
1. The final entity relationship diagram showing all entities, relationships and cardinalities (you don't need to show the attributes in your diagram if you don't have a drawing program);
2. List of entities with their attributes and definitions (data type and size, domain, null support) and keys (primary keys, foreign keys, alternate keys).

Make sure that your data model conforms to third normal form.

Notes
- The requirements stated above might not be complete. If necessary make assumptions and state these clearly.
- Ensure that all the information provided is taken into account.
- Use a word processor or drawing package to produce the diagrams. You can draw the diagrams per hand but please ensure everything is tidy and easily readable. You can use a CASE tool to draw the diagrams if you have access to one.

Comment 2004
You are welcome to use a tool like Visio to create the data model that displays entities and attributes together.

Appendix C Survey

Learning Repository and MarkTool Survey

Please take 5 to 10 minutes to complete the following survey.

General

Please put a √ in the box of your choice

1. What mark do you expect to get from Assignment1 (developing data model for the RPS system) in 159.254?

Very low	Low	Medium	High	Very high
☐	☐	☐	☐	☐

2. Have you tried the Data Modelling exercise?

Yes	No
☐	☐

    If **no,** why?
    Please comment and go to question 9.

3. Have you attempted the data modelling task (assignment from last year) yourself?

Yes	No
☐	☐

4. How many sample solutions have you viewed?

0	1-2	3-5	6-8	All 9
☐	☐	☐	☐	☐

5. How many sample solutions have you marked?

0	1-2	3-5	6-8	All 9
☐	☐	☐	☐	☐

6. How many sample solutions have you viewed together with marker's comments?

0	1-2	3-5	6-8	All 9
☐	☐	☐	☐	☐

7. How long did you spend on average on marking each sample solution? (in minutes)

5-10	10-20	20-30	30-40	More than 40
☐	☐	☐	☐	☐

8. How many comments did you add on average to a sample solution?

0	1-5	5-10	10-20	More than 20
☐	☐	☐	☐	☐

Learning effect

Please put a √ in the box of your choice	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
9. I prefer to look at a range of weak to excellent sample solutions.	☐	☐	☐	☐	☐
10. I think I have adequate knowledge to comment on the sample solutions.	☐	☐	☐	☐	☐
11. I would like to receive feedback on my own solution attempts.	☐	☐	☐	☐	☐
12. I would like to receive feedback on my own marking attempts.	☐	☐	☐	☐	☐
13. When I comment on the sample solutions I think more about my own solution attempt.	☐	☐	☐	☐	☐
14. I would feel confident to share my own marking with others, if this would be anonymous.	☐	☐	☐	☐	☐
15. I would feel confident to share my own marking with others, even if I could be identified.	☐	☐	☐	☐	☐

Please put a √ in the box of your choice	Nothing	Very little	A little	Some	A lot
16. How much did you learn from looking at sample solutions?	☐	☐	☐	☐	☐
17. How much did you learn from looking at marking comments on the sample solutions?	☐	☐	☐	☐	☐

MarkTool

Please put a √ in the box of your choice	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
18. Working with MarkTool was easy.	☐	☐	☐	☐	☐
19. Learning how to operate MarkTool was easy.	☐	☐	☐	☐	☐

20. Have you tried to install MarkTool on your own computer.
       ☐ Yes   ☐ No
              If **Yes,** were there any problems installing it?
              (please add your comments)
                    ☐ Yes   ☐ No

Please comment:

21. How could MarkTool be modified to make it easier to use?

22. What features do you suggest adding to MarkTool to further support learning?

23. Under which conditions do you think learning from marked sample can be an effective learning strategy?

Appendix D Survey Results

<u>Learning Repository and MarkTool Survey Results</u>

This survey was conducted on Monday, 6 September 2004. There were 61 students (3 females) in the lecture theatre. 58 of them handed the survey back.

General

	Very low	Low	Medium	High	Very high	Non-response
1. What mark do you expect to get from Assignment1 (developing data model for the RPS system) in 159.254?		1	24	20	13	

2. Have you tried the Data Modelling exercise? If **no,** why? Please comment and go to question 9.	**Yes** 34 **No** 24 **Reasons for not doing it:** • Too busy (10) • Too lazy (3) • Have not heard about it (4) • Only want do something directly contribute to final marks (2) **No response (5)**

3. Have you attempted the data- modelling task (assignment from last year) yourself?	Yes 18 No 16

	0	1-2	3-5	6-8	All 9	Non-response
4. How many sample solutions have you viewed?	2	15	11	3	3	
5. How many sample solutions have you marked?	17	8	9			
6. How many sample solutions have you viewed together with marker's comments?	10	14	10			

	5-10	10-20	20-30	30-40	More than 40	Non-response
7. How long did you spend on average on marking each sample solution? (in minutes)	14	7	9			4

	0	1-5	5-10	10-20	More than 20	Non-response
8. How many comments did you add on average to a sample solution?	15	14	1	1	1	2

Learning effect

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Non-response
9. I prefer to look at a range of weak to excellent sample solutions.	2	5	4	11	1	1
	1		6	23	4	
10. I think I have adequate knowledge to comment on the sample solutions.	1	5	7	11		
		5	22	5	2	
11. I would like to receive feedback on my own solution attempts.		1	6	14	3	
			4	19	11	
12. I would like to receive feedback on my own marking attempts.	1		12	7	2	2
		2	8	16	8	
13. When I comment on the sample solutions I think more about my own solution attempt.	1		10	7	1	5
		3	7	19	5	
14. I would feel confident to share my own marking with others, if this would be anonymous.	0	7	11	6		
	1	5	7	19	2	
15. I would feel confident to share my own marking with others, even if I could be identified.	3	6	6	8		1
	2	9	10	12	1	

* The shaded (un-shaded) data are for students who did (didn't do) the data modelling exercise.

	Nothing	Very little	A little	Some	A lot	Non-response
16. How much did you learn from looking at sample solutions?	1	1	6	14	12	
17. How much did you learn from looking at marking comments on the sample solutions?	3	1	6	18	4	2

MarkTool

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Non-response
18. Working with MarkTool was easy.	2	2	10	15	3	2
19. Learning how to operate MarkTool was easy.	1	1	11	15	4	2

---

20. Have you tried to install MarkTool on your own computer?
     Yes 17   **No** 14   **Non-response** 3
               If **Yes,** were there any problems installing it?
               (please add your comments)
                    Yes 3   **No** 14

Comments
          a.   Can not use it at my PC and Labs
          b.   Can not see anything including sample solution and comments from
               Marktool on my own computer

---

21. How could MarkTool be modified to make it easier to use?

     a.   Have more help
     c.   Better graphics/art design
     d.   Have simple comments for each part of marking
     e.   Provide more marked samples
     f.   Give more indication at each step
     g.   Why I have to put any titles in the same folder?
     h.   It is quite easy
     i.   Make it easy and clear

22. What features do you suggest adding to MarkTool to further support learning?

     a.   More examples on how to use it
     b.   General Q & A
     c.   Make it easy to use and suitable in all PC platforms

23. Under which conditions do you think learning from marked example can be an effective learning strategy?

    a. If you try it first, understand why they got marked down and then apply it to yourself.

    b. Some type of questions and answers for us to follow

    c. Doing assignments

    d. If the marked example could only be made available to the student if they can prove they have made an honest attempt at the question.

    e. Lab supervision and online support

    f. Learning about O-O programming techniques

Appendix E Screen Shots from the Prototype System

Learning exercise 1

<u>Helping teaching staff to design learning processes</u>

Figure 1 shows the exercise list page which is displayed after the teaching staff member has logged into the system. It displays the list of exercises which have already been added.
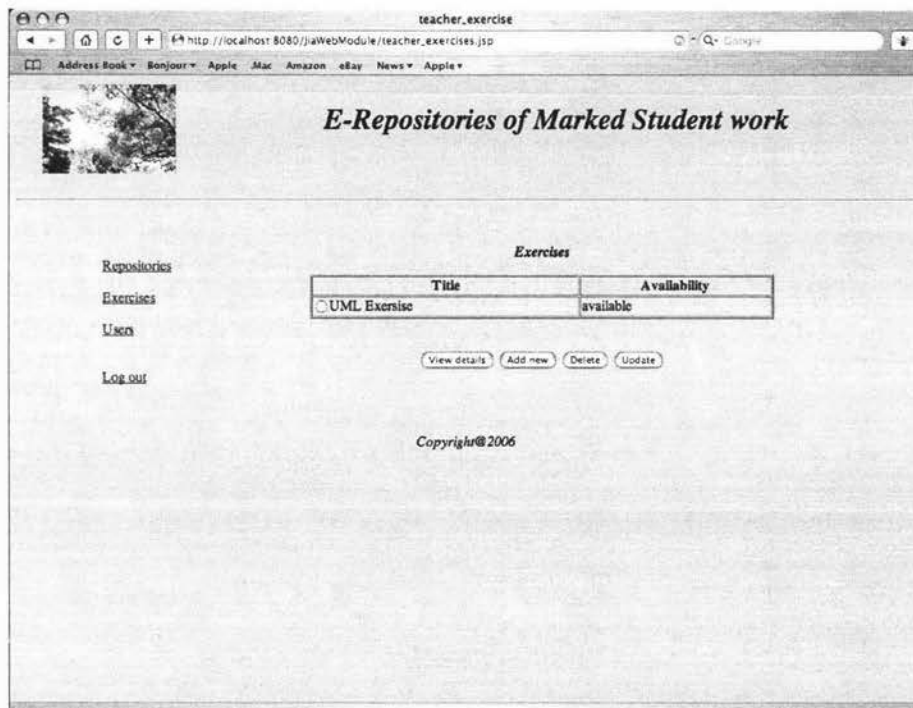
Figure 1 Exercise list page

Figure 2 shows the form for adding a new exercise. The title for the exercise needs to be entered and the assignment task that is associated with needs to be selected. The number of steps in the learning process needs to be selected and the availability of this exercise needs to be set up.
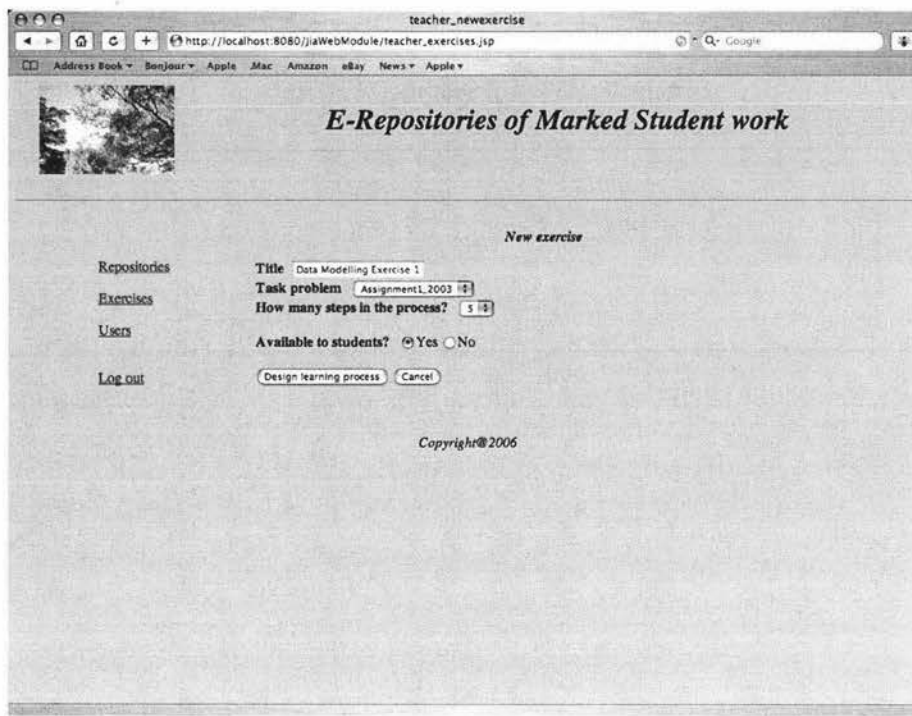
Figure 2 Adding a new exercise

Figure 3 shows the screen of setting up the first step of this exercise. The activity chosen is "DoTask". The start date and due date can be selected from the calendar. The detailed instruction for this step needs to be entered and submission requirement need to be selected. Since setting up the other steps will take the same procedure (only the attributes of each step being different), only the screen for setting up step 1 is shown. After setting up all the steps for the learning process, the teaching staff can view the whole process including the details of each step (see Figure 4).

Figure 3 Setting up a new learning step

Figure 4 Displaying the learning process of Data Modelling Exercise 1 for the teaching staff

Supporting student learning from marked student work

After a student (dubbed as "Allan") logged into the system (see Figure 5), the list of available exercises is presented and the student can select and start to do the Data Modelling Exercise 1 (see Figure 6).
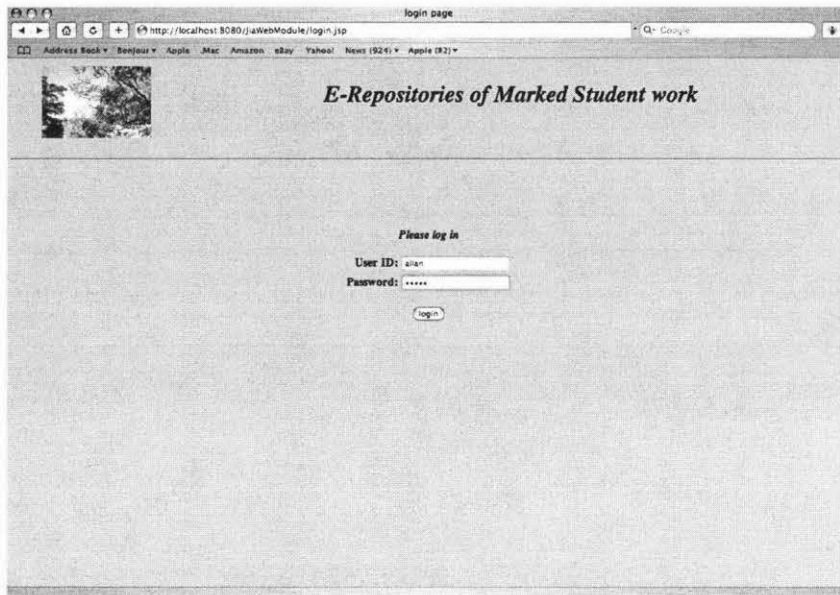
Figure 5 Student ("Allan") logging into the system
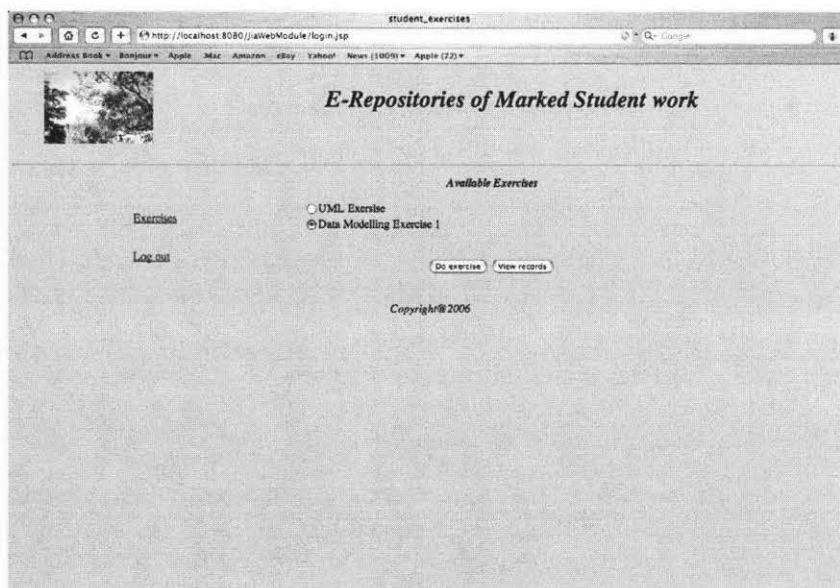
Figure 6 Student viewing and selecting the available exercises

Figure 7 shows the learning process during Step 1 (from 11/11/2006 to 11/14/2006, the date is given in the format of month/day/year). The learning activity for this step is "Solve the problem". Students can upload their work using the "Submit" button and Figures 8 and 9 show the screens associated with the uploading process.
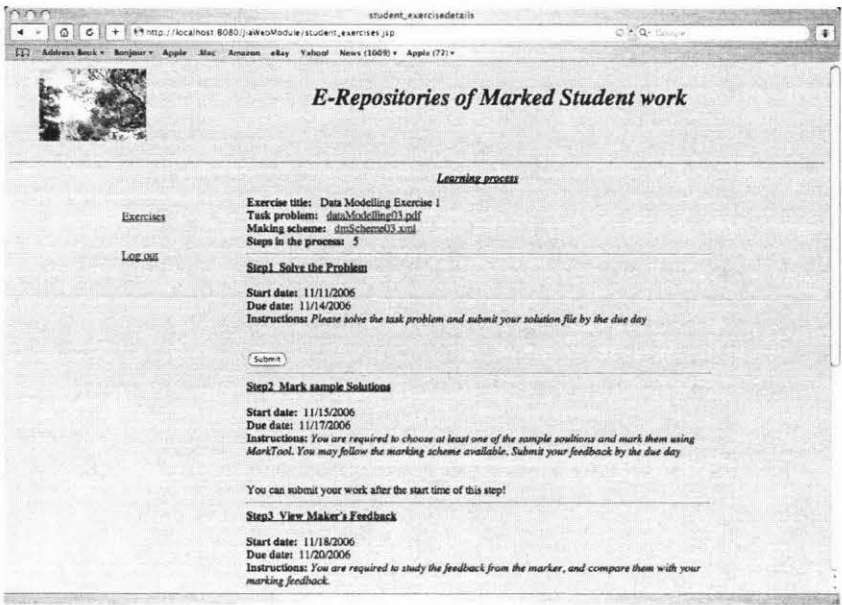
Figure 7 Student viewing the learning process during Step 1
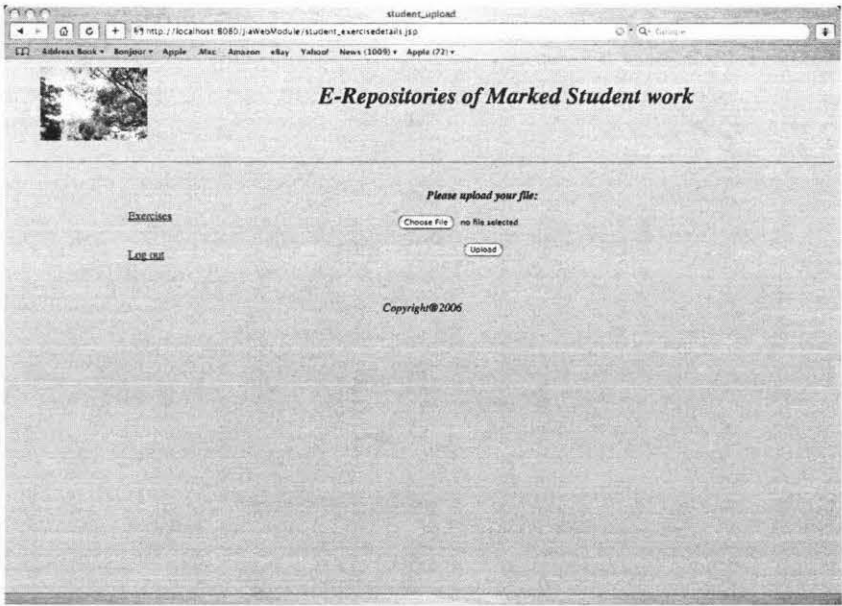
Figure 8 Student submitting his work
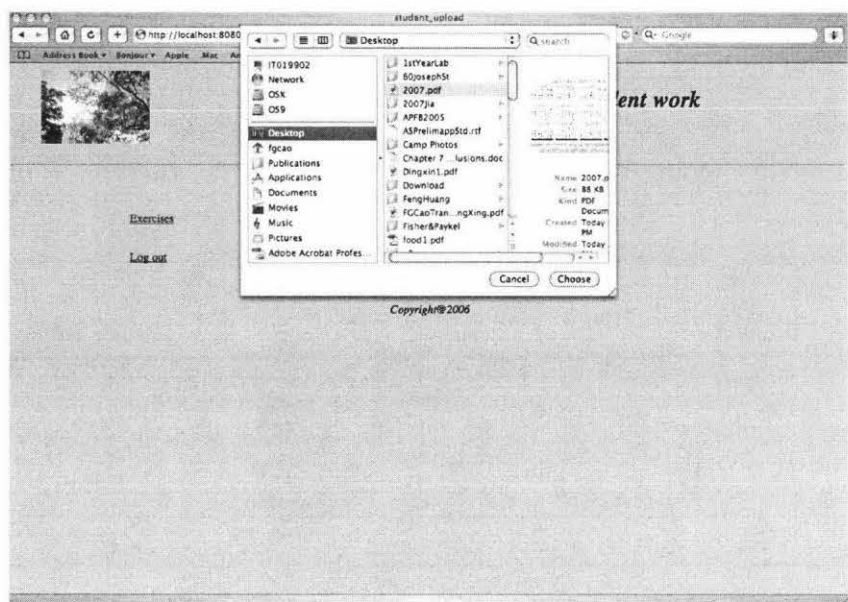
Figure 9 Student choosing a file to upload

Figure 10 shows the learning process during Step 2 (from 11/15/2006 to 11/17/2006). The learning activity for this step is "Mark sample solutions". The sample solutions from previous students are made available to the current students. The submission facility is also provided.
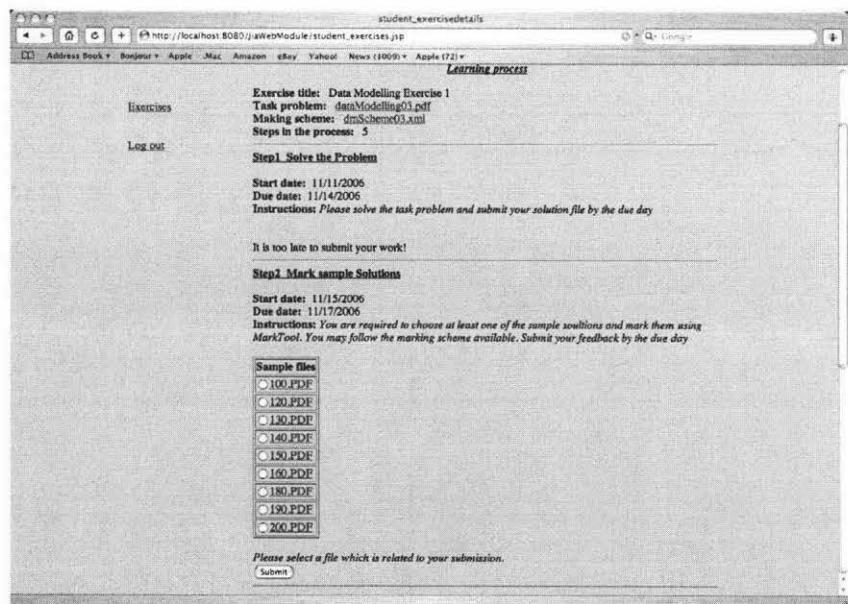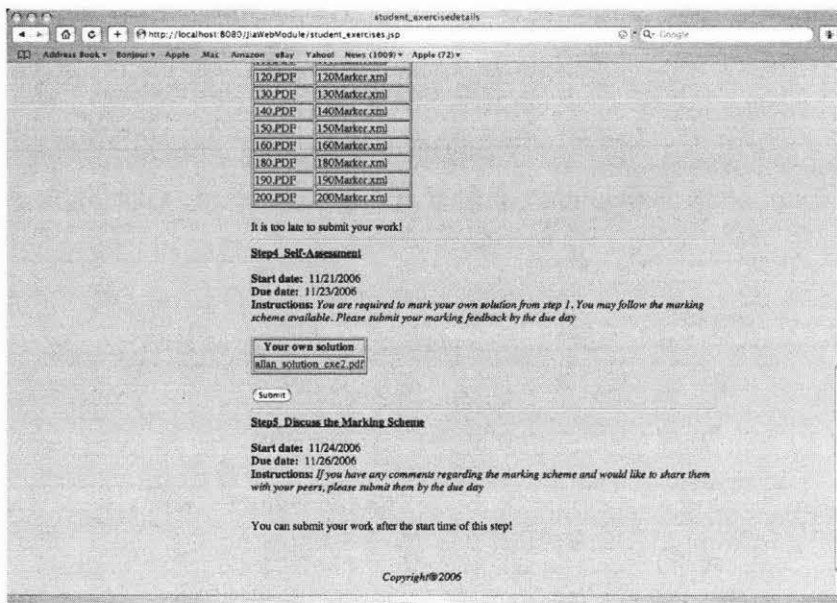

Figure 10 Student viewing the learning process during Step 2

Figure 11 shows the learning process during Step 3 (from 11/18/2006 to 11/20/2006). The learning activity for this step is "View marker's feedback". The sample solutions from previous students together with marker's feedback are made available to the student.
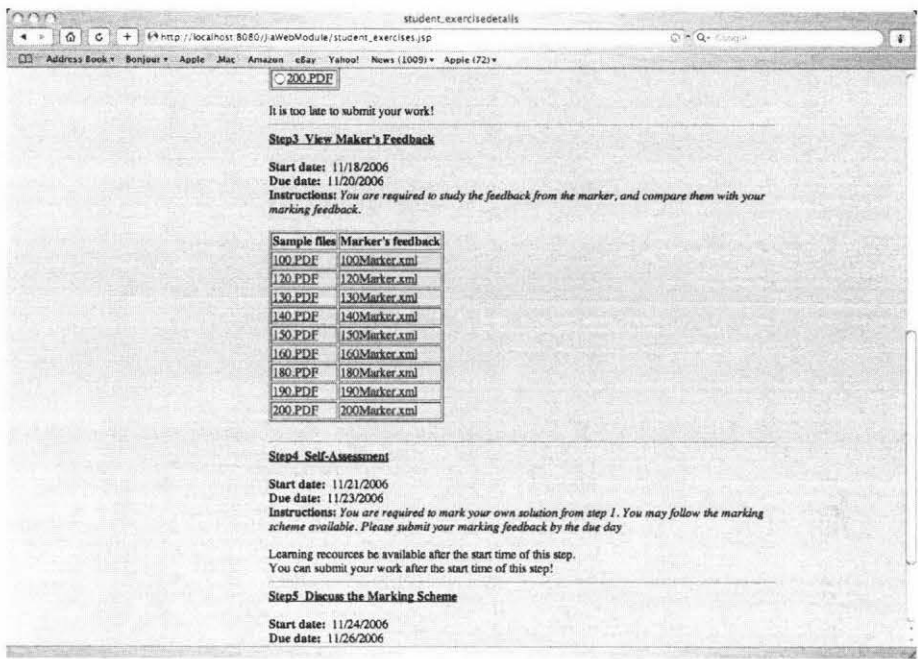
Figure 11 Student viewing the learning process during Step 3

Figure 12 shows the learning process during Step 4 (from 11/21/2006 to 11/23/2006). The learning activity for this step is "Self-assessment". A link to the student's own solution is available. The submission facility is also provided.

Figure 12 Student viewing the learning process during Step 4

Figure 13 shows the learning process during Step 5 (from 11/24/2006 to 11/26/2006). The learning activity for this step is "Discuss the marking scheme". Submission facility is available for the student to upload his comments on the marking scheme which can be viewed by all students.
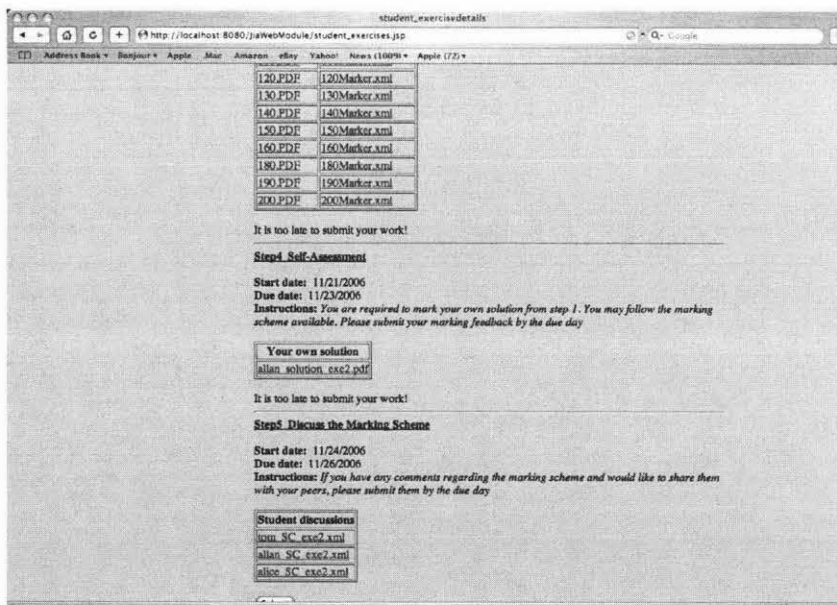
Figure 13 Student viewing the learning process during Step 5

Figure 14 show the screen of the student's submission records for this exercise at the end of the exercise.
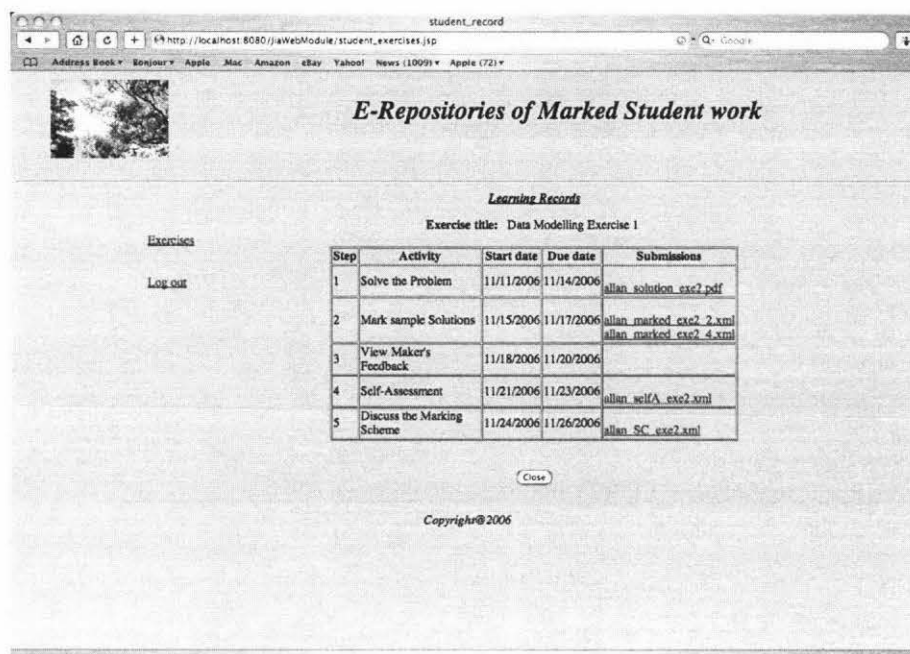
Figure 14 Student viewing his submission record

Learning exercise 2

Helping teaching staff to design learning processes

Figure 15 shows the screen of the exercise list after a new exercise (Data Modelling Exercise 2) has been added. The learning process from the teaching staff's viewpoint for this new exercise is shown in Figure 16.
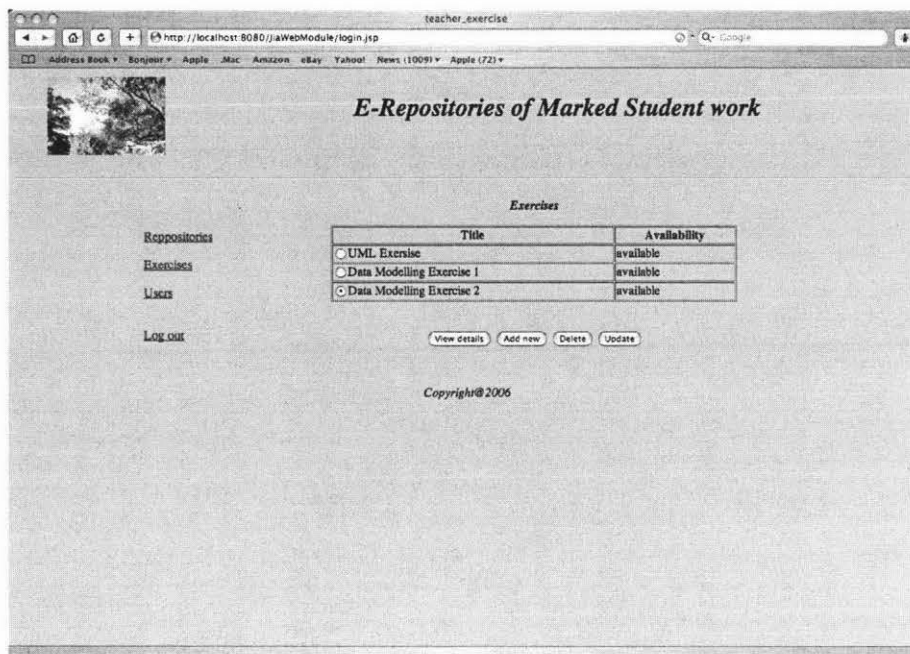
Figure 15 A new exercise (Data Modelling Exercise 2) was added
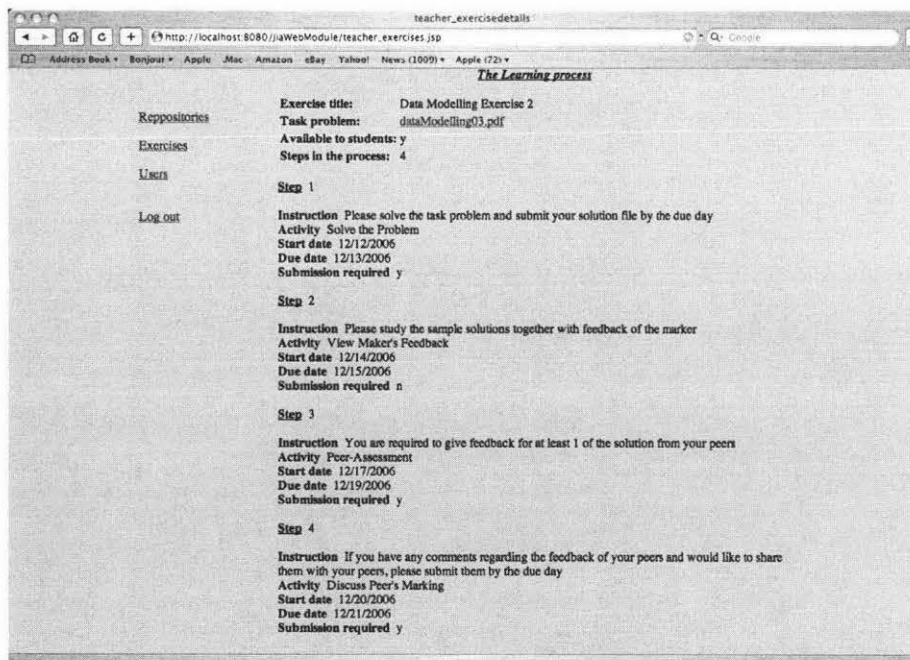
Figure 16 Displaying the learning process of Data Modelling Exercise 2 for the teaching staff

Supporting student learning from marked student work

Figure 17 shows the screen after a student (dubbed as "Tom") logged in the system. The list of available exercises is displayed, and then the student selects to do the exercise.
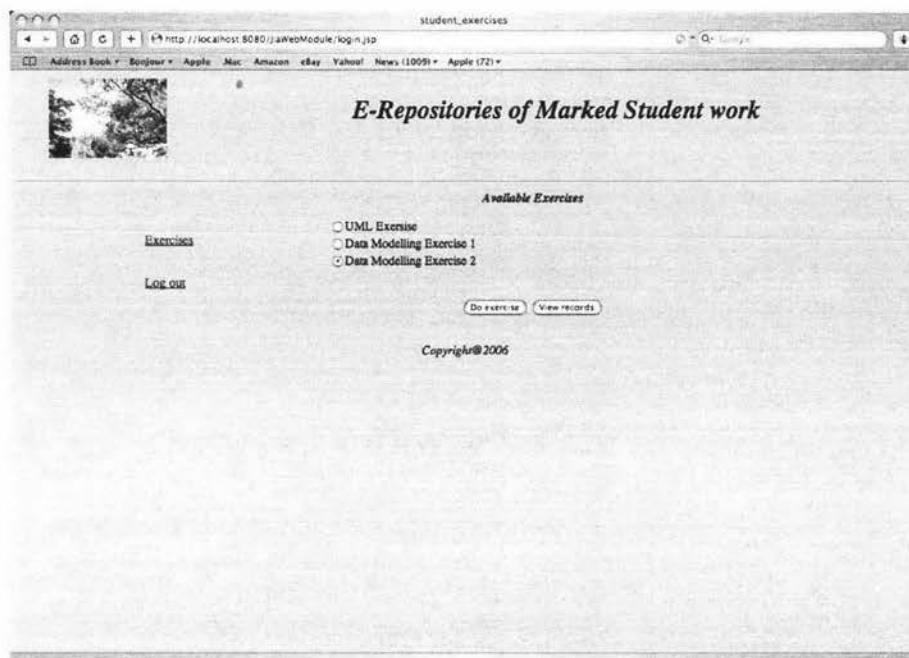

Figure 17 Student viewing and choosing from the available exercises

Figure 18 shows the learning process during Step 1 (from 12/12/2006 to 12/13/2006). The learning activity for this step is "Solve the problem". The "Submit" button is available for the student to upload his work.
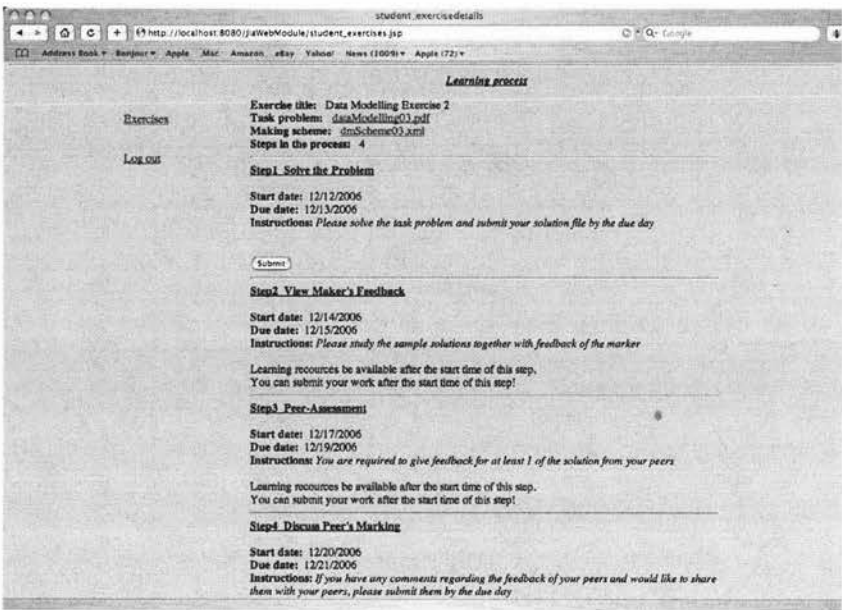
Figure 18 Student viewing the learning process during Step 1

Figure 19 shows the learning process during Step 2 (from 12/14/2006 to 12/15/2006). The learning activity for this step is "View marker's feedback". Sample solutions from previous students together with the marker's feedback are made available to the student.
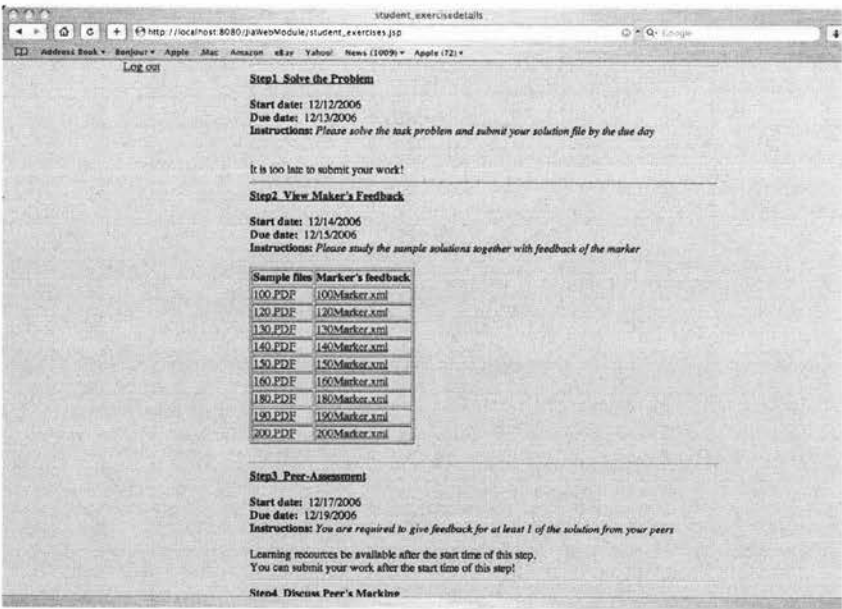

Figure 19 Student viewing the learning process during Step 2

Figure 20 shows the learning process during Step 3 (from 12/17/2006 to 12/19/2006). The learning activity for this step is "Peer-assessment". Students' submissions from Step 1 are made available to their peers who can upload their marking feedback on these submissions through a submission facility.
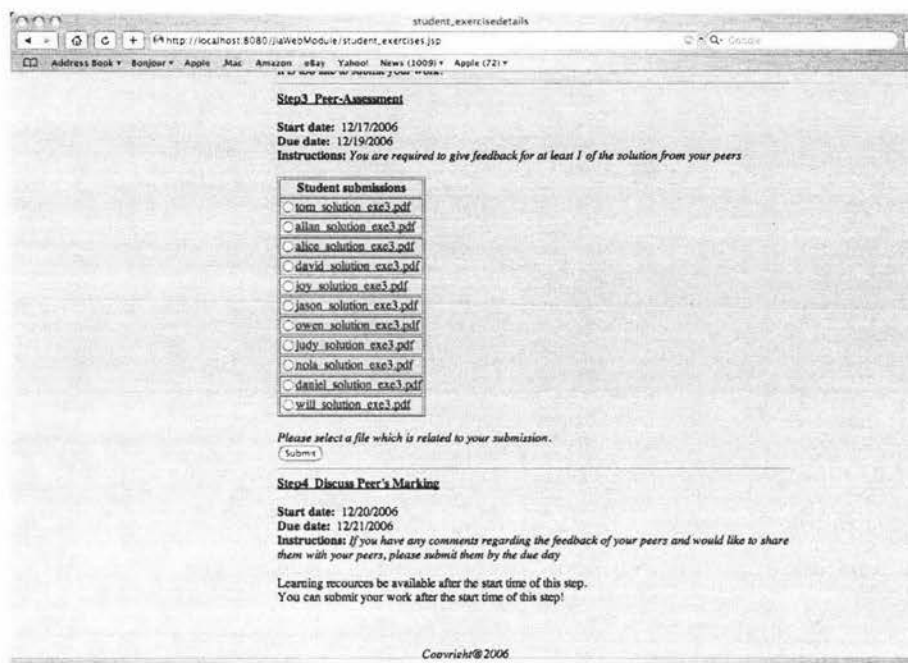

Figure 20 Student viewing the learning process during Step 3

Figure 21 shows the learning process during Step 4 (from 12/20/2006to 12/26/2006). The learning activity for this step is "Discuss peer's marking". The page displays students' solutions to the task (from Step 1) and their peers' marking feedback on these solutions (from Step 3). Students' can make comments on the peers' marking feedback via a submission facility.
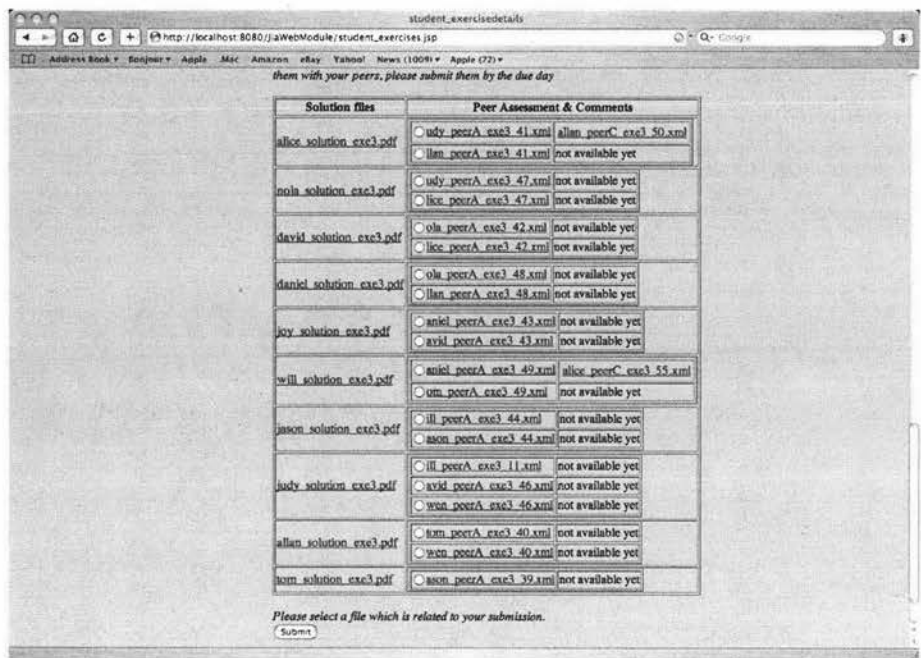
Figure 21 Student viewing the learning process during Step 4

At the conclusion of this exercise, the student can view his submission record through a page similar to that show in Figure 14.