Electronic Repositories of Marked Student Work and their Contributions to Formative Evaluation

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ABSTRACT

The educational literature shows that formative assessment is highly conducive to learning. The tasks given to students in formative assessment generally require open-ended responses that can be given, for example, in essay-type format and that are assessed by a human marker. An essential component is the formative feedback provided by the marker that needs to assist the student in recognising knowledge gaps and in formulating steps to close these gaps. The concepts of 'electronic repositories of marked student work' introduced in this article suggests an approach to support learning from formative assessment. At the core of this concept lies the realisation that the artefacts submitted by students and assessed by markers are a valuable resource. This resource should not just be used by the submitting students but should be made accessible to future students studying the same concepts. These students can learn from the artefacts and the formative feedback attached to these artefacts. Self- and peer-assessment, important concepts closely linked to formative assessment, can be integrated with the repositories to develop the students' subject knowledge, to enhance their critical thinking skills and to familiarise them with assessment procedures. This article develops the concepts of electronic repositories of marked student work. Special emphasis is put on reviewing the educational literature on formative assessment and on binding the concepts introduced into the literature findings.

Keywords

Formative assessment, Web-based repositories, Onscreen marking, eLearning

Introduction

To introduce our work we first want to provide a high-level overview of goals and context followed by an initial look at the technical environment.

Goals and context

Our work on 'Electronic Repositories of Marked Student Work' combines formative assessment and a networked computer environment to offer an innovative learning approach in an eLearning context. In our repositories we deal with formative assessment based on written, essay-type work. Due to the cognitive complexity of essay-type artefacts and the importance of formative feedback we rely on human markers. We regard the essays produced by students and the feedback given by markers as a very valuable resource that we want to retain and make available as a learning resource to future students.

One characteristic of teaching is that to a large degree the concepts to be transmitted remain the same from year to year or class to class. What changes are the examples used to explain, exercise and examine these concepts. An example from our own teaching would be the concept of data modelling using entity relationship diagrams, which we teach to our second year computer science students. The concepts and modelling techniques stay largely unchanged but we vary the example domains, looking at modelling a video library, the management of sports teams or the allocation of parking spaces.

Current eLearning approaches to assessment commonly demand specific question and answer formats. With difference to these approaches we do not want to restrict the way assessment tasks are set but want to support written assignments of any content or format. We aim to provide an approach that can be used by any discipline. With this we explicitly want to include non-technical disciplines like the humanities, education and social sciences. The essay-type artefacts of student work we are looking at can contain a mixture of formats including text, diagrams, graphs and pictures. In short, we are considering anything that can be presented on paper and is printable.

As mentioned earlier the essay-type student work will be assessed by a human marker, who provides formative and summative feedback. This stands in contrast to multiple-choice style tests as offered by learning management systems like WebCT (2003) or BlackBoard (2003). Such tests can be assessed with an automated system and the focus is on summative feedback. Our research presented here does not consider these forms of tests.

An important aspect of our research is that we want to reuse the valuable material that is produced by students and assessed by markers with considerable effort and time commitment from both parties. This material can be used for highly relevant exercises. In our university context students submit assignments throughout the semester and receive feedback within a matter of weeks. We suggest collecting assessed assignments in repositories and using these for exercises for subsequent students. As presented in later sections of this article in more detail these exercises are likely to contain self- and peer-assessment.

We are focusing on a university context and on assignment artefacts yet other uses of the repositories are possible. For example, the tertiary context could be exchanged for a primary or secondary school setting. The student work submitted could be less formal exercises or more formal examination material.

Technical environment

As we want to construct electronic repositories we need electronic copies of the student work. In the tertiary context a large majority of students uses computers to write their assignments. In these cases we can ask the students to hand in electronic copies of their work instead of printed copies. Where students construct their work using pen and paper, for example in drawings, sketches or handwriting, it is possible to generate electronic copies by scanning or taking photographs with a digital camera.

Once we have obtained electronic copies of student work we need access to a marking tool that assists the marker in annotating the student work. Our understanding of 'annotating' is to put textual and graphical comments on the work and to add marks. Figure 1 gives an example of annotations performed with a tool we are currently developing that relates back to work published in Heinrich and Wang (2003). The annotations are added to the student work in electronic format and are stored separately from the artefacts in a database. An important consequence of this approach is that the student work can be presented with and without annotations. In the 'paper world' the analogy would be to write the annotations on transparencies that can be added or removed at will. Yet, as we will see, the electronic version opens many more possibilities.

The marking tool we have just introduced focuses on technical assistance. One of its core design goals is to replicate the way we commonly work with pen and paper. Human markers use the tool to put their assessment comments 'on' the artefacts. While the marking tool is designed to support the markers in their tasks as well as possible it offers no intelligence, cognitive processing or any form of automated marking.

To build repositories we need to compliment the marking tool with a web-based system that provides students, lecturers and markers with access to student work and its annotations. This web-based system needs to include management functionality for uploading work into the repositories and, importantly, to control user access rights. A web-based system brings with it the important advantage of 'any place and any time' access, supporting students working at their own pace and enabling collaboration. As we will see in later sections of this article the control of access rights does not only refer to regulating the access of individuals but also to the management of the timing when releasing information.

After setting the scene with this introduction the reminder of this article is structured as follows. In the next section we link the repositories of marked student work with educational theories on assessment and learning related to assessment. This is followed by a presentation of related work that has taken assessment into an eLearning arena. We then summarise the arguments presented throughout the article that demonstrate the advantages of electronic compared to paper-based repositories. Learning from assessment is a complex area and there are a number of issues that still require full exploration. We present these issues towards the end of the article. Before concluding we give the current status of our work in regard to using repositories for our own teaching. A fuller version of this article has been published as an Institute's report at our university (Heinrich, 2004).

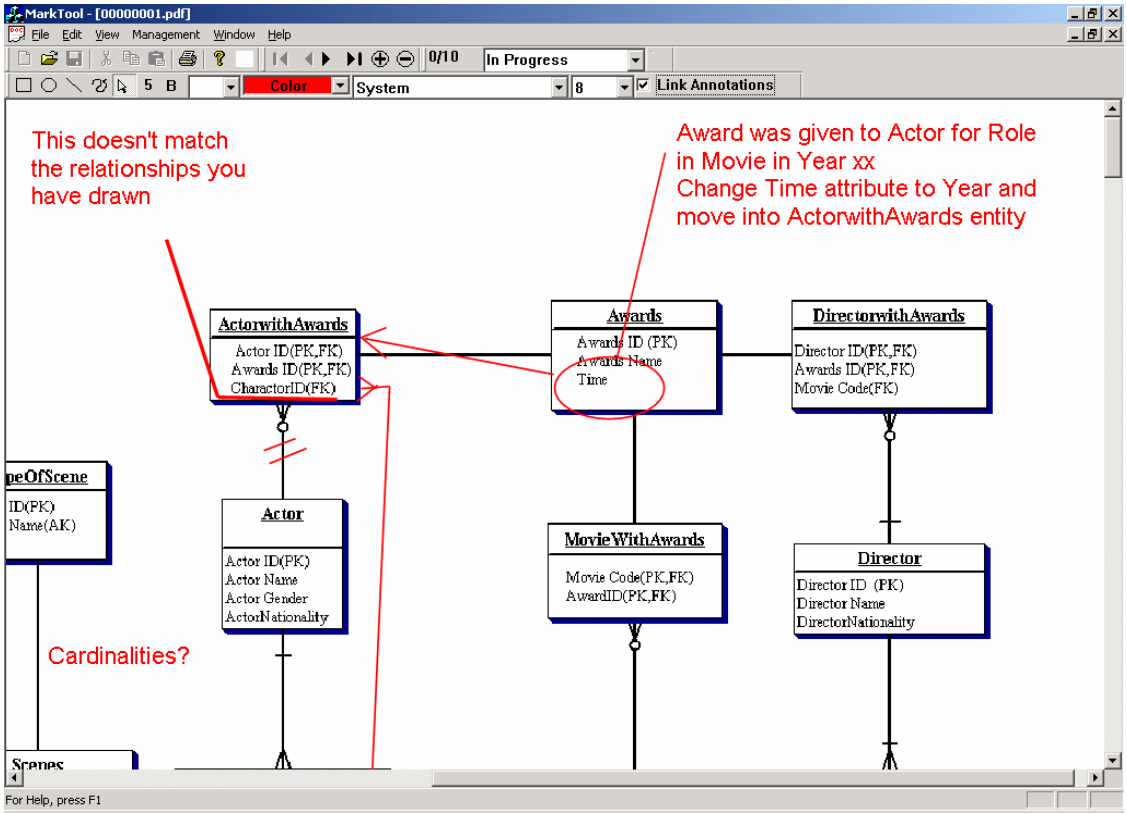

Figure 1: Screenshot of the MarkTool showing the onscreen marking of assignments (the annotations are in a different colour as the assignment artefact which is important for readability; this is lost in a black and white printout)

Foundations in educational literature

In this section we investigate the literature on educational assessment theories and on learning from assessment and relate the findings to the electronic repositories of marked student work. We are using the substantial literature review on classroom formative assessment by Black and William as a major source for this section. In the conclusions to their review Black and William point out the significance of formative assessment for learning: 'The research reported here shows conclusively that formative assessment does improve learning' (p35). They further state that while the theories surrounding formative assessment are not yet fully developed and the impact of feedback is not yet widely understood there is still enough evidence of positive gains to incorporate more formative assessment in various ways into the teaching: 'Significant gains can be achieved by many different routes, and initiatives here are not likely to fail through neglect of delicate and subtle features' (p36). These conclusions encourage us to investigate how we can provide mechanisms to support formative assessment and raise our confidence that we can contribute while still fine-tuning our processes.

Quality of feedback

One important concept of formative assessment is feedback (Black and William, 1998; James, 1998) that focuses on identifying the gap between present and desired achievement and on developing a plan on how to close this gap. The quality of feedback given to the students is of highest importance to the success of formative assessment (Black and William, 1998; Kluger and DeNisi, 1996; James, 1998; Topping, 1998). Feedback should direct attention to task-motivation or task learning processes (Kluger and DeNisi, 1996). Despite this importance of the quality of feedback and its essential role in the assessment process a lack of training of lecturers in assessment is reported (Ecclestone and Swann, 1999). Besides the quality of the feedback it is important to look into the procedures by which feedback is returned to the students. For example, it is essential that the students attempt to answer questions themselves before being given the correct answers, and that they gain access to the answers only after they receive the feedback (Black and William, 1998).

These considerations on the quality of feedback impact on the investigations into electronic repositories in several ways. It is important for our work to look into the training for quality of feedback and into the management of release of information. We need to pick up on the lack of training in assessment, which affects both lecturers and markers. We aim to build quality of feedback training systems that centre on sample repositories. We need to build management structures around our repositories. With these feedback provided by markers can be monitored allowing release to students only after comments have passed through quality filtering. Further, a staggered release of feedback, marks, and sample solutions can be implemented.

The role of assessment in guiding learning

The assessment in education literature calls for a tighter integration of assessment and learning (Black and William, 1998; Ecclestone and Swann, 1999; James, 1998). The potential of formative assessment to motivate learners has to be utilised and actions have to arise from assessment that contribute to learning.

The trends identified have several implications for our work. We can react to the demand of shifting attention towards formative assessment by building repositories that contain essay-type assignments and formative feedback annotations. This is in contrast to components widely available in current learning management systems that focus on multiple choice-style tests representing summative assessment.

The literature calls for using assessment to inform learning. What we want to do with our repositories is to use the artefacts produced by students and marked by lecturers in one year as a learning resource for students in the following years. Students in subsequent years study the same concepts that are presented with different examples. This year's students can learn from the work previous students have submitted by examining their solutions and attempting to assess these. As the repositories contain the feedback provided by the lecturer at the time the new students can compare their own attempts at assessment and benefit from the effort the lecturer has spent. We will expand on these ideas in the later section on the use of examples for learning.

Assessment communities

To be successful it is essential that students understand learning goals, realise the gap between their current and the target levels, identify the steps required to bridge this gap, and take responsibility for executing these steps. One way of achieving this is for students to become part of an assessment community in which they work together with their lecturers on assessment and on improving the quality of their work (Ecclestone and Swann, 1999). A further important aspect of the involvement in an assessment community is the effect of familiarising students with assessment procedures and criteria (Black and William, 1998; Klenowski, 2000; Wilson, 2004).

The idea of assessment communities can be taken up to involve the students in assessment. The core part of this process would see a student gaining access to an artefact contained in the repository without being able to see the annotations provided by the lecturer. The student then assesses the artefact and once this is done compares their comments with the ones given by the lecturer. This core process can be extended in various ways, for example using scaffolding or collaboration, as we will outline in more detail in later sections.

Self- and peer-assessment

Closely linked to the assessment communities are the concepts of self- and peer-assessment, with the literature consistently emphasising their benefits (Black and William, 1998; Brookhart, 2001; Ecclestone and Swann, 1999; James, 1998; Juwah, 2003; Sivan, 2000; Topping, 1998). What is commonly mentioned is that self- and peer-assessment encourages students to take responsibility for their learning, is important for understanding goals, and facilitates the development of critical and independent thinking skills. Looking into the potential problem area of reliability and validity Topping (1998) examined 31 studies and reported that the majority of these studies (18) found adequate reliability and validity.

In the reminder of this section we focus on four specific aspects of self- and peer-assessment, namely feedback on self/peer-assessment, student responses to feedback, formulating assessment criteria, and developing confidence.

Black and William (1998) report on the general discrepancy between students' self-perception of their work and the judgement provided by others and suggest providing students with feedback on their self-assessment. We can integrate this suggestion into our repositories with a collaboration component. Looking at peer-assessment, a student would assess an existing artefact and make their comments available. Other class members can access the artefact inclusive of the first student's comments and provide alternatives, agreement or corrections. The students develop a dialogue, closely focused on the artefacts and assessment comments. Looking at self-assessment, this approach would be extended by the students first developing their own artefacts for a given task. They would then possibly gain access to marking guidelines and others students' submissions before engaging in self-assessment. This approach would concur well with Black and William's (1998) demand that students should initially attempt the answer questions for themselves before being giving feedback or solutions.

One of the issues that arose from studies reported in Ecclestone and Swann (1999) relates to the responses of students to the feedback given to them by their teachers. The question asked is how we can find out which feedback helped the students to improve the quality of their work. One step towards answering this question could be to facilitate a dialogue between student and teacher. After gaining access to their work annotated with feedback via a password-protected electronic system the students could use a dialogue functionality that would allow them to easily respond to a specific comment without having to approach their teachers in their office.

Sivan (2000) suggests that initially the lecturers should provide the assessment criteria and that later in the process the students themselves could develop these criteria. Linked to this are findings by Black and William's (1998) stating that students learn and think more by formulating their own questions. We can integrate these suggestions into our work in various ways. For example, we can direct the students to work on a first set of artefacts for which we provide assessment criteria. We then provide a related set of artefacts (e.g., relating to the same concepts but demonstrated with examples from a different domain) for which the students have to adjust the assessment criteria provided previously. Over various stages we can move from giving guidance towards requiring students to develop their own criteria.

Assessing work provided by others is not an easy task. Besides requiring well-founded subject knowledge, confidence is an important factor and has to be developed over time (Ecclestone and Swann, 1999; Sivan, 2000; Bhalerao and Ward, 2001; Wen and Tsai, 2003). The issues around confidence relate to electronic repositories in various ways, affecting not only student but also staff confidence. In a traditional setup the feedback provided by a lecturer is only seen by the student (or a small group of students) who has submitted the work. A lecturer who employs markers will only conduct spot-checks on a small sample of assignments. The assessed work only 'lives' for a short period of time, mostly until the student has passed the respective paper and moves on to other subjects. An electronic repository has the potential to change these conditions considerably. The lecturer can more easily access the work done by the markers, the marked assignments live in the repositories for years to come, accessible not only to a few students but to the whole class. Careful management will be required to mitigate the potential for resistance against electronic repositories to facilitate taking advantage of their proposed benefits. As the literature reports, it is essential to improve the quality of feedback - supervising and training markers will lead to such an improvement. The more teachers learn about the theories linked to marking the more confidence they develop. Involvement of students in the assessment community increases their understanding and acceptance.

A very different characteristic of web-based systems, that is the lack of face-to-face contact, can help reducing the reluctance towards criticising the work of someone one knows. Anonymity can be conducive to providing feedback and can be implemented fairly easily in an electronic environment (Schuck, 2003; Wen and Tsai, 2003). Electronic repositories will allow us to provide the required degree of anonymity so student (and staff) will feel less inhibited to contribute even in the early stages until more confidence has been developed. This could be supported by introducing pseudo identities meaning that students can choose online identities that hide the students' real identities.

Scaffolding

In the previous section we have mentioned some psychological barriers that might affect peer-assessment. Setting these issues aside, students might initially need some assistance on the actual subject matter or on marking procedures to get started with either self- or peer-assessment. The literature talks about scaffolding. Scaffolding refers to providing a stepping stone rather than a full solution or to supplying an example to guide students in their assessment (Black and William, 1998; Sivan, 2000; Renkl and Atkinson, 2002).

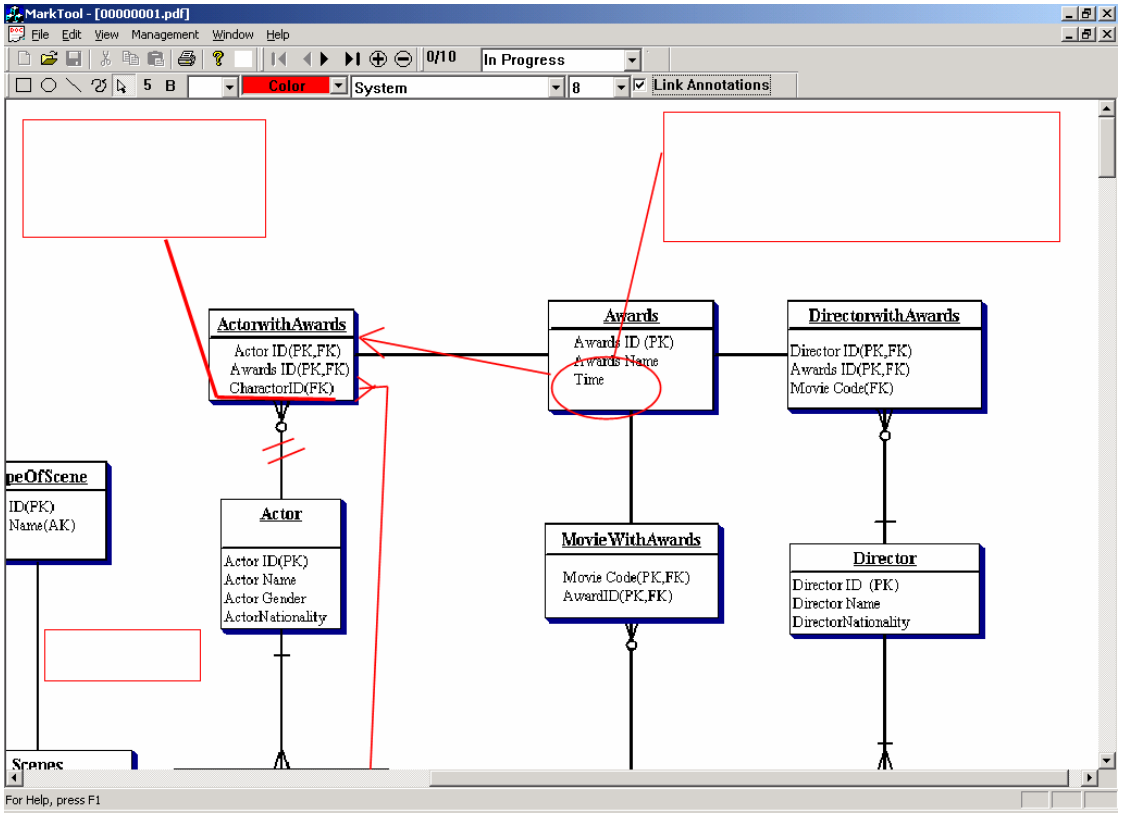

Figure 2: Screenshot of the MarkTool showing the reference points for comments but not the comments themselves

Again, we see various ways of how to integrate scaffolding into electronic repositories. One approach can provide the students with a list of comments that refer to concepts taught and that have to be matched to the applications of these concepts in the artefacts. Taken the data modelling example we referred to previously, one of these comments would be 'this many-to-many relationship must be resolved'. This comment points the students to an important concept in data modelling (the resolving of many-to-many relationships required to normalise the data model) that is frequently violated by data modelling novices. The student performing the self- or peer-assessment can now try to match this comment with an instance in the artefact - a task that is less challenging than having to come up with the idea that many-to-many relationships could be a problem in the first place. Another way to approach scaffolding is to present only part of feedback provided by someone else. Assuming we have an artefact available that has been assessed previously by the lecturer, instead of presenting the artefact to the student including full annotations we can suppress the textual components of the annotations and only show the graphical annotations. This would indicate to the student that a particular part of the artefact requires a comment (the part the graphical annotation points to), but would leave it up to the student to discover what kind of comment is required. Figure 2 gives another screenshot of the MarkTool demonstrating this kind of scaffolding.

Learning from examples

A number of authors advocate the use of examples of student work to benefit both teachers and students (James, 1998; Renkl and Atkinson, 2002; Black and William, 1998; Wen and Tsai, 2003). Access to assessed examples of student work is important to illustrate how standards look in practise and assists teachers in achieving consistency in marking. The examples presented should not be restricted to model answers but can also demonstrate weaknesses. Students can learn from the feedback provided by the teacher that points out the problems in the work and makes suggestions on how to eliminate these problems. Further, students can be asked to analyse the work provided and to construct the feedback themselves.

These references to learning from examples relate very well to our repositories of marked student work. Our artefacts stem from student-submitted assignments and therefore naturally span the range from weak to excellent. Our repositories will contain both assignments and the formative feedback provided originally by the teacher.

Based on the way in which we will store the repositories electronically we will be able to display artefacts and comments both combined and separately. This allows for both forms of learning as suggested in the literature. Local context will be achieved naturally by using the assignments from one semester or year as artefacts in the repositories for the same paper or subject in the following period (yet this local context should not preclude sharing repositories across institutions).

The repositories of marked student work can also be used for the training of lecturers and markers. Both groups can benefit from studying example feedback to improve the quality of their marking comments. Lecturers can use the repositories to demonstrate standards of achievement to their markers and to facilitate consistency across the markers.

Summary

In this section we have examined formative assessment and its relationship to learning. The educational literature stresses the importance of formative assessment and indicates a shift from assessment for ranking towards assessment for learning. An essential component of formative assessment is feedback. Feedback assists the students in identifying gaps in their knowledge and guides them towards measurements to close these gaps. The quality of this feedback is of the highest importance and the literature strongly recommends task- instead of self-related feedback. Self- and peer-assessment help students in the development of higher order thinking skills and bind them into an assessment community. Examples of commented student work benefit both teachers and students, in demonstrating standards and in assisting learning.

Parallel to reviewing the literature on formative assessment we have introduced components of our proposal for electronic repositories of marked student work and have linked these components with the respective educational theories. In summary, we see the following main application areas for the electronic repositories of marked student work:

- Learning from previously assessed work: learning from the formative feedback provided with the assignments through receiving explanations what is correct or incorrect and why; having access to a range of approaches to the task set, providing alternate viewpoints beyond a sample solution; getting a feeling for what is required in volume and level of detail for the assessment in this paper; being able to access all this material in their own time using it both for assignment and examination preparation;
- Learning through self- and peer-assessment: building of an assessment community; attempting the task before having access to the solution; providing and receiving peer-feedback; improving the understanding of assessment criteria and tasks;
- Guidance and supervision of markers: providing of marked assignment samples to markers; collaboration between markers and lecturers in reviewing marking decisions and comments; assisting lecturers in their tasks of monitoring the work of their markers; extracting all textual comments for quick suitability checking;
- Improvement of feedback quality: supporting staff development in the assessment area; staff training systems based on repositories of artefacts annotated with feedback of different quality levels; anonymous access to allow staff to participate in confidence.

We are not aware of any work that addresses formative assessment and its relationships to learning in the way we have suggested. Yet, some aspects of assessment related learning have been covered in other eLearning approaches. In the next section we look at examples of such studies.

Related work linking assessment with eLearning

In this section we present some examples of work that link assessment with eLearning and that demonstrate the application of some of the findings from the literature review on educational assessment theories.

Bhalerao and Ward (2001) advocate the use of multiple-choice tests combined with peer-assessment of free response questions. The authors teach computer programming to large classes of several hundred students and conduct laboratory assessments about four times per course. As with tests in many other disciplines, computer programs cannot fully be assessed automatically. Bhalerao and Ward use a two step system for their laboratory tests that involves automatically assessed multiple choice questions followed by peer-assessed free response questions. Bhalerao and Ward report that the students' results have improved after being involved in the

marking. The authors suggest that their approach, after some modifications, could be used for essays in the social sciences.

Sitthiworachart and Joy (2003) discuss a web-based peer-assessment approach to support students' learning of programming. They have developed a three-stage system in which the students first solve a programming task, and then individually peer-assess other students' programs with subsequent discussion of their peer-assessment in groups, followed by students marking the quality of the peer-assessment provided. Sitthiworachart and Joy report that their approach positively contributes to the students' learning experience. They emphasise that the students need to be given adequate guidance for the marking process and that the marking of the work of friends can result in favourable marks.

Tsai et al. (2002) have investigated the use of peer-assessment to support the collaboration among pre-service teachers conducting open-ended tasks like the design of science activities. The system used is modelled on the submission and review process of academic journals. Tsai et al. report an improvement in performance with the students displaying important cognitive skills. They further state that the students regarded peer-assessment as effective for their learning and were motivated by it. The authors emphasise the opportunities that have arisen for the implementation of peer-assessment with the wide availability of the internet and web-based systems. The advantages of web-based systems are that they overcome time and place restrictions and that they allow for anonymity, important for an objective manner of judging.

Wilson (2004) used an asynchronous learning network environment for the development of multiple-choice style exam questions by students in the teaching of emerging information technologies. The students displayed a high level of participation that can partly be explained through course structure and social pressures but seemed to extend beyond these factors. The identities of the contributing students were visible and the lecturer provided some monitoring of the interactions. Possibly due to this setup the students co-operated in very polite manner. Despite their willingness to participate the students strongly disliked being criticised by their peers.

Nokelainen et al. (2003) report the use of a document-based annotation tool for learner-centred collaborative learning. The tool allows learners to add textual annotations to learning material displayed on the web. The annotations appear in textboxes close to the highlighted reference points in the learning material. The authors show a strong agreement among students that the use of this document-based annotation tool added value to their learning. The students emphasised strongly the benefits they perceived gaining from self-made comments. While the work by Nokelainen et al. does not relate to assessment it shows parallels to our research in the annotation tools used and the collaboration aspect of document-based annotation.

Summary

This small selection of example studies reiterates a number of points made in the assessment literature:

- Answers to free-response questions need to be assessed by a human marker;
- Examples of student work are a valuable learning resource;
- Self- and peer-assessment is highly conducive to learning;
- The monitoring of interactions and the provision of guidance are important;
- Anonymity facilitates the acceptance of peer-assessment;
- Networked computer systems are highly useful for the implementation of assessment.

We are encouraged to see that these issues identified in the literature have been implemented successfully in various projects. While the selection of these projects is obviously not exhaustive it is still interesting to note that the first three projects address a computer sciences/information technology context. The technical nature of the context seems to be typical for projects that either apply some form of automated assessment (beyond multiple-choice style assessment) or that have developed fairly sophisticated systems to guide students through an assessment process.

Why electronic compared to paper-based repositories

Having painted a clearer picture of what we want to achieve with the repositories we now want to summarise the advantages of using computers to support the repositories. While some of the suggestions made in this article could as well be implemented with paper-based repositories the concept overall can only be realised with an electronic format. There is plenty of evidence in the literature for the advantages of electronic or online systems

(Buchanan, 1998-99; Kemm et al., 2001; McLoughlin et al., 2003; Northcote and Kendle, 2001; Renkl and Atkinson, 2002; Sclater and Howie, 2003; Tsai et al. 2002). In the following paragraphs we outline in regard to the repositories how an electronic format opens up possibilities not present in the pen and paper environment.

Document management

Part of the repository idea is that a single artefact is accessible by multiple users. In a paper system that means either the provision of multiple physical copies or restricted access through a sequential scheme, passing on the physical copies from person to person. In the electronic format artefacts can be copied without effort on demand. Electronic repositories can easily be archived and activated when required - today's learning management systems already offer the basis for such facilities.

The conversion of an assignment into an artefact requires some preparation. The identity of the author has to be removed and it might be suitable to split the assignments into different components. With electronic copies these tasks can be performed easily.

A very important advantage inherent in electronic formats is the flexibility gained in regard to adding and removing marking comments. Electronic comments can be displayed or suppressed at will. This means that multiple students or markers can work on the same artefact in parallel and that an assignment can be displayed in its original, unmarked form first, revealing the annotations only after the students have attempted assessment themselves.

A related aspect to this is that the electronic comments will usually be typed and not hand-written. This brings advantages both for the person making the comments, as typing is often physically less strenuous than hand-writing, and for the reader, as typed comments are easier to decipher than most people's hand-writing.

Access management

Access to an electronic repository can be protected by user codes and passwords. Besides controlling who is granted access, schemes can be implemented that stagger the release of information. That can mean creating a timed sequence of access to task description, artefacts, marking comments and sample solutions. While this would be possible in a paper-based system also, the management effort required would be extremely high, specifically if one wants to control access at the individual but not class level. Individual schemes are very important as they allow students to work at their own pace. Electronic formats are essential if one wants to implement an any-time and any-place access policy.

Communication

One feature of electronic repositories is that students (or students and markers) can communicate on marking comments. Students can comment on artefacts and enter these comments into the repository. Other students then read these comments and respond with their own assessments. An electronic repository means that this communication is independent from being at the same location at a specific time and does not require the exchange of physical documents.

Issues requiring full exploration

As mentioned earlier we have so far omitted several critical procedural issues that need to be considered to make these repositories reality. These issues have arisen in wide-ranging discussions with colleagues from a variety of disciplines and both from academia and university management.

Integration of the repositories into the learning process

It is not trivial but undoubtedly technically possible to build the repositories. Technically similar work using the internet and database management systems has been implemented already (Cho and Schunn, 2003; Kemm et al., 2003; Nokelainen, 2003; Sitthiworachart and Joy, 2003; Sung et al., 2003). Further, at least to a certain degree,

the technology can assist with the implementation of protocols or procedures. What we mean by this will become clearer by looking at some examples. The literature on formative assessment states that students should first attempt a task themselves before receiving sample solutions. We have built this into the scenarios by suggesting that students first have to submit their own solution attempt before gaining access to the repository artefacts annotated with formative feedback and to sample solutions. Technically it is possible to monitor submission and to control access rights accordingly. The difficulty occurs on a semantic level. A computer system is generally not able to assess the meaningfulness of a submission. Based only on automated control a student could easily bypass the spirit of the requirement to attempt the task first by submitting a more-or-less meaningless document. A meaningful level of access management would require the involvement of a human assessor, the lecturer or a marker or possibly even a student peer. One of the questions arising therefore is how much active involvement for controlling the learning process should be built into the repository system.

Similar issues arise with access to summative feedback. Again, technically it is easy to separate summative from formative feedback and to give access to marks only after the formative feedback has been studied. The question here is how a computer system decides if a student has actually 'taken in' the comments provided and has not just followed some mechanical steps to fulfil some computer-controlled requirements.

Creating the right atmosphere

In an ideal world everyone would be willing to share their artefacts and assessment annotations. In reality this is not necessarily the case. Conversations with colleagues around the university suggest that people are likely to feel insecure about opening their marking to a wider audience for scrutiny. Open access might prompt students to a higher degree than currently to question marking decisions. It could be psychologically difficult for lecturers to expose their marking performance to their colleagues.

For the success of the repositories it is essential to acknowledge these fears and insecurities and counteract them. One possibility might be to initially work with pseudo identities as has been discussed earlier. This might allow people to start making contributions to marking and to develop more confidence, based on feedback received to these contributions. As the literature reports that the more we know about marking the more confidence we gain about sharing (Black and William, 1998). This would allow us to assume that the fears and insecurities can be overcome with training and education. Part of this will be to develop the right atmosphere, among students in a course, and among lecturers and markers working together in assessment, and among staff participating in staff development.

Ethical issues and informed consent

Ethics and privacy issues have gained increasing importance. From our own experience in dealing with our university's ethics committee we know that, for example, it is necessary to gain informed consent from the students for using their examination answers for research purposes. The right procedures will have to be developed and followed to make student assignments or other work accessible in electronic repositories.

Using an informal approach we surveyed the opinions of our students regarding access to their work. This revealed that students seemed to be willing to grant permission for the use of their assignments anonymously in repositories for teaching in the following year. The students did not feel comfortable with sharing their assignments with their current peers, even if all links to the students' identities had been removed. Our students are from computer science and technology disciplines who commonly work either by themselves or in small groups. Attitudes might be different among, for example, education or social science students.

Institutional policies and support

The successful implementation of electronic repositories as advocated in this article or of any other networked computer support for formative assessment will, to a certain degree, depend on institutional policies and support. At this stage the climate seems to be that individuals have to display a considerable amount of initiative and determination to overcome obstacles. One of the policies required would be on ethics and informed consent, as discussed in the previous section. Another area relates to the security of electronically submitted and stored assignments or student work in general. Learning management systems already offer some facilities in this regard yet these are possibly not sufficient. At our university, for example, the development of an assignment

tracking system is underway that is to facilitate the electronic submission of assignments from our distance education students. A further point concerns the requirement of equal access for all students. If access to suitable computer equipment is essential to participate in a course the university has to classify this course accordingly.

Besides policies, procedures need to be developed towards creating a supportive environment. In relationship to using computer laboratories for tests and examination purposes, the information technology services laboratory administrator at our university recently circulated a message. This message stated that it was necessary to apply for such use of the laboratories three months in advance and that a rationale for this request had to be provided. The information technology section would than decide on granting this request and would advice on costs to be carried by the applying department. Such procedural and decision processes are not conducive for encouraging the use of electronic resources.

We are certainly not advocating a university-wide use of electronically submitted, marked and stored assignments. Yet, we would hope for some level of institutional support to encourage the uptake of these technologies and the related learning opportunities.

Practicalities

Briefly in the introduction to this article we have talked about how to obtain electronic copies of assignments. Ideally we see the repositories to be used in conjunction with electronic submission of assignments and the marking of these electronic copies 'onscreen' (Heinrich and Wang, 2003). This would evolve into a two step process. In the first year, the students submit assignments for assessment. This work is submitted, marked and returned electronically and stays confidential to the submitting students. In the second year, the assignments (without identification of the submitting students) become accessible to the new students as learning material. This process works well with our understanding of the privacy considerations our students have demanded. On a practical level the advantage of this approach is that we gain material for our repositories basically as a by-product of our normal assessment procedures (this actually is a great advantage as experiences with initiatives like LOM (2003) have shown that repositories of learning material grow slowly if there is not strong incentive for contributing material). We will have the assignments as artefacts and the marking comments as formative feedback. Issues to be handled are the removal of student identification numbers and names and the separation of summative from formative feedback.

An alternative process, suitable for fast-tracking the development of the repositories, is to select a representative sample of paper-based assignments and to re-create electronic copies. We have gained some experience in doing this by scanning assignments and using a graphics program to erase any marking comments on the electronic copy. We then used our electronic marking tool to re-create electronic, flexibly removable copies of the original marking comments. Depending on the quality of the paper original and the image settings during and after scanning this process results in artefacts of sufficient quality. We felt that the time effort required was bearable and specifically the re-creating of the marking comments felt surprisingly fast.

One issue that has been raised in context of electronic assignments is the question about the need for printed copies. Are printed copies required, who is responsible for the printing and who bears the costs? In our current university system the students print their assignments before submission. In the full electronic system we envisage the students would submit electronic copies. The electronic copies would be marked without printing and returned to the students electronically. The students could then decide if they wanted to produce printed copies. With this approach, the students would certainly not be disadvantaged in regard to their printing budgets. The university would not incur any costs, as it would not be required to print.

Obviously, electronic assignments depend on the availability of a suitable tool for marking (like our MarkTool) and on the appropriate support processes. Even with the best tools this approach will not be acceptable for everyone for every type of assignment. Yet, this should not stop us exploring the possibilities and the opportunities for learning.

The current status of our work

The implementation of the electronic repositories of marked student work has two main technical components, the marking tool and the web-based repository. For the marking we have an alpha-release application, the MarkTool shown first in Figure 1, available. For the web-based repository we have a preliminary design.

The design of the MarkTool goes back to work by Heinrich and Wang (2003) and technical details of the current version are described in Heinrich and Lawn (2004). A central idea is that we convert assignments into PDF-format (PDF Reference, 2001). This allows us to basically deal with all types of printable documents and therefore does not restrict the students either in format or application program. Further advantages of using PDF are that the documents are protected from change and that formatting and page layout remain unchanged. MarkTool offers a range of annotation features: graphical highlighting in various shapes and colours, textual comments optionally linked to the graphical highlighting, and a numeric tool entering and adding marks. All annotations are automatically stored in a database and the artefacts can be viewed with and without annotations. All document handling features are as expected from a PDF-reader program, including page management and zooming. At this stage MarkTool comes with a simple artefact management component. A class list, exported from our student management system, is imported and used to link artefacts to students. The status of each assignment can be set to 'not marked', 'in progress', 'review', or 'marked'. The current work on the MarkTool focuses on the development of a student-end for the viewing of marked assignments, the implementation of further features and on end-user testing.

The preliminary design for the web-based repository features fairly standard components of a web server, a relational database management system and a web-based user interface. The MarkTool currently is implemented as an application that could be downloaded to the user's computer. We envisage both online and offline modes to allow users to work independently from the web. This will require the definition of an XML schema for the marking information. With this, the marking information could be downloaded to the user's computer in XML format, stored there on a local database and uploaded again as XML data. On upload the annotation data have to be synchronised with other annotations for the respective artefact. This design would allow a student or marker to download artefacts of interest, do their assessment offline and then synchronise with a central repository.

Besides the technical components we have a small sample of twelve, electronically annotated and marked assignments from this year's data modelling class available for use in a first repository. We have gained informed consent from the authors of these assignments to use their artefacts anonymously in next years teaching. Now, where MarkTool is ready for use by a wider audience we will quickly gather more artefacts.

Conclusions

A review of the education literature clearly shows the benefits of formative assessment for learning. Many studies undertaken over the last years have demonstrated that formative assessment can be effectively supported by utilising web-based computer environments. Characteristic of formative assessment is that it requires open-ended response from the students and that multiple-choice style tests therefore are not sufficient. As a consequence automated marking is not possible and the assessment and here specifically the feedback has to be provided by a human marker. Open-ended responses lead to essay-type assignments that are used across all disciplines or subject areas.

The literature also shows that both in theory and practice a lot more needs to be done to improve the quality of formative assessment. One aspect here is the requirement to better educate and train staff providing formative feedback. Another aspect is the integration of formative assessment into the learning process.

In this context we have introduced the concepts of electronic repositories of marked student work. These repositories focus on the learning aspect of formative assessment. A central thought behind the repositories is to regard the students' marked work as a valuable resource. This resource should not only be used as a 'one-off' but should be retained and used with future students. The artefacts provided by students can serve as examples for the solution of tasks. As the literature states, both weak and strong solutions are valuable resources. Besides the artefacts the repositories contain the feedback provided by the marker, originally formulated for the submitting student. This feedback will guide students through their understanding of the example artefacts.

Besides advocating for the electronic repositories we suggest the marking of assignments in electronic format. We suggest a conversion of essay-type assignments into PDF-format and the marking of these assignments 'on screen'. Electronically stored marking annotations open up various possibilities both for the marking process and the flexibility in studying the feedback. An important side-effect of using an electronic marking tool is that the data produced while marking automatically are in the right format for inclusion in the repositories.

The technical implementation issues around on-screen marking and electronic repositories of marked student work can all be resolved. We already have developed a marking application, called MarkTool that allows

marking of electronic assignments in a style similar to the familiar 'pen-and-paper' techniques. System architectures with a web interface and database back-end are fairly common. We suggest such a standard architecture extended by XML data transfer to facilitate the option of working away from a network connection and subsequent synchronisation of data.

As demonstrated throughout the article the concepts of electronic repositories of marked student work fit in very well with educational theories. Yet, for this approach to be successful a number of issues have to be carefully considered. As with any eLearning initiative it is essential to ensure that the technology serves the pedagogy. The repositories need to be integrated well into the learning process. This includes careful selection of repository content, a managed process, possibly step-by-step, of granting access to the full repository data, and the involvement of the lecturer in guiding and monitoring the students. Assignments, feedback and marks need to be treated confidentially. Ethics requirements mean that permission needs to be sought to include material in the repositories. Initial informal inquiries among our students have shown that these are willing to give consent for their work to be used by future students. An important factor will be the level of comfort among lecturers and markers to expose their marking to a wide audience in a repository. Based on conversations with some of our colleagues we are prepared for at least an initial feeling of discomfort in this regard. On the other hand, the literature indicates that confidence in regard to marking grows with increasing knowledge about what constitutes high quality marking. This is paired with a call for better training of lecturers in marking, an issue taken up for example by our own university as a focus for staff development in the upcoming year. We see electronic repositories of marked student work as a tool to assist in this area and are confident that an initial resistance against using the repositories can be overcome.

To conclude, we see an enormous potential for electronic repositories of marked student work to contribute to formative assessment and to student learning.

References

Bhalerao, A., Ward, A. (2001). Towards electronically assisted peer assessment: a case study. *Association for Learning Technology Journal (ALT-J), 9* (1), 26-37.

Black, P., & William, D. (1998). Assessment and Classroom Learning. *Assessment in Education: Principles, Policy & Practice, 5* (1), 7-68.

BlackBoard (2003). Retrieved November 6, 2003 from http://www.blackboard.com/.

Brookhart, S. M. (2001). Successful Students' Formative and Summative Uses of Assessment Information. *Assessment in Education, 8* (2), 153-169.

Buchanan, T. (1998-99). Using the world wide web for formative assessment. *Journal of Educational Technology Systems, 27* (1), 71-79.

Cho, K., & Schunn, C. D. (2003). Validity and Reliability of Peer Assessments with a Missing Data Estimation Technique. In D. Lasser, & C. McNaught (Eds.), *Proceedings of Ed-Media2003 World Conference on Educational Multimedia, Hypermedia & Telecommunications., Association for the Advancement of Computing in Education* (pp. 1511-1514), Norfolk, USA: AACE.

Ecclestone, K., & Swann, J. (1999) Litigation and Learning: tensions in improving university lecturers' assessment practice. *Assessment in Education, 6* (3), 377-389.

Heinrich, E. (2004). Electronic Repositories of marked Student Work. In E. Kemp & D.Bailey (Eds.), Institute of Information Sciences and Technology Report Series (pp. 1-22), No 94, Palmerston North, NZ: Massey University, Retrieved June 4, 2004 from http://www-ist.massey.ac.nz/reports/public_reports/94/IISTReport.pdf.

Heinrich, E., & Lawn, A. (2004). Onscreen Marking Support for Formative Assessment. In L. Cantoni & C. McLoughlin (Eds.) *Proceedings of ED-MEDIA 2004 - World Conference on Educational Multimedia, Hypermedia & Telecommunications*, USA: AACE.

Heinrich, E., & Wang, Y. (2003). Online Marking of Essay-type Assignments. In D. Lasser, C. McNaught (Eds.), *Proceedings of Ed-Media2003 World Conference on Educational Multimedia, Hypermedia & Telecommunications. Association for the Advancement of Computing in Education* (pp. 768-772), USA: AACE.

James, M. (1998). *Using Assessment for School Improvement*, Oxford: Heinemann Educational Publishers.

Juwah, C. (2003). Using Peer Assessment to Develop Skills and Capabilities. *Journal of the United States Distance Learning Association, 17* (1), 39-50.

Kemm, R. E., Williams, N., Fritze, P., Kavnoudias, H., & Stone, N. (2001). Learning of key scientific concepts in a web-based on-campus collaborative learning environment. In C. Montgomerie, J. Viteli (Eds.), *Proceedings of EdMedia 2001* (pp. 914-919), USA: AACE.

Klenowski, V. (2000). Portfolios: promoting teaching. *Assessment in Education, 7* (2), 215-236.

Kluger, A. N., & DeNisi, A. (1996). The Effects of Feedback Interventions on Performance: A Historical Review, a Meta-Analysis, and a Preliminary Feedback Intervention Theory. *Psychological Bulletin, 119* (2), 254-284.

LOM (2003). Learning Technology Standards Committee, Retrieved November 13, 2003 from http://ltsc.ieee.org/wg12/index.html.

McLoughlin, C., Northcote, M., & Marshall, L. (2003). Assessment Online: New Horizons and Blue Skies. In D. Lasser, C. McNaught (Eds.), *Proceedings of Ed-Media2003 World Conference on Educational Multimedia, Hypermedia & Telecommunications. Association for the Advancement of Computing in Education* (pp. 2460-2463), USA: AACE.

Nokelainen, P., Kurhila, J., Miettinen, M., Floreen, P., & Tirri, H. (2003). Evaluating the Role of a Shared Document-based Annotation Tool in Learner-Centered Collaborative Learning. In V. Devedzic, J. M. Spector, D. Sampson, Kinshuk (Eds.), *Proceedings of The IEEE International Conference on Advanced Learning Technologies* (pp. 200-203), Los Alamitos, CA: IEEE Computer Society Press.

Northcote, M., & Kendle, A. (2001). Online Assessment Criteria in Action: Task Design in Contrasting Tertiary Education Contexts. In C. Montgomerie, J. Viteli (Eds.), *Proceedings of EdMedia 2001* (pp. 920-924), USA: AACE.

PDF Reference (2001). *Portable Document Format, Version 1.4, PDF Reference Third Edition*, Boston, USA: Addison-Wesley.

Renkl, A., & Atkinson, R. K. (2002). Learning From Examples: Fostering Self-Explanations in Computer-Based Learning Environments. *Interactive Learning Environments, 10* (2), 105-119.

Schuck, S. (2003). Help Wanted, Please! Supporting Beginning Teachers Through an Electronic Mentoring Community. In D. Lasser, C. McNaught (Eds.), *Proceedings of Ed-Media2003 World Conference on Educational Multimedia, Hypermedia & Telecommunications* (pp. 1904-1911), USA: AACE.

Sclater, N., & Howie, K. (2003). User requirements of the ‘‘ultimate’’ online assessment engine. *Computers & Education, 40*, 285–306.

Sitthiworachart, J., & Joy, M. (2003). Web-based Peer Assessment in Learning Computer Programming. In V. Devedzic, J. M. Spector, D. Sampson, Kinshuk (Eds.), *Proceedings of The IEEE International Conference on Advanced Learning Technologies* (pp. 180-184), Los Alamitos, CA: IEEE Computer Society Press.

Sivan, A. (2000). The Implementation of Peer Assessment: an action research approach. *Assessment in Education, 7* (2), 193-213.

Sung, Y.-T., Lin, C,-S., Chiou, S.-K., & Chang, K.-E. (2003). Using Web-based Progressively Focused Self- and Peer- Assessment to Enhance Students’ Reflective Thinking and Performance on Hypermedia Design. In D. Lasser, C. McNaught (Eds.), *Proceedings of Ed-Media2003 World Conference on Educational Multimedia, Hypermedia & Telecommunications* (pp. 1867-1870), USA: AACE.

Topping, K. (1998). Peer assessment between students in colleges and universities. *Review of Educational Research, 68* (3), 249-276.

Tsai, C.-C., Lin, S. S. J., & Yuan, S.-M. (2002). Developing science activities through a networked peer assessment system. *Computers & Education, 38*, 241–252.

WebCT (2003). Retrieved November 6, 2003 from http://www.webct.com/.

Wen, M. L., & Tsai, C.-C. (2003). College Students' Perceptions of and Attitudes toward Online Peer Assessment. In D. Lasser, C. McNaught (Eds.), *Proceedings of Ed-Media2003 World Conference on Educational Multimedia, Hypermedia & Telecommunications* (pp. 1883-1888), USA: AACE.

Wilson, E. V. (2004). ExamNet asynchronous learning network: augmenting face-to-face courses with student-developed exam questions. *Computers & Education, 42* (1), 87-107.