

Onscreen Marking Support for Formative Assessment

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Abstract: This article addresses the possibilities of supporting formative assessment with eLearning tools. The context between formative assessment, summative assessment and tools in current eLearning environments is established before concepts for an onscreen marking tool, called MarkTool, in support of formative assessment are developed. The consultation process regarding onscreen marking and the resulting requirements for the MarkTool are described. This is followed by a report on first experience with using onscreen marking. The article then explores issues that need to be addressed for the wider application of onscreen marking. Finally, extensions to onscreen marking developing electronic repositories of marked student work are introduced that have the potential to positively impact on student learning and on the quality of marking feedback.

1 Introduction

It is widely recognised that formative assessment is highly beneficial to learning (Black and Wiliam, 1998; Brookhart, 2001; Ecclestone and Swann, 1999, James, 1998; Juwah, 2003; Topping, 1998). The main characteristics of formative assessment are to identify the gaps between actual and target level of knowledge and to develop plans for closing these gaps. Formative feedback is the mechanism via which this information is delivered from the teacher to the student. While an assessment technique the main focus of formative assessment is on learning. To effectively support learning it is important that students not just select from pre-fabricated answers but develop their own thoughts and construct their own answers. Additionally, it is essential that the feedback provided is carefully worded to help the students to identify weaknesses and strength in their understanding of the subject matter and to guide them towards steps for improvement. With these characteristics of formative assessment it is clear that multiple-choice style testing, automated marking and automated generation of feedback are not suitable techniques for conducting formative assessment. Formative assessment is linked to open-ended questions, essay-type submissions and human markers. Detailed information on formative assessment can be found in any of the publications referenced at the beginning of this section.

The task we have set ourselves in the research project reported on here is to investigate how we can utilise computer technology to support formative assessment. We regard this as a very important and interesting task:

- Formative assessment is used across all disciplines and educational levels. These disciplines specifically include non-technical areas like the social sciences, the humanities and education for which only very limited technical support is available.
- Current approaches related to eLearning hardly support formative assessment while tools supporting summative assessment are widespread (e.g., the online tests in learning management systems like WebCT, 2003, and BlackBoard, 2003).

Into the foreseeable future it will not be possible to automate formative assessment. For long time to come it will be necessary to use a human marker to understand the work submitted by the students and to construct feedback conducive to learning. Because of this we are looking into approaches to support the human marker in performing formative assessment and we do not attempt to automate formative assessment in any way. We aim to replicate techniques that have proven themselves in the pen-and-paper world and to add the strengths of computer systems in storing, searching and retrieving information.

At the centre of our approaches is the idea of an onscreen marking tool that was first presented in Heinrich and Wang (2003). Student assignments are converted into PDF documents and annotated with formative feedback on the computer screen by human markers. The PDF format was chosen as it is universally used, 'freezes' documents in their form submitted by the students and allows the development of a tool independent from the application programs the students have used to write their assignments. In the paper presented here we extend the original work. Over the next sections we focus on the requirements gathering we have undertaken, describe the development of a new application, called MarkTool, report on first user feedback, identify issues to be overcome for wider use of onscreen marking, and develop proposals for wider support for learning from formative assessment.

2 Requirements gathering

The original onscreen marking prototype tool had been developed without formal consultation with users. We have addressed this point now and have conducted meetings with a variety of members of the university community. Based on these meetings we have developed requirements and a shortlist of most important features for an onscreen marking tool. These consultations have assisted us as well in identifying procedural and institutional aspects that need to be considered for using a computer supported assignment environment and we report on these issues in a later section of this paper.

2.1 Meetings with members of the university community

We scheduled two types of meetings. In the first type of meeting we explained the basic concepts of our work and used the prototype tool to demonstrate our ideas. In the discussions following our demonstrations our core ideas were validated by the participants in principle and a rich variety of issues were brought forward. In the second type of meeting we presented our understanding of which features our colleagues had suggested, ranked by priority. Again, discussion evolved and gave valuable insights. About fifteen different colleagues attended either one or both types of meetings. These colleagues came from different university areas – education departments, English and media studies department, computer science department, training and development unit, university administration, distance education – and different levels from tutors to professors. All individuals had extensive experience with marking of assignments and with assessment in general.

2.2 Examples of issues discussed

From the many areas discussed we want to highlight the issues relating to the two areas of annotations and marks. We started our discussion on annotations with the following understanding:

- An annotation consists of two components: a graphical component that indicates to which exact area of the assignment the annotation refers; a textual component that provides the main message of the annotation;
- The graphical and textual components are linked.

We regard it as very important to be able to see the textual components in close proximity to their reference points. This makes it much easier for the students to study the comments provided by the markers in context to their own work. This principle of close proximity is supported by Renkl and Atkinson (2002) who, writing about ‘worked-out examples’, demand that explanations should be provided on the same page as the examples they explain. Starting from these assumptions the following issues were discussed and agreed on:

- Textual components: placed in close proximity to their reference point at a position determined by the marker, preferably over ‘white space’; for longer comments additional pages might have to be inserted into the PDF document to create space for the comment; option for listing all comments together at the end of the PDF document; Figure 1 shows style options for textual comments from Adobe Acrobat (Adobe, 2003), the Jaws PDF Editor (Global Graphics, 2003) and our own MarkTool;
- Linking of graphical and textual components: adding these two components has to be convenient for the marker; it should be a ‘one-flow-motion’ – highlight an area, determine where to put the textual component, type the text; there has to be a visual link between the graphical and textual components;
- Colours, shapes, and fonts: the marker should be able to choose colours and shapes for both graphical and textual components; the marker should be able to choose font type and size; different styles and appearances of annotations might be used for categorisations of feedback;
- Editing: it has to be possible to perform all the usual editing operations on both graphical and textual components – copy & paste, delete, resize, change appearance.

While formative assessment focuses on learning it is still common practise to assign marks to individual sections or content aspects of an assignment and to use the overall mark given to contribute to the grade for a subject or paper. There was agreement among our colleagues that an onscreen marking tool would have to have the facility to record marks and to add up these marks. Beyond that there was a somewhat surprising variety of techniques used among the people present in our meetings:

- Format of individual marks: styles commonly used are numerals, numerals with upper boundary or symbols (see Figure 2 for examples);
- Placement of individual marks: the individual marks are put at the exact location of where they were earned, at the start/end of a section/answer, or on a separate marking sheet showing all individual marks for a piece of work;

- Mark allocation: while most people add marks for good points in the assignments some deduct marks where a not one hundred percent satisfactory answer is given; some people work with fixed upper boundaries yet others allow for bonus points.

Based on this variety of preferences it certainly looks like that there will be no 'one-fits-all' solution. For our current MarkTool we therefore decided to initially only implement a minimal solution of displaying individual marks and keeping automatically track of the total sum of marks given. Figure 3 shows the relevant components of the MarkTool. A fuller version of the MarkTool would have to allow for the definition of a marking scheme, the selection of presentation styles plus a specification of the amount of control and checking the software is supposed to exercise.

2.3 Positive aspects of onscreen marking

We discussed a variety of positive aspects of onscreen marking. Some of these were:

- Elimination of handwriting: in the long term the physical strain of handwriting is much stronger than that of typing; onscreen marking with comments that are typed is therefore easier to handle; typed comments are much easier to edit during the marking process; typed writing is in most cases much easier to read for the students than handwriting;
- Lists of frequently used comments: these lists can be developed during the marking process (or can be re-used from previous assignments); these comments can be selected to save time or achieve consistency; they can be adjusted to suit the current context perfectly (lists of frequently used comments are maintained by some colleagues currently and are then edited to provide feedback to students; yet what is missing in their systems is the context, the link to the exact position in the assignments to which the comments refer to);
- Assistance for the marking process: assignments can be easily assigned a status (to be marked, in progress, review ...) that assists in managing the marking process by allowing sorting of assignments according to status or selection of assignments for review by oneself or others;
- Guidance and supervision of markers: onscreen marking works on electronic copies of assignments; all annotations and marks are not hard coded onto the scripts but stored separately in databases; the original assignment is retained unchanged and therefore can be, for example, marked in parallel by multiple markers; this allows the lecturer responsible to develop a training procedure for markers that aims at consistency across markers;
- Elimination of delays from paper handling: if assignments are submitted, marked and returned in electronic format delays caused by handling paper copies are eliminated; electronic handling would be convenient for most students and the elimination of postal delays would certainly be welcomed by distance students.

Admittedly, the colleagues who were prepared to participate in the consultation process are people with a positive attitude towards marking on the computer screen that certainly is not shared by everyone. Yet, when we presented

Note 18/12/2003 12:16:52 p.m. x
ehleinric
This doesn't match the relationships you have drawn

Attributes	Keys	Data type	Null support
Actor ID	PK, FK	Character	Not null
Awards ID	PK, FK	Character	Not null
Character ID	FK	Character	Not null

Annotation with Adobe Acrobat 6.0 Professional

Information Technology Services 18/12/2003 x
This doesn't match the relationships you have drawn

Attributes	Keys	Data type	Null support
Actor ID	PK, FK	Character	Not null
Awards ID	PK, FK	Character	Not null
Character ID	FK	Character	Not null

Annotation with Jaws PDF Editor

This doesn't match the relationships you have drawn

Attributes	Keys	Data type	Null support
Actor ID	PK, FK	Character	Not null
Awards ID	PK, FK	Character	Not null
Character ID	FK	Character	Not null

Annotation with MarkTool

Figure1: Annotation styles of PDF editing programs



Figure 2: Different styles of indicating marks

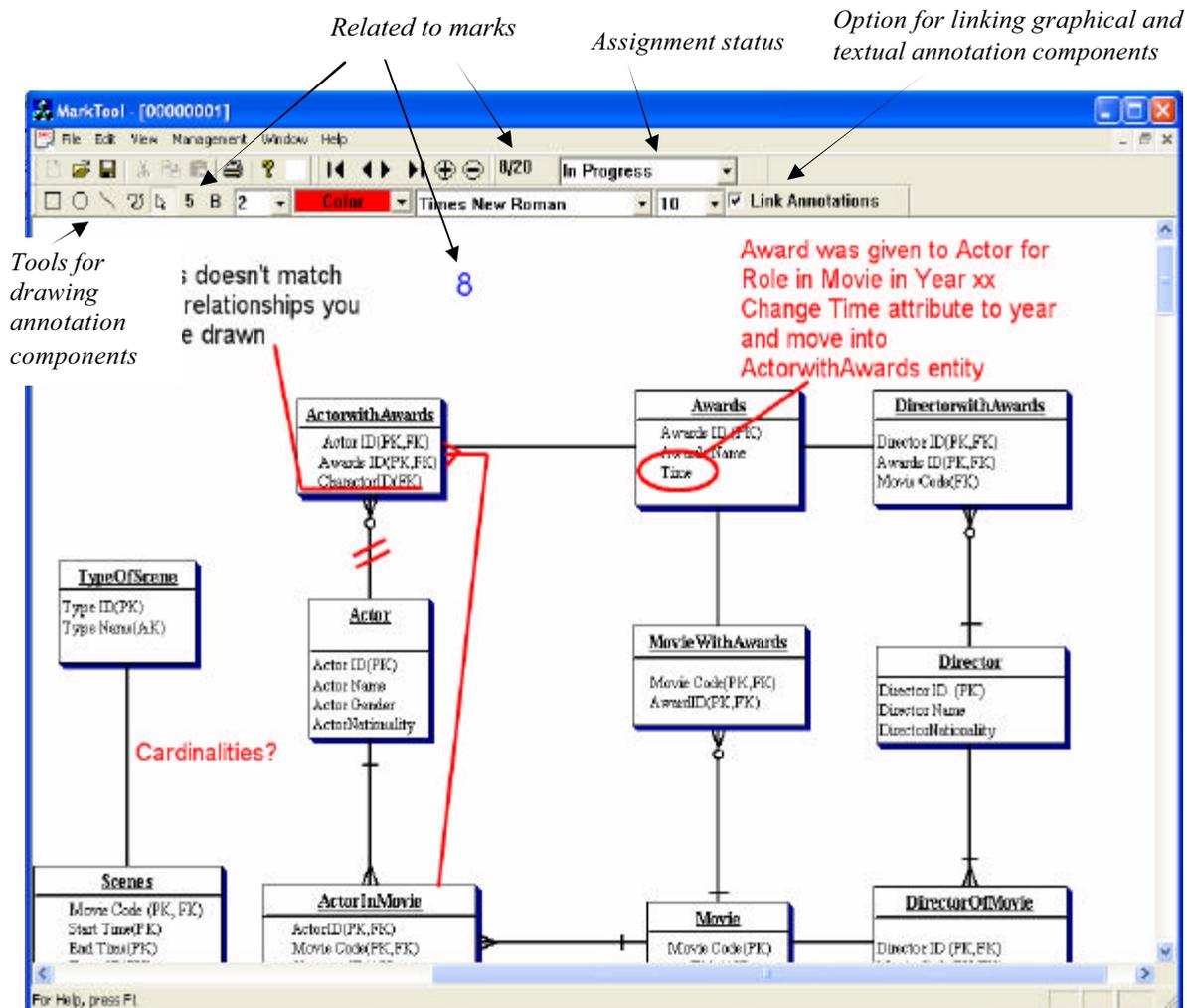


Figure3: Screenshot of the MarkTool with explanations

the concepts of onscreen marking in a workshop at the recent Tertiary Education Research in New Zealand Conference (TERNZ, <http://www.hedc.otago.ac.nz/ternz/2003/index.html>), to a more general audience we received a fairly similar positive feedback.

2.4 Administration of assignments for onscreen marking

Before assignments can be assessed and marks recorded some administration tasks have to be fulfilled. It has to be recorded who submitted which assignment (which file in electronic submission), it has to be checked if this submission was on time and if it is in a suitable format that can be read by the MarkTool (or can be converted in such format). If multiple markers work together markers have to be allocated assignments and approaches like peer-marking and -monitoring could be introduced and managed. The assignment status could be incorporated in such a system. Once the assignments are marked, the total marks have to be recorded. It might be suitable to attach an electronic marking sheet to each assignment. Assignments annotated with feedback and marks have to be made available to the students. Throughout these procedures student work and marking information have to be protected from unauthorised access and secured against data loss.

2.5 The student end

Once the marking is finalised students have to gain access. In the simplest form this can be done by returning one document to the students that contains their assignment together with annotations and marks. While this would be

sufficient initially, we envisage a more sophisticated system. An electronically stored assignment with electronic, separately stored marking comments allows for more possibilities. Students could have choices in which way they view the annotations. This could mean looking step-by-step at annotations of different categories (like conceptual comments, format issues, key points, ...) or looking at comments made by different markers separately. Another extension possibility would be to facilitate interactivity. A student could select a comment, add a response or question to it and start a dialogue with the marker without losing the anchor point in the assignment.

2.6 Shortlist of most essential features

As demonstrated the discussions with our colleagues brought up a wide range of desired features and variations for an onscreen marking tool. From there we developed a shortlist of most essential features for implementation in our MarkTool:

- Annotations with textual and graphical components: as these are the core of the MarkTool they were included in full as outlined above;
- Possibility to record and calculate marks: we settled for the reduced version as stated above;
- Simplified management tool: we specified that the MarkTool has to be able to import a class list (in CSV format) generated by our student management system, to facilitate linking of assignment (PDF file) with student id/name, to record the status of the assignment, and to export a list of students names/ids with their marks;
- Simplified student end: initially, the MarkTool has to be able to print assignments with annotations and marks, and to integrate the annotations and marks into a new PDF file; this new PDF file (containing assignment and marking information) can then be given electronically to the students who only require a standard PDF reader to view it.

While this shortlist addresses the most important features it omits a number of interesting items that should be implemented in future versions of the MarkTool. These omitted items include the list of frequently used, shared comments, the selective viewing of comments as an extension to the student end, using the status field to sort assignments, or support for marking related communication with the students .

3 Development of the new onscreen marking application

Based on the shortlist of most essential features developed in consultation with colleagues around the university we proceeded to implement our new onscreen marking application, the MarkTool. As we had decided when implementing our earlier prototype application (see Heinrich and Wang, 2003), we again went for implementing our own application. To come to this decision we investigated existing PDF commenting applications and searched for other work that builds some eLearning support around assessment.

3.1 Existing PDF commenting applications

The most prominent application in this area is Adobe Acrobat (Adobe, 2003), followed by applications like the Jaws PDF Editor (Global Graphics, 2003). Our arguments, presented here in brief, relate to Adobe Acrobat 6.0 Professional:

- Exact fit for requirements: our requirements analysis established that an important part of the feedback to students are the graphical annotations with their possibilities to highlight the exact reference point in the assignments – Acrobat offers only limited options here with its comment icon (see Figure 1); further, we need the option to give marks and keep track of these with subsequent development of the incorporation of a marking scheme – Acrobat does not offer this;
- Specialised marking features: Acrobat is a general purpose application; while it offers a very rich set of useful options many of these would need to be adapted to fit marking requirements exactly; an example for this is the way Acrobat separates comments into types according to technical characteristics like notes, drawings, text and stamps; while the selective viewing of comments is very useful we would need a separation either according to feedback type, e.g., reinforcement, explanation of a mistake or hint for improvement, or according to problem group, e.g., conceptual, language, or layout, or according to subject classifications of the assignment domain; we want to offer our users a specialist marking tool that very closely supports marking tasks and does not overwhelm our users with general purpose features;
- Need for integration with a class management tool: Marking assignments for a whole class of students requires a range of management tasks like monitoring submissions, linking class members with electronic assignments, sharing assignments among markers, adding marking sheets, or feeding marks back into a student management system; Acrobat does not support these task;
- Full control over annotations: looking ahead to features we plan to implement into our marking tool we require full control over our annotations; to give an example, we want to support various forms of scaffolding;

scaffolding provides students with a stepping stone, gives them some help without presenting the full solution; our annotations exist of two parts, the graphical and textual components; for scaffolding we will present students initially with only the graphical annotations; these will point students to parts of their assignments that, for example, contain mistakes and have been commented on by the markers; with these hints the students can attempt for themselves to understand what mistakes they have made before reading the full textual comments given by the markers (more on these ideas can be found in Heinrich, 2004a and 2004b); Acrobat does not give us enough control over its comments to provide such features.

3.2 eLearning support around assessment

We have searched widely in the literature to find work like ours for the support of formative assessment of essay-type student work. We have not found anything that, in our opinion, comes very close. What we have found are several web-based approaches to support combinations of automated marking and human feedback. Some of these are studies by Nokelainen et al. (2003), who report the use of a document-based annotation tool for learner-centred collaborative learning, by Sitthiworachart and Joy (2003), who discuss a web-based peer-assessment approach to support students' learning of programming, or by Bhalerao and Ward (2001), who advocate the use of multiple-choice tests combined with peer-assessment of free response questions.

3.3 Our development environment

Our criteria for the selection of the development environment included credibility and stability. We decided on using Ghostscript libraries. Our target platforms for the MarkTool are Windows XP and 2000 systems (as the marked assignments will be exported into PDF format they can be viewed on any platform). At this stage in the project we are developing a standalone marking application. As we have outlined in the section on requirements gathering we are implementing initially only a simple management environment. The student assignments have to be converted into PDF format outside the MarkTool and are stored in a directory specified by the user. A class list can be imported into the MarkTool and the MarkTool offers support for matching students and assignments. Based on this information, that is the directory information, the assignment filenames and the class list, the MarkTool generates the required database information in Microsoft Access format. We have chosen Access as the required libraries are included with any Windows XP and 2000 installations. The user of the MarkTool interacts with the databases only via the MarkTool.

We are aware that using a local, unprotected database might not fulfil the security requirements of an ultimate marking application. Covering security fully will be one of the steps required for further work. Currently we are relying on the restrictions of access to a staff computer to protect the marking information which is similar to restricting access to marked paper assignments stored in an office. In the longer run we are planning on using a combination of local database with XML-supported upload to a secure database management system. The considerations behind this setup are, in brief, the simplicity and convenience of a local system for the marker combined with the security and sharing capabilities of a networked database management system. Figure 3 shows a screenshot of the MarkTool annotated by explanations of its features.

4 First testing of onscreen marking

During the last semester we have used the MarkTool to annotate some of the assignments produced by students of our data modelling course. The students produced on average about three A4 pages displaying entity relationship diagrams and textual information. We marked about twelve assignments electronically and the figures in this article display examples. We had received some of the assignments in electronic format and some on paper. Where required we scanned and/or converted the assignments into PDF format.

In this first test of onscreen marking with our MarkTool we focussed mainly on two aspects:

- Can we do everything we are used to doing with pen and paper?
- Can we do our marking conveniently?

We can answer these two key questions positively. Using the graphical annotations we could highlight exactly where our comments referred to. That was essential as in an entity relationship diagram details are important (like the setting of keys or the cardinality symbols) and correct and incorrect items are in close proximity (like a correct and an incorrect attribute in the same entity). The way to link graphical and textual components of an annotation in one flow worked very well. With the MarkTool one draws the graphical component and then drags a link to the position of the textual component. Positioning the textual component oneself allows utilising the white space on the assignments very well.

We enjoyed being able to type instead of handwrite our comments. Typing is faster, less strenuous and facilitates copy & paste. Another very important aspect is that electronic comments can be easily modified during the marking

process. When we study a data model produced by a student we have to consider many aspects of the diagram and the accompanying textual explanations and our understanding of the student work only evolves gradually. With electronic annotations we can start commenting immediately, knowing that we very easily can go back and modify an annotation. We currently have several colleagues exploring onscreen marking using the MarkTool.

5 Steps required to formally introducing onscreen marking

At this stage in our project we are working with enthusiastic colleagues who are willing to experiment with new eLearning approaches. This experimentation requires not only goodwill from colleagues but also from students who have to be prepared to submit their assignments electronically. In a large number of courses at our university electronic submission of work is not stipulated formally – and this might especially applies to courses in our non-technical subject target areas. We have met positive responses from students willing to participate and see no problems in experimenting with onscreen marking.

Yet, the formal introduction of onscreen marking into a course will have to be conducted carefully. As pointed out by senior university management equal access for students and security issues have to be considered. If we require students to submit assignments electronically and if we only return electronic versions of marked assignments we have to ensure that every student has sufficient access to all hardware and software required. Further, we have to develop mechanisms that guarantee the security of the electronic submissions. This includes making sure that we link students and assignments correctly, that we safeguard against loss of files and modification after submission, and that we prevent unauthorised access to the assignments. While these issues have to be taken seriously they can be overcome by selecting the right technologies and developing appropriate procedures. Classification of courses as ‘web-based’, selection of document formats like PDF that protect against modification, and an integration with learning management systems and their secure assignment submission will all be components of a solution that resolves the issues mentioned.

6 Extensions to the concept of onscreen marking

In the article presented here we focus on onscreen marking and the tool we have developed to support this activity. In parallel work we have extended the concepts described here and have reviewed the educational literature on formative assessment and feedback to firmly ground our ideas. We can only introduce these ideas briefly here but a fuller version can be found in Heinrich, 2004a and 2004b.

It is very common in teaching that fundamental concepts remain unchanged from year to year. Assignments often use examples to allow students to explore the concepts and demonstrate their understanding. The markers spend a considerable amount of time to provide, hopefully, high quality feedback to the students. What we want to do is to use the marked assignments of one year as learning resources for next year’s students. This idea is supported in principle in the educational literature and in itself is not new. What is new is that we want to build electronic repositories of marked student work that are based on the electronically marked assignments. If we do this we gain a whole range of advantages from universal access to opportunities for scaffolding and collaboration.

The educational literature fairly strongly criticises the quality of feedback provided to students in general and demands steps to improve this quality. What we plan to do is to not only use our repositories of marked student work to teach students subject knowledge but to as well use the repositories for training staff in providing high quality feedback. The marking annotations in the repositories can be used to demonstrate high quality feedback. Training approaches can be built that allow staff to learn about providing feedback in a supportive and possibly confidential environment.

7 Conclusions and future work

In this article we have outlined our approach to supporting human markers in conducting formative assessment. Formative assessment is a most valuable educational instrument that currently enjoys only very little support through eLearning tools. We have introduced concepts and our new onscreen marking tool, called MarkTool. We have outlined how we arrived at its specification through consultation with colleagues around the university. Initial tests with onscreen marking have proven promising.

To make onscreen marking a success enjoyed by a wider group of colleagues we still have plenty of work ahead of us. Currently, the MarkTool is undergoing intensive testing and we will have to integrate feedback on both concepts and implementation into new versions. Additionally, we have a range of extensions like improved assignment management and collaboration tools identified that are awaiting implementation.

Besides paying attention to these more technical issues we are highly interested in looking at how onscreen marking can have a positive impact on learning. We have identified opportunities in using electronic repositories of marked

student work as learning material and in developing repository based training approaches to lift the quality of feedback provided to students.

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