Using online annotation software to provide timely feedback in an introductory programming course ⊗

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Abstract - **Research has shown that that targeted and timely feedback of student work is critical to successful knowledge and skill acquisition. However, when instructors and students encounter Learning Management Systems (LMS) such as Blackboard, they quickly discover one area that these systems lack is an easy way to provide such feedback. Multiple steps are usually required to accomplish the task. What are needed are better task-specific tools and applications that allow teachers to provide not only timely but targeted feedback. This paper reports on the design, development and the deployment of an online annotation software, RedPencil within a Java programming class.**

Index Terms - annotation technologies, feedback, and usability, RedPencil

INTRODUCTION

Numerous studies and reports have documented the tremendous increase in the development and delivery of instruction through the use of network-based technologies. In particular, colleges and universities have enthusiastically embraced these modes for delivering instruction. Carnevale [1] reported that distance education courses increased by 72% from 1995 to 1998. The National Center for Educational Statistics [2] found in a more recent survey (2000-2001) that more than half (56%) of all undergraduate schools (2 and 4 year) nationwide were offering online coursework. Another 13% indicated that they planned to start in the upcoming year. In addition to colleges and university, business and industry have also embraced the idea of online learning so that "e-learning has emerged as a promising solution to lifelong learning and on-the-job work force training. Effective and efficient training methods are crucial to companies to ensure that employees and channel partners are equipped with the latest information and advanced skills"[3, p. 1].

Even though technology may improve access to instruction, students have had a dismal success rate for online courses. Carr [4, p.1] reported "anecdotal evidence and studies by individual institutions suggest that course–completion and program–retention rates are generally lower in distance–education courses than in their face–to–face counterparts". The situation is probably even more acute because most online delivery environments force teachers and students to adapt to the constraints imposed by the system. This is keenly brought home by the difficulties that teachers and students encounter when using Learning Management Systems (LMS) such as Blackboard or WebCT. One capability that these systems lack is an easy way to provide timely feedback. If offered they, usually require multiple steps to accomplish the task. What are needed is task-specific tools and applications that allow teachers to teach and students to learn.

Research [5] has shown that that targeted and timely feedback of student work is critical to successful knowledge and skill acquisition. This paper reports on the design, development and delivery of RedPencil, a web-based application created to provide timely online feedback and critique of student assignments

ANNOTATION TECHNOLOGIES

The annotating of documents is a time-honored practice that dates back to the beginning of writing itself. In documents from the Egyptian Pharaoh to the Hittite Kings, scribes would insert marginal comments to their counterparts. Medieval scholars inserted textual glosses that attempted to provide insight into the meaning of a difficult passage. Teachers (especially of high school English) would provide mechanical and conceptual feedback by inserting comments in a student's homework.

Given the multitude of purposes and types of annotation "it is no surprise that annotation technologies are similarly based on a range of models" [6, p. 476]. According to Wolfe [6] there are seven primary factors that classify annotation software: input, interface, base-text, anchor, storage, searching/filtering, and specialized behavior. These seven factors cover the gambit of technologies ranging from standalone systems to network-based systems.

The process of marking up documents can vary widely. Systems such as Microsoft Word's Track Changes or Adobe's Acrobat use a local proprietary file system, which requires the use of either a Word or PDF file. Over the past few years, there have been attempts to develop online systems that allow for a more collaborative markup system. For a complete

⊗ Portions of this paper were presented at
Washington Interactive Technologies Conference Arlington VA 2004

review of online systems, see Wolfe [6] or Heck, Luebke, and Obermark [7].

Many collaborative network based annotation systems have similar features – they allow the insertion of comments into a document. Nonetheless, each system has it own idiosyncrasies. For example, Third Voice requires the Internet Explorer browser and can annotate only a web page. iMarkup requires Internet Explorer but allows the use of a graphic based markup tool. Further, according to Wolfe [6] annotation technologies have a short half life – "Unfortunately, many annotation programs are funded by research grants, and support for the program discontinues once the funding runs out" [6, p. 493].

Based on the 7 factors as illustrated by Wolfe [6], RedPencil is annotation software that embeds an intra-textual icon as its markup system. More specifically:

Input. RedPencil primarily uses the keyboard and the mouse for user input. However, given the rich features in Java other forms of data input could be considered in the future.

Interface. RedPencil uses an intra-textual icon to indicate a response. The student simply clicks on the "pencil" and the system displays a text window containing the reviewer's comments.

Base-text. Simple text is the base-text format for RedPencil.

Anchor. The anchor in RedPencil is currently the pencil icon. The icon is associated with the text by proximity. Further developments in regard to the anchor are to allow the underling of the text in conjunction with the icon. Additionally, we plan to research whether different icon images have an impact on the quality and type of feedback. For example, a specific icon image might indicate to the student a spelling or mechanical error while the pencil image may indicate a more general and conceptual response to the writing.

Storage. RedPencil is a server–based system and stores the submitted homework document separately from the annotated markup-file.

Filtering and searching. At this point RedPencil does not support filtering or searching. In the future, searching techniques may be added. However, instead of a generalized search strategy a specific filtering technique would be more appropriate. For example, it has been suggested that enabling a filtering by assignment could possibly reduce the cognitive overhead and provide better feedback.

Specialized behavior. RedPencil uses a technique similar to "sticky notes". A textbox is attached to a portion of the document (see Figure 1).

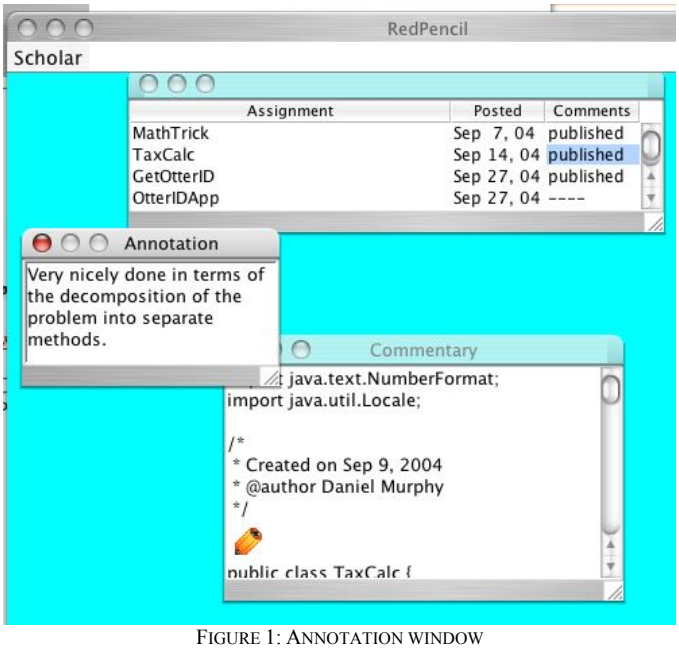

FIGURE 1: ANNOTATION WINDOW

According to Wolfe [6] sticky-notes are inferior because they "often obscure the underlying text"(p. 485). However, the text window in RedPencil floats, so it can be easily moved out of the way if it obscures any text.

DESIGNING REDPENCIL

There were two major design goals for the development of RedPencil. First the design used an open system approach which addresses one of the major issues as cited by Wolfe - application obsolesce. An open system approach requires the use of standard, non-proprietary development tools. Therefore, the user interface for RedPencil was developed in Java 1.4.2 and php 4.3.7. Data design was created using standard XML in conjunction with a MySQL database server.

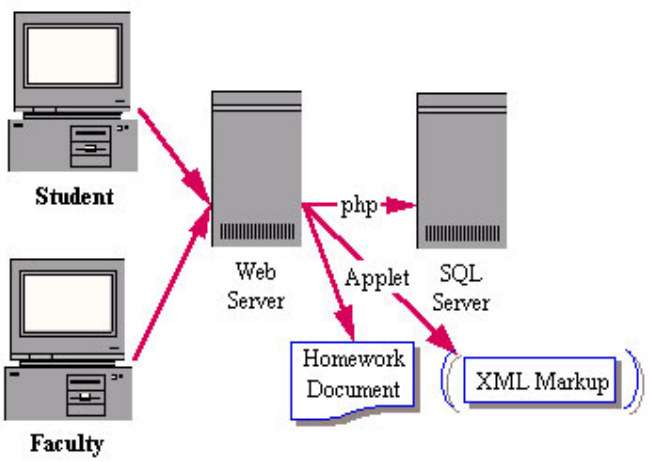

FIGURE 2: ARCHITECTURE

Secondly, the goal was to make the application transparent and easy for both faculty and students to use. With this goal in mind the prototype was developed with a

minimal feature set oriented to the needs of online instructors and students.

*System Design***.** RedPencil was designed using an open system approach. A major design goal was for RedPencil to be transparent and easy to use. In order to achieve this goal it was determined early in the design cycle that users would not download or install software. Therefore, as illustrated in Figure 2, the system was designed as a web-based application.

In contrast to many other annotation systems, RedPencil restricts user access. Therefore, the system requires a security login, which determines the status of the user in order to provide access to the various elements in the system. Once in the system, a student for example can upload assignments and check their progress. Faculty can access the assignment and provide feedback within the document. In any event, the process of submitting, reviewing and posting of assignments is streamlined.

For example, the student prepares and posts an assignment to RedPencil. The instructor views the assignment and can proceed to provide feedback directly online. Once the instructor publishes the feedback, the student has access to it immediately online. Further, RedPencil provides a status report of the transactions while storing the original online.

*Data Design***.** The design of the data is based on the notion that the model and view are separate. Separating the original file from the data markup file gives RedPencil tremendous flexibility.

Currently, RedPencil annotates only text-based files but will eventually be able to deal with different file formats such as rtf and pdf as well as image files such as GIF or JPEG. RedPencil uses XML to model the resulting markup file as illustrated below in Figure 2.

```
<?xml version="1.0" encoding="UTF-8" ?>
 <!DOCTYPE commentary (View Source for full doctype...)>
- <commentary>
    <targetFile>Nunez_Exp1_1387</targetFile>
    <location>40550/published/</location>
   - <markup>
     - <notation>
        <author>Terence</author>
        <index>1672</index>
        <comment>The reason is because we
            defaulted the position to the
            center of BorderLayout() - if we
            do that then the component fills
            the entire space of the applet.
        </comment>
      </notation>
    </markup>
</commentary>
```

FIGURE 2: REDPENCIL.MARKUP FILE

The markup file is only indirectly linked to the original document. This provides RedPencil a high level of flexibility in dealing with the various markup issues. By using a non-proprietary file format RedPencil can be easily adapted in the future to deal with many different file types.

*Interface Design***.** The design of the RedPencil interface was constrained by the need for transparency and functionality. The application had to be very easy to use and relatively self-explanatory requiring minimal training.

The primary impetus behind the interface design and development was to make it easy for faculty to provide feedback to students who submitted their homework online. Therefore, to provide appropriate and targeted feedback an intra-textual markup system was chosen.

The intra-textual markup system uses a dynamic icon as the indicator for the faculty comments (see Figure 3). Students and faculty can easily identify the pencil icon as the feedback indicator to specific elements within the document. This approach seemed to provide the most flexibility for the widest possible assignments, which could range from software code to formal proposals.

It was also decided that RedPencil should be a web-based application making more universally accessible.

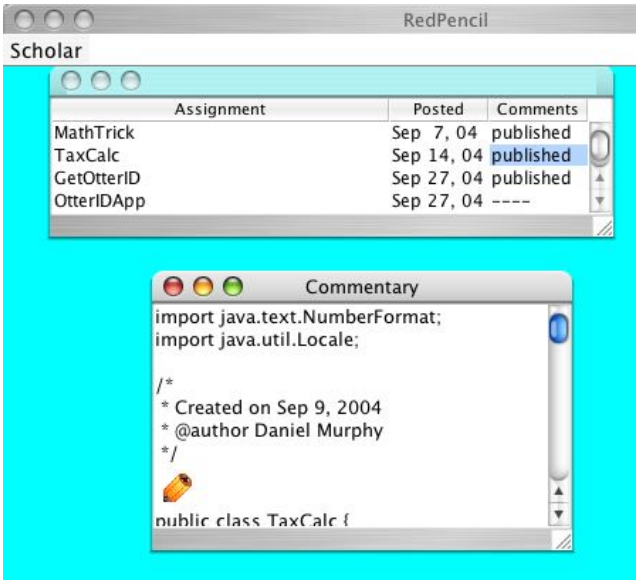

FIGURE 3: INTRA-TEXTUAL MARKUP SYSTEM.

PHP and Java are the underlying technologies used to design the user interface. PHP makes it easy to create a simple web-based interface that authenticates both the faculty and the students. (Figure 4)

FIGURE 4: AUTHENTICATION

Additionally, php was an excellent choice because it

provides a convenient mechanism for document uploading coupled with its ability to interface with SQL databases.

Java was chosen as the actual document-processing interface not only because of its ability to deal with multiple file formats but also because of its rich interface design elements. Further, Java allows easy access to standard SQL databases and can array the data within a table that is quickly accessible. For example, in Figure 3, the students can easily track the status of an assignment under review. Further, Java is becoming a truly cross-platform vehicle so that anyone can use RedPencil regardless of the computer system used to access it.

Usability

RedPencil was deployed in CST 336 Internet programming: Introduction to Java. Early in the semester, the students were instructed on how to use RedPencil and were asked to use it to submit their programming assignments. In any event, they were given the opportunity to use other methods for submission such as the digital drop box available on the Blackboard course site or even submitting hardcopy of the code if they were uncomfortable with using RedPencil.

Initially 16 students enrolled in CST 336. Before the fourth meeting, six students had dropped the course resulting in 10 remaining students. There were three female students along with seven males.

During the first six weeks of the course there were weekly programming assignments. The students would submit their programming assignments to RedPencil. The instructor would review the assignment and provide feedback inserted into the text at a point of comment (see Figure 6).

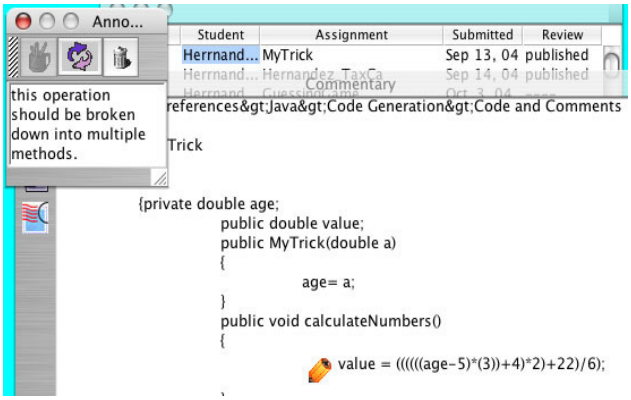

FIGURE 6: EXAMPLE OF ASSIGNMENT MARKUP

In this example, even though the code was correct, it did not meet the coding requirements for this particular assignment. The instructor was able to provide feedback at the point of confusion without having to execute a number of different techniques to provide feedback to the student. In addition, as soon as the comments were "published" the instructor's remarks were immediately available for review (see Figure 7).

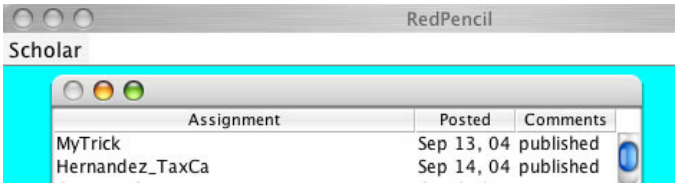

FIGURE 7: STUDENT VIEW OF ASSIGNMENTS

The student did not have to wait for the next class session nor would they have to download the document in order to view the comments. They would simply click on the assignment they wished to view and the text with the pencil icons would appear.

Table 1:
Usability factors

Usefulness:	Can users essentially use the product
Effectiveness:	Can users effectively use the software to perform a task
Learnability:	Can a user learn how to use it
Attitude:	How does the user feel about using the software

The student could click on an embedded pencil in order to view the comment. On the surface the system seemed to work well. Nonetheless, there are four major factors in testing for usability [8]: To investigate the usability of the RedPencil system, the students completed the Computer System Usability Questionnaire [9] at the end of the term. This questionnaire was selected because it was oriented along the four dimensions of usefulness, effectiveness, learnability and attitude. The completion of the questionnaire was entirely voluntary which resulted in only 6 of the remaining 10 students completing the survey.

The survey uses a Likert type scale ranging from 1 (strongly disagree) to 7 (strongly agree). The results are reported in Table 1.

The results were overwhelmingly favorable for RedPencil. The students felt they could use RedPencil easily to submit their assignments as indicated by the high ratings reported by Question 2. Learnability was also highly rated as indicated by the responses to Questions 6 and 7.

However, problems with the software surfaced, especially in reference to the software effectiveness. Issues with the documentation, security, as well as the look and feel were reported by the students as indicated by the responses to Questions 7, 8 and 9 which are grouped toward the middle of the range. However, given the prototype nature of the software these responses were expected.

The students attitude toward RedPencil was assessed not only by the questionnaire but also through the availability of open-ended questions.

The results are somewhat contradictory. For example Question 1 asked, "Overall, I am satisfied with how easy it is to use this system" was rated rather highly. Contrast this with the last Question 18 which asked, "Overall, I am satisfied with this system" was scored much lower.

Nonetheless, when we consider some of the open-ended responses the students were clearly excited about the idea. For example, "I just love the fact that I can see the list of assignments I have turned in." Alternatively, as another student writes "quick feedback in the code itself" supports the interlinear markup system. Finally one student simply wrote "Cool idea".

TABLE 2:
RESPONSE TABLE

	Strongly disagree						Strongly agree
Questions	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1. Overall, I am satisfied with how easy it is to use this system	0	0	0	0	0	7	0
2. It was simple to use this system	0	0	0	0	0	4	2
3. I can effectively complete my work using this system	0	0	0	0	1	3	2
4. I am able to complete my work quickly using this system	0	0	1	0	0	4	1
5. I am able to efficiently complete my work using this system	0	0	1	0	2	2	1
6 I feel comfortable using this system	0	0	0	0	0	3	3
7. It was easy to learn to use this system	0	0	0	0	0	4	2
8. I believe I became productive quickly using this system	0	0	0	1	1	2	1
9. The system gives error messages that clearly tell me how to fix problems	0	1	0	2	0	2	0
10. Whenever I make a mistake using the system, I recover easily and quickly	0	0	3	1	0	1	1
11. The information (such as online help, on-screen messages, and other documentation) provided with this system is clear	0	0	2	2	1	0	1
12. It is easy to find the information I needed	0	0	0	4	0	2	0
13. The information provided for the system is easy to understand	0	0	0	2	1	2	1
14. The information is effective in helping me complete the tasks and scenarios	0	0	0	1	3	1	1
15. The organization of information on the system screens is clear	0	0	0	0	4	1	1
16. The interface of this system is pleasant	0	0	0	1	2	2	1
17. I like using the interface of this system	0	0	0	2	3	0	1
18. This system has all the functions and capabilities I expect it to have	0	0	2	3	1	0	0
19. Overall, I am satisfied with this system	0	0	0	3	2	1	0

DISCUSSION

The features that the students really liked were the ability to track the status of submitted homework. Further, they did not have to wait for the next class session to receive feedback on the current assignment. Additionally they could see where the error was in context. This can have a very positive effect on the student's performance. Finally, the limited feature set was an added bonus.

An area for improvement is in the effectiveness of the interface. The comment popup window had a tendency to popup behind the primary document, which obscured the text and required the user to bring it to the foreground.

Areas for further research include investigating the markup behavior of the instructors. Also it has been suggested that filtering by assignment may be a useful feature. Finally, researching the effectiveness of RedPencil on conceptual development is an important issue.

ACKNOWLEDGEMENTS

Funding was provided from a Mini-grant from The Foundation California State University Monterey Bay. For further information please contact Terence C. Ahern, Ph.D. terence.ahern@gmail.com.

REFERENCES

[1] Carnevale, D. Survey Finds 72% Rise in Number of Distance-Education Programs. *The Chronicle of Higher Education*, 2000.

[2] National Center for Educational Statistics (NCES) Distance Education at Degree-Granting Postsecondary Institutions: 2000–2001 [online at http://nces.ed.gov/surveys/peqis/publications/2003017/index.asp]

[3] Zhang, D., J.L. Zhao, L. Zhou and J. Nunamaker. Can e-learning replace classroom learning? *Communications of the ACM* 47 5), 2004, pp. 75-79.

[4] Carr, S. As Distance Education Comes of Age, the Challenge is Keeping the Students. *The Chronicle of Higher Education*., 2000

[5] Driscoll, Marcy P. *Psychology of learning for instruction* 2nd Edition Allyn & Bacon,1994.

[6] Wolfe, J. Annotation technologies: A software and research review. *Computers and Composition* 19,2002, pp.471-497.

[7] Heck, R.,.Luebke, S., Obermark, C., A survey of web annotation systems [web page]. Grinnell College 1999 [online at www.math.grin.edu/~rebelsky/Blazers/Annotations/Summer1999/Papers/survey_paper.html]

[8] Mandel, C. *The elements of user interface design*. Wiley: New York. 1997.

[9] Perlman, G. Web-Based User Interface Evaluation with Questionnaires [online at :www.acm.org/~perlman/question.html}