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Drawing Diagrams in an Online Examination

Pete Thomas

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***Department of Computing
Faculty of Mathematics and Computing
The Open University
Walton Hall,
Milton Keynes
MK7 6AA
United Kingdom***

<http://computing.open.ac.uk>



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Pete Thomas

Open University

Milton Keynes, UK

MK7 6AA

+44 (0) 1908 652695

p.g.thomas@open.ac.uk

ABSTRACT

This paper describes a study into the drawing of diagrams in an online examination. The diagrams were produced by students during an on-line examination using a simple drawing tool. The students' examination answers, which included a diagram, were submitted over the Internet to an automatic marking tool for grading and feedback. This paper describes the diagram drawing tool and discusses the students' reactions to its use under examination conditions. Whilst only a small number of students were involved in the trials, drawing simple diagrams using a software tool during an examination did not pose major problems for most of them. We conclude that the use of such a tool is feasible and should be investigated further.

Categories and Subject Descriptors

K.3.1 [Computer and Education]: Computer Uses in Education – *Distance learning*.

General Terms

Design, Experimentation, Human Factors.

Keywords

Diagrams, online examinations.

1. INTRODUCTION

For several years we have been investigating the automatic grading of examination taken online in which student answers are all free-form text. That is, the questions require answers that are akin to essays and are not multiple choice questions [1, 2, 3, 15]. The students type their answers into a web form using a PC at home and submit their answers via the Internet to a server for grading. This electronic examination system gives immediate feedback by providing a grade and textual feedback for each answer. The results have been encouraging [5, 13].

However, until recently, the system would only deal with textual answers; there was no provision for the creation or marking of diagrams. Feedback from students had indicated that they would like a drawing capability.

To provide such a facility raises a number of issues, among which are:

1. What features should a drawing tool provide?
2. How familiar should students be with the tool prior to the examination?
3. How should the tool be provided to students in order to be used under examination conditions?

4. How should a diagram be represented for transmission to the server?
5. How should a diagram be represented for grading purposes?
6. How to grade a diagram?
7. How to provide feedback on a student's diagram?

Whilst this paper is primarily concerned with the first three questions, the decisions taken in relation to questions 4 to 6 all have a bearing on the ultimate direction that was taken. Question 7 poses some fundamental questions that we have only just begun to address. Our approach to grading diagrams automatically is reported in [11, 12, 13].

There is a great deal of literature on the representation and recognition of diagrams and a well-developed theory of visual languages [4, 7, 9]. Much of this work has been motivated by the desire to facilitate multimodal communication and interaction between humans with important applications in the CAD field, and more recently attention has turned to diagrammatic reasoning [8]. However, we have not seen this work applied to the needs of online examinations.

This paper examines the provision of a drawing tool for use during an online examination and discusses the students' reactions to the tool. The next section addresses the nature of the drawing tool that was used in the initial trials. We then report on student feedback on the use of the tool in the examination. Finally there is a discussion of the issues that arose from the trials.

2. THE DRAWING TOOL

Given that the student volunteers did not require the use of a drawing tool of any description for their course, we felt that a simple tool that would require minimal familiarisation would be appropriate. The tool should also facilitate the drawing of diagrams appropriate to the examination – in order to minimise the time of use during the examination. In addition, we are primarily interested in diagrams that commonly occur in the teaching of computing (such as E-R and UML diagrams).

Therefore, we adopted a very simple approach in which the drawing tool supported the creation of diagrams that are limited to two simple geometric objects that we have named boxes and links. A box has a rectangular shape and can contain text. A link is a directed line (arrow) and can also be associated with some text. The text associated with each object can be used for labelling and explanation purposes. Furthermore, the role of a link is limited to joining two boxes and can be used to indicate a relationship between them.

Objects are placed on the drawing canvas using a drag-and-drop technique. Boxes can be placed anywhere on the canvas, but links must join two boxes. A link is constructed with the mouse by left-clicking inside one box, dragging the cursor to another box and releasing mouse button.

A range of editing and file handling facilities are also provided. However, if the user wishes to delete a box from the diagram, any associated links will also be removed (but not before the user has been prompted with an appropriate warning). A link can be removed at any time.

Figure 1 shows an example of a drawing constructed with the drawing tool that will be used throughout the remainder of the paper. The drawing illustrates a computer processor architecture known as a 4-stage pipeline. The boxes represent the four stages of execution of a machine code instruction (fetch, decode, execute and write) and the links shows the order in which the stages occur. In this example, there are two pipelines and an association labelled "forward" between the two execution stages.

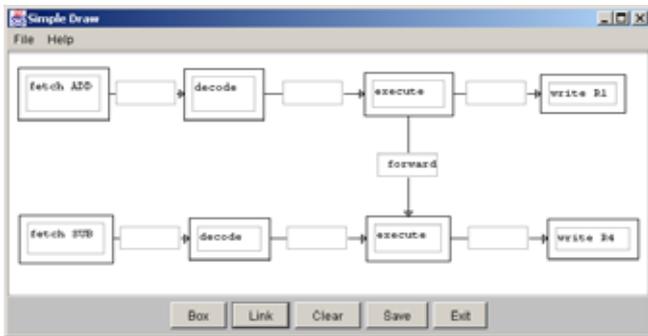


Figure 1. The drawing tool interface.

The drawing represents a specimen solution to the examination question given in Figure 2 that was posed to students in the online examination.

Use the drawing tool to draw a diagram that illustrates how the data hazard inherent in the execution of the pair of instructions:

ADD R2, R3, R1; SUB R1, R5, R4

by a 4-stage pipeline, can be overcome.

Figure 2. The examination question.

The drawing tool was easily accessed through a single click on a button on the electronic examination paper. Once the student had completed their drawing it could be saved to their local disk by clicking on the Save button. A simple textual encoding of the diagram including spatial co-ordinates, text and associations between elements was stored. This encoding was sufficient for the diagram to be re-displayed whenever the student wished to amend a previously saved diagram.

We so arranged the tool that it would write to a specific file on disk that was automatically uploaded to the server once the student submitted the exam as a whole. The simplicity of the tool meant that there was very little overhead in deploying the tool and saving the diagram.

3. STUDENT FEEDBACK

Two trials of the system have been undertaken to date. In the first trial we wanted basic student reactions. Students were provided with the opportunity to try out the tool in advance of the examination but few took advantage of this offer. Of the 6 students who used the tool one said it was very difficult to use, 3 said it was difficult to use, 1 felt it was moderately easy to use and 1 said it was easy to use. Those who did not answer the diagramming question thought that it would take up too much time in the examination although they had not practiced with it before the exam. Some minor changes were made to the tool as a result of this feedback.

In the second trial, 15 students took the examination 11 of whom attempted the drawing question specified in Figure 2. This was a compulsory question and was worth 4% of the marks on the whole paper. Eight students successfully submitted an answer to the question, 3 students tried to draw a diagram but gave up without submitting, and 3 did not attempt the question. Figure 3 summarises student opinions of the drawing tool (only 14 students provided feedback).

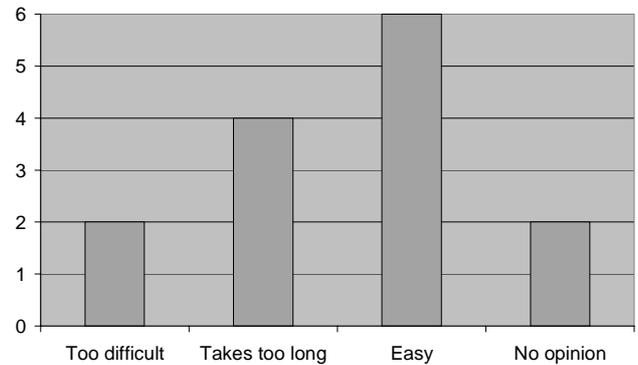


Figure 3. Opinions of the Drawing Tool

The main problems experienced by students was a perceived lack of space to type in the boxes and a dislike of scrolling. The following are typical comments.

"The scroll bars in the boxes I found offputting, I started off drawing boxes that were too small - I nearly didn't do this question because of that."

"Text boxes needed to be bigger so could see whole answer at once without scrolling"

"The text boxes could be a bit bigger - at least big enough to contain the expected answers. It was a bit disconcerting trying to scroll up and down the boxes."

There is no limit imposed by the tool on the amount of text that could be entered into a box. The boxes could be expanded by dragging, and scroll bars are available on all items. This was explained in the help menu but it is doubtful whether students referred to it given the time constraints they were under.

Despite these problems, 6 students felt that the drawing tool was easy to use, and no-one cited their difficulties as a drawback to their overall experience of the online examination when compared to a conventional closed book examination (see Figure 4).

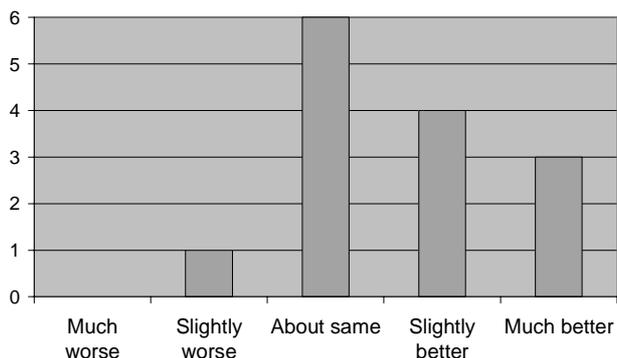


Figure 4. Opinions of the Online Examination

The specimen solution given in Figure 1 illustrates the expectation that students would draw explicit relationships between boxes (shown by arrowed 'links'). However, students represented the temporal associations between the stages of the pipelines using spatial associations as shown in the typical student diagram in Figure 5.

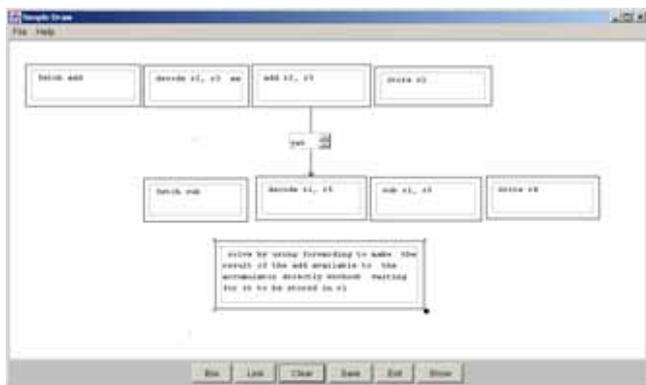


Figure 5. A typical student drawing.

This figure also illustrates how the size difficulty, particularly with the links, was often overcome – with an additional 'comment' box, positioned in this example at the bottom of the diagram.

4. DISCUSSION

Unsurprisingly, there is a definite reluctance on the part of some students to attempt to use a software tool under examination conditions, primarily due to the anticipated length of time it would take to complete a drawing. In these trials, students were faced with a using a tool that the majority of them had not seen prior to the exam, which would only exacerbate the situation. In addition, the question, whilst in the compulsory part of the paper, was of a 'low stakes' variety being worth only 4% of the total mark for the examination. We might assume therefore, that students would avoid such a question without too much concern. However, only 3 out of 15 students did not attempt the question (but we do not yet know whether these students avoided the question because they did not know the answer or whether it was a reluctance to use the tool; we intend to resolve this point in a follow-up questionnaire). This suggests that despite natural reluctance, students will generally attempt to use the tool. No

doubt that if the students had experience of the tool prior to the examination, this hesitancy would have been reduced.

It was clear, however, that whatever tool is used, it must have certain qualities, not the least of which are ease of use and good affordance. In these trials we minimized the functionality of the tool but students still had to determine how to use it within a very short period of time. From the comments received, the tool was easy to use once the student had learned how to use it but there was a degree of initial difficulty to overcome. At least one student felt bewildered by what they were initially faced with. We conclude that a redesign of the interface would be necessary to improve the affordance. It was also the case that students did not investigate all the features of the tool (such as moving and resizing the boxes) which leads to the conclusion that prior exposure to the tool is essential.

However, placing students in the position of not knowing a tool and having to learn it under examination conditions is unlikely to be a common situation. One would normally expect students to be exposed to the tool during their normal studies. We were surprised therefore to see how well the majority of students coped with situation. Nevertheless, a complex tool with irritating features is certainly to be avoided.

The minimal set of drawing features provided by the tool did not seem to be an issue. The students were able to convey their thoughts adequately enough (albeit not in the expected way) and did not mention this limitation as a drawback in their post-examination comments. The most irritating feature was the apparent lack of space in the text fields and the appearance of scroll bars. Students often got around this problem by drawing additional boxes to act as comments. In this particular question, there is no standardized syntax for diagrams and free-form diagrams were acceptable. In more formal situations (as with E-R or UML diagrams) additional features would undoubtedly be necessary and a different approach taken to capturing large amounts of textual information.

The approach taken for launching the tool directly from the exam paper appeared successful. One student found that the tool failed to launch but we were unable to find a reason for this. The saving and uploading of the drawing file worked without fail.

As with all our work on the automatic grading of examination papers, we asked a number of independent graders to mark the students' answers. In the case of the drawing question, three graders were used who awarded a modal mark of 3 out of 4 (the average was 2.8 with a standard deviation of 1.05) indicating that students were able to produce meaningful diagrams under examination conditions.

5. FUTURE WORK

In this paper we have discussed only one feature of the general problem of automating the examination process. To enable students to communicate through diagrams electronically requires a number of issues to be resolved. We intend to pursue improvements in the drawing tool based on the requirements for a tool with minimal features that provides good affordance and can be launched speedily.

To-date our work on diagram understanding, and grading diagrams in particular, has produced good results for small diagrams [10, 14]. The representation of diagrams that we have

used has proven to be adequate for both capturing the basic data from the drawing tool and for interpreting the diagrams. We are currently examining the use of constraint multiset grammars [6] as a way of formalizing our ideas to enable us to look at alternative representations.

The most challenging question, however, is how to provide useful feedback to students on their performance in the examination. In the present system, communication between student and marking tool is entirely textual. Students' answers, including diagrams, are text-based, and the feedback is in the form of a textual commentary on their answers. Our current feedback on the diagram question is simply a brief textual description of the specimen solution. We feel that the feedback should be diagrammatic, so we shall be investigating how to provide such a feature which is likely to require further development of the drawing tool to display the information. Whilst we shall continue the practice of enabling the tool to be launched from the examination paper, a stand-alone application will be required for viewing the automatically produced feedback.

6. CONCLUSIONS

Asking students to use an unknown software tool under examination conditions would not normally be recommended. However, most of the students in our trials were able to use a simple drawing tool to construct meaningful diagrams in response to an examination question.

Despite the small number of examples of student drawings obtained in the trials and the clear difficulties that some students faced, we feel encouraged to continue the development of the tool and to undertake further trials.

7. ACKNOWLEDGMENTS

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