A TOOL FOR AUTOMATED CONTINUOUS ASSESSMENT IN NUMERICAL METHODS COURSES

Tanveer Hussain Awan[1], Frode Eika Sandnes[2]

Abstract *¾ The online assessment is becoming a feasible and practical way of evaluating students. Online assessment tools provide an ideal mix of human interaction and technology that supports active learning. Educators can include online assessments as supplementary material in their courses. Configurable online assessment tools allow students to be evaluated more frequently. At Oslo University College a group of students have developed a tool for automated assessment of numerical methods coursework. This paper presents some of the technical and pedagogical issues that have to be addressed when developing such tools. The tool provides a practical way of continuously assessing the students enrolled onto a numerical methods course. It provides students with real-time feedback on the quality and correctness of their coursework. Both students and teachers can thus identify their weak spots.*

Index Terms ¾ Internet, numerical methods, online assessment, student evaluation.

INTRODUCTION

Computers play a significant role in modern-day education, and their importance as teaching and training tools continues to increase [11, 20]. Innovations in computer technology have created novel and creative ways by which to overcome time and distance in the quest to narrow the distance between teacher and students. The practice of using computer technology for regular assessment of students is gaining ground. Teachers are able to evaluate students more frequently and while the course is ongoing, rather than one exam a few weeks after the last lecture at the end of term. This increased interaction between the student and teacher allows the teacher to better accomodate for the individual students' needs.

Students are motivated by the desire to perform well. Therefore, the means by which the student is assessed are an integral part of the learning process. The student is able to assess the relative importance of assessable tasks and the teacher has greater control over the topics on which the students are focusing.

Further, matematics-related subjects have over the last decade become increasingly unpopular amongst students. Students have difficulty in realising the importance of mathematics and generally consequently devote too little effort to such subjects. The general weak mathematics skills amongst engineering students is a problem as it affect other specific engineering courses that require a sound mathematical knowledge and skills. Several educators are trying new approaches to revive the students' interest in mathematics – either by clearly illustrating the practical purpose of mathematics, or by the means of modern technology and tools that minimise the tedious symbol manipulation allowing students to focus on the mathematical ideas. Further, such tools illustrate the implications of these mathematical concepts more visually and pedagogically [9, 14, 15, 16, 17].

This paper considers the pedagogical and technical aspects of an online automated assessment tool. The pros and cons of online assessment is discussed. A web-based automated assessment tool for Numerical Method-oriented courses (NME), which is being developed by a students at Oslo University College, is also presented.

THE CHARACTERISTICS OF GOOD TEACHER

Computer-assisted coursework assessment relies on the "intelligence" of the courseware to take on the responsibilities of the teacher. The qualities of a good teacher must be identified, and once defined, the computer must be provided with these qualities. Defining these characteristics proves to be the first obstacle.

What do students expect from a good teacher? What makes a teacher successful? A teacher's most basic function is to guide the students toward a clear set of educational objectives. Good teachers have a very clear conception of the academic goals, in the attainment of which they hope to guide their students. They must have well defined academic aims and a vision of what they expect their students to achieve [22].

Assessment and feedback plays an important role in the learning process. Good teachers assess the results of their instruction by frequently questioning students in a more or less formal fora. Good teachers use a variety of questioning techniques in order to assess student comprehension and development of mastery in the subject. The knowledge gained from assessments influence the preparation of future teaching methods [5, 8, 22].

The accumulated findings of the assessment throughout the duration of the course is important. Good teachers, however, must also assess themselves and the effectiveness in their effort in helping their students in reaching academic

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goals. This can be done by comparing the students' individual and collective results to those of similar students' [21, 22]. For this reason, an assessment tool must be able to fulfill this function. Statistical information should automatically be acquired and be readily available to allow students to see how they compare to their peers. If assessments reveal unsatisfactory results, the teacher can reorganize or adjust the instruction [22].

The collaboration of students and teachers is vital in the cultivation of a good learning evironment. Students' opinions should be considered and be part of the assessment. Immediate feedback allows the students to quickly assess themselves and their knowledge**.** Collaborate learning should be encouraged, as students themselves are typically very able to absorb and incorporate new knowledge from feedback [21, 22].

ARCHITECTURAL OVERVIEW

NME is built according to the Java 3-tier Client/Server architecture (See Figure 1) [6, 18]. The client-side Java applet communicates with the student database through the NME Java server. The NME Java server also issues the students' browers with the applet. Due to browser security restrictions a general applet can only communicate with the same server from which it was downloaded. One of the benefits of the 3-tier architecture is that students can log in and access the teaching application from anywhere on the Internet and NME stores the student's assessment report in one place – the database.

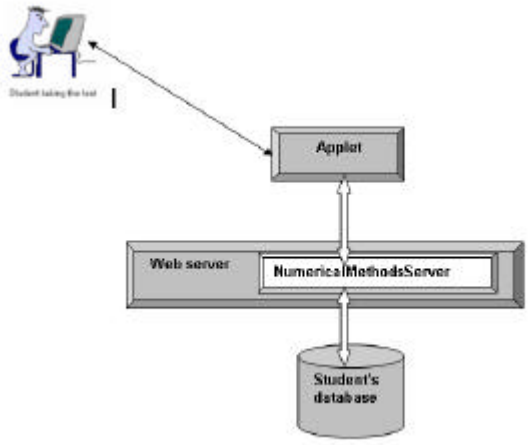

FIGURE. 1
ARCHITECTURAL OVERVIEW OF THE 3-TIER NUMERICAL METHODS EXAMINER. THE PRESENTATION-TIER COMPRISE OF THE APPLET, THE APPLICATION-TIER COMPRISE OF A JAVA SERVLET AND THE DATA-TIER COMPRISE OF A RELATIONAL DATABASE.

TESTING MODULES

NME provides a selection of computer-moderated interactive quizzes and tests. Teachers can configure NME though the various options that control assessment and feedback. The teacher can request that the results of tests and quizzes automatically are transmitted to the student. The student is less restricted by deadlines, and is therefore able to study at a pace more suitable to his or her own needs.

NME enables students to be interactively tested in the following topics in numerical methods[3]:

- Numerical root-finding methods
- Numerical solution of linear algebraic equations
- Numerical integration
- Interpolation and polynomial approximation
- Differential equations

Each interactive tests is implemented as an independent applets, and the different tests are totally independent of each other. Most of the exercises given in the Root finding applet are represented graphically using animations (See Figure 2). Visual representation gives the student more freedom in generating exercises that change dynamically in accordance with the students' input. This feature proved a great advantage in tests where the answer is strongly related to the graphical context. Without the necessary visual cues, problem formulation and solving is more arduous.

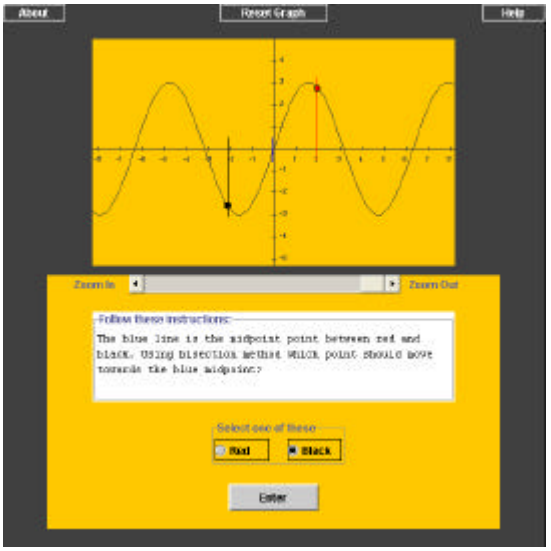

FIGURE. 2
SCREENSHOT OF THE ROOT FINDING APPLET. THE CLIENT-SIDE APPLET RESPONDS IMMEDIATELY TO STUDENT STIMULI.

A majority of the exercises provided by the linear algebra applet are divided into multiple steps. For example, to check if a student is able to solve the given set of linear equations with the lower and upper decomposition, the

[3] Still under development

applet does not only ask for the final solution; the student has to go through a set of steps given by the applet (See Figure 3). The main advantage of this approach is that even if a student makes a minor mistake in one of the steps, he/she will still get full points for the remaining steps. It also helps to check if the student is familiar with the prerequite basic concepts required to solve the exercise. The main steps for this equation solving method are follows [1]:

- Factorise the matrix as the product of lower-triangular matrix L and an upper-triangular matrix U; $A = LU$.
- Solve $LY = B$ for Y using forward substitution.
- Solve $UX = Y$ for X using back substitution.

The way NME represents this exericse is shown in the figure given below.

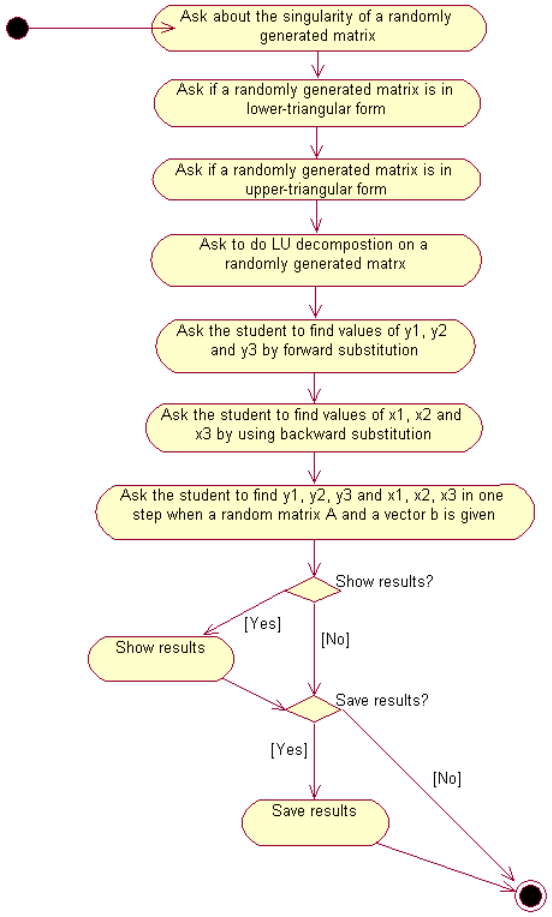

FIGURE. 3
ACTIVITY DIAGRAM FOR THE LOWER AND UPPER DECOMPOSITION TEST GIVEN IN THE LINEAR ALGEBRA APPLET

The Gaussian elimination test in the Linear algebra applet is also another good example of how an exercise can be divided into different steps (See Figure 4). The main purpose of the Gaussian elimination test is to check if a student is able to execute a series of matrix row operations to eliminate coefficients in order to form the triangular matrix. This test includes questions about different pivoting methods (See Figure 5 and 6). Four pivoting algorithms are implemented:

- Simple pivoting
- Partial pivoting
- Scaled partial pivoting
- Total pivoting

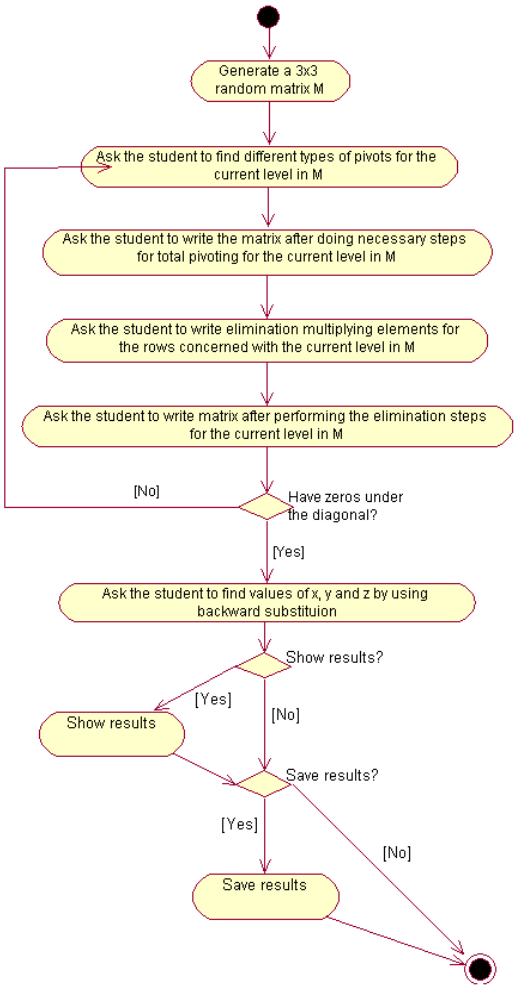

FIGURE. 4
ACTIVITY DIAGRAM FOR THE GAUSSIAN ELIMINATION TEST GIVEN IN LINEAR ALGEBRA APPLET

The way each question is formulated is vital in assessing the students. For example some questions can check the students' understanding more accurately if given as standard multiple choice questions. But others are more suitable when students are given no alternatives and they have to solve the question themselves and submit answers. Clever quiz design can even enable the system to spot and identify common mistakes made by students. For example it

has been noticed that some students find it difficult to differentiate between different types of pivoting algorithms. In order to identify this kind of mistake in the pivoting step for the Gauss-Elimination test, four alternatives are given. Each alternative represents different types of pivoting algorithm, namely simple, partial, scaled partial and total pivoting algorithm. In this way we can see whether the student is able to differentiate between pivoting algorithms.

It is difficult to create reasonable alternatives for certain multiple choice questions. In such situations we should avoid using multiple choice tests and instead let the students supply an answer computed manually by hand.

FIGURE. 5
SCREENSHOT OF THE GAUSSIAN ELIMINATION TEST GIVEN IN THE LINEAR ALGEBRA APPLET

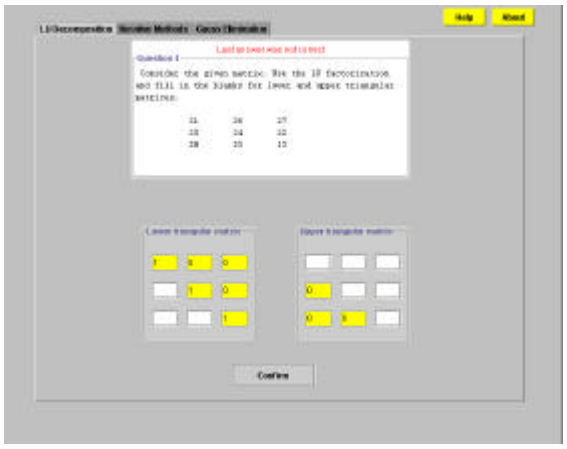

FIGURE. 6
SCREENSHOT OF THE LOWER AND UPPER DECOMPOSITION TEST GIVEN IN THE LINEAR ALGEBRA APPLET

It is important to address the disadvantages and shortcomings related to the use of such a tool. One disadvantage is the difficulty that computer assessment demands a limited set of correct answers. While the Internet has opened a great many doors and offers a great deal, it is not without obstacles and difficulties. Although all forms of assessment are in some extent threatened by the possiblity of dishonest tampering, the Internet increases the risk that work is submitted under false pretences. A username and password protects the student, to a certain degree, but the assessor is unable to determine the authenticity of the submittor, and has no evidence upon which to rely [21].

THE USE OF MATHEMATICA AS THE COMPUTATIONAL ENGINE

The implementation of all the mathematical computations involved in an assessment tool can be very complex and time consuming. Mathematica can be used as a computational engine. J/Link is the Java API to the Mathematica protocol developed by Wolfram Research [19]. It allows a Java program to outsource all of its mathematical computations to the Mathematica kernel. However, to develop applets that use J/Link the following security issues have to be considered [2].

"The only thing that J/Link needs special browser security permission for is to load the J/Link native library... You cannot do anything with J/Link without requiring the native library to be loaded...Different browsers have different requirements for allowing applets to load native libraries. In many cases, the applet must be "signed," and the browser must have certain settings enabled. Note that letting Java applets launch local kernels is an extreme breach of security, since Mathematica can read sensitive files, delete files, and so on. It is probably not a very good idea in general for users to allow applets to blast such an enormous hole in their browser's security sandbox. A better choice is to have Java applets use a kernel residing on the server. In this scenario, the browser's Java runtime does not need to load any local native libraries, so there are no security issues to overcome. This requires significant support on both the client and server side. This support is not part of J/Link itself, but it is a good example of the sort of programs J/Link can be used to create."

CONCLUSION

This paper addresses online assessment tools for mathematical subjects. The major advantages of having online assessments include accessibility and visual representation. The exercises might involve some complex mathematical and physical concepts that are difficult to explain using only text and diagrams. Mathematics is not a straightforward subject for many students. Some are intimmidated by the sometimes owerwhelming mathematical theory or the the huge amount of symbols that has to be manually managed during algebraeic manipulation [23]. Textual examinations do not allow the visual element to play a part [7]. Visual representation is very helpful in

understanding the application of mathematics to concrete situations [18].

Even if there is a general consensus about the importance of online assessment tools in teaching, they can only be incorporated as supportive elements in the teaching process. The teacher is still an integral part of the educational process. By improving and increasing the extent of online assessment tools however, teachers can cope with an increasing number of students. With more online assessment tools, more students can be evaluated in a cost-effective manner. The teacher can change his teaching plan dynamically according to the results of different assessments. A web based tracking system can be used to assist the instructor in identifying abnormalities in study patterns and thus identify students with difficulties. This enables the instructor to focus the attention on the most immediate problems and gives the instructor a better and continuous overview of the class situation when responsible for a large number of students[3]. Online assessments tools give students the freedom to take tests anywhere, at their discretion. Studying can similarly be done at the students own pace.

As an aid, online assessment tools will make teaching and learning more effective, fun and help activate the students. However, they are not a substitute for good teachers and solid resource lectures [4].

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