Beyond the “Multiple Choice Culture”: Realizing Hybrid Exams with Tablet-PCs

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Abstract - The vast number of different types of examinations - together with the considerable broadness of scientific fields to be covered - presents a strong challenge for all academic institutions. So far, many eLearning environments offering electronic examination tools face a severe problem in their acceptance through the academic community since their evaluation methods are usually restricted to simple mechanisms such as multiple choice, short-answer, gap-filling exercises etc. Yet, at higher levels of education, examinations usually contain problems which require deep analytical thinking. Here, the answers are to be given by a freely phrased text, by a detailed diagram with annotations or by a (mathematical) proof with explanatory intermediate steps.

Tablet PCs hold a large potential to overcome these problems: Their ability to deal with handwritten texts, sketches, diagrams, and pictures, enables a new type of “hybrid examinations”, combining the advantages of the new media with long-established and well proven examination procedures. Within this project, electronic examination environments are extended, enabling them to network and support both, “simple” problems with automated validation and grading mechanisms as well as “complex” problems with individual correction through a human expert.

I. Introduction

As a result of the harmonization of the academic degree system, the European higher education system will change substantially over the next years. Since international communication skills and intercultural competences are growing in importance in a globalized world, the goal is to enhance the comparability of the different courses and classes in the various countries in order to increase the mobility and flexibility of the students throughout Europe.

Based on the Bologna Declaration of the ministers of education from 29 European countries in 1999 [1, 2], the harmonization process requires a “fine-”modular course system where every single module is to be completed by an examination. Thus, the number of examinations at European universities is going to increase dramatically in the near future. Additionally, due to changes in German national law, German universities are now allowed to select their students not only on the basis of their high school diploma (“Abitur”), but on the basis of more specific criteria of suitability, in particular through entrance and aptitude tests, which again leads to an increase of examination processes.

To cope with this increasing number of examinations, new concepts for the academic examination organization have to be developed [3, 4]. Clearly, at this point electronic examination systems play an important role [5, 6]. However, up to now most of these systems (commercial systems as well as open source projects, e.g. Hot Potato, tests in moodle) are mainly based on multiple choice, matching, ordering, gap filling etc. The “simple” methods of validation mechanisms may be used for pre-learning scenarios, quizzes etc., but at European universities they are neither accepted nor acceptable for final examinations on an academic level. More sophisticated systems using more advanced analysis approaches are restricted to very special fields, e.g. computer algebra system to verify the correctness of mathematical formulae and symbolic manipulations. On an academic level, most teachers demand electronic examination systems which include the possibility for extensive textual answers, hand sketches, diagrams etc. allowing the formulation complex explanations and extensive lines of argument.

Unfortunately, no system will be available within the near future that would include handwriting recognition and intelligent automatic text analysis. Therefore, from the point of view of university teachers an ideal electronic examination system combines simple, but stable test scenarios with automatic evaluation and more advanced components like computer algebra systems with tools to attach handwritten text, sketches, diagrams etc. Additionally, in order to improve the “logistics" of the examination procedure, the examination documents should be available on a central server to support cooperative content development, distributed grading of the results, availability of the results for the students and documentation of the complete examination process for the central examination office.

- To support an efficient document handling, all examination documents are stored on a central examination server. Thereby, the destination of all relevant examination documents is ensured on a sustainable basis. Most important, different teachers may be simultaneously involved in the evaluation process.

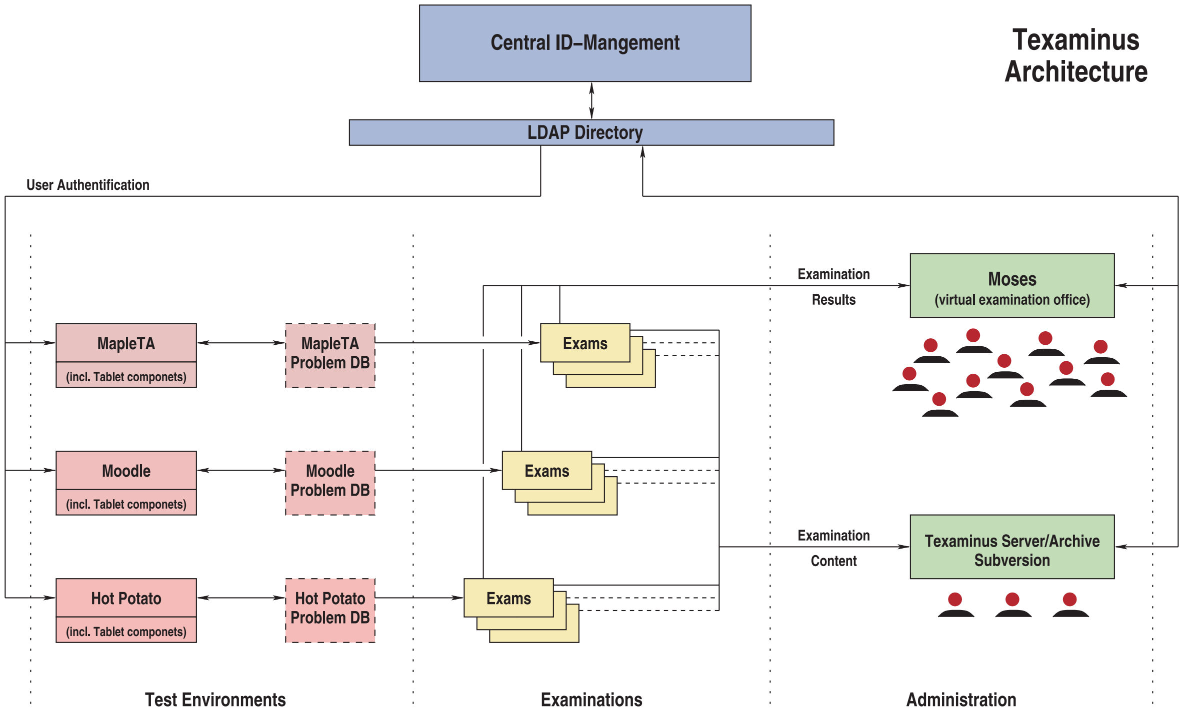

Figure 1: The architecture of the TeXaminus project

II. General Project Description, Impact and Expected Outcomes

Diagrams, utilizing the advantages of Tablet PCs, a flexible and continuous concept for digital examinations on a university level will be realized. Examinations are carried out in a “hybrid model”, that is, students are inserting the answers partly by keyboard, partly via handwriting. The project consists of the following key-components:

- Simple tests that can be automatically evaluated (up to algebraic manipulations that can be validated by computer algebra systems) are graded by the computer. This automated validation can be overruled by the teacher if necessary, in particular in case of ambiguities or semi-correct solution approaches. Complex, handwritten documents will only be evaluated by human teachers. In case of freely phrased text handwriting recognition programs may come into place to preprocess the answers.
- After determining the complete examination results, students are informed by email. Through the central examination server, the whole examination document (including evaluation annotations etc.) is available in read-only format to allow students to inspect their results. After a suitable period of time for complaints, the final results will be automatically transferred to the students' records.
- The administration of the examinations is handled by the software component MosesKonto[1] (open source software, developed at Berlin University of Technology [7]). Within Moses, students can register for examinations, teachers get access to the students' data, the results from any testing software can be uploaded and stored in a standard format, and, finally, the students have access to their grades. Using the MosesKonto, the examination procedure is integrated into the central identity management model of the university. Authentication via LDAP allows integration of Hybrid Examinations with the

[1] http://www.moses.tu-berlin.de

central ID-management for user authentication (see Fig. 1 for a diagram of the intended TeXaminus architecture). Web services shall be used to integrate Hybrid Examinations into our existing learning management system[2] (moodle).

- Finally, a security concept will be developed to guarantee the integrity of all examination documents and to reconstruct every examination step during the whole process.
- The project will be realized by integrating the quiz components of the learning management system moodle[3] , the examination software Hot Potato[4] (both open source projects) and the well known testing system Maple T.A.[5] together with software components for handwriting recognition, annotation of documents etc.

TeXaminus aims at providing all results of the project to non-profit organizations extensively following an "OpenSource, OpenContent, OpenAccess" strategy: All software components will be made available under an open source license as far as without causing conflicts with any software used. The evolving examination content will also be made available under an open content license as far as possible, while of course avoiding any conflicts with prior rights.

III. Educational Research Questions

The Texaminus project addresses several educational research questions: First the potential of prospective students shall be measured ¬ before they start a course of studies that possibly does not math her/his skills and needs; secondly the degree of automation in exercise and examination analysis has to be raised in order to cope with the rising student numbers and finally electronic examinations are needed in order to test skills and abilities which cannot (or only with a great expenditure of time) be checked with pen and paper.

A. Measuring the potential

Today universities all-over Europe face the challenge of supporting their prospective students in selecting a course of study that fits their needs and abilities. Traditionally future students had to take those tests, which were written examinations, at a fixed place and date.

When conducting entrance examinations - and due to the heterogeneous previous knowledge of freshmen - the goal is less to measure their present skills, but to determine the occupational aptitude of a candidate for a certain course of study. Therefore, an important education research question is how to identify "potential" instead of "knowledge" by means of hybrid electronic examination environments.

Online-Self-Assessment-Test take the burden of traveling around the country to take different tests from the candidates, making it easy for them to check their knowledge and skills from any place at any time they. So-called aptitude tests are the adequate tool to check, sound knowledge, abilities, skills and personal characteristics [8]. Therefore psychological tests are utilized in the form of questions, advice situations, personal conversations and the generalized in-tray. The problem to this is the time expenditure for the evaluation and execution of these tests. Hybrid examinations can take remedial action here. Aspects of the personal conversation and the generalized in-tray could be carried out virtually at the computer.

Other questions, particularly for technical and scientific courses of studies, can be improved by visualization of experiments, editable graphic representations, which can be processed directly, and the possibility to measure motor functions. Since it is conducted at the computer anyway, it is natural that the evaluation should happen automated for the most part. Thus statistical analyses of the results from different points of view (student, teacher, assignment, and question) are easily possible. The part which cannot be automatically evaluated is prepared and can be already semantically enriched for the human proofreader. Thus Hybrid Examinations make online testing and assessment cost effective and simple to carry out. The automatically evaluated results are available instantly after the student has completed the assignment and the results can e displayed graphically and numerically.

Moreover by the online execution of the tests nearly any handicaps can be considered in order to make the examinations accessible for handicapped as well as non-handicapped students and guarantee comparable conditions in the examination [9].

Finally a feedback mechanism can be implemented to monitor whether the results in the tests correlate with the student's later achievements to adjust the questions in the preliminary tests.

B. Re-Formulation for automatic validation

Due to the large number of examinations, all types of automated validation mechanisms are of great importance to reduce costs and to allow extensive training of the individual learner. The questions arise how prob-

[2] http://www.isis.tu-berlin.de
[3] http://www.moodle.org
[4] http://hotpot.uvic.ca/
[5] http://www.maplesoft.com/products/mapleta/

lems can be re-formulated in order to use automatic validation mechanisms without reducing the quality of the original problem, and which technologies is best suited to the different examination goals. For any course requiring mathematics complex, free-form entry of equations and intelligent evaluation [10] of answers are of crucial importance. Embedded in a web-based system for designing assignments, tests and examinations - automatically assessing student performance and answers – the variety of questions is no longer limited to multiple choice, fill-in-the-blank, matching, clickable image, and numeric with margins of error Moreover symbolic and numeric exercises, free-response questions, which can be tested for mathematical properties such as equivalence, open-ended questions with infinitely many possible answers and questions containing 2-D and 3-D plots based on randomized values can be implemented.

Entangled with virtual laboratories and/or remote experiments [11] practice problems can be quickly generated in order to give students hands-on-experience. Beyond the enrichment and the simplification of the realization of examinations students' collaborative skills can be activated by requiring them to discuss the methods the applied to solve their assignment, not just share the final answer [12, 13].

C. Added value of online examination technologies

The integration of new technologies into the academic examination process does not only provoke new challenges but also provides new options: An important issue is to investigate the potential of hybrid computer-supported examinations for the improvement of examination procedures beyond the questions of resources and other organizational aspects, but in particular in respect to different examination goals. For example, asking a student to calculate the minimum of the curl of a certain vector field in a traditional examination leads to a long calculation showing that the student is aware of the underlying algorithm. But asking to select the area of minimum curl of the vector field in an interactive applet (by trekking the mouse event) allows verifying if the student is aware of the geometrical meaning of the concept of "vector field curl".

Another example: within a written exam it is more or less impossible to test the ability of a student to construct and perform physical, chemical or technological experiments. However, extending online examination tools with virtual laboratories and remote experiments (for details see chapter 4) allows examining the students' knowledge and his or her "hands-on" capabilities.

IV. EXCURSUS: VIRTUAL LABORATORIES AND REMOTE EXPERIMENTS IN ONLINE EXAMINATION SCENARIOS

Experiments play a central role in natural and engineering sciences. The integration of new media into teaching and research has led to two principle kinds: virtual laboratories and remote experiments. Integrated into a cooperative knowledge space, they enhance access to experimental setups for all students independent of limitations in time, budget or access to classical laboratories.

Virtual laboratories (Karweit, 1997 and Jeschke and Richter, 2006) use the metaphor of a "real", scientific laboratory, thus providing a framework that emulates a scientific workplace for hands-on training in a virtual environment. Similar to a real-world laboratory, devices and measurement tools are provided that allow experiments within a specific field. Virtual laboratories for different fields of mathematics and physics form an important contribution to the realization of new learning and research scenarios and are therefore currently under intense development. For theory-oriented areas such as mathematics, theoretical physics and chemistry, they help to bridge the gap between the abstract theory and the real phenomena. Applications of virtual laboratories range from practical support for traditional lectures (e.g. demonstration), over homework assignments and practical training for students up to aiding researchers in experimentation and visualization.

Complementary to virtual laboratories, remote experiments are real-world experiments, remotely controlled from anywhere outside the laboratory, at almost any given time. Remote experiments consist of two vital parts, namely the experiment itself, which is supposed to be conducted remotely, and the remote control mechanism. Remote experiments are capable of enhancing the access to "real" experimental techniques which are often extremely complex or cannot be transported and are therefore restricted to a rather small community of students and researchers.

In both scenarios, the experimenter manipulates a set of parameters controlling the experiment and interacting with it, e.g. by a motor, the magnetic field, or - in case of a virtual laboratory - also by manipulating the boundary conditions. Additionally, a set of measurement tools is provided to collect data from the running experiment, e.g. the temperature, the magnetization, a rotation frequency, the mechanical force, etc. Thus, the different approaches possess a number of similarities, but also enrich each other through their differences: remote experiments allow the investigation of real objects including hands-on measurement experience, which obviously does not hold true for virtual laboratories. On the other hand, virtual laboratories are capable of mapping the complete process of constructing an experiment, whereas this kind of flexibility is clearly reduced in remote experiments.

Integrated into online examination tools, both, virtual laboratories and remote experiments dispose of an important potential to design new examination procedures in order to examine different learning goals.

V. Impact and Expected Results

Impact and expected results can be summarized as follows: Within the Texaminus project, a "hybrid exam" system will be developed, where standard elements of electronic examinations like multiple choice, matching, ordering, gap filling etc. allowing automated validation are complemented by extensive (handwritten) textual answers, hand sketches, diagrams, formulae etc. that are to be corrected by human teachers. The Texaminus project will contribute to increasing the deployment of Tablet PCs as an important basis for a modern academic education.

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