Implementing Computer-assisted Exams in a Course on Numerical Analysis for Engineering Students

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Motivation

As in many courses on applied mathematics, one is tempted to enrich the course by more realistic, i.e. real-world, problems in order to increase the practical relevance of the course. As a result one is confronted with large computations which are usually done by computers. However, when it comes to exams on such topics students are often asked to apply the learned methods, which are suited for large systems, to very small problems by pen-and-paper. We will explain how we did overcome this gap by transforming the examination procedure from a pure pen-and-paper exam to a hybrid exam, i.e. a combination of a pen-and-paper and a computer-assisted exam (e-exam).

Pros and Cons for e-Exams

The usage of computers during exams has some advantages and disadvantages, see Conole and Warburton [1], Doukas and Andreatos [2], Sindre and Vegendla [3], Küppers and Schroeder [4], and references therein.

PROS

- Using the computer as a tool, exams can be constructed to fit much better to learning goals, applications and practical relevance.
- Less effort on grading, either when the computer can grade automatically, or because typed solutions are much easier to read.
- High sustainability if the problem set for an e-exam is generated in an intelligent way (automatic randomization).
- Better comparability of e-exams during time resulting in higher reliability of measurements of long-term evaluations of student developments.

CONS

- e-Exams may tend to standardize the exam in a way that constructiveness is not rewarded any more (or even penalized).
- Higher effort to conceive a good e-exam compared to a classical pen-and-paper exam.
- Not all questions for a pen-and-paper exam can be copied to an e-exam without adjustment.
- Software packages may change in time due to updates, thus one needs to check compatibility and adjust the problems and setup if needed.

Different Types of e-Exams

Providing computers during exams enables two basic features, which can also be used to classify e-exams:

A) Computers and software as a tool to create and solve more advanced problems during exams. Grading is done exclusively by the lecturers.

B) Computers and software as a tool to create and solve more advanced problems during exams. Grading is done by the computer, adjustment by the lecturers.

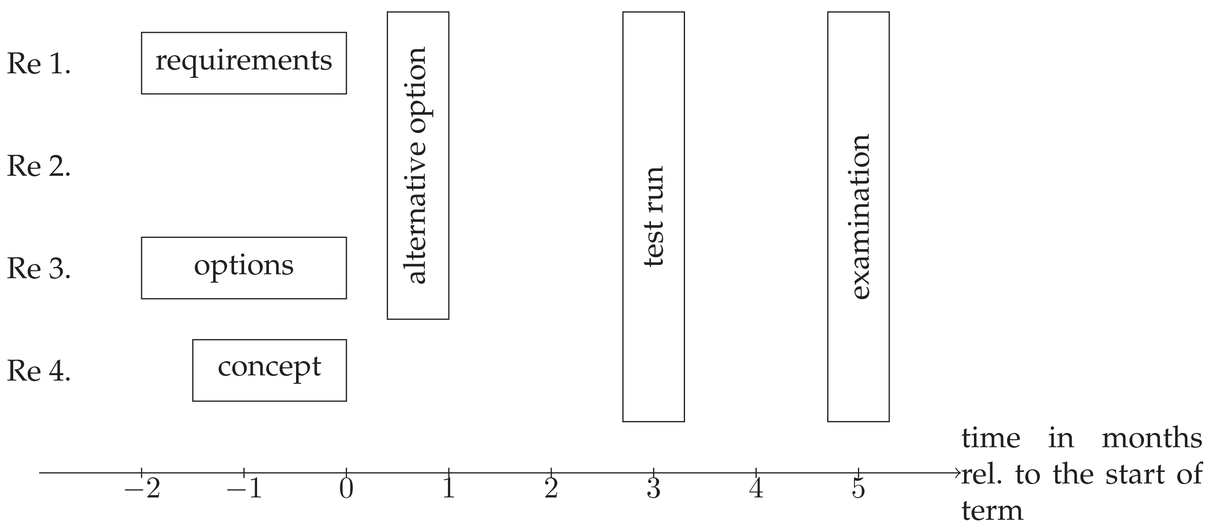
Variant B) can be seen to include A). However, different tools may be needed for A) and B), respectively, since for B) one needs a tool to grade automatically the solutions, which in practice may result in different software requirements and thus B) may not just be an upgrade of A). Of course, either variant can be combined with classical pen-and-paper exams to obtain hybrid types of exams.

Topics to consider and a Timetable

In order to plan computer-assisted exams one has to take into account four major topics:

1. legal topics
2. organizational aspects
3. technical aspects
4. educational topics

Timetable for introducing e-exams



How to transfer the Framework

The following checklist contains all the relevant tasks for introducing e-exams and may be used to transfer the framework developed in our course to other courses, institutions or countries (with suitable adjustments if needed).

General tasks before the course starts

- ☐ Prepare your desired e-examination scenario

Legal topics

- ☐ Examination regulations checked
- ☐ Secure storage of students' solutions planned
- ☐ Personal data protection considered

Organizational aspects

- ☐ University data centre contacted to discuss wishes and needs
- ☐ Test run planned
- ☐ Students divided into subgroups
- ☐ Alternative option conceived

Technical aspects

- ☐ Computer ready-to-use
- ☐ Communication channels configured
- ☐ Examination accounts generated
- ☐ Initial data sets provided, submission of solutions resolved

Educational topics

- ☐ Centre of teaching and learning contacted to discuss wishes and needs
- ☐ Tutorial for software packages provided
- ☐ Variants of the exam including data sets generated

Introducing e-Exams within a particular Course

Course on Numerical Analysis, winter term 2017/18

- **Concept:** Use of MATLAB during examination, exam of hybrid type
- **Legal topics:** settled two month before start of term
- **Organizational aspects:** settled two month before start of term, test run a month before examination, 1 back-up pen-and-paper exam
- **Technical aspects:** thirty laptops available for the exam, data centre generated examination accounts for each examinee, identifier was printed on exam, data centre created webserver for download of data sets created for the exam and upload of solutions
- **Educational topics:** MATLAB tutorial at the beginning of the course, tasks and projects with MATLAB in exercise classes during the course
- **Exam:** ∼70 examinees divided in 3 groups a 25 persons, 3 different hybrid exams, laptops in kiosk mode via Safe Exam Browser of the ETH Zürich only allowing access to MATLAB and website for up-/download, lecturers had access to upload directory, uploaded solutions were equipped with the proper identifier and a time stamp

References

[1] G. Conole, B. Warburton: *A review of computer-assisted assessment*. ALT-J. 13:1 (2005), 13–31.

[2] D. Nikolaos, A. Andreatos: *Advancing Electronic Assessment*. International Journal of Computers, Communications and Control. Vol II, No 1 (2007), 56–65.

[3] G. Sindre, A. Vegendla: *E-exams versus paper exams: A comparative analysis of cheating-related security threats and countermeasures*. NISK. (2015)

[4] B. Küppers, U. Schroeder: *Vergleich von Papierklausuren und elektronischen Prüfungen*. Informatik 2017, LNI, Gesellschaft für Informatik, Bonn. (2017), 307–318.

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