Mathematical eAssessment at its Best: News from Maple T.A. R8

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Abstract

Bologna-compliant studies enforce a strict framework and timetable for students and do not leave much room for practicing mathematical skills. eAssessment systems like Maple TA help to overcome this problem and are discussed by many authors. However, the learning curve for using these systems is often quite steep so that teachers are shying away from using them. To show that there is no need to be afraid, the focus is put on the workflow from designing mathematics exercises, combining them into tests, running the tests, grading and giving feedback to the students to keep up the records. From this point of view some general remarks on using eAssessment systems at schools and universities are made and the resulting demands on such systems are presented. Maple TA meets at least some of these demands. In the latest release some interesting new features like ‘adaptive questions’ or ‘secure testing environment’ improve the system and are discussed in some detail.

Introduction

We need more and better-qualified scientists and engineers but receive less and less well-educated freshmen in engineering and natural science courses of studies (Risse, 2008). There are many reasons but with regard to mathematics (core zero! comp. Alpers, 2011) the shrinking time for practice at schools and then at universities is easily identified as one major problem. Crash courses (often called bridging courses) do not really help and it is reasonable to use the short time available for face-to-face teaching in tutorials. Therefore, the classical teacher-centered unidirectional lecture can be replaced by a self-learning scenario if the progress of the students is assessed continuously. (Otherwise they won't do it.) This formative assessment can be done automatically using an eAssessment system, which of course also applies to final examinations i.e. summative assessments. The use of eAssessment systems in general found its way into the core curricula (Alpers, 2011) and is discussed by many authors, e.g. Lethonen (2008), Enelund (2011), Schramm (2008). Several solutions have now existed for more than 20 years and have evolved well. However, some aspects have proved quite helpful and should be considered.

- ·Separate content from administration: avoid monolithic software solutions with burned-in (hardwired) content. A good practice would be the use of a learning platform such as Moodle, OLAT or ILIAS, which have built in eAssessment properties, even for mathematics to some extent - at least for asking questions. For grading answers the situation is more subtle.

- If questions have purely numerical, calculable or otherwise fixed or foreseeable

answers, there is no problem with standard systems. If the questions are dynamically generated (including diagrams) and have formula-based answers, computer algebra systems (CAS) should be used to generate the questions from templates and to check the answers for correctness.

- For the long term use it is reasonable to separate the questions or their templates from the assessments (tests, exercises, examinations) they are used in. If the questions are stored in a dedicated data-base (question banks), they can be used in different contexts and can be easily shared.

- Define and separate the roles of the administrator, the authors (instructor, teachers) and the candidates (students). Other roles to be foreseen could be tutors, scorers or proctors. While the tutor coordinates the use of the system, the scorer helps grading the answers (possibly replaced by a CAS), the proctor delivers the assessment, for example the proctor could log in the students after checking their identity cards.

Those demands on an eAssessment system can in parts also be found in the IMS QTI 2.1 (2006) specification, using somewhat different designations published by the IMS Global Learning consortium. The QTI (Question and Test Interoperability) standard defines also a lot of question types (multiple choice, fill in the blank, or true/false choice etc.) but is still under development, especially concerning mathematics. The main purpose for the standard is the exchangeability of the question banks between different systems but at the price of lacking mathematical flexibility.

A solution that meets the design pattern mentioned is Maple T.A. (2012). This server-based mathematical eAssessment platform goes far beyond the QTI standard with the transparent use of the CAS Maple 15 engine in the background. It is used and described by several authors (for example, as already mentioned, by Lethonen (2008), Enelund (2011), Schramm (2008)) and also sometimes criticized, for example by Bolton (2008) who preferred the STACK (System for Teaching and Assessment using a Computer-Algebra Kernel) system because of the adaptive and flexible response to wrong answers. STACK is an open source package under development by Sangwin (2012) in the School of Mathematics at the University of Birmingham. However, Bolton described an old release (2.5 to 3) and some progress was made particularly concerning the adaptive response in the current release 8.

Maple T.A. Release 8

As a user of Maple T.A. a teacher gets an account to the system typically as an instructor with predefined classes. Registered Students can choose their class or be enrolled by the instructor perhaps by an uploaded list. For choosing a class the typical web-interface (Internet Explorer) looks like Fig. 1. The pre-defined assignments could be chosen and altered via the Content Manager in the menu. However, the first task is to construct questions. For this purpose the Question Repository is chosen - shown in Fig. 2. It shows the question bank Math 1 containing two groups. The first one (Demo Class Questions) is inherited and contains many examples that could be used as templates.

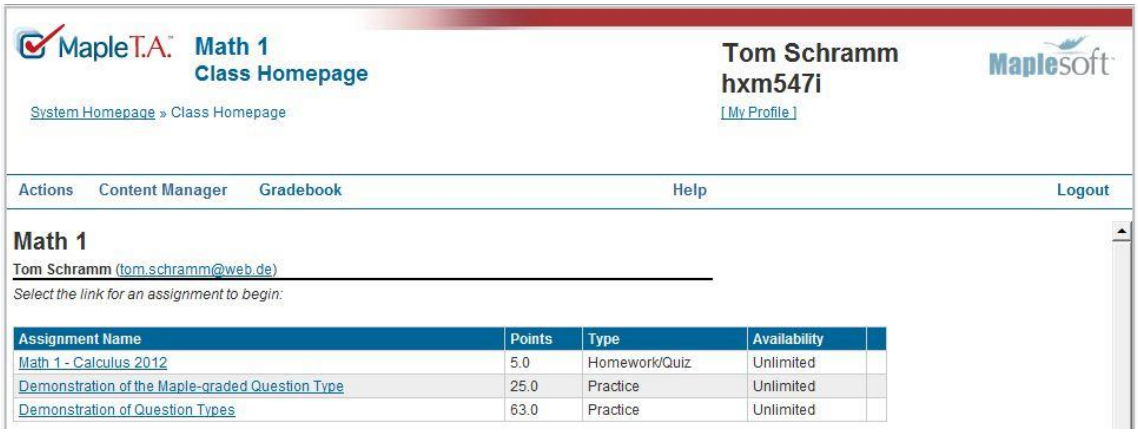

Fig. 1.Class Homepage -- Instructor's view.

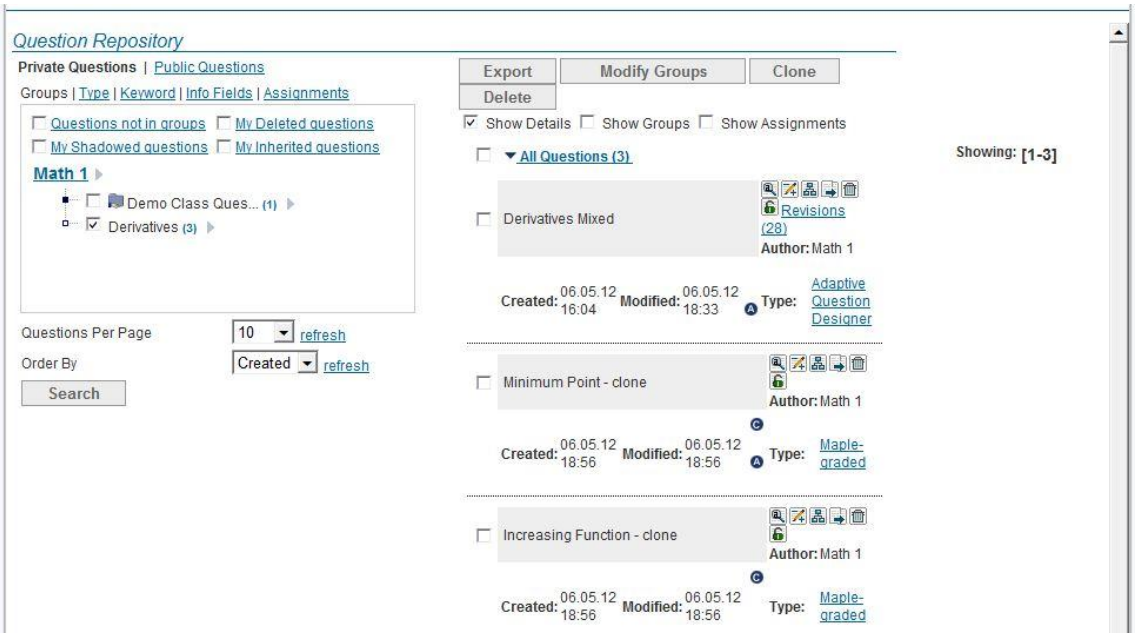

Fig. 2. Question Repository, groups and questions.

The second one (Derivatives) was introduced by the instructor, containing three different questions as an example. The last two come from the demo-group but the first one, designed by the instructor, will be used as an example for adaptive questions. From here it can be looked at, edited or cloned, to work on as a new template or to supply to other instructors. This "Derivatives Mixed" question was designed using the Adaptive Question Designer, which is shown in Fig. 4. A maple-graded question type was chosen to use the help of the CAS Maple 15. The $-preceded variables are defined in the Algorithm-Editor shown in Fig. 3 and invoke Maple commands by maple("..."). The first line defines two random but not equal whole numbers used as index to specify an element from the lists for the outer and inner part of a composed function to be differentiated.

```
$CI=range(1,4);$CO=range(1,4); condition:not(eq($CO,$CI));

$OUTER=maple("[sin,cos,tan,cot][$CO]");
$INNER=maple("[1+arcsin,1-arccos,1-arctan,2*arccot][$CI]");
$PROBLEM=maple("$OUTER($INNER(x))");
```

Fig. 3 Algorithm-Editor

As shown in Fig.4 these variables can simply be used in the text field of the Question-Designer to describe the question text.

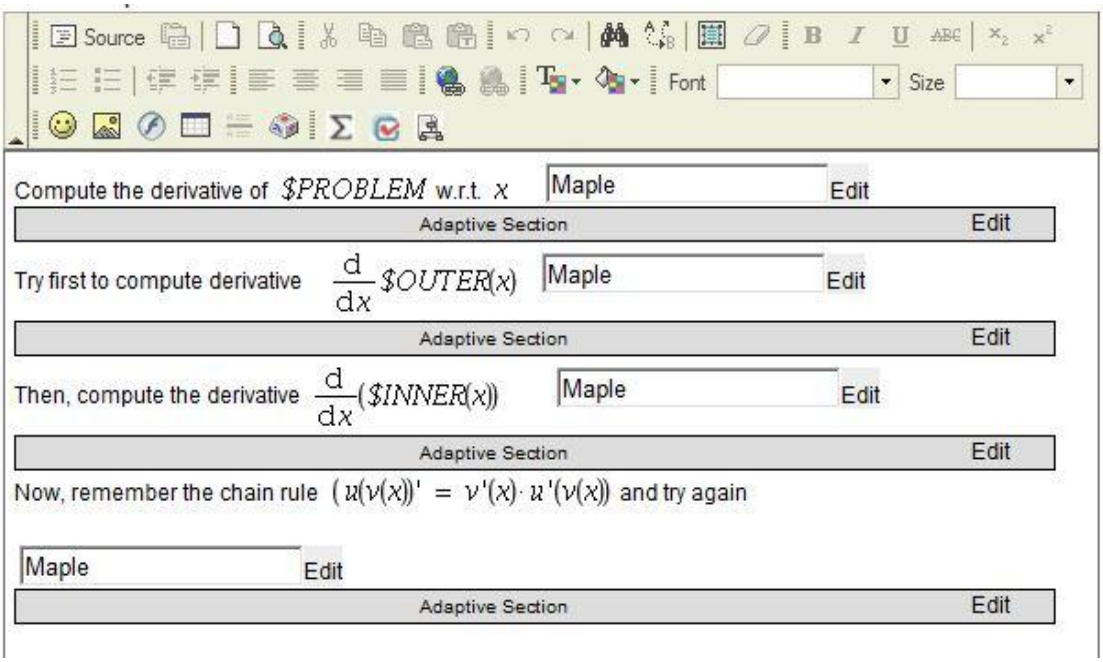

Fig. 4. Adaptive Question Designer

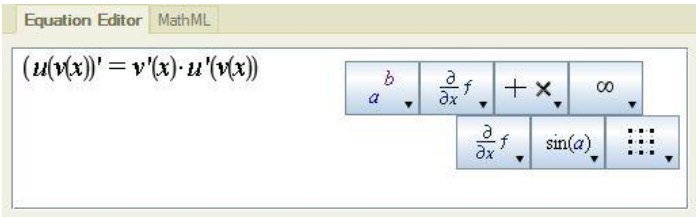

Fig. 5. Equation-Editor

For the construction of formulas an Equation-Editor can be invoked clicking on the ∑-button of the menu containing palettes with all necessary mathematical elements. This editor can later also be used by the students to enter their answers to the questions. The response area is prepared by the field Maple Edit that starts the Response-Editor (Fig. 6).

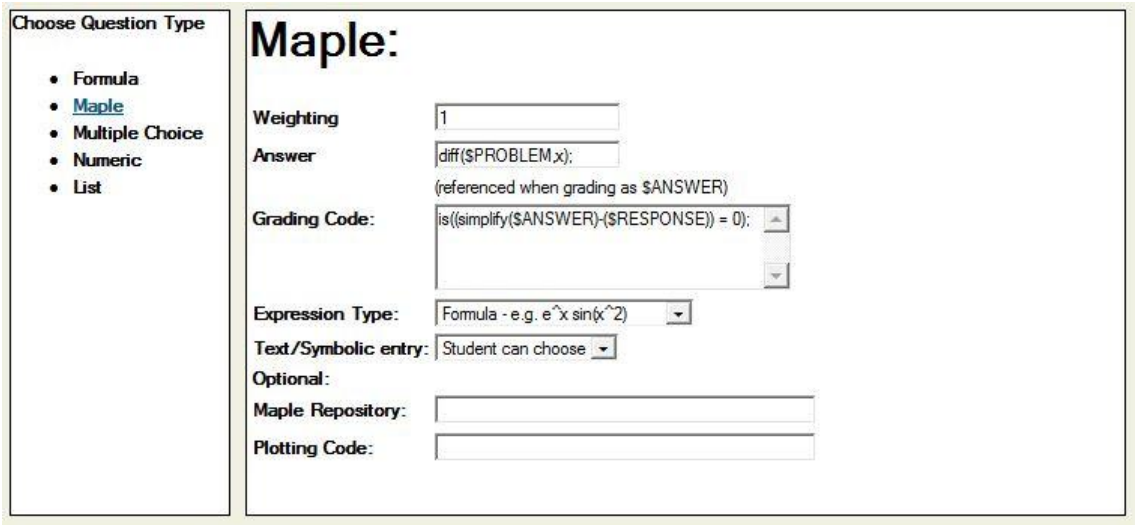

Fig. 6.Response-Editor

In this Maple-type question the correct answer is simply computed by the CAS and stored in a variable $ANSWER. The student's answer is stored in the variable $RESPONSE. The instructor must supply a Grading Code that must evaluate to a Boolean true for an answer to be correct. In this case the Maple simplify command is used for the difference $ANSWER-$RESPONSE that must be zero. Without the simplify command the check for correctness could fail because of the complex structure of all possible true answers. The simplify command invokes the knowledge of Maple about, for example, trigonometric identities or algebra. Because it is sometimes not easy to determine whether two expressions are mathematically identical it is no wonder that it is sometimes hard to find the appropriate Grading Code especially if expressions are randomly chosen.

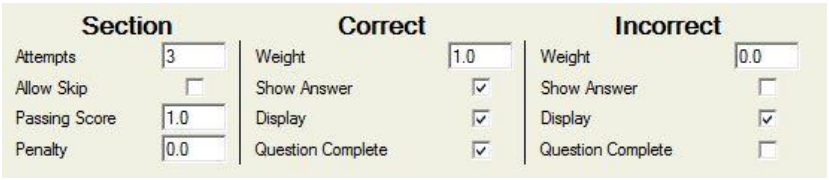

Fig. 7. Adaptive-Section-Editor

The most important point in the adaptive question types are the Adaptive-Section-fields. Using these fields it is possible to react to a possibly wrong answer. An incorrect answer can then lead to the next field where a subpart of the original question can be asked and automatically answered if the response is still wrong or skipped. In the end, the original question can be asked again to see whether the student understood all the hints and can then get at least a part of the marks available. We show an example (Fig.8) where the student fails to give the correct answer for the derivative of a composite function. Then the derivatives for the inner and outer part are separately questioned and finally the chain rule is given and the first question is asked again. Of course the student gets only a part of the points.

In this example the most complex question type of Maple T.A. was introduced. Other more simple types containing purely numerical, simple formula, multiple-choice or 'fill in the blanks' questions etc. are also easily built using the appropriate editors. Once having the questions stored in a question bank the assignment can be designed using this and possibly other banks with a lot of options. All the banks and assignments relating to one class can be stored in a course-module, saved, exported or imported by other instructors.

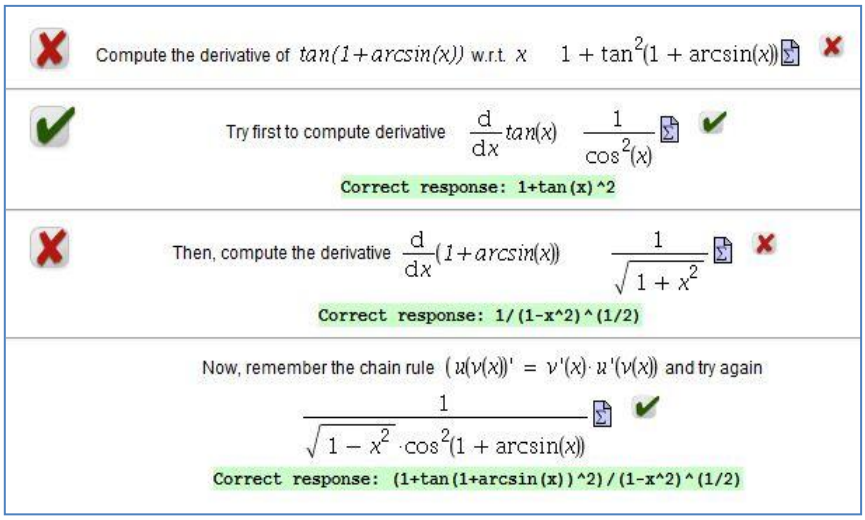

Fig. 8. Direct adaptive response

The students use the assignments perhaps for practice or for final examinations and a full record of the results is kept (if wished by the instructors) and a number of statistical reports are possible. New in the last release is the proctored browser, which offers a secure environment that hinders the student from using other applications than the browser used for the examination or to switch to other sites than specifically allowed. If the student tries, the instructor gets a cheating-message.

Conclusion

The general demands on an eAssessment system are presented and it was shown how these demands are fulfilled at least in part by a real application such as Maple T.A. To show the simplicity, the workflow for designing and using an adaptive question was shown step by step.
However, it should be noted that starting with a set of existing possible entangled questions is probably not a good idea. The instructor should first learn about the possibilities of the system and then rethink what he is going to test or what he wants to know from the students to avoid disappointment.

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