USING MAPLE AND THE WEB TO ADMINISTER MATHEMATICS TESTS

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Abstract
We present AIM (http://calculus.rug.ac.be:8080), a web-based system designed to administer graded tests with mathematical content. Its main features are: use of Maple as the engine and implementation language; several methods of giving partial credit; various feedback mechanisms; randomisation of quizzes and questions; versatility in question and quiz design; extensive grade reporting and monitoring capabilities; ability to collect surveys; web interface for both teacher and student. AIM can be used to administer graded tests, homeworks or ungraded self-assessment exercises. A case study using vector calculus was conducted and more courses are being planned for September 2000, including linear algebra, ODEs and precalculus. Preparation is also under way to use AIM to mark a part of the final exam for linear algebra in Febuary 2001.

AIM [1] (Alice Interactive Mathematics) is a web server for automatically administering graded tests and homeworks with mathematical content. The two distinguishing features of AIM are its use of Maple for performing computations and visualization of mathematical formulas; and its facilities for giving partial credit.

The use of Maple is ideally suited for questions that require symbolic answers and whose verification involves mathematical operations. Typical such question are to compute an indefinite integral, or give an example of a non-zero matrix whose square is identity. For these questions, there are

infinitely many correct correct answers. Grading the first question requires differentiation – and perhaps and using trig identities - things that Maple is good at. Grading the second question requires matrix manipulation. Maple is also used to display math formulas including integrals, greek letters and matrices.

AIM has several different mechanisms for giving partial credits. One such mechanism penalizes students for wrong answers while at the same time printing a warning and giving the student a chance to try again. For example students may get a maximum of 90% if they make one wrong trial, a maximum of 80% for two and so on. This method has several advantages: it is automatic, requiring no effort from the question designer; it forces the students to be careful and to verify their answer. Moreover, students know immediately if they made a mistake and have a chance to correct it - they don't have to wait for days, as with traditional paper homeworks. Another mechanism for giving partial credits is to use *multiple-response* questions for which the students must choose all right choices from a list of right and wrong choices. Finally, the question designer can use a custom grading procedure, programmed in Maple, which may give part marks depending on the form of the answer.

To facilitate question creation, AIM supports several predefined question types, such as *constant*, *matrix*, *multiple choice* and *multiple response*. For these types a standard grading procedure is used. In addition the teacher can use any of existing Maple's types. For example, a question that asks to compute the normal at some point to some surface will have a Maple type `[constant, constant, constant]`. Students will be warned if their answer is not of a specified type.

AIM also provides several mechanisms for automatic feedback to students. Any syntax error or type mismatch is immediately reported without any penalty to the student. Customised warnings that depend on the form of student's answer can be added. For instance a student can be warned if their answer to a question about a rank of a given matrix is greater than its dimension. In addition, the teacher can set up a *due date* after which the students can download a model solution to the test.

To discourage cheating among students, AIM maintains a large database of questions from which questions can be chosen at random using customizable selection criteria, based on topic and difficulty level. In addition, most questions also have some randomly generated component. As a result, each student receives a unique, *personalised* set of questions.

All administration of the server is done through a web interface. Using this interface, a teacher can edit questions, generate statistics and grade reports and monitor student's progress.

We have used AIM to administer vector calculus tests that make full use of Maple's symbolic capabilities. The preliminary results indicate that AIM is a good alternative to marked pen-and-paper homeworks, at least for such computation-dependent courses as vector calculus or differential equations. In a survey, most students indicated that the system was helpful in preparing them for the final exam, and about a half actually preferred AIM over traditional pen-and-paper homeworks marked by teaching assistants.

The software is available for free by contacting the authors. AIM is currently being used at two universities in Belgium, and two universities in England. We are currently developing questions for differential equations, linear algebra and pre-calculus mathematics, to be used in September 2000. It is our hope that this system will provide a useful addition to exercise classes for first-year mathematics courses.

References

[1] Alice Interactive Mathematics (AIM)
http://allserv.rug.ac.be/~nvdbergh/aim

[2] Calculus on the Web (COW) http://fourier.math.temple.edu/

[3] Heriot-Watt WebTest http://webtest.ltc.hw.ac.uk/

[4] WebWorks http://webwork.math.rochester.edu/docs/

[5] Web Hosted Assessment of Mathematics (WHAM)
http://l62.csm.port.ac.uk/