Development of teaching-modules in computational Mathematics and STACK in cooperation with students.

M. Brekke[*], A. Duranovic[*], A. N. Jevne[*] and C. Sangwin[+]
[*] University of Agder
[+] University of Edinburgh

ABSTRACT: We report a project assigned to two second year bachelor students. They create two modules that first year students in electronics test out in February 2017. In module one they create a small course in Computational Mathematics using Maxima to solve problems in Integration. In module two they create a training course in STACK. STACK is an advanced Computer Aided Assessment system for mathematics which goes well beyond relying on multiple choice and other selected response question types. In particular, random versions of a particular question are generated in a structured mathematical way. The main goal of the project is that, under staff guidance, students create a test in STACK for students in the following year. This is similar to "peer tutoring", but involves peers in assessment design. The authors believe that it requires one to have a deeper understanding of a topic to make a test for another, and this is therefore a valid task for students themselves to seek to undertake. The teacher and developer of STACK will evaluate the quality of work the first year student groups deliver. The question is whether this approach helps students gain a better understanding of integration.

1 INTRODUCTION

In 2014 the bachelor programme for electronics engineering at the University of Agder was revised. The aim was to strengthen students' performance by adapting the mathematics to the programme's technical subjects and that this should contribute to a better learning processes and increased understanding of mathematics [1]. This paper reports a project assigned to two second year bachelor students (authors two and three). They create two modules that first year students in electronics test out in February 2017. The focus is on the STACK [2] module, but since STACK uses the computer algebra system (CAS) Maxima [3], students are introduced to this module first.

1.1 Module 1 Maxima

A four-hour introduction course in Computational Mathematics using Maxima. Students work in groups and tasks focus on solving integrals using the trapezium and Simpson's rule. By working in groups, students are encouraged to reason how to solve and at the end discuss results. The purpose of this module is also to be familiar with Maxima to be better prepared to use STACK. And of course, give students a suitable tool to help them solve difficult mathematical problems within engineering.

1.2 Module 2 STACK

A four-hour training course in how to use STACK. Students create a short integration assignment for the following year's engineering students. This assignment will consist of four different questions.

1. Integrate a power of x.
2. Integration by substitution.
3. Integration by parts.
4. Integration using partial fractions.

Students work in groups and should focus on creating problems that are intended to help new students gain a better understanding of integration. The tasks should also provide useful feedback and if possible partial credit on submitted answers.

2 ABOUT MAXIMA

Maxima is a system for the manipulation of symbolic and numerical expressions, including differentiation, integration, Taylor series, Laplace transforms, ordinary differential equations, systems of linear equations, polynomials, sets, lists, vectors, matrices and tensors. Maxima yields high precision numerical results by using exact fractions, arbitrary-precision integers and variable-precision floating-point numbers. Maxima can plot functions and data in two and three dimensions. An example of a solution of the task; *Use the trapezium rule with 5 strips to estimate* $\int_0^1 tan^2(2x)dx$ is given in *Fig. 1*.

```
(%i1) f: tan(2*x)^2$
(%i2) a: 0$
(%i3) b: 1$
(%i4) N: 5$
(%i5) h: float ( b - a ) / N$
(%i6) sum: ( ev( f, numer, x=a) + ev(f, numer, x=b ) ) / 2.0$
(%i7) t: float(a)$
(%i8) for i: 1 thru N-1 do
( t: t+h,
sum: sum + ev ( f, numer, x = t)
)$
(%i9) print ("Trapezoid Estimate is: ", h * sum)$
Trapezoid Estimate is:  236.4216741448413
```

Fig. 1. Example of using Maxima to solve an integral.

3 ABOUT STACK

STACK is an advanced Computer Aided Assessment system for mathematics which goes well beyond relying on multiple choice and other selected response question types [4]. In particular, random versions of a particular question are generated in a structured mathematical way. STACK typically requires a mathematical expression from a student as an answer, and establishes the objective properties of such expressions in order to provide feedback. Specific formative feedback is most likely to be effective and avoids the well-known difficulties with multiple choice and similar question types. Data on all attempts at one question, or by one student, are stored for later analysis. *Fig. 2* shows how STACK presents an integral question for a student.

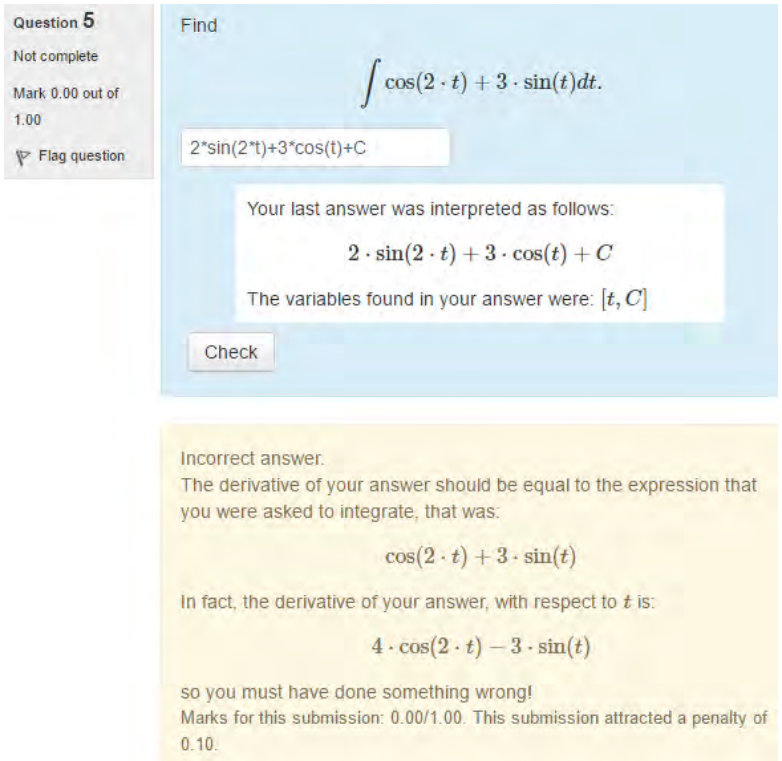

Fig. 1. Example of a question in STACK.

Students write in their answer in the blue field, the system check how their answer was interpreted. It is done to ensure students have entered their expression correctly – or as they intend. Students click on the *Check* button and immediately get feedback on their answer in the yellow field. As you can see in *Fig. 2* they get a hint of what they could have done wrong. So the system not only gives 'correct' or 'incorrect', but helps students to see what mistakes they might have done. They then can correct their answers and try to submit again, but will then get a penalty of losing 0.10 marks.

4 APPROACH

There are a total of 30 students taking this course and they are divided in groups of 3 to 4 students.
One student assistant and the teacher are available 4 hours a week through the project for all groups. The groups are provided with a Moodle [5] account. The reason for this is that STACK provides a question type for the Moodle quiz which is specifically designed to enable sophisticated computer-aided assessment in Mathematics and related disciplines, with emphasis on formative assessment.

4.1 Implementation of module 1

The four-hour introduction course in Maxima is presented in week 7, 2017. The task is the use of symbolic algebra packages to find solutions to integrals. In week 11 each group submits solutions of 8 different integral problems.

4.2 Implementation of module 2

The four-hour introduction course in STACK is presented in week 8, 2017. The student groups work on the project in week 8, 9 and 10. After week 10 the teacher (first author) and developer of STACK (fourth author) will evaluate the quality of work the first year student groups deliver.

The goal of the project is that, under staff guidance, students create a test in STACK for students in the following year. This is similar to "peer tutoring", but involves peers in assessment design. It is believed that it requires one to have a deeper understanding of a topic to make a test for another, and this is therefore a valid task for students themselves to seek to undertake.

5 RESULTS

The results of the project will be presented at the MNT-conference 2017, 30 – 31. March in Oslo. Deadline to students for delivering 4 questions in STACK is the 12th of March 2017. We present both the best and worst cases, but at the time of writing it is not known what outcome will be observed. The central question is whether this approach helps students to gain a better understanding of *integration*.

REFERENCES

[1] Brekke, M. (2016). Embedding mathematics content within the electronics courses for engineering students. The 18th SEFI Mathematics working group seminar, 27-29 June, 2016 Gothenburg, Sweden.
[2] https://stack.maths.ed.ac.uk/demo/
[3] http://maxima.sourceforge.net/
[4] Sangwin, C. J. (2013). Computer Aided Assessment of Mathematics, Oxford University Press.
[5] https://moodle.org/course/view.php?id=54