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STACK is more than Maths – Development of Online-Problems for Mechanics and Electrotechnics

Cosima Klischat[1], Peter Becker[2] und Mikko Vasko[3]

Abstract: STACK is an online system for computer aided assessment. It was designed for mathematics teaching, but STACK is able to do more than mathematics. It can be applied to all disciplines were mathematics is somehow involved, which is especially the case in the technical courses in engineering programs. This contribution reports about the implementation of STACK-problems to mechanics and electrotechnics at Karlsruhe University of Applied Sciences (HsKA).

Keywords: computer aided assessment, engineering education

1 Introduction

It is widely agreed at the HsKA, that the behaviour of students at our university has recently changed with students becoming younger and therefore less self-reliant. The reason for this is up to various political changes during the last couple of years in Germany [Ho18]:

- In 2011 the "Wehrpflicht", the duty of a young man to serve for the military, was suspended.
- In the years between 2011 and 2013 most German regions cancelled a school year enabling students to finish school with "Abitur" after 12 years instead of 13.

Furthermore, the percentage of young people studying in Germany has increased from about 36% in 2006 to 57% in 2016 [Ho18]. This is especially promoted by the German industry, which is permanently seeking for young people with a good technical education, and politics thus taking the necessary actions.

Due to these changes, adjustments in teaching are recommendable to be able to better support the students. For example, university teachers should assign homework on a more regular basis. The computer aided assessment system STACK [Sa13] has proved to be an

[1] Karlsruhe University of Applied Sciences, Faculty of Electrical Engineering and Information Technology, Moltkestr. 30, 76133 Karlsruhe, cosima.klischat@hs-karlsruhe.de
[2] Karlsruhe University of Applied Sciences, Faculty of Mechanical Engineering and Mechatronics, Moltkestr. 30, 76133 Karlsruhe, peter.becker@hs-karlsruhe.de
[3] Karlsruhe University of Applied Sciences, Projekt SKATING, Moltkestr. 30, 76133 Karlsruhe, mikko.vasko@hs-karlsruhe.de

ideal tool to implement online homework and make the students work on technical problems.

2 STACK-Online-Problems in Mechanics

More than 100 STACK-problems were developed in early 2018 and tentatively tested in the summer semester 2018 in a "mechanics of materials"-course. The mechanical engineering students at HsKA had to complete online homework, working on 3 to 5 STACK-problems every week. They had to collect 80% of the maximum number of points awarded for correctly solving the problems to be permitted to participate in the final exam.

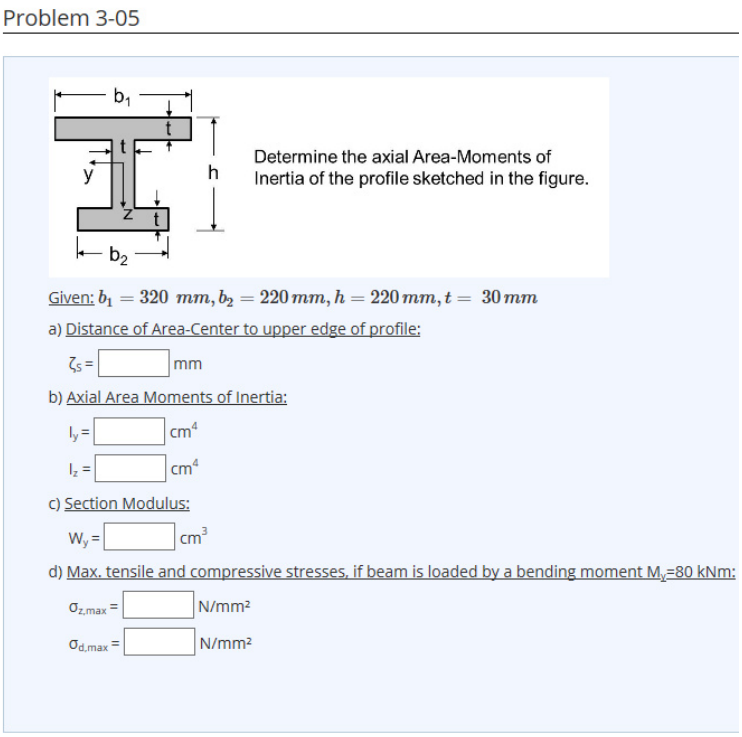

Figure 1: A typical STACK-problem in the "mechanics of materials"-course

The problems in mechanics of materials can usually be divided into several parts, which build up on each other. A typical problem implemented in STACK is shown in figure 1. In this problem the students have to finally determine the maximum tensile and compressive stresses for a beam with the given profile stressed by a bending moment. To be able to calculate the stresses, various cross-sectional quantities have to be determined

in advance: the section modulus has to be calculated, which can only be determined if the axial area-moment of inertia is known. This again can only be computed if the location of the area center is determined first.

In STACK-based online problems the students can check the different steps and receive immediate feedback from the system, whether the answer is correct or incorrect (figure 2). In the shown problem the area centre of the cross-section has to be computed first. After solving this part of the problem the student can check his result. In this way the student has a possibility to get a feedback on his partial solution, and even more important, if the feedback is positive ("Correct!"), he can be sure to continue the problem with the correct value of the location of the area centre.

In the problem shown in figure 1, it would of course be possible to ask only for the final answer, which is the quested stresses. However, if the students enter an incorrect answer, it might become very difficult for them to find out in which part of the problem they have done the mistake. It is therefore much more efficient and helpful for the student to split up the problem into various steps, which are necessary for solving it. In this way the student is perfectly guided through a problem.

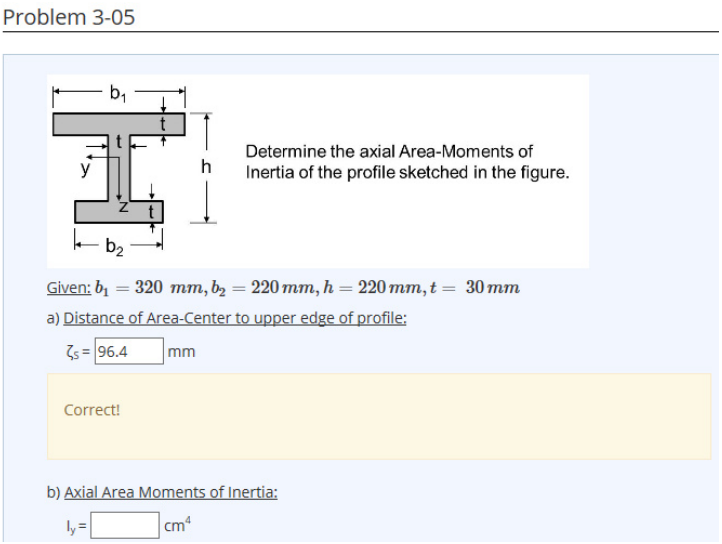

Figure 2: Feedback on the first part of the problem

3 Application of STACK-Problems in Electrotechnics

One of the objectives of the "Electrotechnics Learning Center" at the HsKA is the preparation and distribution of digital learning material about the basics of electrotechnics for all faculties of HsKA as well as for all German universities. On the internet-platform

"H.ErT.Z"-Online (www.hs-karlsruhe.de/hertz) interactive and didactically well-prepared educational material is open to a broad public. Lecture notes, exercise problems with solutions, videos and JavaScript applications to the basic principles of electric fields, direct current and alternating current are offered. These materials are mainly for self-studying purpose and are available as Open Educational Resources (OER) to interested students and lecturers. At HsKA this platform is a supplement to the offered courses.

Online exercise problems have also been developed in the Learning Management System ILIAS (www.ilias.de). These problems are open to all lecturers of HsKA in terms of a problem-pool. Many lecturers use the problems for online homework, which may lead to bonus points for the final exam.

Electrotechnics problems often include complicated formulas and the final result should usually be given as a decimal number in scientific notation. Before STACK was introduced, only simple numerical or multiple-choice answers were possible. In addition, the correct answers could be easily copied, since all students received the same problems. These issues can be solved with the STACK-system [Sa13].

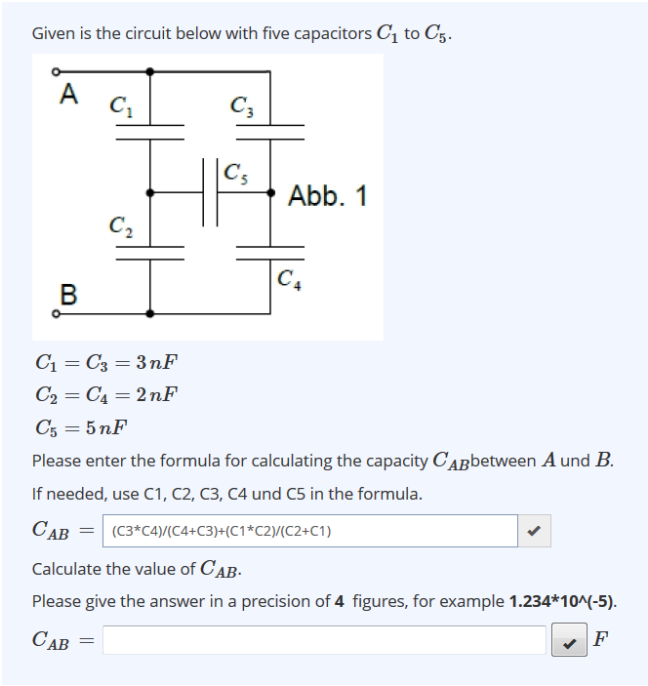

Figure 3: A typical STACK-problem in electrotechnics

In most STACK-problems developed at the HsKA for electrotechnics, the students first have to enter the formula, before calculating the numerical result (figure 3). This gives

them a possibility to check the validity of their approach. Furthermore, the STACK-problems can be randomized, so that each student receives a similar, but not the same, problem. This gives the students a possibility to discuss about the approach, without exchanging the solutions.

To increase the learning outcome and to support the problem solving competence of the students, meaningful feedback should be implemented. At first, to avoid frustration, the syntax of the answer should be checked. STACK provides feedback to common syntax errors, before assessing the answer (figure 4).

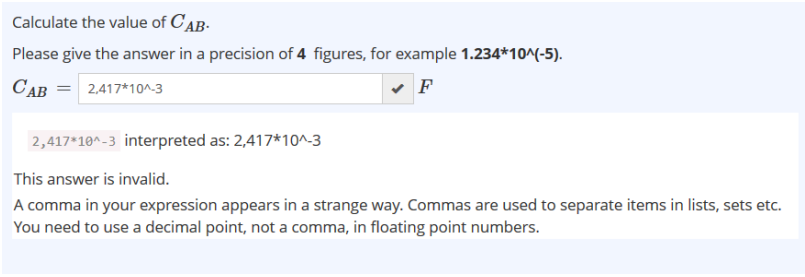

Figure 4: Feedback on the syntax of the answer

When solving electrotechnics problems, students often make mistakes with the order of magnitude. This should also be considered in the feedback provided to the students. The flexible tree-structured feedback system of STACK makes it possible to provide answer-specific feedback to the students (figure 5).

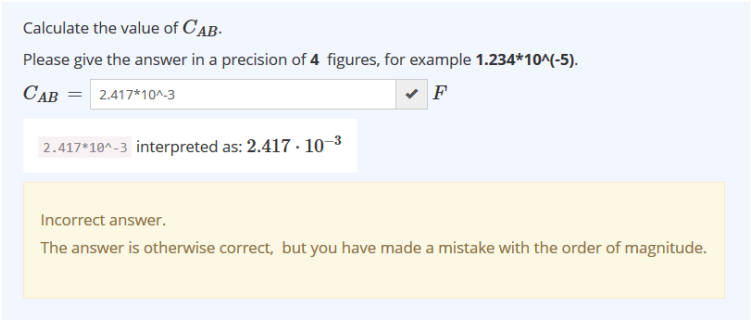

Figure 5: Feedback on an order-of-magnitude mistake

4 Graphical Problems in Electrotechnics

In addition to extensive calculating problems, there are many problems in electrotechnics, which should be solved graphically. For example, determining electricity and voltage in alternating current circuits with the help of phasor diagrams. Before STACK was

introduced, graphical solutions could only be tested by multiple-choice questions. By combining JavaScript-based JSXGraph-applets with STACK the student can solve graphical problems by drag-and-drop on the computer screen [Va18]. Phasors can be dragged adjusting their length and direction, and they can be arranged in series. Students prefer this kind of problems because of their playful character (figure 6).

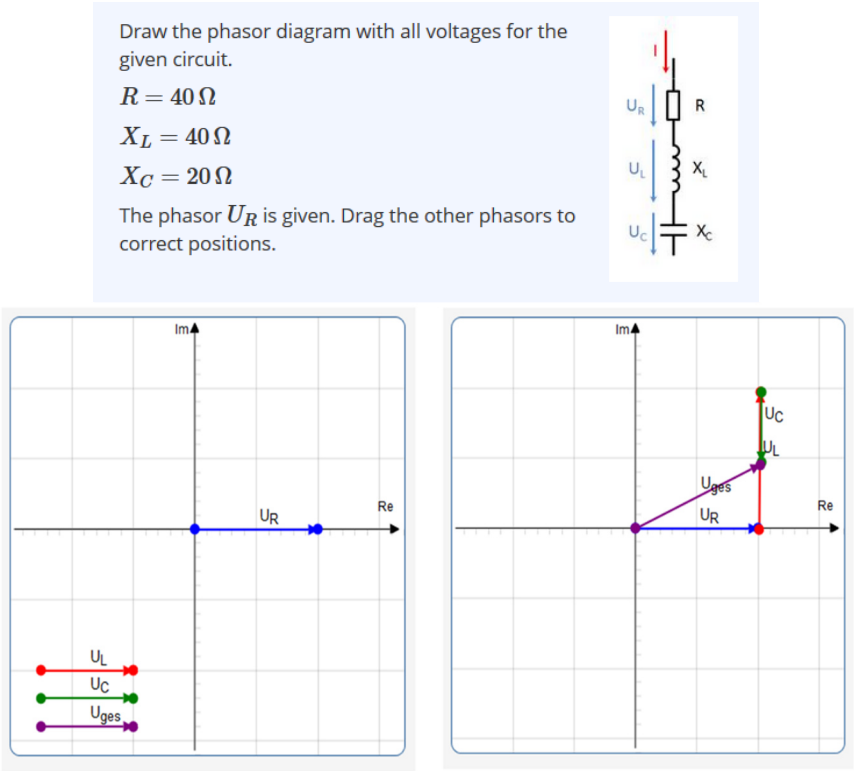

Figure 6: A graphical problem showing the initial positions of the phasors as well as the correct solution

Design aids such as the indication of the angle, auxiliary circles and the possibility of shifting the coordinate system make it easier for the students to solve these problems. These design aids should be pointed out in the problem assignment (figure 7).

The flexible feedback system of STACK can be applied in graphical question as well to provide meaningful feedback to the students (figure 7). It is possible to provide answer-specific feedback, for example pointing the student out which phasor is incorrectly placed. Furthermore, the length and the angle of a phasor can be separately considered, for example, to point out to the student if the length of a phasor is correct but the angle is not.

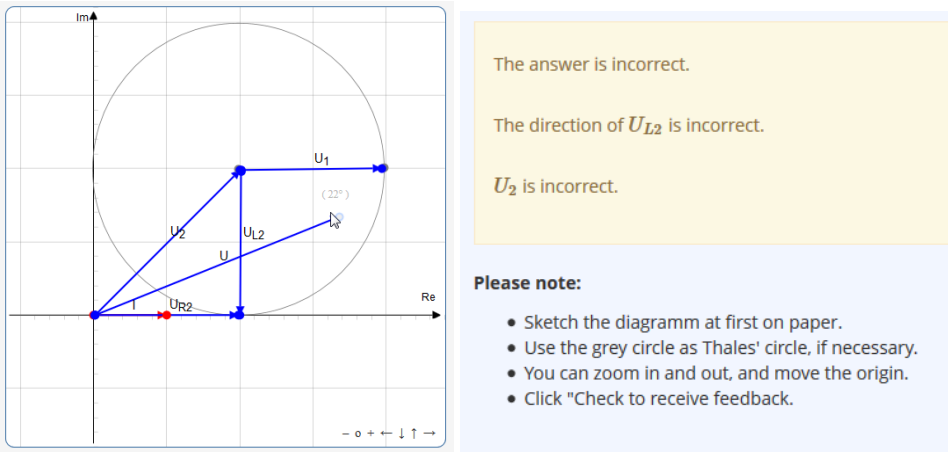

Figure 7: The design aids and their use, as well as the answer specific feedback.

A phasor diagram is only one example of meaningful interactive graphical problems in electrotechnics. Further problem types include drawing the directions of current and voltage into circuits or drawing I-V curves. For the design of a circuit diagram, the electric circuit can be given, the components being offered at the edge of the diagram. To solve the problem, the student has to drag the components into the correct positions (figure 8).

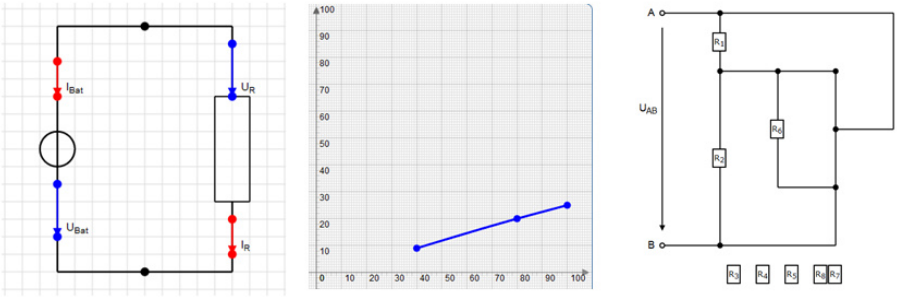

Figure 8: Various interactive graphical problems in electrotechnics. On the left drawing the directions of current and voltage. In the middle an I-V curve. On the right, designing a circuit diagram with given compoments.

5 Discussion

Although the STACK-problems have turned out to be very fruitful and an excellent supplement to the lectures, they also have a disadvantage. Since the students only enter their results, the way these results were determined cannot be controlled. Students might tend to solve the problems very sloppy, for example poorly sketching free body diagrams

when calculating forces. They might then stick to these bad habits when writing their final exams. These possible disadvantages should be observed and considered in future research.

It can, however, be stated that the advantages of STACK clearly dominate. Once the problems have been generated it is very easy to put together a homework assignment. The students receive feedback and the assessment of the answers is done automatically by the system, saving a lot of time of the teaching staff. The randomization of the problems is also very important to make each student work on the problems and to prevent the answers being distributed among students.

6 Summary

STACK has proved to be very useful in the technical education especially for young students of lower semesters. Positive comments in the semester evaluation show that the students accept this kind of exercise. Although some students complained about the increase in the workload, most students see the necessity of working on problems in addition to the lecture to improve the learning outcomes. In mechanics and electrotechnics many different kinds of problems can be generated and assigned for fruitful use. Interactive graphical elements contribute to a higher motivation and understanding of the students. In the future it is planned to implement STACK also for other courses, i.e. dynamics.

7 Acknowledgment

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8 References

[Ho18] Hochschulen auf einen Blick. Ausgabe 2018. Statistisches Bundesamt, Wiesbaden, 2018.

[Sa13] Sangwin, C.: Computer Aided Assessment of Mathematics. Oxford University Press, Oxford, 2013.

[Va18] Vasko, M.: Interaktive grafische Aufgaben mit STACK und JSXGraph. Beiträge zur Mathematikunterricht 2018 (S. 1855-1858). WTM-Verlag, Münster, 2018.