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CONTINUOUS, VERSATILE AND FLEXIBLE ASSESSMENT METHOD ON ENGINEERING PHYSICS COURSES

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ABSTRACT

The global COVID-19 pandemic and lockdowns required many educators to redesign their courses for an online environment. Not only the delivery of contents needed to go online, but also assessments and socio-constructive learning elements, such as group work, discussions, and argumentation etc. This paper presents the continuous assessment arrangements and methods used in engineering physics courses at Tampere University of Applied Sciences during lockdowns and in online courses. Since physics is an empirical science, also the assessment contains elements of measurements and data handling - now in blended and online learning environments. The assessment is based on a basic level exam, week exams, measurement assignments and final exam. The basic level exam is an automatically assessed exam in Moodle with randomly generated initial values for calculus-based problems and with randomly chosen multiple choice problems. Students are able to try the basic level exam as many times as needed to pass it. It generates new values and randomizes questions for each try. The main idea is to make the course completion more flexible for the students and reduce teachers' workload in relation to assessment. By completing the basic level exam with sufficient points, the students pass the course with the lowest possible grade. Many students want a better grade and also accomplish the other elements of the online assessment: week exams, measurement assignments and final exam. This paper also presents data of how the students interacted with the different elements of the courses and how they used the basic level exam as a learning tool.

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1 INTRODUCTION

In engineering education, the assessment of learning outcomes typically consists of some or many of the following elements: 1) formative assessment during the course with the help of quizzes, forms or polling surveys etc.; 2) laboratory work with written or oral reports; 3) homework assignments; 4) summative assessment containing mid-term exams and/or final exam.

Usually the summative assessment is justified by the need for quality control of the education. It offers a controlled environment for assessing student learning gains and academic performance. However, the final exam session can be very stressful for the students, and sometimes students underperform during the final exams. Many university students have been found to report poor sleep due to academic stress, which in turn has a negative impact on for performance [1]. Stress levels typically increase during mid-term and final exams [2]. Based on own teaching experience, this unfortunately applies especially to those students, who already are in danger of failing the course.

The role of formative assessment is to offer feedback for the students of their learning, support their self-efficacy and self-regulated learning. By using formative assessment, it is possible to boost student learning and thus enhance learning outcomes [3-5].

The teacher's workload increases as more and more elements are included in the assessment repertoire. This is even more true for the past year during which the global COVID-19 pandemic and lockdowns required many educators to redesign their courses for an online environment – including assessment. Especially due to the pandemic situation, during the past year a significant part of teacher's workload come from arranging retake exams and considering students' requests for late handout of exercises. To ease teachers' workload, a versatile assessment method including CAA (Computer aided assessment) was utilized and its usage was piloted as part of physics courses' final assessment in Tampere University of Applies Sciences.

2 ASSESSMENT METHOD

2.1 Overview

In Tampere University of Applied Sciences, engineering physics contains separate theory and laboratory courses. It should be noted however, that conceptual understanding and perception of measurement data is essential also in theory courses. Therefore, the assessment method piloted in this study consists of a many different elements. Some of them are group assignments, some individual assignments. Both traditional, calculus-based problem-solving questions and hands-on -type of doing were used. The summary of all the assessment elements is presented in Figure 1 together with their relative weights. Basic level exam and measurement assignments form the basis of continuous assessment and they are described more in detail in the following chapters. Final exam and homework assignments are rather traditional and are thus not discussed any further.

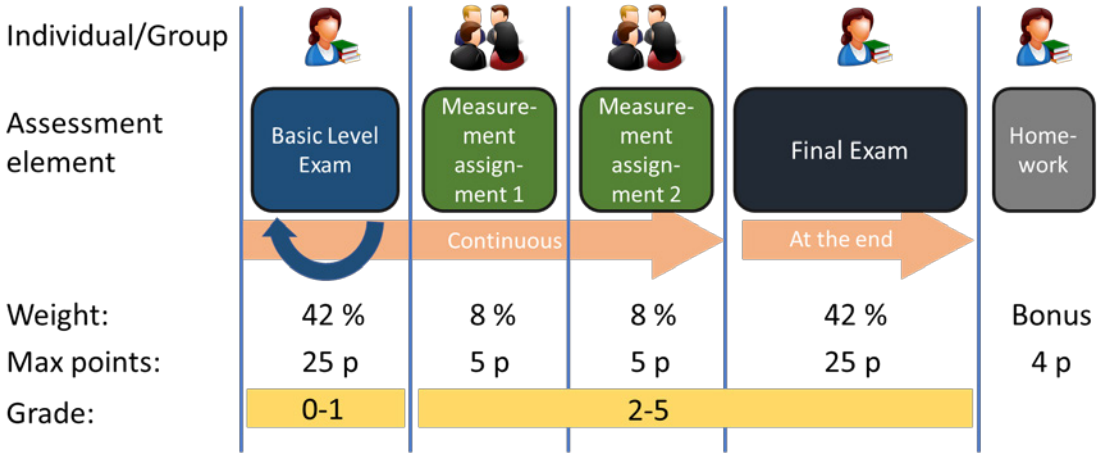

Fig. 1. Assessment method and its elements piloted in this study.

2.2 Measurement assignments

The basic idea in measurement assignments is to deepen the understanding of laws of physics by actually seeing and measuring different phenomena. This also brings an element of hands-on doing to online physics courses, which in turn activates the students. The measurement assignments are usually one-topic, relatively simple tasks, which doesn't need very complicated equipment. In online studies, the equipment should be easily available at home. The students are strongly encouraged to accomplish measurement assignments in small groups, but not forced to do so due to COVID-19 lockdowns. Students need to find the relevant laws of physics and the correct ways to implement them with the given problem. This they can best achieve by discussing, reasoning and considering different arguments and counter arguments together in the group. The emphasis is on the phenomenon and physics, not on the measurement skills. Measurement assignments have learning objectives beyond the topic itself: the students learn to argument their opinion, evaluate peers' opinions, evaluate if they themselves really know, based on laws of physics, or just have a certain "feeling". Moreover, an engineer needs to know (and admit it) when he/she doesn't know. Not to pretend knowing. And seek for support from colleagues. If the student group ends up to a wrong answer in measurement assignment, they then have opportunity to find where their own cognitive model was incorrect and rebuild it. These aspects make measurement assignments in theory courses a beneficial way to activate students. The two measurement assignments of thermodynamics and fluid dynamics course are presented in figures 2 and 3 as examples.

For the measurement assignment 1 students were provided with a video supplemented with data in Excel format (fig. 1). Based on the video and the data, the students were then asked to calculate the specific heat of copper. This was the simpler of the two assignments since the students didn't need to actually build or measure anything themselves. Instead, they needed to understand the phenomenon and the limitations of the method, choose a model for the calculation, pick values from the video and Excel-data and carry out the calculations. And as always in

physics, conceptual understanding is also important and this was tested with open ended questions in addition to the calculations.

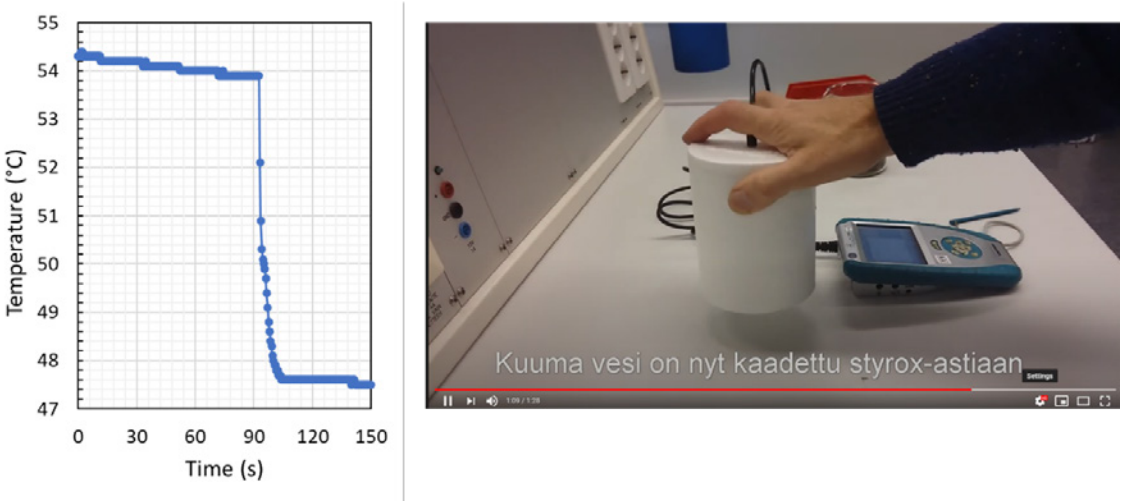

Fig.2. Example of a measurement assignment 1 from thermodynamics and fluid dynamics course: determining the specific heat of copper from video+ data set in Excel.

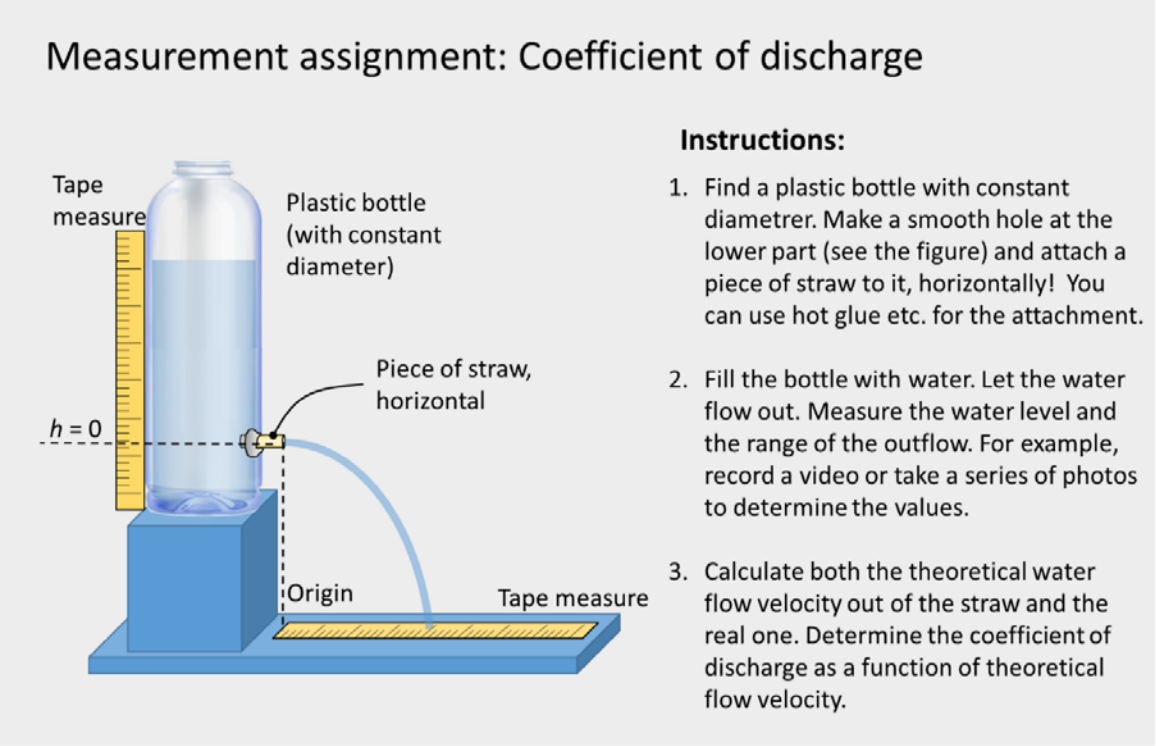

Fig.3. Example of a measurement assignment 2 from thermodynamics and fluid dynamics course: determining the coefficient of discharge with own measurement at home.

2.3 Basic level exam

The basic level exam is an automatically assessed exam in Moodle with randomly generated initial values for algebra-based problems and with randomly chosen multiple choice problems. Students are able to try the basic level exam as many times as needed to pass it. It generates new values and randomizes questions for each try. In our curriculum, the criteria for passing a course with the lowest possible grade state among other things: "…student is able to analyse physical phenomena qualitatively and solve simple problems that resemble those presented in course materials." In regard of this statement, the basic level exam doesn't have very complicated algebra-based problems and thus the problems are well suited for simple, dichotomous grading: correct/incorrect. The exam has seven algebra- based problems and six multiple choice problems which in turn have various number of questions.

3 ANALYTICS OF THE ASSESSEMENT

3.1 Measurement assignments

As described earlier, the measurement assignment 1 (MA1) was somewhat simpler than 2 (MA2). This is also visible in the points distributions for the two assignments presented in figure 4. The average score for MA1 was 2,71 and that of MA2 1,33. Even though students usually appreciate the possibility to learn hands-on, this do-it-yourself assignment didn't encourage all students to take action. Thus, approximately one third of them didn't hand it in at all, which drops the average score. It should be noted that this particular assignment was somewhat time consuming to do and this also might have influenced the accomplishment.

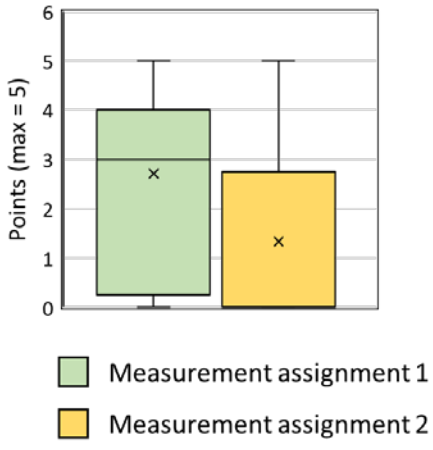

Fig. 4. Point distributions for the two measurement assignments. Maximum was 5 points.

3.2 Basic level exam

At the time of writing this article the physics courses implementing the basic level exam were still going on and therefore the data here is preliminary and limited to one thermodynamics and fluid dynamics course only. On thermodynamics and fluid

dynamics course there were 42 attempts by 16 students. In the following data only serious attempts are included, since there were some attempts that had lasted only a minute or two. This is far from the needed time to accomplish the exam and these peeks to the exam are thus omitted. Figure 5 presents the results of basic level exam of one engineering physics course. Cumulative time students had spent accomplishing the exam is presented on the x-axis, and points they got on y-axis. Each data point represents one exam attempt and the lines connect attempts by the same student. Even though the data set is still small, it can be noted that students have spent significant amount of time in accomplishing the exam. Some students have tried to improve their score even ten times and the largest cumulative sum of time spent is more than 5 hours. In traditional paper exams those students who are in danger of failing or who are struggling with their studies usually spend just a few tens of minutes before giving up. In comparison to that, this automatically assessed, recurring basic level exam with all possible material available has encouraged the students to spend significantly more time in interaction with the exam. This is a remarkable finding.

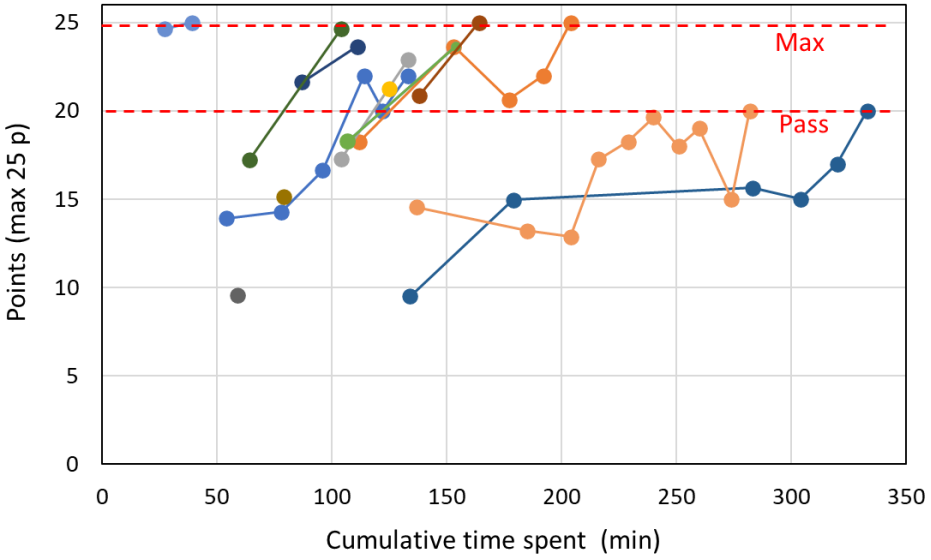

Fig. 5. Basic level exam points as a function of cumulative time attempting the exam. Each line represents one student and each point one attempt.

Another interesting question is how much time the students spent between the attempts. This is illustrated in figure 6 which shows that almost all the students and almost every time start a new try after only a short pause (0-5 min). Some of the pauses are a bit longer (6-30 min) but unfortunately almost nobody had a longer pause during which he could have studied further or had a rest. Instead of having a pause for resting or studying, it seems that students want to keep trying consecutively until they pass the exam. Or until they get the highest possible points, as some students seem to have aimed at, based on fig. 5. The results shown in figures 5 and 6 suggest that the students didn't actually spend more time studying the course materials, but they used much more time with the exam than traditionally. Even though this seems like a kind of "trial and error" -approach, it should be noted

that to pass the exam they needed to do a lot of calculations. Thus, they couldn't just randomly retry multiple choice questions but rather needed to get the principles and equations right for the numerical problems.

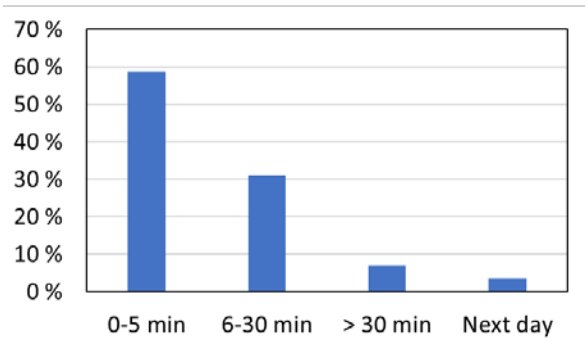

Fig. 6. Length of the pause between consecutive exam attempts.

4 CONCLUSIONS

The assessment method in engineering physics courses at Tampere University of Applied Sciences was presented. The aim was to bring hands-on doing to theory courses especially now during COVID-19 lockdowns and to online courses in general. The basic level exam was introduced as a method to decrease teacher's workload in arranging retake exams and to offer students a flexible way to accomplish the courses. Since the courses implementing these assessment methods are still going on at the time of writing this article, no student feedback is yet available. However, based on the results of student interaction with the assessment elements - measurement assignments and basic level exam - it seems that most of to goals are met: students spend considerably long time in attempting the basic level exam and actually pass it after a few or several attempts. The total exam time was found to be larger than normally in paper exams, even five hours. This suggests that the basic level exam works well as a learning tool, not only as an assessment method. Measurement assignments offer hands-on type of activity for the online course and they also have discriminating power from the assessment point of view since the point distributions were found to be spread out. The next step in this pilot is to gather more data and interview teachers and collect student feedback. Those results will then be used to further fine-tune the assessment method and the measurement assignments.

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