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First Steps Towards Gamification Of Online Physics And Mathematics Assignments

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FIRST STEPS TOWARDS GAMIFICATION OF ONLINE PHYSICS AND MATHEMATICS ASSIGNMENTS

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ABSTRACT

The objective of this practice paper is to describe and analyse the use of online learning tasks on engineering mathematics and physics courses. The development of learning tasks was inspired by the promising effects of gamification techniques in higher education. Hence, some gamification elements, such as bonus points and immediate feedback were integrated into the learning tasks. Course results and student feedback demonstrate the positive impact of gamification of online learning tasks on students' motivation and learning. In the end, further possibilities of increasing the number and repertoire of gamification techniques in engineering mathematics and physics courses are discussed.

1 INTRODUCTION

Many universities are currently developing domestic and international distance learning programs and other means to provide distant and continuous learning experiences in engineering. These often result in growing student intake as well as increasing diversity in the starting level knowledge and skills of the students. This situation, in turn, calls for the development of motivating and pedagogically meaningful online tasks with diverse and continuous automatic evaluation.

Well designed and constructed online tasks can simultaneously increase students' understanding of the topic and their motivation. One advocated approach for creating these is the gamification of education and game-like elements, such as scores, rewards, and challenges, have been shown to have the potential to promote learners' motivation, engagement, and performance (Alomari, Al-Samarraie and Yousef 2019). Points, leaderboards, badges, and levels are the most often used gamification techniques in university education (Alomari, Al-Samarraie and Yousef 2019) as well as in engineering education (Milosz, and Milosz 2020). Points and badges refer to rewards assigned for completing a task, leaderboards to display the ranking of the players, and levels to the variance of difficulty of player's actions (Milosz, and Milosz 2020).

The fifth most common gamification technique used in engineering education is feedback, which helps the players to avoid getting confused or lost (Milosz, and Milosz 2020). In learning situations, the feedback from game-like tasks can offer a constructive way to communicate that there was a mistake in the student's work, but also to praise them for a task well performed (Yong et al. 2021). Research shows that feedback is an integral part of learning and a pre-requisite in constructing new information structures (Yong et al. 2021), (Krause, Stark and Mandl 2009). Learning is more efficient the more often personalised feedback is received. In game-like tasks, errors and mistakes can be corrected based on instant feedback and hints. Mistakes should not be overly avoided but they should be seen as a way to improve one's learning (Yong et al. 2021).

Solving mathematical problems provides good grounds for gamification. Correct answers can be rewarded with points or badges, the requirement level can be adjusted through the complexity of the problems, most typical mistakes can be pointed out through hints and feedback, and the collected points can be used as the basis for leaderboards or progress bars. In addition to learning mathematics, gamification elements can also foster students' learning skills when they plan for the best gaming tactics, and even their interaction skills when they consult their peers for better success (Ariffin et al. 2022).

Online learning tasks with gamification elements encourages and motivate students to participate more actively in the learning process. The active role of the learner improves learning results. The active role of learner is included in the constructive learning theory (Hui, and Mahmud 2023). According to the constructivist learning theory, the learning process is self-directed and that creates new understanding and knowledge for the learner (Agarkar 2019).

In our work in university-level engineering education, we added game-like elements to online learning tasks in physics and mathematics. Here, we present our experiences on the effects of interactive online tasks on student learning and motivation from one such course, 'Basics of Vibration and Wave Motion'.

2 METHODOLOGY

2.1 Description of course implementation

The bachelor program first-year physics course (Basics of Vibration and Wave Motion) utilizes weekly independent online assignments. This course is worth two ECTS credits and it extends over seven weeks. The course includes lectures, assignments, independent weekly online exercises, and an examination at the end of the course.

2.2 Evaluation of the course

At the beginning of the course, the students are presented with the evaluation criteria. The course grade is determined by the examination at the end of the course. The final online examination includes 5 tasks with 10 points each, resulting in 50 points as the total maximum.

Additionally, it is possible for the students to raise their accepted grades by one by independently completing weekly online tasks. These voluntary tasks provide a maximum of 6 extra points (EP), based on equation (1), where r indicates the percentage of correctly solved weekly extra tasks.

$$EP = \frac{r}{100\,\%} \cdot 6 \qquad (1)$$

For example, if the student achieves 35 points from the exam and has completed 69% of additional tasks ($EP = 4.14$), the student receives a total of 39.14 points. The final grade is assigned according to Table 1.

Table 1. Determination of grade from points

Grade	Points
0	< 23
1	23 - 28
2	29 - 34
3	34 - 40
4	41 – 45
5	46 – 50

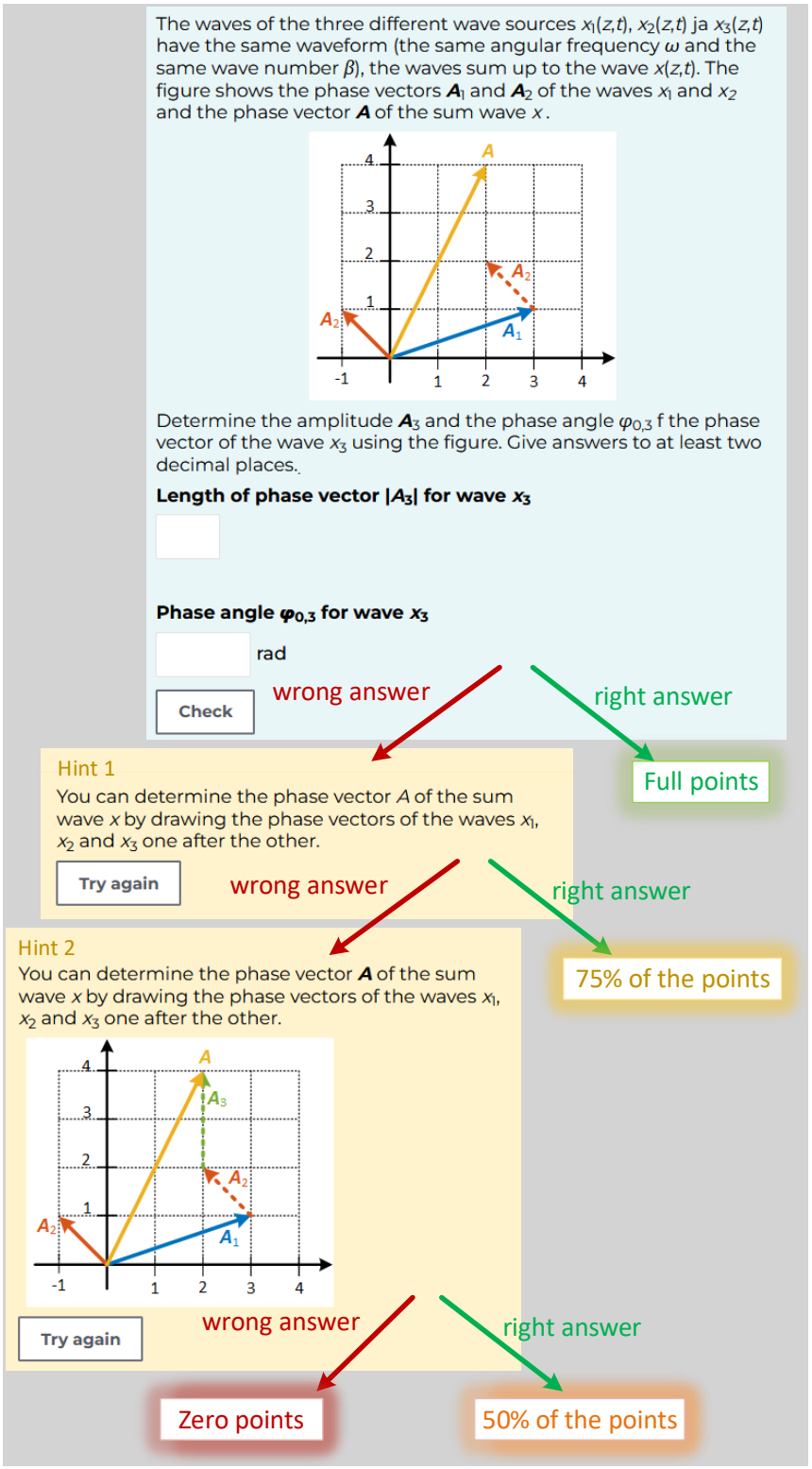

Fig. 1. Example on a numerical question and the scoring principle.

2.3 Online learning tasks

The weekly online exercises of the study unit are diversely implemented. By completing them, students' learning from the weekly subject is measured and deepened. The exercises are evaluated automatically and gamification elements like instant feedback as well as interactive hints are utilized. The exercises involve multiple choice questions, image interpretation and calculation tasks.The student gets instant feedback about if the answer was right or wrong. If the answer was right the student gets full points. If that is not the case the student gets a hint. The new trial gives 80% of the maximum points as a result of success. The student can have 2 or 3 new trials depending on the question. In figure 1, an example on numerical question is shown.

3 RESULTS

3.1 Tables

Thetask completion rate, lecture attendance and participation in either contact or video tutorial session have been recorded weekly, with results shown in Figure 2.

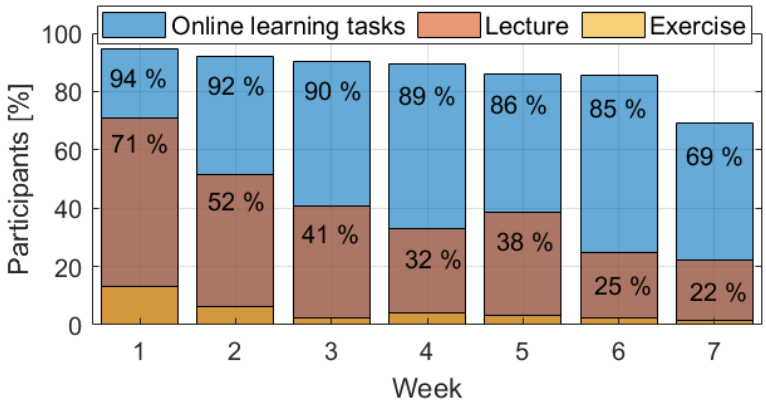

Fig. 2. Students' completion rate of online tasks and attendance on lectures and exercise/tutoring sessions in percentage.

The arithmetic mean of online task completion was 87% of students, lecture attendance 47% and exercise session attendance 15%. Comparatively, students were significantly more active in doing the online tasks. The conclusion is that despite these tasks being also in practice optional, students were motivated to complete them. To explore the benefit between completing online tasks and learning results, the arithmetic mean of the final grade for each quintile of online task completion has been observed in Figure 3.

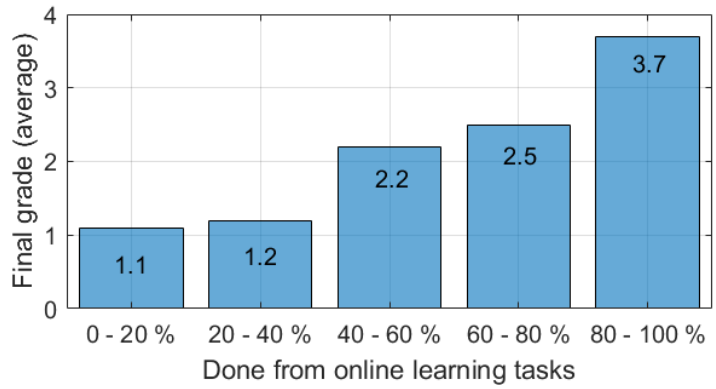

Fig. 3. Correspondence between online task completion percentage and final grade.

Students who have done more than 80% of online tasks had a final grade average of 3.7 (out of maximum 5.0) whereas students who had done less than 40% of online tasks had a final grade average of slightly more than one.

After completing the course, feedback was collected from the students, using the evaluation of several statements. Figure 4 shows the responses to the statement "*Course's online learning tasks supported my learning*".

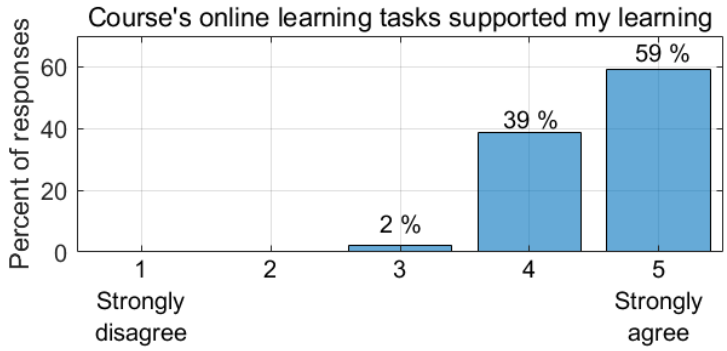

Fig. 4. Distribution of replies to "Course's online learning tasks supported my learning" in percentage.

The arithmetic mean of the replies was 4.6 and the standard deviation was 0.5. A total of 59% of replying students strongly agreed that the online tasks supported their learning.

In free verbal feedback, students made the following comments, among others:

"*The online learning tasks were nice and just suitably challenging*"

"*Challenging tasks and rewarding when solved*"

"*Online learning tasks supported learning a lot, especially because tasks have multiple attempts with hints*"

"*Weekly online learning tasks motivate continuous learning*"

4 LIMITATIONS OF THE METHODS AND STUDY

Gamification of learning often focuses on teaching concepts with measurable outcomes, well-defined rules, and quantification. To embed qualitative tasks that involve reflection, interpretation, and critical analysis might be challenging but not impossible. Another limitation is to provide personalised and meaningful feedback, particularly on qualitative tasks. Moreover, gamification heavily focuses on grasping student's attention by giving immediate rewards, feedbacks and competition. Complex skills, such as critical thinking, logical reasoning, and narrative building might not be achieved by the gamification of simple exercises.

Our study was also conducted within limited subjects and a single university; it might be better to use more diversified approaches in future studies. The study period of the analysed courses is seven weeks, but results could differ if the study period is longer.

5 SUMMARY AND ACKNOWLEDGMENTS

Course statistics show that the students were highly motivated to do the voluntary online learning tasks even though the effect of the tasks on the final grade was rather small. Completing online learning tasks was much more common than attending the lectures or exercises throughout the course and the temporal decline in the activity of doing the tasks was smaller than for other activities during the course.

The effect of online learning tasks for learning was evident, with a positive correlation between the task completion rate and final grade. Although active completion of the learning tasks was rewarded by increasing the final grade by a maximum of one category, this was not enough to explain the differences in grades between those having done a little and those having done a lot of learning tasks. Also, the student feedback indicated that the learning tasks strongly supported their learning.

Qualitative feedback from students revealed that the students perceived the online learning tasks to be suitably challenging, motivating and rewarding. The feedback in the form of hints was also appreciated. These, as well as the quantitative findings, are all well aligned with the discovered effects of different gamification techniques (Alomari, Al-Samarraie and Yousef 2019, Ariffin et al. 2022).

Based on this preliminary study, it is not yet possible to draw far-reaching conclusions about the effect of online tasks with gamification elements on learning. In the future potential feedback loops and further individualization of the course to the student level (e.g., adjusting difficulty level) should be considered. It would be also possible on the currently used learning management system to add other gamification elements, such as high score tables. These will be the next steps in the gamification of online learning tasks, which will be study in the future.

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