Using digital tools and gamification to improve e-course

Martina Holenko Dlab

University of Rijeka, Department of Informatics, R. Matejcic 2, Rijeka, HR-51000, Croatia

Abstract

The quality of e-courses is an important issue, actualized recently by the pandemic COVID-19 and the shift to online learning. It is expected that in the post-pandemic period different models of e-learning will be used, including hybrid models that combine the advantages of onsite and online learning. Contemporary approaches to e-learning promote didactic models that include activities (e-tivities) that support the achievement of learning outcomes and encourage students to actively participate in the learning process, taking into account the context in which the course is offered, but also the individual characteristics of the students. In the process of designing an e-course, an appropriate e-learning model, teaching methods and digital tools should be selected.

In this paper, a didactic model for the blended learning course "Operations Research" is presented. The model of the course was continuously improved based on the experience of the teachers and the feedback of the students using the design-based research approach. In the last cycle of improvements, gamification was introduced as an attempt to motivate students for a continuous approach to learning.

Keywords
Blended learning, Digital pedagogy, Gamification, E-tivities, Operations Research.

1. Introduction

The events caused by the COVID-19 pandemic have encouraged many university teachers to explore different models of e-learning and digital tools which they may not have used before. Considering their benefits to higher education, it is expected that they will continue to use them in their teaching practices. To ensure the quality of e-courses to be performed in the post-pandemic period, it is necessary to encourage teachers to think carefully about which e-learning models and tools are appropriate for their context and for their students.

E-learning is a term that describes the educational process enhanced by the use of new information and communication technologies (ICT). At the University of Rijeka, e-learning is classified into two main approaches, based on the degree of differentiation from traditional learning [1]. The first is *online teaching*, which is a form of teaching where students learn independently and completely without attending classes in the classroom (also called onsite teaching). The second is *hybrid or blended education* which is a combination of traditional, onsite teaching in the classroom and teaching that takes place online. The advantage of hybrid education is the ability to adapt the teaching process to different circumstances and contexts, as well as to the characteristics and needs of individual students [2]. Although e-learning is supported by technology, when evaluating its quality, the focus should be not only on the technology but on the teaching process as a whole. The teaching process should be student-centered and encourage active learning, application of new knowledge and mutual collaboration between students and teachers [1].

One of the digital pedagogy approaches for developing e-courses that promote active learning is the e-tivities based approach proposed by Gilly Salmon [3]. In e-tivities, students collaborate with each other and with teacher in an online environment to complete a specific task and achieve learning outcomes. Examples of e-tivities include creating digital content such as multimedia presentations, case studies, solving a WebQuest, and participating in online discussions [4]. Although the original definition of e-tivities refers to collaborative activities, e-tivities can also be adapted for individual student work with the help of the teacher who guides the student (e.g., problem solving or project-based tasks). During e-tivities, students can use various digital tools that are not necessarily integrated into the learning management system (LMS) but are available on the web.

E-tivities can be used to assess the achievement of course learning outcomes as part of formative [5] and/or summative assessment [6]. While summative assessment results in points or a grade at the end of the teaching process (e.g., at the end of the semester or teaching module), formative assessment is conducted during the teaching process with the goal of gathering information about student progress and providing feedback to students in order to guide their further learning.

Student motivation is one of the most important elements for the successful learning process. Incorporating frequent assessment activities into the didactic model of the course can be used as a motivational strategy to ensure that students actively and continuously approach their learning, thus gaining a deep understanding of the course concepts and acquiring the required skills [7], [8], [9]. This is seen as particularly useful for applying to younger students to help them adopt routines and work habits. Continuous formative activities aimed at providing feedback to students can be time-consuming and lead to teacher overload, so they need to be carefully planned and supported with digital tools where possible [5], [10], [11].

Digital tools can also be used to implement gamification [12] as an additional motivational strategy [13], [14]. Gamification involves the use of game design elements in non-game contexts and one of the ways of implementing it is through the use of digital badges [15], [16]. A digital badge is a visual icon that represents a student's achievement, talent, skill, or similar. In addition to the icon (image), a digital badge also contains metadata that includes relevant information about the digital badge (i.e. name, description, issuer, expiration date, criteria, tags, evidence) [17]. Digital badges can be created by anyone who has access to platforms that issue digital badges. Examples of such platforms include digital tools such as Badgr [18], Open Badge Factory [19], and also learning management systems (e.g. Moodle [20], Canvas [21]). Students can share/show their digital badges on social media, through e-portfolio or by creating badge collections with tools such as Badgr Backpack [18] and Open Badge Passport [22].

This paper presents a didactic model for the blended learning course "Operations Research" and improvements made by introducing gamification with digital badges. The Design-Based Research (DBR) model was used for this research [23]. DBR assumes iterative cycles of testing and refinement of solution in practice [24] so the didactic model of the course was improved in a sequence of DBR cycles, based on the results obtained from the collaboration between students and teacher/researcher. In the last cycle, gamification with digital badges was introduced to encourage students to engage in continuous learning and active participation in weekly formative assessment activities. The paper presents student attitudes towards the use of digital badges in the course and plans for future work.

2. Methodology

The course Operations Research is a blended learning course [25] so its didactic model includes onsite teaching and online learning supported by an LMS and digital tools. From year to year, the didactic model was improved in accordance with the DBR model, based on teacher's experience and the students' feedback. From the academic year 2020/2021, the course is conducted in the second year of undergraduate studies, where the number of students is significantly higher. In order to adapt the didactic model to these new circumstances, changes were introduced in the model, starting a new DBR cycle. The most significant change in this cycle was the introduction of gamification with digital badges for formative assessment activities.

In order to determine students' attitudes towards the use of digital badges in the Operations Research course, the following research questions (RQ) were investigated:

RQ 1) What are the students' attitudes towards the importance of continuous learning during the course?

RQ 2) What are the students' attitudes towards the use of digital badges to promote continuous learning in the course?

RQ 3) What are the students' recommendations regarding the future use of digital badges in the course?

2.1. Participants and data collection tool

The participants of the research were second year undergraduate students of Computer Science at the Department of Informatics, University of Rijeka, Croatia, who took the Operations Research course in the academic year 2020/2021.

To collect their attitudes about digital badges, an online questionnaire with a set of Likert-scale statements was conducted. The following Likert scale of attitudes was used: 1 – Strongly Disagree, 2 – Disagree, 3 – Neutral, 4 – Agree, 5 – Strongly Agree. Questionnaire also contained a couple of multiple-choice questions and open-ended questions for comments and suggestions.

From a total of 55 students, 46 students (84%) filled the questionnaire.

2.2. Course context and activities

The overall goal of the Operations Research course is for students to acquire basic knowledge of operational research and skills in applying methods to solve linear programming and transportation problems in order to support decision making.

The course was originally developed for the graduate program in computer science at the Department of Informatics, University of Rijeka and was attended by 20-40 students. From the beginning [25], the course is enhanced by the combining various activities, including e-tivities, and digital tools. Students are encouraged to adopt an active learning approach during the semester, as this is the most effective way to achieve the learning outcomes of the course. During the DBR cycles, the didactic model was aligned with the course context. For example, the number of students enrolled in the course has increased (from 20-40 to 50-100), which should have been taken into account when designing e-tivities and selecting tools.

The course is taught by one teacher as a combination onsite and online learning. The classes are divided into lectures and practical exercises. At the beginning of the semester, students are presented with a schedule indicating when classes are held in classrooms and when they are held online. During the past year, students have been warned that a sudden transition to fully online classes is possible due to the spread of COVID-19 disease. If it is not possible to have a lecture in the classroom, it will be delivered via the BigBlueButton video conferencing tool [26] and/or made available via the LMS. In the LMS, all learning materials are also available in text form. In this way, the delivery of learning materials is adapted to different learning styles of students [27].

Students are required to use the Moodle learning management system where the teacher regularly posts announcements about the course, learning materials, assignments for exercises or homework, and other relevant information. As can be seen in Figure 1, which shows the flow of the course activities, each lecture is followed by exercise. Since the course material includes mathematical concepts and quantitative methods, and the content presented is interrelated, students are encouraged to work continuously. They are expected to participate in formative assessment activities to gain insight into whether they have mastered certain topics and to better prepare for exams.
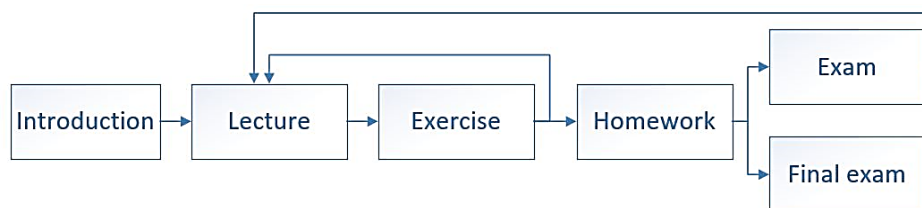

Figure 1: Flow of activities for the course Operations Research

Students are encouraged to collaborate in solving given problems and, in the case of forum discussions, to comment on other students' answers. For exercises, students use the following software and online digital tools to solve linear programming problems: LPSolve [28], Geogebra [29], Transportation and Assignment Problem Calculators [30]. They enter the solutions they get as answers in a quiz or forum, and sometimes they submit screenshots or program code files. At the end of the week, the teacher marks one of the correct solutions in the forum and, if necessary, asks individual students to explain their solutions with comments. The teacher also posts group feedback for assignments that are solved in the form of quizzes (e.g. often mistakes, correct answers). Students can earn a maximum of 12 points by regularly submitting solutions of tasks included in exercises (1 point per exercise).

During the semester, students also complete homework assignments as part of formative assessment. Each homework assignment includes writing short essay or solving a set of problems and is evaluated based on predetermined criteria, with up to 5 points. The types of tasks included in the homework are similar to the tasks in the exam. In this way, students know what to expect and become familiar with the technical side of the exam.

Exams are organized twice during the semester to test knowledge of theoretical content and problem-solving skills. As part of the summative assessment, the exams are in the form of online tests that are solved under controlled conditions (in the classroom). In order for a student to take the exam, he or she must submit completed homework assignment that precedes the exam. Depending on the accuracy of the questions answered and the tasks solved, the student can earn up to 20 points on each exam.

By completing the planned activities, students can earn a maximum of 70 points during the semester (Table 1). It should be noted that the points from the formative assessment activities are also included in the score as a reward for the students.

Table 1
Course activities and points

Activity	ECTS*	Number of activities	Implementation in the LMS	Type of assessment	Points (max)	Threshold
Exercise	1.5	12	Online test or discussion in forum	Formative	12	-
Homework	1	3	Online test	Formative	18	-
Exam	1.5	2	Online test	Summative	40	-
Final exam	1	1	Online test	Summative	30	15
TOTAL	**5**	**18**			**100**	**50**

*ECTS - Credits according to the *European Credit Transfer and Accumulation System*

Students who earned at least 35 points and turned in solved tasks from all homework assignments on time can take the final exam. The final exam is an online test that includes theory questions and practical assignments. Students can earn up to 30 points on the final exam. To pass the final exam, the student must achieve at least 50% of the points - a minimum of 15 (there is no threshold for course activities during the semester). If the final exam is passed, the collected points added to the previously collected points and the corresponding grade is formed according to the following scale: A - 90 100, B - 75-89.9, C - 60-75.9, D - 50 59.9%, F - 0-49.9. Otherwise, the student has the right to access the final exam 2 more times (up to 3 times in total).

2.3. The introduction of gamification using digital badges

The main change in the didactic model made in the summer semester of the academic year 2020/2021 was the introduction of gamification through digital badges. Considering that the course participants are now younger students (undergraduates) who need more guidance and encouragement from the teacher, digital badges are introduced as a way to motivate students to continue learning. The approach to the use of digital badges is tailored to the size of the group (between 50 and 100) by using the capabilities of the Moodle system to automatically allocate badges.

A set of digital badges created for the Operations Research course is shown in Figure 2. Students can earn digital badges for submitting solutions of the weekly exercises on time. For the exercises, students can earn up to 12 points, so these points are associated with badges - for each badge, students can earn 1 point. Previously, students could only earn points for homework. The suggestion of the students was that some of the points should be awarded for solving the exercises as well, which was accepted.
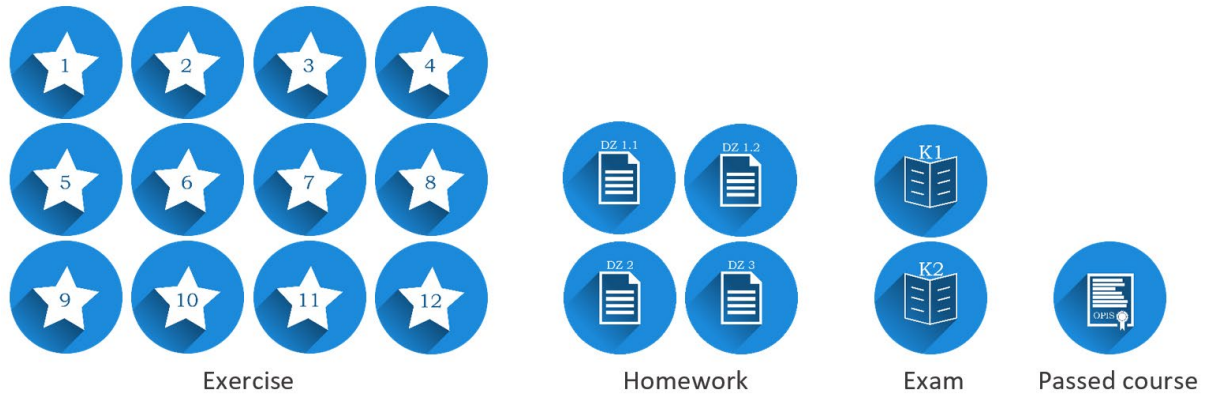

Figure 2: Digital badges for the course Operations Research

Given the large number of students on the course, the Moodle system options are used to automatically assign these badges to students. For each digital badge, one or more requirements (criteria) are defined so that the teacher does not have to manually assign the badges on a weekly basis. The criteria include completing one or more activities (e.g., submitting a quiz or posting a response in the discussion forum) before the specified deadline. In this way, the gamification approach was adapted to a large group of students enrolled in the course. The teacher typically reminds students two days before the deadline that they need to complete the exercise and invites them to ask questions.

Additionally, students may earn digital badges for submitting homework assignments and for taking exams during the semester. Students are not rewarded with the course points for earning these badges. In the learning system interface (Figure 3), badges they can win are displayed along with the corresponding activities (quizzes or a series of questions in discussion forums).

When they earn a badge, students receive a notification and the badge is displayed to them in a list of their badges in the LMS. If they wish, students can add it to one of the badge collection systems, share it on social media, add it to their e-portfolio, or similar.
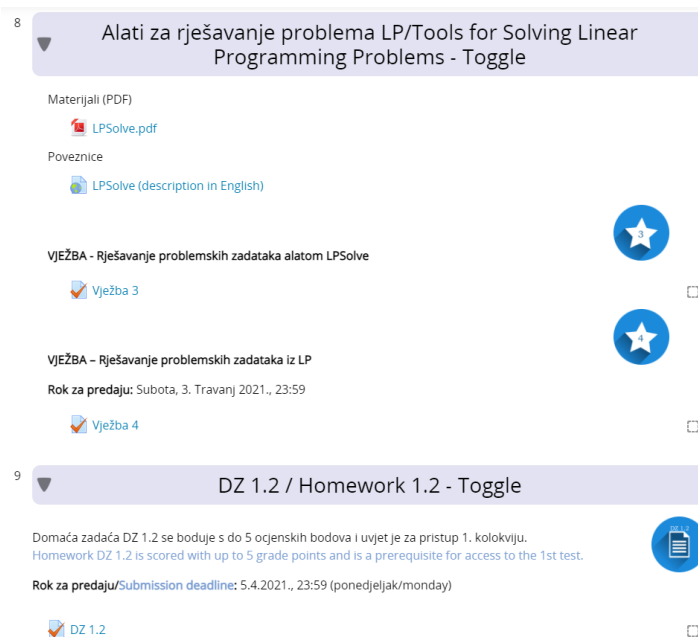

Figure 3: Course activities in the Moodle LMS and associated badges

3. Results

The results of the questionnaire conducted to collect students' attitudes about digital badges are presented in Table 2. To answer RQ1, statements S1 and S2 were included in the questionnaire. The results show that 89% percent of the students agree that a continuous learning approach is important to achieve the learning outcomes of the Operations Research course (11% are neutral). A total of 98% of the students believe that such a continuous approach is important to prepare for exams through exercises.

Table 2
Anonymous questionnaire results (N=46)

	Questionnaire statements	5	4	3	2	1	Avg	StDev
S1	You believe that a continuous approach to learning is important to achieve the learning outcomes of the course.	56%	33%	11%	0%	0%	4,46	0.69
S2	You think that solving exercises regularly is a good way to prepare for exams on this course.	72%	26%	2%	0%	0%	4,70	0.51
S3	You think it is good that some of the course points can be earned by regularly solving the exercises.	87%	11%	0%	0%	2%	4,78	0.65
S4	You think that it is more interesting to get a digital badge for a submitted solution of the exercise instead of just points.	33%	37%	24%	0%	6%	3,83	1.08
S5	You find that gamification using digital badges is an effective way to motivate students for continuous learning.	28%	42%	24%	0%	6%	3,78	1.00
S6	When you receive a message in the LMS that you have received a digital badge, you feel satisfaction.	41%	33%	17%	7%	2%	3,89	1.14
S7	You would like to have chance to earn digital badges in other courses as well.	28%	35%	31%	2%	4%	3,72	1.02

Statements S3-S6 were used to answer RQ2. Almost all students (98%) agree that it is good that part of the course points can be earned by solving the exercises regularly, while 70% of students think that it is more interesting to get a digital badge for this effort instead of just getting points and consider gamification with digital badges to be an effective way to motivate students to study continuously (24% are neutral). 74% of students stated they feel satisfaction when they are notified about the new badge they have earned.

Students' attitudes regarding RQ2 were further explored using the question about the process of collecting badges. The results, shown in Figure 4, indicate that 32% of the students consider collecting badges a challenge and want to collect as many badges as possible, while 61% of the students do not consider collecting badges a challenge but are happy when they earn a badge.

Figure 5 shows the results regarding students' recommendations for the future use of digital badges in the course (RQ3). In their opinion (91%), badges should be used, especially those that carry points. To answer RQ3, students were also asked to state their recommendations in an open-ended question. Some students stated that the idea of badges and their implementation is great and that nothing needs to be changed. Others gave their ideas for awarding additional badges (e.g., for the quickest correct answer) and points (e.g., for students who collect all the badges), while one student suggested that students who earn all the badges should not be required to take the final exam.
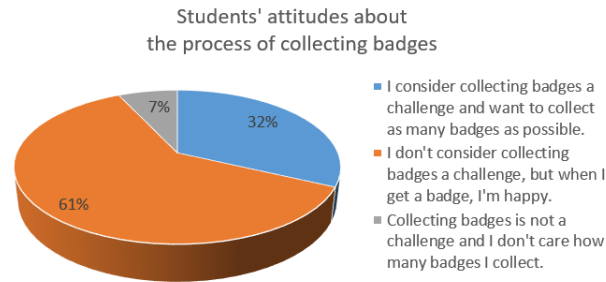
Students' attitudes about
the process of collecting badges

- I consider collecting badges a challenge and want to collect as many badges as possible.
- I don't consider collecting badges a challenge, but when I get a badge, I'm happy.
- Collecting badges is not a challenge and I don't care how many badges I collect.

Figure 4: Results regarding the process of collecting badges

Students' recommendations for
the future use of badges

- Keep badges, especially those that carry points
- Keep using badges, but badges should not carry points
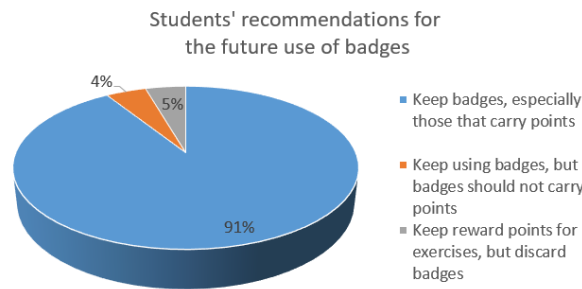- Keep reward points for exercises, but discard badges

Figure 5: Results regarding the recommendation for future use of badges

On average, the students who answered the questionnaire have so far collected 6 out of 8 digital badges during the Operations Research course. Most of them did not have the opportunity to collect badges in other courses (3 students indicated that they had the opportunity to collect digital badges in 1 course, while 1 student had the opportunity to collect digital badges in 2 courses). 63% of students would like the opportunity to collect digital badges in other courses (31% are neutral).

Students were also asked to write other comments about the use of digital badges in the course. While some students stated that only the points encourage students to solve assignments, the others said that they are very satisfied and that collecting badges keeps them motivated. One student wrote, "1 point per badge is not much, but it is quite enough to motivate me to study the materials and do the exercise because I know my effort will be rewarded."

4. Conclusions and plans for future work

The main objective of the paper was to present the didactic model of the Operations Research course that includes gamification using badges, as well as the results of the research conducted to explore students' attitudes regarding the use of digital badges to promote continuous learning.

Students consider continuous learning and regular participation in weekly activities (exercises) necessary to pass the Operations Research course (RQ1) and have positive attitudes regarding rewarding their continuous activity with points. Moreover, it can be concluded that they like the fact that they can earn badges in addition to points (RQ2) and would recommend the use of badges (with points) in this course in the future (RQ3). They consider gamification with badges to be an interesting, fun, and effective way to motivate students to actively participate in the weekly formative assessment activities. In the context of the Operations Research course, gamification would hardly be possible without the capabilities of a digital tool used to support course delivery - the Moodle learning management system. The Moodle LMS allows the teacher to define rules for the automatic awarding of badges related to the completion of course activities and defined deadlines. This saves the teacher's time by not having to award each badge to the students who earn it.

Based on the results of this DBR cycle, it can be concluded that digital badges with associated points should be used in the course to motivate students to actively participate in weekly formative assessment activities. Further opportunities for gamification will be explored as part of the Digital Games project [31]. These include the introduction of additional badges (e.g., an additional badge that carries points

for all badges collected or an additional badge for creating digital learning materials that can be used by other students) and additional game elements (e.g., progress bars, achievement levels, leaderboards).

In future DBR cycles, course improvement will be guided by the Framework for e-course development and evaluation developed at the University of Rijeka [1]. It contains a set of elements grouped into four main categories: E-course organization, Learning materials and methods, Monitoring and evaluation, and Communication and three levels of quality are defined for each: initial (minimal quality), developed (satisfactory quality), advanced (high quality). The focus will be on possible improvements in terms of activities that will enable personalized learning pathways and on promoting a higher level of collaboration among students.

5. Acknowledgements

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