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EXPLORING THE EFFECTIVENESS OF CONTINUOUS ONLINE SUMMATIVE ASSESSMENT IN A VOCATIONAL STEM COURSE

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ABSTRACT

There is limited research on continuous summative assessment and its benefits for students and teachers. The development of online tools that reduce teacher workload has enabled further research that can be conducted in real educational settings. The findings presented in this paper are intended to help expand understanding of the positive impact of intensive continuous online summative assessments on students. Design-based research (DBR) was used as the methodology for the research presented. The parameters of the experiment were modified during the experiment according to the DBR approach and were based on the feedback received from students and teachers during the experiment. Three successive generations of vocational undergraduate students participated in the experiment (88 students in total). The results of the experiment show that the introduced intensive continuous online summative assessment motivated students during the semester and consequently led to more students achieving learning outcomes. It can be concluded that intensive continuous summative assessment, when implemented online, can have positive effects on the process of achieving learning outcomes. If implemented properly, it can help teachers and students continuously adjust their activities during the semester to meet the specific needs of the teaching and learning process.

Key words: *continuous assessment, STEM education, ELARS*

1. INTRODUCTION

Advances in online technologies have significantly changed educational practices over the past decade. Online systems designed to enable distance learning have been developed and tested in real educational settings. Starting with the combination of traditional face-to-face courses with online activities (e-tivities) (Mezak et al. 2015), in recent years, due to the COVID-19 pandemic, educational processes have been tested in a fully online environment (Olasile Babatunde, Soykan, 2020; Duwi Leksono et al. 2020). This change has encouraged research in this area and has led to advances in all areas of online education. In addition to the technological advances required for successful online education (Anderson, Hajhashemi, 2013), research has also been conducted on motivational strategies that can be used successfully in an online environment (Aras, Wulandari, 2021; Karsen et al., 2021).

In STEM (science, technology, engineering and mathematics) education, specific approaches to the organization of teaching and learning have been developed to meet the specificities of this field. Student motivation as one of the most important prerequisites for successful learning (Naghizadeh, Moradi, 2015; Krelja Kurelovic et al., 2014) has been extensively researched. Various approaches have been adopted (e.g., the use of compatible learning and teaching styles (Felder, Silverman, 2002), the design of appropriate online teaching and learning materials (Felder et al., 2000), the implementation of active learning approaches based on e-tivities (Mezak et al. 2015), gamification (Dichev, Dicheva, 2017; Plantak Vukovac et al., 2018) etc.). Motivation through the use of formative and summative assessments has also been investigated (Elmahdi et al., 2018). In a series of research experiments, this motivational strategy proved to be successful in motivating STEM students (Trotter, 2006; Azmi et al., 2017). The transition of educational practice to a fully online format opened up the possibility of adapting traditionally conducted formative and summative assessments to the online environment (Andersen et al., 2020).

This paper aims to increase understanding of how formative and summative online assessments can be successfully implemented into online STEM educational practices and used as a motivational tool for STEM students. To achieve this goal, a study was conducted with students enrolled in the course Electrical Energy Networks, which includes a series of formative and summative assessment activities. Students' academic results in the online and offline assessment activities, as well as their attitudes, were analysed, compared, and discussed.

2. THEORETICAL BACKGROUND

Assessment can be used as an effective tool to increase student engagement in STEM education (Trotter, 2006; Azmi et al., 2017), along with other motivational strategies (such as compatible teaching styles, active learning approaches or blended learning courses, the use of digital tools for learning, etc.).

Assessment methods used in education are usually divided into two types: formative and summative (Leena, Muthuramalingam, 2016). Traditionally, formative assessment is conducted continuously during the semester, while summative assessment is conducted two or three times in the form of midterm exams (exams that cover a logically related group of course topics). Both approaches have their goals: formative, to provide students with quick feedback during the semester (so they can focus on their learning activities), and summative, to assess student performance (Glazer, 2014). In order to implement each of these types of assessment, a careful planning phase must be conducted prior to their use. Factors such as the particular conditions of the learning environment, the size of the class or the different learning approaches of the students must be taken into account (O'Mahoney, 2013; Rahman et al., 2012).

Although formative and summative assessment have different purposes, summative assessment can also be considered, at least in part, as formative assessment (Holmes, 2015). After students receive the summative assessment grade, they can use this feedback to focus their learning on course content that they need to additionally master at a higher level.

Summative assessment in STEM has traditionally been conducted offline using a paper-based approach consisting of math-based tasks. With the development of online tools, the opportunity has arisen to conduct examinations in an online environment. Therefore, it was necessary to adapt the examinations to an online environment while ensuring that all elements specific to the subject of study were transferred from the offline to the online environment (Andersen, 2020).

Summative assessment within the course can also be implemented using hybrid approach by combining offline and online assessment sessions. Although summative assessment usually takes place under controlled conditions, a hybrid approach to summative assessment may involve a combination of both assessment sessions under controlled conditions (e.g., in the classroom with teacher present) and uncontrolled conditions (e.g., from home without the supervision of the teacher), especially for the online portion of summative assessment.

Although educational practices have been the focus of much research, there are not many examples of the use of continuous assessment (Holmes, 2015). Intensive continuous assessment is usually conducted weekly during the semester, as opposed to the traditional approach of midterm exams. The authors in (Llamas-Nistal et al., 2019) combined intensive continuous assessment with the flipped classroom model using the BeA (Blended Assessment Online Tool) to investigate the effectiveness of the proposed approach and its impact on the number of students who passed the theory portion of the course. In (Trotter, 2006), the authors employed weekly organized continuous assessments to improve the learning environment for students. The authors in (Cole, Spence, 2012) investigated how weekly organized continuous assessment can be successfully introduced in a large class to improve student engagement in the learning process, while in (Rahman et al., 2012) the author evaluated the introduction of continuous assessment from the students' perspective. In all the above experiments, student feedback was positive and student engagement increased over the course of the semester.

Student motivation is one of the key factors in the educational process. If students are properly motivated, they will be engaged and actively participate in the educational process (Williams et al., 2016). The level of students' motivation affects their persistence and choices as well as their performance during the semester (Kim et al., 2012). The feedback students receive during the semester plays an important role in their motivation (along with personal relevance, the feeling that they can master the course content, and that they have some control over the learning process) (Zhu et al., 2017). Frequent feedback information from formative and continuous summative assessments can be successfully used to motivate STEM students during the semester (Azmi et al., 2017).

3. RESEARCH DESIGN AND METHODOLOGY

The study presented in this paper examined possible approaches to implementing formative and summative online assessments in STEM education with the aim to expand the understanding of how different approaches affect students' results and motivation.

Design-based research (DBR) methodology was used in this research (Wang, Hannafin, 2005). It provides the opportunity to change some of the experimental parameters depending on the observed initial results (Chavan, Mitra, 2019). In this way, DBR provides a framework for testing educational theories in real educational settings when conventional approaches may be inadequate.

The present study involved two cycles of DBR. Each cycle included online formative assessment activities and intensive summative assessment activities conducted in different environments (online and offline in the first cycle and fully online in the second cycle).

The research questions were:

RQ 1: Does the use of intensive continuous online summative assessments increase STEM students' motivation and result in more students achieving the learning outcomes?

RQ 2: Can online assessments conducted in an uncontrolled environment (online assessment without teacher presence) replace assessments conducted in a controlled environment (with teacher presence during assessment)?

RQ 3: Do students positively accept the introduction of intensive, continuous online assessments?

3. 1 Participants

Three consecutive generations of STEM students enrolled in the 3rd academic year of the vocational undergraduate study program of Electrical Engineering at the Faculty of Engineering, University of Rijeka, Croatia, in the compulsory course Electrical Energy Networks held in the 5th semester participated in the experiment. The main objective of the course is for students to develop an understanding of modeling, calculation and analysis of electrical conditions in electrical energy networks. Therefore, mathematical assignments are primarily used to assess student learning. The course is taught by one teacher.

The total number of students in the experiment was 88. The control group consisted of all students who took the course in the 2018/2019 academic year (first generation, N=36). These students did not participate in either the formative activities or the continuous online summative assessment activities. Two experimental groups consisted of all students who took the course in the 2019/2020 academic year (second generation, N=27) and 2020/2021 (third generation, N=25) and participated in the online formative assessment activities. For second-generation students, a hybrid approach to summative assessment was used that included both offline and online assessments, and for third-generation students, summative assessment was conducted exclusively online. The students were predominantly male (only three female students in the first generation and one in the third generation).

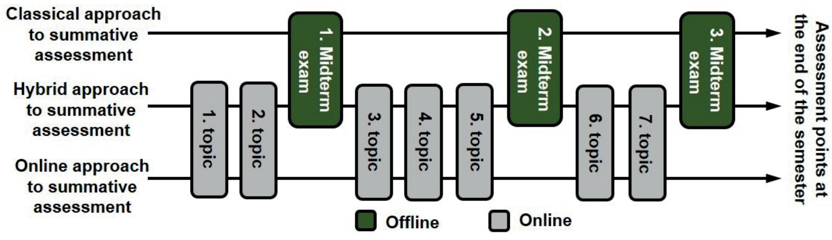
Students from the different generations were compared based on their grade point average (GPA) prior to the experiment. The results of the one-way ANOVA showed that there was no significant difference between all three generations of students ($F(2,27) = 2.45748$; $p = .065201$). In addition, students were compared based on final grades in three subjects that were prerequisites for enrollment in chosen course. The results of the one-way ANOVA showed that there was no significant difference between the observed groups: Mathematics 2 ($F(2,98) = 1.44407$, $p = .240941$), Electrical Engineering 1 ($F(2,101) = 1.13195$, $p = .326461$), and Electrical Engineering 2 ($F(2,99) = 2.51849$, $p = .085734$).

3. 2 Study design and procedure

At the University of Rijeka, students can earn a maximum of 100 assessment points for each course, 70 points during the semester and 30 points on the final exam. To earn assessment points during the semester, students must take exams, each consisting of one or more logically grouped course topics. Students who have earned at least 35 assessment points during the semester have met the established learning outcomes and are eligible to take the final exam (where they may earn up to 30 additional assessment points). The total number of assessment points (earned during the semester and on the final exam) determines the final grade for the course.

As a starting point for the study, the results (assessment points earned) of the control group of students at the end of the semester were analyzed. Students in the control group did not participate in either the formative activities or the continuous online activities for summative assessment. The summative assessment for this group was based on three paper-based midterm exams (Figure 1.) with math-based tasks that covered several course topics. Students had 90 minutes to complete the tasks for the 1st and 3rd midterm exams and 120 minutes for the 2nd midterm exam. Students earned their assessment points during the semester as shown in Table 1. Within each math-based task, assessment points were distributed between the intermediate and final results and were awarded to students for correct answers. This distribution of assessment points within each math-based task served as a template for preparing the online assessment sessions with the experimental groups of students. In addition, students had the option to retake one of the midterm exams at the end of the semester if they were unable to take the scheduled midterm exam during the semester for any legitimate reason (e.g. illness).

Figure 1. Approaches to summative assessment during the semester for each generation of students



Source: Authors

Table 1. The maximum number of assessment points that can be earned during semester through summative assessment approaches

	1. topic	2. topic	1. midterm exam	3. topic	4. topic	5. topic	2. midterm exam	6. topic	7. topic	3. midterm exam	**Total**
Classical approach to summative assessment (control group)	-		20	-			30	-		20	**70**
Hybrid approach to summative assessment (1st experimental group)	5	5	10	5	5	5	15	5	5	10	**70**
Online approach to summative assessment (2nd experimental group)	10	10	-	10	10	10	-	10	10	-	**70**

Source: Authors

For the first experimental group, formative assessment activities were organized and a hybrid approach to summative assessment was used that combined offline midterm exams and intensive online summative assessment sessions. Following lectures on each topic, students had the opportunity to take online formative assessment in preparation for the scheduled summative assessments. The approach to summative assessment included offline midterm exams covering multiple course topics (as with the control group) and intensive online summative assessments that required students to solve a task related to one course topic. Students had two attempts, one week apart, to solve the task regarding particular topic. Each week, students had two hours with a fixed start point to complete the first attempt for the course topic covered one week earlier and the second attempt for the course topic covered two weeks earlier (if they chose to use second attempt). They were free to choose which task they wanted to solve first. Since students were required to take an online and an offline assessment for each course topic, the assessment points were divided equally between the offline and online assessments, as shown in Table 1. Scores obtained on the offline and online assessments on the same topic were compared to determine if there were any significant differences (suggesting the use of illicit help during the online summative assessment). For those students with similar offline and online scores, all earned points from both parts of the summative assessment were awarded. For students who were suspected of having used illicit help during the online portion, only the points earned during the offline portion of the summative assessment were awarded. This part of the experiment constituted the first DBR cycle.

Formative assessment activities were also organized for the second experimental group, but the summative assessment was conducted entirely online. As with the first experimental group, students had the opportunity to complete two tasks each week (first and second attempts for two consecutive topics). The difference from the previous generation of students was that students had to follow a fixed schedule for each topic, with a short time gap between these attempts. In addition, each course topic was given a different amount of time to complete the task, based on the difficulty of the task and feedback from formative assessments. End-of-semester assessment scores were calculated as the sum of the assessment points earned for each topic (Table 1). This part of the experiment constituted the second DBR cycle.

For both experimental generations of students, the intensive online summative assessment was administered using a series of similar math-based tasks that were randomly assigned to students. Students had two attempts for each topic in order to avoid technical difficulties and to reduce the stress associated with any exam, especially those where students were dependent on technology (a variation on the option to retake one of the midterm exams at the end of the semester that the control group of students had). The better result of two possible attempts for each topic was used to calculate the assessment points earned. Formative assessments were used throughout the semester to track student progress and refine the organization of summative assessments (especially during the second DBR cycle).

3. 3 Implementation of online assessment

ELARS (E-Learning Activities Recommender System) was used to implement formative and continuous intensive online summative assessment. ELARS was originally developed to promote the use of digital tools and the personalization of collaborative learning activities (Hoic-Bozic et al., 2016). Assessment functions for STEM were added to the system to explore the possibility of combining recommender systems with online assessment tools (Durovic, et al., 2019). The implemented assessment functions allow the ELARS system to be used for formative assessments as well as for conducting online summative assessments, including intensive summative assessments during the semester.

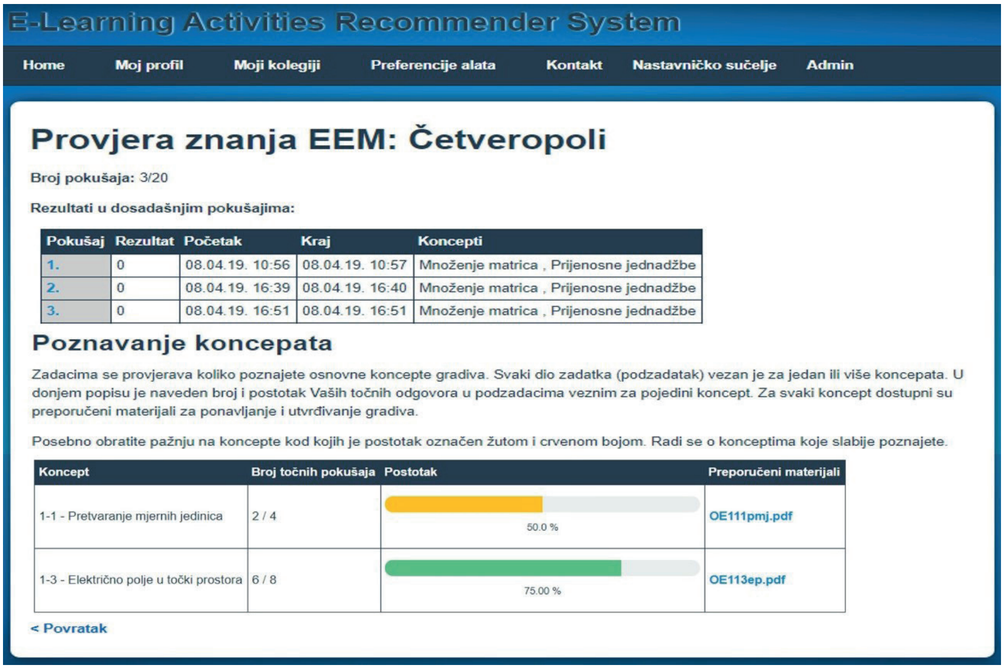
Within ELARS, math-based tasks are organized into groups that correspond to course topics. For each topic, it is possible to define the number of tasks that a student can attempt to solve, the time period during the semester that students can access each topic, and the time it takes to complete each task (depending on the difficulty of the task). Once a student starts a session, a randomly selected task is presented.

In the system, a group of math-based tasks has been prepared for 7 course topics of the course Electrical Energy Networks. These tasks were prepared in such a way that students had to enter intermediate and final results for each task. In this way, it was possible to track students' progress within the math-based task, link this progress to the concepts of the course (which are part of the learning outcomes for the course) and generate feedback information for students at the level of intermediate and final results (they receive immediate feedback on the correctness of answers with correct results for incorrectly entered values). The idea was to mimic the traditional analysis of the process of solving an assignment (traditionally done on paper in the presence of the teacher) in an online environment. In this way, feedback was provided more quickly and helped students learn (at the time when they needed the feedback most). Using the data collected through the system, the teacher can track student progress (both as a group and for each individual student) and make the necessary changes in the learning process accordingly.

Math-based tasks prepared for the formative and summative assessments in ELARS were of equal difficulty so that students could adequately prepare for the summative assessment. For the formative assessment, there were a total of 52 different math based tasks (6 to 10 tasks for each of the 7 course topics). For the summative assessment, there were different versions of the same math-based tasks (15 to 30 versions generated from two to three different tasks within each course topic) prepared in such a way that these tasks were very similar and yet different (e.g., with different values for the same parameter). This was done to ensure that all students would be randomly assigned math-based tasks of similar difficulty and would be in the same situation when taking the online exams.

In addition, students will be able to access an individualised feedback information page that will include information on the proficiency level of the course concepts as well as written online materials for additional learning. Students can also revisit previously solved tasks through this page, as can be seen in a screenshot of ELARS in Figure 2.

Figure 2. An example of the ELARS feedback information page for students



Source: Authors

3. 4 Data collection and analysis

First generation students (academic year 2018/2019) were used as the control group. Second and third generation students used ELARS over the DBR cycles described above. The data collected during the experiment and used for statistical analysis came from several different available sources.

As mentioned earlier, students of different generations were compared on the basis of their pre-experiment grade point average (GPA) and final grades in three subjects that were prerequisites for enrollment in the chosen course. The results of the one-way ANOVA showed that there was no significant difference between all three generations of students.

For each generation of students, the number of assessment points earned during the semester was collected and compared to determine the number of students who achieved the learning outcomes. In addition, the total number of assessment points (the sum of points earned during the semester and on the final exam) was collected and compared to examine the possibility of using uncontrolled online assessments to grade students. One-way ANOVA statistical test was also used for statistical analysis in these cases.

System logs were used to collect information on student use of ELARS. The number of students who used the system and the number of math-based tasks students accessed and solved during formative assessment were used to monitor student motivation during the semester. In addition, the number of points students scored on the math-based tasks in each course topic (for correct answers to intermediate and final results) was used to track student progress within the course topic. In the second DBR cycle, the time students took to complete the math-based tasks during the formative assessment was used to determine the maximum amount of time students could spend on each course topic during the intensive online summative assessments.

A paper-based questionnaire was also administered to determine student satisfaction with the implemented approach to summative assessment and with ELARS as a system for conducting online activities. The anonymous survey was administered at the end of each DBR cycle. After the first DBR cycle, a paper-based questionnaire with multiple-choice and open-ended questions was administered. After completion of the second DBR cycle, students were surveyed with an online questionnaire consisting of statements with a 5-point Likert scale (1 - strongly disagree, 2 - disagree, 3 - no opinion, 4 - agree, and 5 - strongly agree) and open-ended questions.

Before, during, and after each DBR cycle, the course teacher was continuously surveyed. The teachers' feedback was used to modify the parameters of the experiment according to the DBR methodology (e.g., the time allowed for solving the math-based tasks in the different course topics, the difficulty level of the prepared tasks, etc.).

4. RESEARCH RESULTS

The number of students that have achieved learning outcomes (at least 35 assessment points during the semester) for each of the student generations is presented in Table 2.

Table 2. The number of students in relation to the achievement of learning outcomes

DBR cycle	Academic Year	Number of students enrolled in the course	Achieved learning outcomes (min. 35 assessment points)		Not achieved learning outcomes (less than 35 assessment points)	
			N	%	N	%
-	2018/2019	36	20	55.55 %	16	44.45 %
1st	2019/2020	32	21	65.63 %	11	34.37 %
2nd	2020/2021	25	20	80.00 %	5	20.00 %

Source: Authors

In addition, the number of assessment points earned by students at the end of the semester was used to compare student success during the semester. Only the scores of students who earned at least 35 assessment points (and earned the right to take the final exam) were used for comparison. The mean value of assessment points earned for each of the three generations of students, as well as the number of students who failed the final exam are shown in Table 3.

Table 3. The number of assessment points earned by students who pass the course and number of students that have failed at the final exam

Academic Year	N	Mean value of earned assessment points during the semester	Mean value of earned assessment points (overall result)	Number of students that have failed at the final exam
2018/2019	20	52.25	77.06	2
2019/2020	21	49.,60	70.36	3
2020/2021	20	51.45	74.07	1

Source: Authors

The results of the one-way ANOVA test show that there is no significant difference between all three generations of students when compared on the basis of assessment points earned during the semester ($F(2,93)=2.1824$; $p = .118703$) and total assessment points earned during the semester and on the final exam ($F(2,61)=1.90708$; $p = .15771$).

The difference between the total number of tasks solved using ELARS between the experimental groups of students is shown in Table 4.

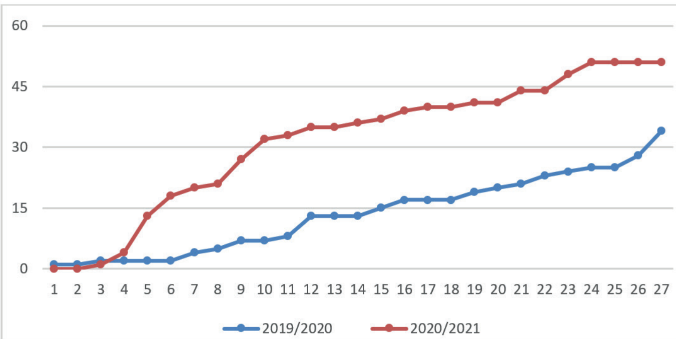
Table 4. The total number of math-based tasks solved by students

Topic	Number of tasks in ELARS	2019/2020 1. DBR Cycle (N=27)		2020/2021 2. DBR cycle (N=25)	
		Number of solved tasks	Time for solving each task (in minutes)	Number of solved tasks	Time for solving each task (in minutes)
Inductance	7	101	60	118	30
Capacity	7	70	60	89	30
Equivalent model of power lines	8	62	60	148	30
Equivalent model of transformers	10	32	60	182	45
Absolute value method	6	39	60	106	45
Unit value method	6	24	60	90	75
Distribution networks	8	37	60	120	75
In total:	52	365		853	

Source: Authors

Figure 3. shows the comparison between students in terms of the total number of tasks solved by each student (sorted from the lowest to the highest number of tasks solved by each student within each experimental generation).

Figure 3. Graphical representation of overall number of solved math-based tasks.



Source: Authors

In addition, paper-based questionnaires were used at the end of the semester (for the experimental groups). The main results of the questionnaires are presented in Table 5.

Table 5. Paper-based survey results

Question	The academic year 2019/2020		The academic year 2020/2021	
	Predominantly Yes	Predominantly No	Predominantly Yes	Predominantly No
I used the possibility to prepare for the weekly organized summative assessment sessions by solving available tasks using ELARS	91.67 %	8.33 %	95.46 %	4.54 %
Using the ELARS in preparation for summative assessment sessions I solved more tasks than I would have solved otherwise	75.00 %	25.00 %	90.91 %	9.09 %
The opportunity to take the part of the summative assessment each week encouraged me to study continuously during the semester	66.67 %	33.33 %	95.46 %	4.54 %
Taking the part of the summative assessment each week suits me better than taking multiple parts in the form of midterm exams	79.17 %	20.83 %	100.00 %	0.00 %
The opportunity to take the same part of the summative assessment twice suits me more than when I can take it only once (as in classic midterm exams)	91.67 %	8.33 %	100.00 %	0.00 %
I would recommend using the ELARS to my colleagues	87.50 %	12.50 %	90.91 %	9.09 %

Source: Authors

5. DISCUSSION

5. 1 The impact on student motivation and achievement of learning outcomes (RQ 1)

A hybrid approach to summative assessment was developed for the first experimental group of students (the academic year 2019/2020 - the first DBR cycle). The proposed hybrid model included both online and offline assessments of the same course topics. In addition, students had the opportunity to practice for summative assessment using an organized online formative assessment available to them after completing the first lecture on each topic.

Students in the second experimental generation (academic year 2020/2021 - second DBR cycle) had the same opportunity for formative assessment while preparing for the continuous intensive online summative assessment. As can be seen in Table 4, students from both generations took advantage of this opportunity and used formative assessment to prepare for the weekly summative assessment. Over 90.00% of students used ELARS to prepare for the summative assessments. In both generations, the majority of students were motivated to study continuously throughout the semester, with over 90.00% of second-generation students doing so (validating the concept of the online intensive summative assessment introduced).

There was also a significant increase in the number of tasks solved by students in preparation for the summative assessment. While most students in both generations reported that they solved more tasks than they normally would during preparation with ELARS, the number of tasks solved increased significantly between these two generations. While students in the first generation solved a total of 365 tasks, students in the second generation solved 853 tasks. This increase by a factor of 2.3 between generations in the number of tasks solved while preparing for the continuous intensive online summative assessment sessions indicates that students were more motivated to learn during the semester.

As can be seen in Table 2, the proposed approach helped a larger number of students reaching the established threshold of 35 assessment points at the end of the semester than the control group (only 55.55% in the control group, while 65.63% in the first experimental generation and 80.00% in the second experimental generation of enrolled students).

From the obtained results, it can be concluded that the introduction of online formative assessment and continuous intensive online summative assessment influenced students' motivation during the semester and improved the achievement of learning outcomes. A greater number of students within the experimental generations earned the right to take the final exam, but their results measured by the assessment points achieved showed that there was no significant difference between the experimental and control groups (for students who had the right to take the final exam).

5. 2 Controlled vs uncontrolled environment for conducting summative assessment (RQ 2)

Because of the hybrid approach to summative assessment in the first experimental group of students, online scores for each student were compared with offline scores for each of the tasks. In most cases, the results were similar, but for some students the difference was too great to be acceptable (with near perfect scores on the online and extremely poor scores on the offline portion of the summative assessment). This result shows that some students abused the opportunity to take the exam online, either by using other students to help them with the online portions of the exam or by using other, unapproved materials that they were not allowed to use in the presence of the teacher. The organization of the online assessment sessions was identified as part of the problem, as students had a total of 120 minutes (60 minutes for each task, regardless of the difficulty of the task) to complete the two weekly scheduled tasks from the two consecutive topics, and they were free to choose the order in which they worked. This available time allowed some students to seek unauthorized help and prompted a change in the organization of the online assessment in the second DBR cycle.

Lessons learned from the first DBR cycle were used to change the parameters of the experiment during the second DBR cycle. The organization of the online summative assessment was changed in that the time limit for solving each task was different (shorter, as seen in Table 4). The time was set by the teacher and was based on the time students took during their online preparations that preceded the weekly continuous intensive online summative assessments. In addition, a different fixed start time was set by the teacher for each task to limit the possibility of students seeking unauthorized help in completing them.

The final exam was used in order to check the results of the students of both generations during the semester. As can be seen in Table 3, in the first experimental generation, 3 out of 21 students who had the right to take the final exam failed it and had to repeat the course in the following academic year. In the second experimental generation, 1 out of 20 students failed the final exam.

There is also no significant difference between all three generations of students when comparing the total assessment points obtained. This result shows that the results of the experimental generations (using both the hybrid approach and the fully online approach to summative assessment) are credible. The results of the final exam also confirm that the students have achieved the learning outcomes.

The results obtained show that unsupervised online summative assessment can be used as a substitute for conducting summative assessment in a controlled environment, but only with some verification within the controlled environment (hybrid approach or carefully organized online assessment with later verification in the controlled environment during the final exam of the course).

5. 3 Acceptation of introduced approach to summative assessment by students (RQ 3)

As can be seen in Table 5, students in both experimental generations responded positively to the summative assessment approach that was introduced. The opportunity to take part of the summative assessment every week encouraged students to study continuously during the semester (66.67% in the 1st experimental generation and 95.46% in the 2nd experimental generation). It proved better for majority of the students to take only part of the summative assessment related to the particular course topic during the weekly organized summative assessment sessions (79.17% in 1st and 100.00% in 2nd experimental generation), and almost all in both generations prefer to have more than one opportunity to be graded for the same course content (91.67% in 1st and 100.00% in 2nd experimental generation).

Satisfaction with ELARS is also confirmed by student feedback, with 87.50% in the 1st experimental generation and 90.91% in the 2nd experimental generation indicating that they would recommend the system to their fellow students.

The results show that students have accepted the introduced approach of summative assessment in the form of continuous intensive online summative assessment organized weekly.

6. CONCLUSION

The introduction of continuous intensive online summative assessments has had a positive effect on STEM student motivation. From the results of the experiment, it can be concluded that the responses to all the research questions posed are positive. The proposed implementation of continuous intensive online summative assessment has positively affected student motivation and contributed to more students achieving the learning outcomes. Continuous intensive online summative assessment can be successfully organized and implemented if the time parameters of the assessment are carefully set (randomly selected tasks, a fixed start time for the assessment sessions, a reasonable time limit for solving a given task) and students' results are verified in a controlled environment. Students also respond positively and accept the proposed approach to summative assessment.

It can be concluded that the introduction of continuous intensive online summative assessment into the course can improve the educational process for students. The results presented have confirmed that it can be successfully introduced into STEM education, both as a hybrid and purely online approach.

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ISTRAŽIVANJE UČINKOVITOSTI KONTINUIRANOG *ONLINE* SUMATIVNOG VREDNOVANJA U STEM KOLEGIJU STRUČNOGA STUDIJA

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SAŽETAK

Postoji relativno malen obim rezultata istraživanja kontinuiranog sumativnog vrednovanja i njegovog pozitivnog utjecaja na rad studenata i nastavnika. Razvoj digitalnih alata koji smanjuju opterećenje nastavnika omogućio je provođenje daljnjih istraživanja koja se mogu provoditi u stvarnom obrazovnom okruženju. Rezultati istraživanja koji su prikazani u ovom članku namijenjeni su proširivanju razumijevanja pozitivnih utjecaja intenzivnih kontinuiranih online vrednovanja na studente. Kao metodologija za predstavljeno istraživanje korišteno je istraživanje temeljeno na dizajnu (DBR). Parametri eksperimenta modificirani su tijekom trajanja eksperimenta u skladu s DBR pristupom te su promjene zasnovane na povratnim informacijama dobivenim od studenata i nastavnika tijekom provođenja eksperimenta. U eksperimentu su sudjelovale tri uzastopne generacije studenata stručnog preddiplomskog studija (ukupno 88 studenata). Rezultati provedenog eksperimenta su pokazali da je uvedeno intenzivno kontinuirano online vrednovanje motiviralo studente tijekom semestra te posljedično dovelo do većeg broja studenata koji su ostvarili ishode učenja. Temeljem toga može se izvesti zaključak da intenzivno kontinuirano online vrednovanje može imati pozitivan utjecaj na proces ostvarivanja ishoda učenja. Ako se pravilno implementira, navedeni pristup može pomoći nastavnicima i studentima da kontinuirano prilagođavaju svoje aktivnosti tijekom semestra kako bi odgovorili na specifične izazove procesa poučavanja i učenja.

Ključne riječi: *kontinuirano vrednovanje, STEM obrazovanje, ELARS*