Identifying the Impact of Online Tests in Learning Management Systems on Learning Success

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Abstract—**The digital transformation of higher education demands effective and efficient methods for learning assessment. Research has shown that tests have the potential to be an appropriate medium not only to diagnose learning success but to improve learning outcomes/processes in general. In this study, we examine possible connections between the use of digital tests and learning success. Based on a survey (n=71) and a quantitative analysis (n=214) with logging and exam assessment data, we find three points that indicate positive correlation: Firstly, students perceive digital tests as motivating and useful. Secondly, we detect a positive relation between the points students achieved in the online tests and the exam results (Spearman correlation coefficient of 0.39), and thirdly, students who participated continually in the digital testing system on average succeeded and passed the exam. The results show the importance of systematic digital testing in learning management systems, but also the need for more research with respect to other contexts and domains.**

Index Terms—**Digital tests, learning success, learning motivation.**

I. INTRODUCTION

The Covid-19 pandemic accelerated the digital transformation of higher education, which presented a few challenges [1]. Students are forced to work much more independently and to organize themselves. Recent studies have shown that this unexpected remote learning scenario has led to a decline in learning success [2]-[4]. Hammerstein *et al.* [5] conclude that the effects achieved by online learning are about the same as if no instruction had been conducted. In line with this result, Sbai *et al.* [6] attested a decline in terms of learning motivation due to the distance learning semester in Morocco. Nevertheless, Hammerstein *et al.* [5] observed that this negative trend was reversed if systematic online learning materials were offered by the educational institutions. Arnold *et al.* [7] points out that digital tests could be an important component that can provide students with orientation during remote teaching. Online tests offer this opportunity and create a framework in which students can independently check their knowledge without having to be physically present.

In this paper, we want to assess the impact of such online testing frameworks empirically to find out whether online

assessment by means of tests could be a possible enhancement in the field of teaching via learning management systems.

Given the benefits of tests as proposed by Arnold *et al.* [7] and further discussed in the following section, we expect a positive relation between the points students achieved in the exam and the points students achieved in the online tests. Thus, our first hypothesis is:

H1: Online tests are perceived positively by the students.

We assume that this positive perception is also reflected in the learning success. Thus, we hypothesize:

H2: The points students achieved in the exam are positively related to the points students achieved in the online tests.

However, in order to fully benefit from the positive effects of online testing, students might need to take the tests continuously throughout the semester. Thus, we formulate our third hypothesis:

H3: The points students achieved in the exam are positively related to the continuous participation in online tests.

The paper is structured as follows: in Section II a brief overview of previous studies and related work is given, followed by a detailed explanation of the study design in Section III. Methods of how the collected data was analyzed and the results obtained are presented and discussed in Section IV, before the final section concludes the paper and gives a brief outlook on future work.

II. RELATED WORK

Reflection of knowledge through examinations or tests is often perceived negatively by learners in school or university contexts. Lecturers, on the other hand, often reduce them to the sole function of monitoring knowledge. However, this places very tight limits on the potential uses of tests because they can exert a strong positive influence on learning and retaining processes. This is referred to as the "test effect" [8]. By offering tests, learners are encouraged to practice their skills and refresh their acquired knowledge. Applying and consolidating acquired knowledge in a self-assessment environment can lead to better learning outcomes [9].

Experimentally, Blunt and Karpicke [10] compared two groups. One group was instructed by repeating and reworking the learning content, the other group had to participate in tests related to the learning content. The authors were able to demonstrate that nearly the same memory performance can be achieved in the reworking of learning material and in tests at short notice. In the experiment, the state of knowledge was re-examined after one week, with the

result that tests were able to improve knowledge retainment performance by almost 50 percent in the long-term compared to the group who only reworked and repeated the content. This not only increased pure knowledge retention, but also initiated processes of understanding. Mietzel *et al.* [11] point out that especially for weaker students or students who do not prepare diligently or follow-up on learned materials, tests can lead to an improvement in the final exam performance.

As a result of the digital transformation of higher education and the associated increased use of new media, learners are given the opportunity to actively determine their own learning methods and processes. This creates a *didactic potential* from which a *didactic value* can be created if properly applied [12]. Within the solutions that have emerged from the digital transformation, online tests contribute to increasing motivation and thus also to the activation of learners, since students can measure their learning progress independently and determine the number of repetitions by themselves [13]. Repetitions are a key driver of learning success. Karpicke and Roediger [14] formulate: "Repeated retrieval of information is the key to long-term retention".

Due to the increased self-determination of learners in E-Learning environments, there are more heterogenous conditions and progresses than in usual classroom teaching scenarios. This could lead to a lack of orientation. According to Arnold *et al.* tests could be an appropriate solution to guide students virtually. Furthermore, tests help students to combine individual learning content. This enables learners to comprehend the content in context to gain a deeper understanding [7].

Arnold *et al.* [7] suggest that while online tests increase motivation, complex issues might get lost due to the simple answers and questions. Online tests such as multiple-choice or drag-and-drop tasks are not sufficient to gain an understanding of complex issues. This requires comprehensive, complex learning tasks, which are then assessed by tutors or the community of learners. This is in line with Mietzel [11], who indicates that questions in a test that require an open answer stimulate more effective learning than methods such as multiple-choice tasks.

To sum up, some studies show the positive effect of tests on learning success. Thereby, the integration of tests into learning management systems is still largely unexplored. Moreover, it remains unclear whether simple multiple-choice online tests have a positive effect on learning success.

III. STUDY DESIGN

The study design of this research is divided into two parts: The examination of a survey, which was conducted over two semesters (consolidated data set of both years: n=71), and an extensive analysis of course logging data (n=214) in conjunction with exam results in the winter term 2020/ 2021. The research was carried out over two years. The tests examined were embedded into an undergraduate economics course. The class was a first-semester course base module, which was conceptualized as an export module for students from various different degree programs. It was taught at the University of Applied Sciences Mittweida in Germany in the winter term of 2019/ 2020 and 2020/ 2021. Due to the Corona Virus Pandemic the complete course in 2020/ 2021 was conducted online by means of virtual Zoom Sessions. The learning materials and the tests were provided via the Learning Management System OPAL.

A. Test Arrangement and Context

The Learning Management System OPAL is used widely by various universities in the German Free State of Saxony. It is designed for the distribution of learning materials and to enhance interactivity in web-based instruction. One of the interactive components of the system and of the examined online course are the embedded tests. The plug-in software ONYX offers the opportunity to create and conduct tests and exams with a wide range of different task-types. The task-types used in this study are:
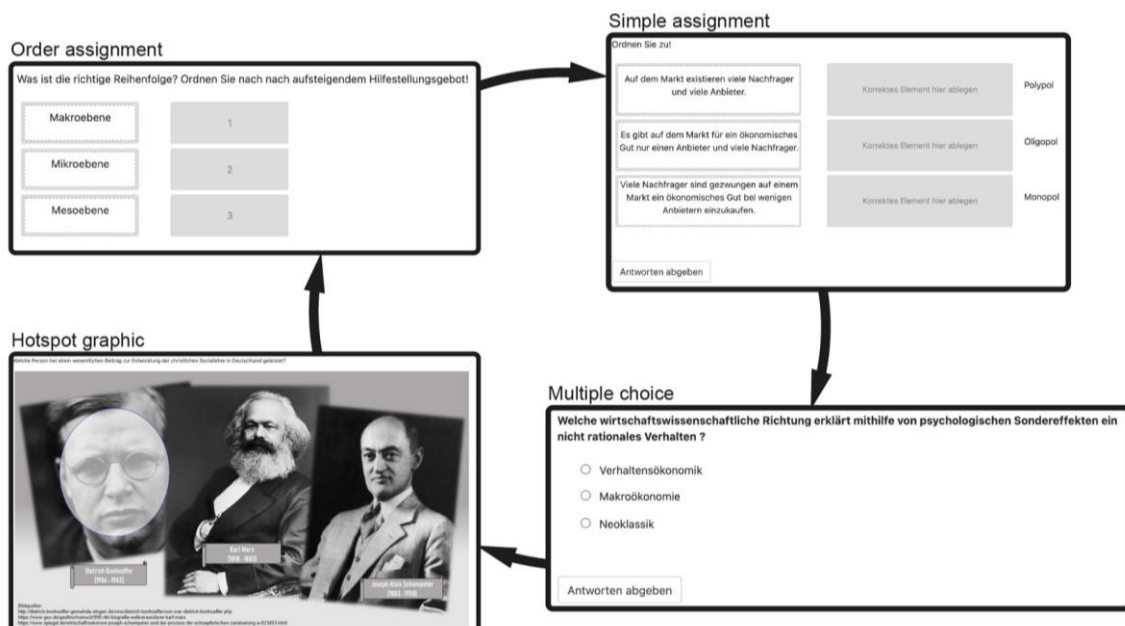

Fig. 1. Task types.

- Multiple choice
- Hotspot graphic
- Simple assignment
- Order assignment

The multiple-choice task type requires different response options out of which the learner have to select the correct set. A similar principle is used for the hotspot tasks. The learners are presented with a graphic containing various sectors and the learner has to decide which sector fits to the correct solution option. The simple assignment task type enables the assignment of response pairs to each other via drag and drop. The drag and drop function is also used by the order assignment type. Here, the learner has to arrange the elements in the right order. The different task types are shown in Fig. 1.

The online course with the examined tests is subdivided in four chapters with at least two subsections (overall, the course consists of 11 subsections). Each subsection is concluded by a test. To unlock new learning content, students must pass the test by achieving at least 50% of the points. In total, there are eleven tests corresponding to 11 subsections of the course. However, the tests were not mandatory. The extensive virtual learning path with the tests can be considered as a supplementary offer to the students. All students had the opportunity to visit the lectures and had access to a pdf file including the complete learning content. Thus, it was possible to pass the exam without passing the tests. Activities of the students within the tests like click figures could be tracked by a logging-instance.

Similar to the tests, the exam was also conducted via the OPAL learning management system. For reasons of network stability, it was separated on an extra server. As opposed to the tests, the exam consisted almost exclusively of open answer questions.

B. Survey Design

The study sample was made up of college-age students who were surveyed after the last lesson of the semester in both years. We use a non-guided survey format. It featured a mix of open and closed questions: the first part was approached quantitatively with multiple choice Likert-scale questions. The Likert-scales [15] ranged from 1 to 5, indicating for instance "1 – agree strongly" and "5 – disagree strongly". Students were able to select their perceived value, out of which the average value (av) was calculated. The survey intended to evaluate the subjective assessment of the students' perceived connections between the test design and learning success as well as learning motivation. The second part of the survey was intended for a qualitative evaluation of students' perceived attitudes towards the advantages and disadvantages of the test design. Students were also provided with space to provide feedback or suggestions for the use of the tests.

C. Logging and Exam Assessment Data

Our sample consists of 214 exam participants in the winter term 2020 / 2021. For each participant, we measure the total points achieved in the exam ("exam_scores") and the total points achieved in online tests ("test_scores"). Further, to test Hypothesis 2, we define a measure of students' continuous

participation in the tests. In order to proceed to the next subsection of the online content, students have to pass the online test. After the online test in subsection 11, no further content was available. Hence, after passing the test in Subsection 10, students unlock the last part of online content. Therefore, we define continuous participation in online tests as a dummy variable which is equal to one if the students passed at least the online test in subsection 10, and zero otherwise ("test_continuity"). Table I provides descriptive statistics for the variables "exam_scores", "test_scores", and "test_continuity".

TABLE I: DESCRIPTIVE STATISTICS

	Mean	Median	Standard Deviation	Min	Max
Exam_Scores	27,69	28,00	12,256	1	50
Test_Scores	41,92	53,00	20,746	0	60
Test_Continuity	0,6776	1,00	0,4685	0	1
Observations			214		

IV. DATA ANALYSIS AND RESULTS

A. Survey Data

The first quantitative part of the survey with Likert-scale questions shows that most of the students perceived the tests as useful learning tools which helped them to prepare for the exam, which is in line with $\mathcal{H}1$. The data indicate that the motivation of the students is positively determined by the test-linked locking mechanisms. The majority of the participants (45) was motivated by this, fifteen students neither agree or no disagree and eleven participants were not motivated by the test-based locking mechanism. Furthermore, the testing process was perceived as enjoyable for most of the students (51) and they felt better prepared for the exam by taking the tests (57). Interestingly, 53 students stated that the test framework motivated them to spend more time in self-study. In general, the data show that the tests support learning motivation and were perceived as an important enhancement. Only a minority could not benefit from the test framework. The survey results thus confirm $\mathcal{H}1$ and are shown in detail in Fig. 2.

The qualitative part of the survey supports the results of the quantitative data analysis. Students indicated that they liked the test system and wanted more tests and more test questions per chapter. The locking mechanism was perceived as a "learning guide". One student stated: "it was helpful to be forced to work through the learning content step by step". As improvement suggestion, students wished for more detailed feedback and more visibility as to which tests and which learning content have successfully been completed and which parts are still open. We conclude that the survey results support $\mathcal{H}1$.

B. Logging and Exam Assessment Data

As the variables "exam_scores" and "test_scores" are not normally distributed, we use the Spearman correlation coefficient to test $\mathcal{H}2$. We find that the points students achieved in the exam are positively related to the points students achieved in tests. The Spearman correlation

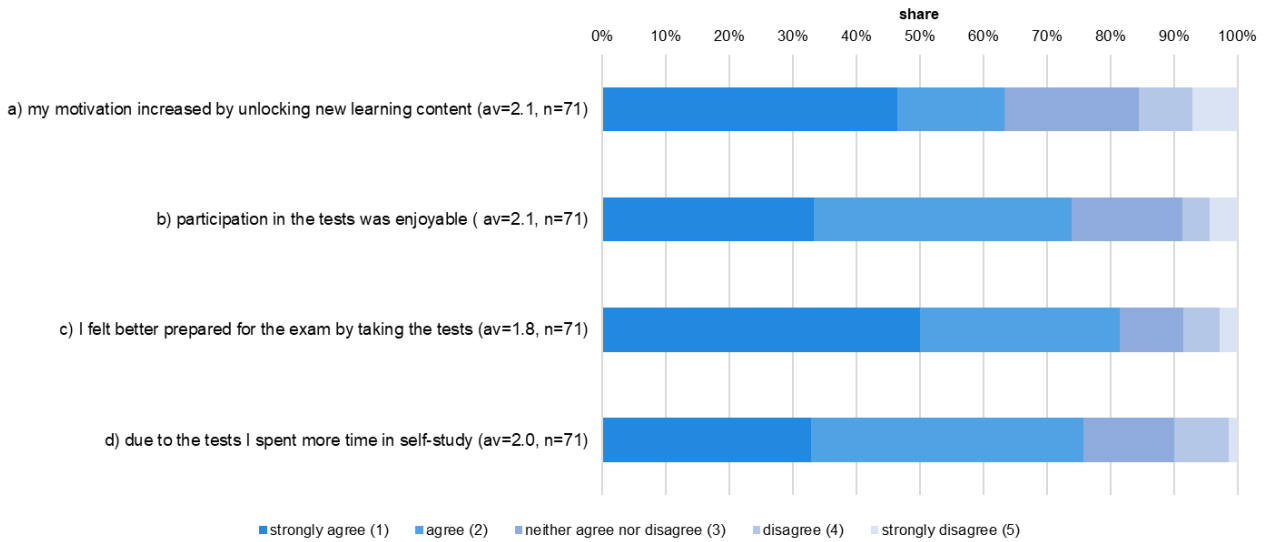coefficient of 0.39 indicates a medium effect. Thus, we find support for $\mathcal{H}2$.

Fig. 2. Survey data.

$\mathcal{H}3$ conjectures a positive relation between the points students achieved in the exam and the continuous participation in online tests. In order to assess how many students continuously participated in the online tests we investigated a frequency distribution which is shown in Fig. 3. It shows the last test that the students passed. To pass a test, students need at least 50% of the points. Since no content was unlocked after the online test in subsection 11, we define that the students who passed at least the online test in subsection 10 (i.e., passed the online test in subsection 10 or in subsection 11) continuously participated in online testing.
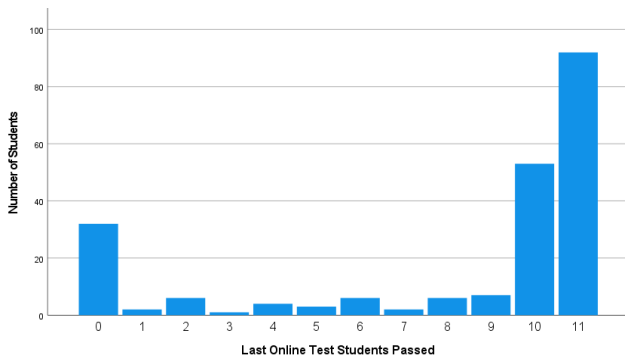

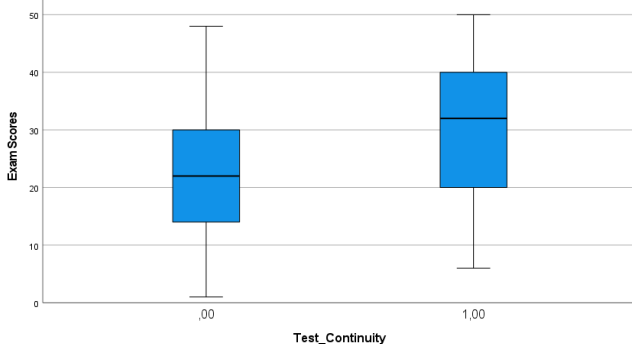Fig. 3. Frequency distribution of the last online test students passed.

Fig. 4. Boxplot graph of exam scores for students who continuously participated in online tests vs. other students.

In order to test $\mathcal{H}3$, we use the Mann-Whitney test (Mann & Whitney 1947) to test for differences between the points

achieved in the exam by students who continuously participated in the online testing throughout the course (i.e., passed at least the test in subsection 10) and students who did not complete the online tests. We find that students who continuously participated in the online tests scored higher on the exam (median = 32 points) than other students (median = 22 points), Mann-Whitney test statistic: U = 3304, p < 0.01. Cohen's (1992) effect size is r = 0.274, corresponding to a medium effect. Fig. 4 illustrates our result.

V. DISCUSSION

In line with the discussed literature, we find that online tests are positively related to student motivation and to learning success as measured by the exam performance. Overall, we find that these positive effects are less pronounced than in the previous literature (e.g., [7] and [10]). Nevertheless, our results support findings by Schulte *et al.* [2], who indicate that the systematic deployment of online courses is a key driver of distance learning success.

In our setting, using online tests to unlock consecutive content after each subsection contributed to structuring the course and gave orientation to students.

Our field-study design is associated both with advantages and disadvantages. An important benefit of the field-study design in contrast to the experimental settings in the previous literature is that we are able to investigate real-life learning performance of the students. This might also explain the less pronounced positive effects of online tests on learning success. Furthermore, the pandemic situation influenced teaching and learning in the considered scenario. The major downside of using the field-study design is related to testing the $\mathcal{H}3$. In particular, participants are not randomly assigned to conditions "continuous participation in online tests" and "no or incomplete participation in online tests". Thus, participants in the two conditions potentially have a different amount of prior knowledge on the topic and/or differing levels of motivation and engagement with the topic.

Furthermore, Arnold *et al.* [7] show that multiple choice

task types do not support understanding of complex issues.

Even though we used only "simple" task types in online tests and more complex free text tasks in the exam, our data suggest a positive relation between participation in online tests and the exam performance.

Despite comprehensive online learning materials and self-assessments, only 59% of the course participants passed the exam indicating an overall weak learning success. Even among the students who continuously participated in the online tests (approximately 68%), there are students who have failed the exam. Nevertheless, on average, students who continuously participated in online tests tend to be more successful in the exam. In particular, those students passed the exam by achieving 32 points on average (median). In contrast, the students who did not participate in online tests or did not complete the tests, failed in the exam with 22 points on average (median).

VI. Conclusion and Future Work

The present work aimed to provide insights into the impact of digital tests on learning success. We investigated online tests in a field-setting analyzing an economics course offered at the University of Applied Sciences in Mittweida (Germany). The data evaluation and data analyses lead to three key findings:

1) The majority of students perceived the online tests as motivating and useful for their exam preparation. By taking the tests, they also spent more time in further self-study. Especially the "gatekeeping effect" provided by the test-based locking mechanism to unlock sequential learning content was seen as helpful.

2) Furthermore, the data shows a positive relation between the points students achieved in the online tests during the semester and the exam results. The Spearman correlation coefficient of 0.39 indicates a medium effect.

3) Not all students who participated continually in the online tests passed the exam. However, on average, students who participated continually in the online tests succeeded and passed the exam. Students who did not continuously participate in online tests failed the exam on average. In conclusion, participation in online tests did not guarantee success in the exam, but rather provided a very useful tool for enhanced exam preparation.

In general, the results show the importance of digital tests in the teaching setting considered in our study. To derive more generalizable statements and to evaluate the results of this study in a broader context, further research in other subject domains is needed. Additionally, future studies could examine the research questions posed in our study under experimental conditions by randomly assigning participants and using a control group.

Regarding the analyzed course, an optimization of the online testing system should be considered. Students expressed a desire for more feedback elements, e.g., progress scales. Thus, the use of online tests could be enhanced with more gamification elements to increase the share of students who participate in and benefit from online testing.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

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