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Identifying the Impact of Various Course Elements of Learning Management Systems

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Abstract

The digital transformation of higher education demands effective and efficient methods for learning support and assessment of learning processes. This paper relates learning support and assessment to each other in the context of learning management systems. It refers to previous studies carried out in multiple introductory economic courses of the University of Applied Sciences Mittweida which examine possible connections between the use of digital tests and learning success, investigate student's acceptance and self-perceived learning success with respect to the web-based portion of a blended course and a purely online based course. Based on a survey ($n = 71$) and a quantitative analysis ($n = 214$) with logging and exam assessment data, the previous work shows that students approached the web-based course portion with rather reserved attitudes. Still, they perceived the individual course elements, namely videos, podcasts, interactive worksheets, online tests, and a comprehensive PDF file to be beneficial to their learning experience. Especially we could indicate a positive correlation between the points students achieved in the online tests and the exam results.

Keywords: distance education, blended learning, e-learning, learning motivation, learning success

1 Introduction

Because of the Covid-19 pandemic, students around the world were forced to work much more independently using almost exclusively material that was provided to them via online services. In this regard, the pandemic accelerated the already existing digital transformation of higher education, which presented some worrying challenges (Adedoyin & Soykan, 2020). Recent studies have shown that this unexpected remote learning scenario has led to a decline in learning success (Engzell et al., 2021; Schult et al., 2022; Tomasik et al., 2021). Hammerstein et al. (2021) conclude that the effects achieved by online learning are about the same as if no instruction had been conducted. In line with this result, Benhima (2021) attested a decline in terms of learning motivation due to the distance learning semester in Morocco. Nevertheless, Hammerstein et al. (2021) observed that this negative trend was reversed if systematic online learning materials were offered by the educational institutions.

Generally speaking, the few studies that examine the impact and application of e-learning methods either as purely web-based or blended format, i.e., using both traditional classroom and web-based instruction, often show even positive results. Zheng et al. (2020) found that the effectiveness of flipped classroom approaches is highly dependent on the appropriate pedagogy, noting that collaborative learning, inquiry based learning, and problem-based learning can maximize the efficacy of inverted classroom concepts, with pre-class videos demonstrating the biggest impact on students' learning experiences. In a second order meta analysis, Tamim et al. (2011) also found that, in general, technology-assisted learning was more effective than traditional, non-technology-assisted approaches (although it is worth noting that some of the studies analyzed in the meta analysis pre-date the internet, meaning Tamim et al. do not exclusively investigate web-based technologies). As for web-based instruction specifically, Sitzmann et al. (2006)'s meta-analysis compared web-based and classroom instruction and found that e-learning produced slightly better learning results for declarative knowledge, equal efficacy for procedural knowledge, and equal learner satisfaction in both approaches.

These findings indicate the importance of thought-through, practical frameworks to provide students with online learning materials: Learning Management Systems (LMS). LMS are frameworks designed to cover all facets of learning, both instructional and administrative (Watson & Watson, 2007). They are usually employed enterprise- or institution-wise and are web-based, either as applications or websites (Coates et al., 2005). Born out of the general move towards digitalization in the 1990s, LMS established themselves as viable learning tools in the early 2000s, when they were adopted by many educational institutions and matured into widespread usability. Nowadays, LMS cover a broad range of features and functions, such as course management and pedagogical tools designed to conceptualize and create online learning environments. Their scalability makes them ideal for bigger institutions as they can easily handle institution-wide learning content delivery. Embedded in the right instructional context, they can even serve as standalone delivery methods for exclusively web-based instruction (Szabo & Flesher, 2002). LMS cannot only be used to deliver content but may also be used to track learning progress both on a macro and micro level, comparing individual student, class, or program progress (Gilhooly, 2001; Queen & Lewis, 2011). This is facilitated by a number of elements that can be implemented into an LMS, such as online group chats, discussion boards, homework collection, grade books, podcasts, and course management and evaluation tools (Yueh & Hsu, 2008; Zanjani et al., 2017).

In this paper, we use the results of the two studies Wittrin et al. (2021) and Wittrin et al. (2022) which have examined different aspects of the LMS OPAL, such as digital self-assessment and perceived learning success. OPAL is an LMS that is used widely by various universities in the German Free State of Saxony. The aim is to make conclusions about the impact of the following course elements of the LMS OPAL: videos, podcasts, interactive worksheets,

online tests, and a comprehensive PDF file.

The paper is structured as follows. The methodology used is described in section 2. Subsequently, the results are analyzed and in section 3 and afterwards discussed in section 4. Finally, the conclusion is given in section 5.

2 Methodology

2.1 Course Design

The course examined was an undergraduate economics course, which did not require any preexisting knowledge. 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 as regular classroom-instruction with about 200 students, then in the winter term of 2020/2021 the classroom teaching was replaced by virtual Zoom sessions due to the Covid-19 Pandemic. In both instances, all learning materials, tests, and supplementary materials were distributed via the LMS OPAL.

OPAL is designed for the distribution of learning materials, learning content, and to enhance interactivity in web-based instruction. OPAL offers opportunities to conduct tests and exams, and a big share of the asynchronous examinations during the COVID semester were conducted on OPAL. It features integrated group management (which allows students to subscribe to tutorials and gives lecturers and tutors the opportunity to address a specific student group), role management (only course authors are able to edit course elements and students only see relevant content and interface options), access regulation, which is automatically managed by information stored in the database (such as seminar groups, to which students can also be added manually), and a logging system, which counts click figures for each element and allows tracking of test results, durations, and attempts. One of the interactive components of the system and of the examined online course are 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, such as multiple choice, simple assignment, order assignment, and hotspot graphic.

The course itself was divided into multiple subsections, each with a specific purpose. Students were able to access notifications, which displayed recent changes and updates to the course. Furthermore, general information was provided with brief introductions of both lecturers and tutors, as well as the option to enroll in the tutorial, join the online lecture, watch recorded meetings, or contact the lecturer. The next section provided the actual course material, which was divided into thematic sections and different media formats (such as videos, podcasts, and interactive worksheets). The next two sections were exam preparation, which summed up relevant questions and provided exercises for students to revise with, and OPAL help, where technical support was provided to students. The last subsection was the administrative section unavailable to students, which was used to import new content and organize the course. Various media was used in the course. Each chapter of the course consisted of three distinct parts: first, an interactive, text- and visualization-based virtual worksheet; second, learning content videos; and third, tests needing to be passed to access the next chapter of content.

The interactive worksheets contained all relevant content and for some chapters featured interactive dialogue simulations, where virtual characters explained the learning content. The videos were only embedded in the course and contained relevant, yet supplementary information, and were accompanied by podcasts providing additional information for each chapter. The examined online course was subdivided in four chapters with at least two subsections (overall, the course consisted of 11 subsections). Since each subsection was concluded by a test, the students had to pass 11 tests. To unlock new learning content, students had to score at least 50% of the points. However, the tests were not mandatory. The extensive virtual learning path with the tests can also be considered as a supplementary offer to the students, because all necessary learning content was provided in the non-restricted lectures and a comprehensive PDF file containing the entire learning material for the course. Thus, it was possible to pass the exam without passing the tests.

2.2 Study Design

To get a more comprehensive and valid idea of the impact of various course elements of the LMS OPAL, we combine the results of two earlier studies (Wittrin et al., 2021; Wittrin et al., 2022) conducted over two years between 2019 and 2021. In the previous works, a study sample of college-age students (consolidated data set of both years: $n = 71$) was examined using a voluntary questionnaire. Additionally, an extensive analysis of course logging data ($n = 214$) in conjunction with exam results in the winter term 2020/ 2021 was used. The questionnaire featured a mix of open and closed questions: the first part was quantitative with multiple choice Likert scale questions, which intended to evaluate the subjective estimation of the students' perceived connections between the LMS design and learning success as well as learning motivation. The Likert scale (Likert, 1932) 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 second part was intended for a qualitative evaluation of students' perceived attitudes towards the advantages and disadvantages of having used an LMS for supplementary content. Students were also provided with space to provide feedback or suggestions for the use of the LMS. Moreover, click figures were tracked and evaluated as well as consolidated with the survey data. The logging and exam assessment data was gathered from 214 exam participants in the winter term 2020 / 2021. For each participant, the total points achieved in the exam ("exam_scores") and the total points achieved in online tests ("test_scores") were measured. Activities of the students 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. Further, a measure of students' continuous participation in the tests was defined. In order to proceed to the next subsection of the online content, students had to pass the online test. After the online test in subsection 11, no further content was available. Therefore, continuous participation in online tests was defined 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 1 provides descriptive statistics for the variables exam_scores (ES), test_scores (TS), and test_continuity (TC).

Table 1: Descriptive statistics of test and exam data

	μ	$\tilde{x}$	σ	min	max
ES	27.69	28.00	12.256	1	50
TS	41.92	53.00	20.746	0	60
TC	0.6776	1.00	0.4685	0	1

3 Results

Following, using the survey results and click figures described above, we analyze student's acceptance of the various course elements provided and their self-perceived learning benefit from them. Special attention will be given to the provided online tests, as they constituted the course element with the highest engagement rates according to the questionnaire.

3.1 Acceptance

As a first indicator of general course acceptance, we have examined the logged click figures (which are indicative of the clicks the students have made in the OPAL learning environment) of the most recent winter term 2020/2021 course, which were collected during the course duration. In total, the course had 240 participants and ran for 16 weeks. As Figure 1 shows, click figures showed an expectedly strong start in the first week with almost 7,000 clicks, meaning every student made approximately 29 clicks within the course. Even though the numbers subdued in the coming weeks, the first half of the course saw relatively strong engagement numbers with a mid-term spike of around 5,150 clicks in week nine in the wake of a mock exam. This spike was followed by a sharp drop in click figures in week ten and eleven with 1,188 and 367 clicks respectively. The engagement numbers picked back up in week 12 to 15 with relatively stable click figures of 2,147 clicks on average, but did not reach pre-mock exam levels, indicating a decreased student engagement in the latter half of the course. This trend is illustrated by the dotted line in Figure 1, which shows a linear regression along all data points. Students most likely entered their exam preparation phase in week 16 shortly before the final exam, where click figures spiked to 6,701 clicks. This data clearly shows that student had certain engagement touch points triggered by class events, such as the course beginning, mock exam, and final exam, but that overall engagement did decrease over the course duration like Figure 1 shows.

As a further indicator of acceptance, we have examined the results of the consolidated questionnaire data from both course years. We have found that the meta-structure of the course was potentially facilitating course acceptance, as students indicated that they found the course to be easily understandable ($av = 1.5$). They also had no trouble orienting themselves in the course intuitively and easily ($av = 1.9$). In contrast, a minority consisting of 40% of students agreed that having the course materials online was "practical", only 18.6% agreed that this fact helped them be motivated, and only 25.3% saw potential for their grades being positively influenced by the materials being provided online. As for the individual course elements, students showed varying acceptance for different media types and content. When asked which course elements they had used regularly, 35.2% had regularly used the course element "learning objective", which was a singular slide detailing the courses ILOs. 76.1% indicated they had regularly used the interactive worksheets, a slide-based delivery method for learning content featuring interactive elements, such as dialogues and click-triggered animations. The provided PDF document summing up the entirety of the learning content was regularly used by 70.4% of students, whereas the supplementary videos were used by only 46.5%. The podcasts had one of the lowest engagement rates with only 15.5% of students indicating that they regularly had made use of them. The highest engagement rates were found when it came to the use of the provided tests, which 93% of students used regularly – a fact easily explained by the obligatory nature of this feature, students had to complete the tests to unlock new learning content. In general, students agreed that the individual course elements were useful to them ($av = 1.8$), even though they did not tend to feel like the broad variety of course elements did particularly increase their study motivation ($av = 2.9$) or that they helped them study more regularly ($av = 2.6$).

Sun et al. (2008) have found that many users use e-learning much less frequently after their initial experience. Our findings corroborate that statement in so far, that over the course duration student engagement did decrease. However, we also found that certain trigger events (such as the initial kick-off, the mock exam, and the final exam) can cause extensive spikes in engagement. As for the general course acceptance, only a minority of students saw practical use or improvement potential in their grades facilitated by the digitally provided learning content, and only certain course elements (such as the interactive worksheets and the PDF document) were used on a recurring basis, whereas others (such as the podcasts) were neglected by a majority of the students. The tests stand as a special case with the highest engagement rates, which was also facilitated by their function as unlocking mechanisms for future learning content. In conclusion, the course structure seems to be well-liked and accepted and the media variety is perceived as useful, yet not necessarily seen as a heavy motivator. Interactive, exam-relevant learning elements are favored, and those learning elements perceived to be rather supplementary (such as videos or podcasts) are neglected by the majority.

3.2 Perceived Learning Success

To evaluate the students' self-perceived learning success, we have distinguished between course elements (such as media used to transport learning contents) and didactic elements (such as certain types of learning content being transported in the course element, specifically in the interactive worksheets). Firstly, students were asked to evaluate whether the individual course elements facilitated their learning progress. 88.7% of students claimed that the tests facilitated their learning process. Up next was the PDF, which 67.6% of students found to be helpful for their learning endeavors. The interactive worksheets were deemed to

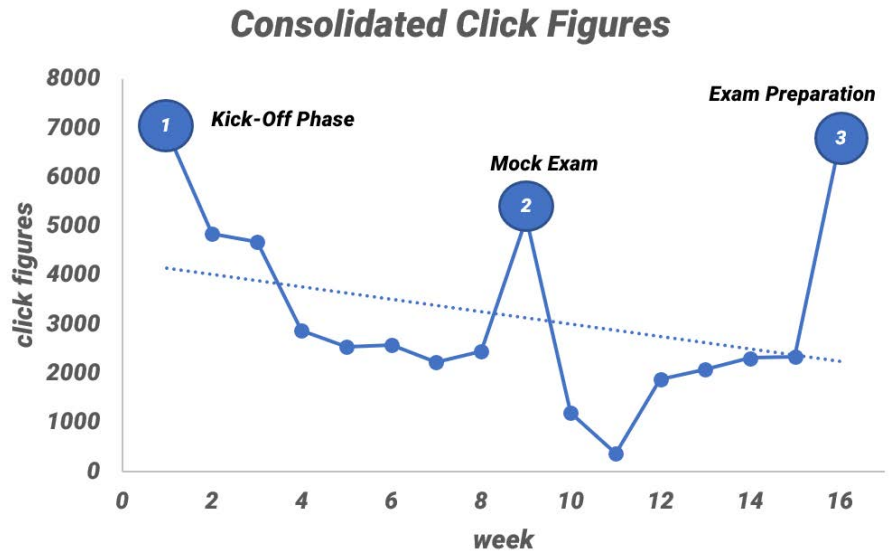

Figure 1: Consolidated Click Figures (source: Wittrin et al., 2021)

be helpful by 62%, whereas 49.3% agreed that the videos and learning objectives respectively furthered their learning success. A minority of 18.3% felt that the podcasts had facilitated their learning experience. Secondly, students were asked to evaluate the didactic elements in a similar fashion. For instance, the use of examples as didactic elements proved to be most helpful to students by a big margin, with 77.5% of students finding them useful; followed by visualizations, definitions, and application of learning content all with approximately 50%. Our findings show that tests were a major facilitator of students' self-perceived learning success, which is in line with other studies seeing similar effects around testing (Roediger et al., 2011). Interestingly, students liked the tests as locking mechanisms for other content, i.e., they perceived the gatekeeping effect of tests as positive ($av = 1.9$) and motivating ($av = 2.1$). This stands out insofar as it may have been reasonable to expect that students would feel pressured by such locking mechanisms, as they impose sanctions (i.e., the remaining locked off content) in the case of failure or non-participation. This might be an indicator for students' preference of having a set framework of rules to move within and also being faced with challenges in a sense of learning gamification – unlocking new content here can be perceived as "unlocking a new level" in the course content. Moreover, tests gave students a way to check their own learning progress, therefore verifying that they are fulfilling course demands and providing a sense of security with respect to knowing they were on the right track.

Furthermore, students perceived that the PDF contributed slightly more to their learning success than the interactive worksheets, the creation of which is not only time-consuming, but also requires expensive software to do so. Therefore, the cost-benefit ratio of interactive worksheets is questionable, unless their appeal for students using them is increased (e.g., by implementing more interactive elements and less of the slide-based approaches). As we have found that students especially prefer the option to take notes on conventional PDF documents, one way to increase the appeal of interactive worksheets might be to provide note-taking mechanisms to combine the appeals of both approaches.

Videos and podcasts turned out to not be perceived as helpful as we had anticipated. One of the reasons for this might be that the content supplied through these formats was not directly embedded into the learning path of students, but was rather a supplementary offer for students to deepen their knowledge of the respective topic. 75% of students felt like the number of videos (two to three per subsection) was appropriate, meaning the frequency did not seem to be a deciding factor in the consumption of this format. It is striking that videos were not watched regularly, but rather just as exam preparation measure (71% of students), which was reflected in the click figures as well.

3.3 Learning success related to online testing

As the variables *exam_scores* and *test_scores* are not normally distributed, we use the Spearman correlation coefficient. 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.

In order to assess how many students continuously participated in the online tests we investigated a frequency distribution. 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.

In order 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 use the Mann-Whitney test . We find that students who continuously participated in the online tests scored higher on the exam ($\tilde{x} = 32\,points$) than other students ($\tilde{x} = 22\,points$), Mann-

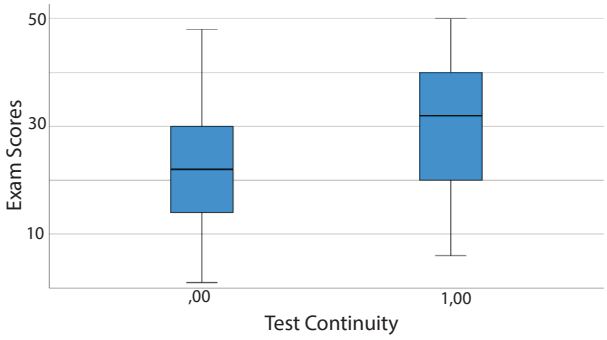

Figure 2: Exam Results and Test Participation (Wittrin et al., 2022)

Whitney test statistic: $U = 3304$, $p < 0.01$. Cohen (1992)'s effect size is $r = 0.274$, corresponding to a medium effect. Figure 2 illustrates our result.

4 Discussion

This research is embedded in the context of a broad body of research on e-learning; however, we have chosen to approach the subject from a case study perspective, examining one specific blended course and a purely online based course in detail. This poses both an advantage and a limitation in itself: our findings remain hard to abstract, yet provide a very in-depth look at how students perceived the web-based part of their blended learning experience. Generally speaking, our findings fall in line with previous research: students seem to decrease engagement over time, value interactivity, and enjoyed the tests as a performance measure for themselves. What we do, however, lack is insight into why certain media formats were preferred over others, and how the engagement with others media formats can be improved. In the same sense, we were able to distinguish certain trigger events that spiked engagement rates, but we were unable to discern which other events could potentially be used to influence class engagement. While we acknowledge that click figures can only ever be a rough estimate of student interaction as they are not intrinsically tied to specific persons, we believe that by consolidating them with the survey data we were still able to paint an accurate picture of how students interacted with the course. A key takeaway from our study is that students were skeptical towards the concept of the web-based portion of this blended course with low acceptance numbers (24%) for statements such as "the online learning material delivery has the potential to positively influence my grades", indicating a rather reserved baseline attitude towards the course format in itself. This assumption is supported by the fact that only 26.2% of students would prefer to study entire chapters or sub-chapters of their course material in a purely web-based format.

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).

5 Conclusion

This paper aimed to provide insights into the impact of individual course elements of the web-based portion of a blended economics course at the Mittweida University of Applied Sciences in Germany. It refers to previous works which examine possible connections between the use of digital tests and learning success and investigate student's acceptance and self-perceived learning success. We came to determine five different key findings:

1. Course engagement decreased over time and was driven by certain trigger events. The kick-off phase does not need a separate trigger event, but the beginning of the class is enough to maintain momentum throughout the first half of the course. However, it would be worth exploring how classroom instruction and web-based instruction portions can be interwoven to deliberately cause engagement spikes and facilitate an improved overall course acceptance especially in the latter half of the semester.

2. Students had no trouble orienting themselves in or understanding the course. Still, only a minority of students saw potential learning benefits in the online content delivery with respect to motivation, grades, or course practicality. We see room for further research in the question how pre-course communication might improve these baseline attitudes by elaborating on the purpose of the blended nature of this course, and how more positive course attitudes might benefit course acceptance and engagement in the long run.

3. The interactivity of content delivery did not necessarily influence students' acceptance of media, as acceptance figures for both the static, comprehensive PDF and the interactive slide-based worksheets were on similar levels. Nonetheless, when asked directly about interactivity, students valued more interactive worksheets over less interaction. However, the precise factors which determine distinct media acceptance still need to be determined, as we were only able to gain insight into which media was favored, not why a specific medium was favored over another.

4. Despite their negative baseline attitudes towards the blended course concept, students did generally perceive various course and didactic elements as beneficial to their learning process (with the exception of those that only offered supplementary material). Students also emphasized tests as especially beneficial. The question that arises out of this is whether supplementary material can be made more attractive to students and if so, which factors contribute to an increased attractiveness in supplementary material.

5. Special attention should be paid to the online self-assessment tests. It was the individual course element with the highest engagement rates. The majority of

students perceived them 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. Furthermore, the data shows a positive relation between the points students achieved in the online tests during the semester and the exam results.

Here, it is striking that students had rather negative baseline attitudes towards the course, but still perceived various course elements as beneficial to their learning process (cf. key insights 2 and 4). This warrants further inquiry on how both aspects are connected and whether student attitudes can be influenced and utilized to improve students' learning experience as a whole. Moreover, it appears to be necessary to target the origin of this discrepancy to actively improve the course communication in favor for a more positive course perception. Another insight we have gained is that the integration of interactive material must be carefully considered with its benefit-cost-ratio in mind. Time-consuming course elements did not always yield the expected positive results, making them unfeasible as a larger-scale content delivery mechanism. Students did seem to depend on the structured nature of the course rather than interactivity, with the tests guiding them through the course material instead of the interactive content delivery mechanisms. In conclusion, it appears to us that the web-based portion of this blended learning course offered students many tangible added benefits (such as the self-benchmarking via the tests), but at times failed to activate and draw students into the course material as intended. Here, it remains vital to engage in further research as to how individual course elements can be improved to mitigate both acceptance and engagement deficits and offer students the best possible learning outcomes and experiences.

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