Quizzes and Eggs: Exploring the Impact of Course Design Elements on Students' Engagement

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Keywords: Online Learning, Course Design, Engagement, Exploratory Study, Logfile Analysis.

Abstract: In this paper, we explored the impact of course design elements that aim to support and sustain students' engagement during a 12-week online course. The course we analyzed targeted higher education, master-level students of Computer Science and Educational Technologies, and took place fully online during the COVID-19 pandemic. The course was facilitated by a Learning Management System (LMS), and due to the circumstances, the instructor's primary goal was to motivate students to actively participate during the course duration. To that end, the instructor implemented a course design focused on integrating elements such as interactive activities, short quizzes, hidden "easter eggs," and real-time webinars. To study the impact of these elements on students' activity, we carried out an exploratory analysis of students' activity as recorded by the log files of the LMS and the qualitative feedback that students provided to the instructor. Our results suggest that the course design supported sustaining students' engagement. The level of students' activity varied for the learning materials and resources, but we confirmed a high usage of the quizzes over the course duration.

1 INTRODUCTION

Over the past semesters, we witnessed the attempts of many higher education institutions to change their classes from fully face-to-face to completely remote (Bozkurt and Sharma, 2020) due to the COVID-19 pandemic. This switch to Emergency Remote Teaching (ERT) had the primary goal of maintaining instruction quickly and reliably instead of replicating a robust educational ecosystem (Hodges et al., 2020). During ERT, students showed negative reactions to the pandemic-related online learning (Besser et al., 2022), and related research suggested that COVID-19 had a negative impact on the mental health of college students (Copeland et al., 2021). In this work, we present a case study where the instructor of a 12-week-long, fully-online higher education course prepared a course design with the aim of scaffolding students' motivation and sustaining student engagement. For our research, we studied how students engaged with digital learning materials (or else, "resources") over the course's duration. Additionally, we explored how the students interacted with game-like and fun elements, in this case, a treasure hunt (where students were asked to find hidden *"easter eggs"*, such as music videos or mini web-based games) and voluntary short quizzes in the form of fun trivia, that the instructor implemented to support students' motivation and self-reflection.

In this context, we formulated three research questions:

- **RQ1:** Are there differences in the usage of the different resources (for example, videos vs. reading material), or are resources used in similar ways?
- **RQ2:** Is there a difference in students' activity over time (for example, do they lose interest or is student engagement sustained)?
- **RQ3:** Is there a relationship between quiz and treasure hunt activity, and how did students perceive these design elements?

The remainder of this document is structured as follows: In section 2, we present research related to online learning in higher education and student engagement. In section 3, we discuss the methodological setup, and in section 4, we present the results of our analysis. Finally, we conclude with a contextualized discussion about the theoretical and practical implications of this work, reflections, limitations, and future work.

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Michael, L. and Chounta, I.
Quizzes and Eggs: Exploring the Impact of Course Design Elements on Students' Engagement.
DOI: 10.5220/0011745000003470
In *Proceedings of the 15th International Conference on Computer Supported Education (CSEDU 2023) - Volume 1*, pages 25-34
ISBN: 978-989-758-641-5; ISSN: 2184-5026

2 RELATED WORK

2.1 Online Learning in Higher Education

The past two years (2020-2022) were marked by an increase of studies and research works that tackle topics on course design, facilitation, effectiveness, and efficiency of online learning arguably due to the COVID-19 pandemic and the emergency transition to remote teaching (Bozkurt and Sharma, 2020). Nonetheless, online learning – especially in higher education – has been relatively mainstream for – at least – the past 20 years with academic leading institutions offering online learning courses in multiple forms (Kentnor, 2015). Typical forms of online learning facilitation include Learning Management Systems (LMSs), Intelligent Tutoring Systems (ITSs), Virtual Learning Environments (VLEs), Online Labs, and Massive Open Online Courses (MOOCs).

The benefits of online learning are rather obvious: providing access to quality materials and instruction without the restrictions of physical presence and supporting students to follow courses and learn at their own pace. Additionally, online learning environments like LMSs allow instructors to offer diverse course designs with various types of learning materials and learning resources, such as reading materials, videos, and worked examples (Ziebarth et al., 2015); supporting students to engage with learning activities at their own pace, thus maintaining a high degree of control, and providing the framework and tools for highly-structured learning management that minimize overhead (Fadde and Vu, 2014).

At the same time, the lack of physical presence and in-person communication challenge structural and social aspects of learning: students experience feelings of isolation or boredom, lack of motivation, and attrition which potentially may lead to disengagement and even dropouts (Hussain et al., 2018). To minimize the negative impact that the lack of physical interaction may have on students' learning, related research explores how students engage in meaningful activities and in what ways students' engagement can support their performance. The core rationale is that a student who engages with learning materials and actively participates in learning activities will perform better in terms of learning gains (Kuh, 2003).

2.2 Student Engagement in Online Learning

According to (Kuh, 2003), student engagement is "the time and energy students devote to educationally sound activities inside and outside of the classroom, and the policies and practices that institutions use to induce students to take part in these activities." (p. 25). In other words, student engagement describes how and to what extent students get involved with learning resources (activities and materials) within an educational context. At the same time, (Bond et al., 2020) discussed the struggle of finding a common definition and terminology, which leads to inconsistencies across the field. This struggle pinpoints that student engagement is a complex construct. (Chiu, 2022) discussed the multidimensional nature of student engagement that can be broken down into behavioral (students' involvement in learning activities), cognitive (students' mental effort while carrying out learning tasks), emotional (students' affective state), and agentic engagement (students' initiative and contribution). Similarly, (Groccia, 2018) elaborated on the multidimensional perspective of student engagement and the diversity of the meaning of student engagement, pointing out that this is precisely why student engagement can have a positive impact on learning. On the one hand, students who engage in productive learning activities expand their skillset for personal development (Kuh, 2003). On the other hand, students' lack of engagement can affect students' performance and retention (Staikopoulos et al., 2015).

Sustaining student engagement in online learning for higher education is a challenging task, especially due to the lack of the traditional communication channels that characterize in-person learning. To sustain or to scaffold engagement instructors typically – and among others – design activities that involve the use of technologies (or else, tools) that support knowledge or artifact construction, organization and sharing (de Jong et al., 2021; Manske et al., 2015) and that are non-disruptive (for example, related research suggests that tools such as blogs, portfolios or social networking tools can be more disengaging than engaging (Bond et al., 2020)), learning materials of diverse types and for various purposes (Ziebarth et al., 2015), integrate gaming, gamification, and fun elements into the course design in order to enrich students' learning experience (Ab. Rahman et al., 2018). Nonetheless – despite the rigorous research around online learning and student engagement – during the emergency transition to remote teaching due to the COVID-19 pandemic, we still witnessed disruptions and challenges that had to be addressed, for both students and instruc-

tors. For example, instructors without experience in online learning struggled to adapt to remote teaching. Students, on the other hand, reported high levels of stress and anxiety while others struggled to sustain motivation and maintain engagement on similar levels as in the in-person condition.

3 METHODOLOGY

3.1 Setup

Here, we present an exploratory analysis of the logfile data from a master-level course on Learning Analytics (LA) for students of Computer Science and students of Educational Technologies in a Higher Education Institution (HEI). The course was taught in the English language and there was no difference in terms of instruction for students of different curricula. In general, the student population was diverse in terms of knowledge and cultural background. The course took place fully online during COVID-19 and was facilitated by an LMS (Moodle). To maintain personal contact with the students, the instructor offered four webinars (one webinar per month) and also virtual office hours (weekly). During office hours, students were invited to drop in without notice and discuss the course topics that interested them. Furthermore, the course included video lectures and other digital learning materials, such as guest video talks, reading resources (textbook chapters and articles), and coding resources (for example, coding notebooks) (Table 1). The course lasted for 12 weeks, from September 2020 until December 2020. Not all course weeks had the same amount of days (see Table 1 caption). From now, week 1, week 2 and so on, refer to the course weeks as presented in Table 1.

Each week, the instructor suggested the order in which the participants should engage with the materials. To support students' self-assessment, the instructor created short quizzes and prompted students to create knowledge resources, such as wiki articles or forum discussions. Additionally, the forum was used to motivate students to communicate questions and reflections. To sustain student engagement over the course duration, the instructor incorporated a "treasure hunt" into the course plan. Students were informed at the very beginning of the course about the treasure hunt and the possibility of finding hidden objects (so-called "easter eggs" which we will refer to as eggs below) within the learning materials. Nevertheless, students didn't know in which course weeks the eggs were hidden nor what they looked like (such as, videos, mini web-based games). The instructor awarded bonus points for participation in the quizzes (a student could take a particular quiz only once), and the treasure hunt. To give an example, one easter egg was hidden in the presentation slides in the form of a URL that directed the students to a YouTube playlist. Students were asked to leave a comment in the comments section of the playlist to earn the bonus point for the easter egg. At the end of the course, the instructor visited the comments section and awarded bonus points to the students who left comments. Within the course, students had to complete and submit four graded assignments, where the fourth was a "revise-and-resubmit" of one of the three previous assignments, aiming to improve students' grades. The final exam was prepared as a quiz and was administered on the last day of the course. The final grade for the course was calculated in equal parts from the final exam – formulated as a quiz – and the average grade of the assignments. The bonus points from the quizzes and the easter egg were awarded on top of the final score. In total, 25 students took part in the course and agreed to also participate in this research by providing informed written consent. Student population was balanced in terms of gender.

3.2 Method

To answer our research questions, we analyzed data from two sources: log data of the LMS and qualitative feedback from the students. We pre-processed and tidied the data according to (Wickham, 2014) and analyzed the data from two perspectives: a) materials' weekly usage, that is, how many times resources were accessed every week; and b) individual student's behavior regarding materials' usage, that is how often individual students engaged with the resources. We started the exploratory analysis by studying the data on the student level regarding the usage of digital learning material in general, and the usage divided by the various types of resources. Here, usage is defined by the number of accesses (that is, how many times a particular resource was accessed). To determine potential patterns for different resources, we grouped the resources into 8 main categories: assignments, quizzes, reading material, video lectures, video talks, live webinars, Q&A forums, and coding resources. The decision was led by the instructor of the course and was based on the content of the different resources (Table 1). The exam was excluded, as we wanted to concentrate on the usage of the resources during the course. Next, we analyzed resource usage throughout the course duration. Here we focused on the differences in usage patterns in the different weeks of the course. Finally, we took the quali-

Table 1: Overview of the course structure and the course weeks (marked in bold). Week 1 to week 9 each lasted 7 days. Week 10 lasted 14 days, and week 11 lasted 5 days. Week 12 lasted 2 days (exam week). Below we present the weeks, the weekly topic, whether this week's materials contained a Quiz ("Q") or an Easter Egg ("E"), and the resources that were provided week by week. The resources' abbreviations are: Lecture Video (LV), Reading Material (RM), Video Talk (VT), Consent Form (CF), Webinar Video (WV), Webinar Link (WB), Slides for the Webinar (SL), Weblinks (URL), Assignment (AS), Video Instruction (VI), Assignment of Research Articles (LST), Coding Notebook (NB), Download of the Coding Notebook (DN), Question & Answer Forum (QA). The resources were grouped into the following main categories: 1 = Quizzes, 2 = Videos Lectures, 3 = Reading Material, 4 = Video Talks, 5 = Live Webinars, 6 = Assignments, 7 = Coding Resources, 8 = Q&A Forums.

Week 1	**Week 2**	**Week 3**	**Week 4**
What is Learning Analytics?	Learning in Context	Data: How do they look like?	Extended focus on Data
E, Q[1]	E, Q[1]	E	E
LV[2], RM[3], VT[4], CF	WV[2], RM1[3], RM2[3], WB[5], SL[3]	LV[2], RM1[3], RM2[3], URL, AS[6]	VT[4], VI[7], URL[7], URL[7], URL, URL
Week 5	**Week 6**	**Week 7**	**Week 8**
Data (part 2): The Data Whisperer	Analytical Methods	Applied Learning Analytics (part 1)	Applied Learning Analytics (part 2)
E	E, Q[1]	Q[1]	E, Q[1]
WV[2], RM1[3], RM2[3], RM3[3], AS[6], WB[5], SL[3]	VT1[4], VT2[4], LST[3]	NB[7], DN[7], QA[8], VL[2]	NB[7], DN[7], RM[3], QA[8], VL[2]
Week 9	**Week 10**	**Week 11**	**Week 12**
Applied Learning Analytics (part 3)	FATE and Learning Analytics	Revision	Exam
E, Q[1]	Q[1]	n/a	n/a
NB[7], RM[3], WV[2]	RM1[3], RM2[3], VT[4], AS[6]	WB[5], QA[8], AS[6]	exam

tative feedback of the course participants into consideration to assess the effectiveness of the course design elements.

4 RESULTS

4.1 Students' Engagement with Learning Resources of Different Types

The first step of the analysis examined the usage of the resources, per student and per resource type (that is, reading material, videos, and so on). To measure the resource usage we calculated the times a resource was accessed. Here, we did not consider the duration of engagement with resources for two reasons: a) the LMS provides limited information about time on task. For example, the system logs when a resource is accessed but not for how long. Although one could calculate the engagement duration as the difference between the timestamp the student accessed the resource and the timestamp of the student's next action, this could be highly inaccurate (for example, a student who leaves the browser open and calls a friend on the phone); b) the LMS allows downloading resources, which consequently means that a student may choose to download a pdf file and engage with it "offline." The resource usage per student (Figure 1) ranges from 18 accesses (student 184) - that is, student 184 accessed resources in general 18 times throughout the course - to 593 (student 175) (M = 274.76 SD = 142.51). As the high standard deviation suggests, we could not see a clear pattern for the students' individual engagement except for the two students 133 and 184 who showed less engagement compared to their peers.

Consequently, we explored whether the usage of resources varied based on their type, for example, whether students used video resources more than reading resources. We saw high usage rates (that is, a high number of accesses) for the assignments (2668 accesses in total), closely followed by quizzes (2518 accesses in total). The reading material (657 accesses in total), coding resources (347 accesses in total), and video lectures (344 accesses in total) followed. Furthermore, we saw even lower usage rates for the guest video talks (161 accesses in total), Q&A forums (128 accesses in total), and live webinars (46 accesses in total). It is important to point out that the resource usage did not reflect the resource distribution over the lecture's duration (Table 1). For example, assignments were accessed more than video re-

sources. However, over the duration of the course, there were more video resources than assignments available. Based on the high usage of the assignments and quizzes, we looked in detail at the usage patterns of these resources by the individual students (Table 2). We observed that students who demonstrated low usage rates usually showed a higher usage of the assignments than of the quizzes. Depending on whether usage rates were below or above the mean M=274.76 (SD = 142.51), we assigned the students to two different groups. Out of 25 participants, 13 students who belong to group II in Table 2 showed total usage rates below the mean. Of these 13 students from group II, 10 students showed a higher usage of the assignments rather than the quizzes. We assumed that students, who used the resources less, prioritized their work in a different manner. They might have set their priorities according to the things that needed to be done first before proceeding to the things that could be done later. The submission of the assignments was mandatory to pass the course, whereas the quizzes were an optional and additional offer. It was possible to earn bonus points, but there was no obligation to take the quizzes. In contrast to this observation, two-thirds of the students in group 1 - who showed generally higher usage rates than the mean usage - also showed higher usage rates for the quizzes. The frequent usage of the quizzes could be an indication that the quizzes were popular and kept engagement high.

4.2 Students' Engagement over Time

Next, we wanted to gain insight into resources' usage over time. Figure 2 illustrates the total resource usage per week during the course duration. Overall, we saw that resource usage increased from week 1 to week 2. In both weeks, a quiz and an egg were provided. In week 3, a week with an assignment and an egg, the resource usage dropped. A possible explanation could be the provision of the assignment, as students had two weeks to complete it. From week 4 to week 7, the resource usage started increasing again and dropped in week 8. The lowest point of resource usage was shown in week 9. This was three weeks before the exam took place, students might have needed a break. In week 10, which consisted of 14 days, the usage rose steeply to the peak and dropped slightly in week 11. In the week of the exam (week 12) the resource usage was still quite high. It is worth mentioning that week 12 only consisted of two days, it started on Monday and the exam took place on Wednesday.

Additionally, we inspected the engagement patterns of the individual students during the course weeks (Figure 3). Comparing the resource usage of the individual students in Figure 3 with the accumulated resource usage in Figure 2, we could not find the exact same pattern. Some students (e.g. students 160, 175, and 178) showed continuous resource usage with comparatively high resource usage around week 6 and week 7 and around the end of the course. Looking back at Table 2, most of the students who showed a higher total resource usage than the mean, also showed continuous resource usage in Figure 3. A few students (such as students 161 and 163) showed higher resource utilization at the end of the course than continuously throughout the course. Additionally, the differences in resource usage by students 133 and 184 as depicted in Figure 3 compared to the rest of the students is striking. They engaged to a minimum extent with the resources during the course. Indeed these students dropped out.

4.3 Students' Engagement with Quizzes and Eggs

Finally, we looked in detail at how students interacted with the quizzes and eggs (that is, how many students took each quiz and how many students found an egg). Our findings (Table 3) suggested that the participation was high for the first three quizzes in week 1 (17 students), week 2 (18 students), and week 6 (16 students). About half of the students who attended the course took the fourth quiz in week 7 whereas a little more than one-third of the students participated in the quizzes in weeks 8 and 9. For the last quiz in week 10, only 7 students out of 25 participated.

We discovered a similar pattern for students' activity in the treasure hunt. Students found more eggs in the first three weeks than in the following weeks (Table 4). The first egg was found by 15 students, the second by 18 students, and the third by 20 students. In week 4, 7 students detected the eggs, whereas the eggs in weeks 5 and 6 were found by a few more students (9 and 10 students). Only 2 students detected the egg in week 8 whereas the egg in week 9 was found by 9 students.

With regard to the identified eggs, we need to take into consideration that the numbers don't reflect how much time and effort students spent searching for the eggs. For example, one may argue that some eggs (such as the egg in week 3) were easier to find than other eggs (such as in week 8).

Additionally, we explored whether there was a correlation between the points students collected by finding the eggs and the points students collected by participating in the short quizzes. The correlation analysis suggested that the points students' scored from collecting eggs correlate statistically sig-

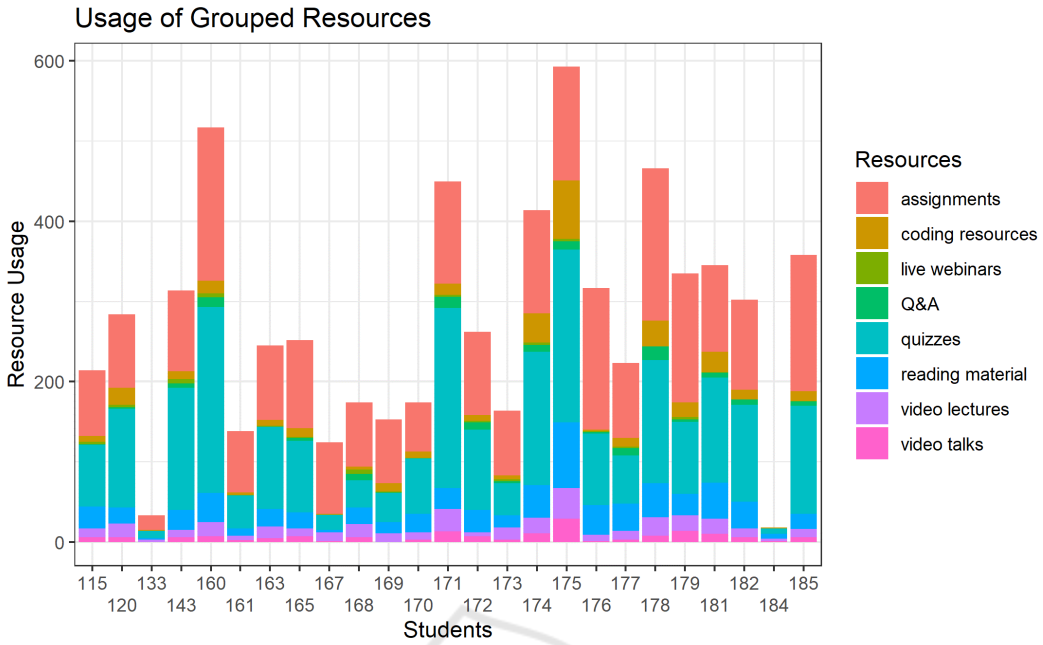

Figure 1: Resource usage per student for the course's duration. The resources are grouped into the categories Assignments, Coding Resources, Live Webinars, Q&A, Quizzes, Reading Material, Video Lectures and Video Talks.

Table 2: Overview of the Student IDs, the Total Resource Usage, the usage of Assignments and the Usage of Quizzes for the individual students. Based on the mean usage (M=274.76, SD=142.51), the students were assigned to group I - usage rates higher than the mean - and group II (usage rates below the mean).In the columns Usage of Assignments and Usage of Quizzes, the higher value of both is shown in bold.

Student ID	Total Resource Usage	Usage of Assignments	Usage of Quizzes	Group
175	593	142	**216**	
160	517	191	**232**	
178	466	**190**	154	
171	450	128	**225**	
174	414	129	**166**	
185	358	**170**	135	group I
181	345	108	**131**	
179	335	**161**	90	
176	317	**177**	89	
143	314	101	**152**	
182	302	112	**121**	
120	284	92	**123**	
172	262	**104**	100	
165	252	**110**	89	
163	245	93	**103**	
177	223	**93**	60	
115	214	**82**	77	
168	174	**80**	34	
170	174	61	**69**	group II
173	164	**81**	40	
169	153	**80**	36	
161	138	**76**	41	
167	124	**89**	19	
133	33	**18**	9	
184	18	0	**7**	

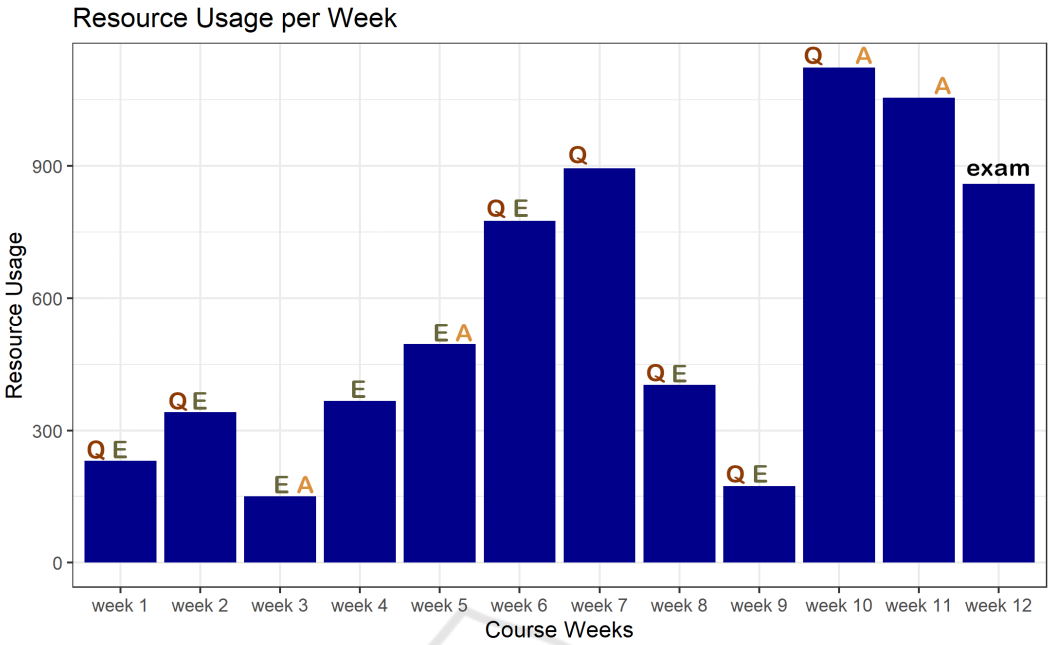

Figure 2: Resource Usage of all students during the Course Weeks. For each week which contained a Quiz (Q), an Egg (E), an Assignment (A), or a combination of these resources, this is shown by the letters Q, E and A above the bars.

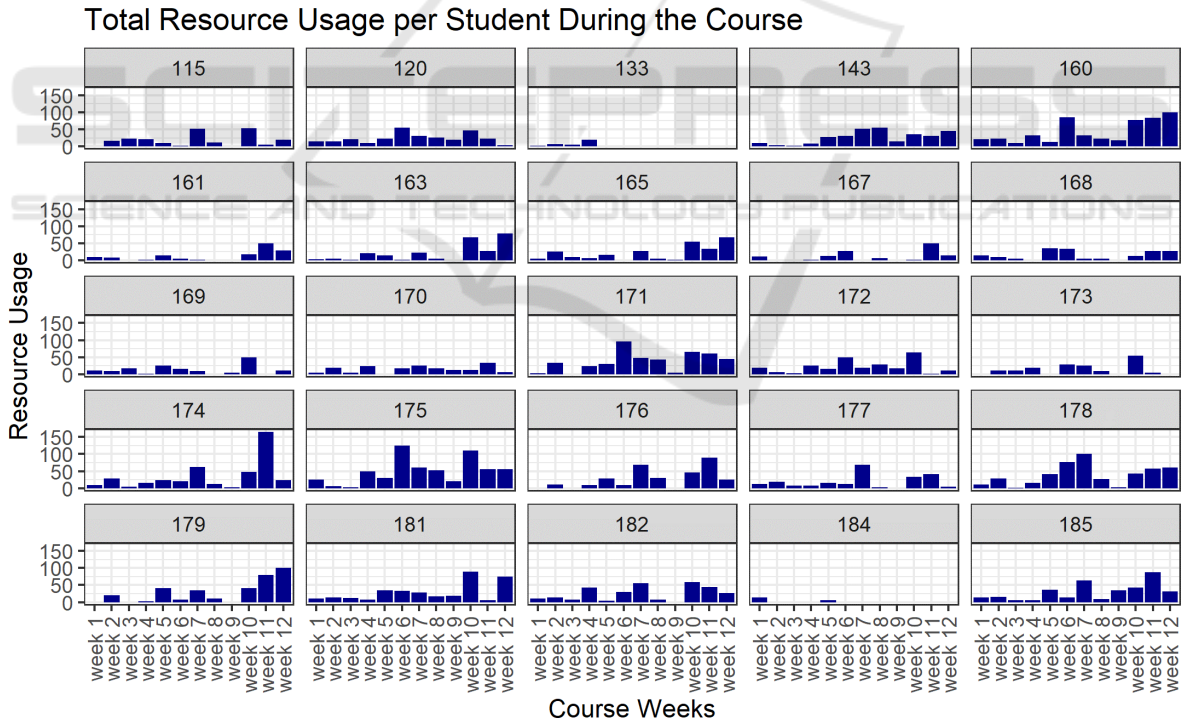

Figure 3: Students' individual Resource Usage during the course.

nificantly and positively with the number of total interactions they performed in Moodle ($\rho = 0.41, p = 0.04 < 0.05$). Similarly, the points students' scored from engaging with the course quizzes correlate statistically significantly and positively to a moderate extent with the number of total interactions the students performed in Moodle ($\rho = 0.54, p = 0.006 < 0.01$). These findings suggest that indeed the students who were involved with the introduced course design elements - that is, the eggs and the quizzes -

Table 3: Overview of the Course Weeks and number of quizzes that were completed during the course. The first row shows the Course Week of the quiz. The second row shows the number of students who completed the quiz.

Week 1	Week 2	Week 6	Week 7	Week 8	Week 9	Week 10
17	18	16	12	9	9	7

Table 4: Overview of the Course Weeks and number of eggs that were found during the course. The first row shows the Course Week in which the egg was provided. The second row shows the number of students who found the egg.

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 8	Week 9
15	18	20	7	9	10	2	9

also performed more actions on the platform. Furthermore, the correlation analysis indicated a strong, positive, and statistically significant correlation between the points students' scored by collecting eggs and the points scored by engaging with course quizzes ($\rho = 0.85, p = 9.1e^{-08} < 0.001$). This suggests that the students who actively engaged in the treasure hunt and located eggs are the same students who also engaged with the course quizzes.

4.4 Students' Feedback for the Instructor

In addition to the log files, the instructor gathered qualitative feedback from the students after the end of the course. Students were asked to submit their feedback by completing the form *"I like ..., I wish ..., I wonder ..."* - a popular method to gather feedback in workshops or retrospectives. In total, 14 students submitted their feedback. Of these, five people (st.01, st.02, st.03, st.04, st.05) mentioned the eggs explicitly and in a positive way below the *"I like"* section. Two of them additionally mentioned the quizzes (st.04, st.05). In addition, one other student (st.06) mentioned the quiz below the *"I wish"* feedback form. In the following, we have listed some exemplary statements:

- *"Easter Eggs (element of fun was brilliantly introduced into the learning)."* (st.01)
- *"Easter eggs and all other off-topic activities which I wish were present in all other courses."* (st.02)
- *"The easter eggs were a lot of fun, we all need that in our lives."* (st.03)
- *"Egg-hunting made me back to child-heart as well. Quiz were useful to refresh memory."* (st.04)
- *"Overall I really liked the structure of the course especially the weekly quizzes that helped me to keep up with the course and assess my learning. [...] P.S. - I also enjoyed looking for the Easter eggs!"* (st.05)
- *"feedback was provided sooner...in some instances/quizzes I didn't know if I was on the right track or completely off base."* (st.06)

In addition to the eggs and quizzes, all students - except for one - either explicitly mentioned further resources or the structure or atmosphere of the course in the "I like" section. The other student directly commented on the instructor (I like *"Your enthusiasm and passion for your subject"*). Looking into the "I wish" and "I wonder" categories, we noticed that three students wished to receive more credits for the effort they put into the course, and three students wished for another similar course or a continuation of the course. It is worth mentioning that the feedback was requested after the students had gotten their grades. Furthermore, the feedback was not enforced but was a voluntary option.

5 CONCLUSION

Our results about resource usage showed that the "assignment" was the most used resource, followed by the resource "quizzes." All other resources were used much less. When interpreting the resource usage, we have to remember that some resources could have been downloaded (e.g. reading material) or saved locally (e.g. URLs) and accessed without having any action log data saved by the Moodle database. Furthermore, it is important to note that the work on and the submission of the assignments was a compulsory task to complete the course. Opposite to this, the quizzes were an additional offer to support self-assessment and reflection. On the one hand, students could collect bonus points for each quiz. On the other hand, they did not have to expect any disadvantages when they didn't complete one or multiple quizzes. The high usage of the quizzes could mean that the initial idea of the instructor to motivate the students to engage with the learning material might have worked for this specific resource. Considering individual resource usage, we saw that two-thirds of group I, according to Table 2, showed a higher us-

age of the quizzes. In contrast, the other third showed a higher usage of the assignments. The students in group II (Table 2) showed lower usage rates on average than students in group I, and they used the assignment more than the quizzes. Our hypothesis was that people who used little of the learning material might have spent less time on the course and prioritized the tasks that needed to be done before they interacted with optional resources. The other way around, the students who used the learning materials substantially, also showed higher usage rates for the quizzes than for the assignments. With regards to **RQ 1**, we established that there were differences in the usage of different resources. Assignments and quizzes were used considerably more frequently than the other resources.

Concerning **RQ 2**, we could see differences in student activity over time (Figure 2). We saw three noticeable drops in the third week and in weeks 8 and 9. Simultaneously, we observed high resource usage for four weeks in the middle of the course and for three weeks at the end of the course. We can't provide a clear answer to the question whether students lost interest in the weeks with the decline of resource usage. Apart from these two declines, we could see continuous resource usage. This consequently could serve as an indication that engagement was sustained over the course.

In response to **RQ3**, we could show a relationship between quiz and egg activity. Firstly, we saw a correlation between the points students' obtained when identifying eggs and the total resource usage. Secondly, we observed a correlation between the points students' scored in the course quizzes and resource usage. Thirdly, we found a strong correlation between the points students' got by finding eggs and the points they got by completing course quizzes. These positive and statistically significant results suggest that students who were involved with the eggs and the quizzes also showed higher resource usage in the course. The third correlation result suggests that the students who actively engaged in the treasure hunt and located eggs are the same students who also engaged with the course quizzes. With regard to the perception of the design elements, the instructor received positive qualitative feedback. Many students commented on the course design and the content of the course. Additionally, students appreciated the fun design elements (treasure hunt and quizzes).

We envision that our work contributes towards sustainable student engagement in online learning for higher education. Firstly, we established that students interacted with the quizzes although they were not mandatory learning resources. The students who completed the quizzes are the same students who actively engaged in the treasure hunt. This could suggest that the implementation of a treasure hunt and the provisioning of quizzes is a good combination for an active course design. This assumption is complemented by the students' positive feedback. Looking at the chronological resource usage over the 12 weeks we did not see a dominating pattern. One may argue students started with high intrinsic motivation at the beginning of the course. After the first two weeks, the intrinsic motivation might have dropped and been replaced by an extrinsic motivation to submit the assignments. This could explain why the weeks with the assignments showed higher usage rates at the end of the course.

However, we need to remember that we looked at raw action log data and did not know the context of each student and the circumstances in their personal life - especially during a worldwide pandemic. When interpreting our findings we need to consider this as a first notable limitation. Additionally, we should bear in mind that our course was a master-level course on Learning Analytics, studied by students majoring in Computer Science or Educational Technology. The background of our student group might impact their engagement and behavior throughout the course. It could be interesting to replicate the course setup with a different student population. The fact that we could not include factors outside of our course setup and the LMS environment also leads to another limitation. We could not determine whether certain resources were used outside of the platform, e.g. reading material was downloaded, links were saved locally and accessed outside of the Moodle course or students searched for further resources online or offline. Additionally, the application of gamification elements can be discussed as well. The use of game design elements has been explored in educational contexts with studies suggesting beneficial effects on learning performance (de Marcos et al., 2016) or engagement (Denny, 2013). Here, we did not use surveys or other measures for the (self-)assessment of variables such as motivation or satisfaction and followed an exploratory study design but one could consider for future work to study in particular the impact of fun, game-like elements (such as "easter eggs") on the classroom's environment. For future research, it would be beneficial to get more contextual information and insights into the students' personal circumstances. For instance, one could follow up with qualitative interviews or integrate further questionnaires which could survey motivation and personal well-being.

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