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Game-Based Digital Quiz as a Tool for Improving Students' Engagement and Learning in Online Lectures

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ABSTRACT Distance teaching and learning are gaining popularity, especially amidst the COVID-19 crisis at the beginning of 2020. Several schools, colleges, and universities across the globe, as a result, have adopted the online mode of teaching. While the businesses and day-to-day activities were shutting down, eLearning tools and online education platforms saw considerable demand. Many institutions with digital infrastructure in place and prior distance teaching experience had a smoother transition from on-campus classes and lecturing to online teaching and learning. In contrast, for many, the transition involved challenges, including keeping students' motivation, interaction, and interest alive, in addition to adapting tools and technologies. This paper reports on students' engagement and motivation levels along with the learning curve during the online learning using a game-based digital quiz tool within a Human-Computer Interaction course in a university in Kosovo. The study investigates the effect of in-lecture quizzes in online classes and correlating the effect of students in the learning curve over four months. Two key motivation parameters-students' engagement and interaction - are compared and analyzed using two different online quiz platforms and the impact of its uses reflected in the learning curve. The results indicated a significant increase in students' engagement and interaction levels in lectures with systematic in-lecture quizzes. Further, the results show that the learning curve is steeper when using in-lecture quizzes (with 73%) in contrast to classes where in-lecture quizzes are not used (57.5%).

INDEX TERMS Online lecture, dynamic classes, education, learning curve, Kahoot!.

I. INTRODUCTION

Over the past ten years, online education has grown tremendously [1]. Open and distance learning are the delivery formats that will become the key driver of transnational higher education as predicted by the International Council for Open and Distance Education (ICDE) [2]. Moreover, the recent corona-virus crisis (hereafter COVID-19 pandemic) resulted in the physical closure of universities leading to accelerated digitalisation of teaching [3]. A survey of teachers concerning online teaching indicated that most academicians had adapted their ways of teaching, and now most of them organise and conduct their lectures online, either live or pre-recorded [3]. According to the World Bank report, the total number of students as part of higher education institutions affected by this situation for Europe and Central Asia has reached about 97% [4], [5]. Due to this situation, this mode of instruction (online education) has become more prevalent. Therefore it is vital to understand the teaching and design of online courses, identify the challenges the teachers face, and highlight the developed effective practices to propose strategies that can be tested empirically [2]. Online teaching and learning occur in highly varying forms and have been identified with different names, e.g., distance learning, technology-based learning, digital learning/teaching, online learning/teaching, and eLearning. Furthermore, there are variations where an effective learning process is achieved by combining activities in different ways, e.g., combining blended learning online and traditional methods [3], [6], [7]. However, many challenges have been identified in teaching online classes including lack

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of teacher-student interaction, students' difficulty focusing on major concepts resulting from lack of active learning, and lack of engagement in lectures are typical constraints [8]. Researchers focus on improving student-teacher interaction in online teaching and include active learning to provide an experience similar to face-to-face class sessions [8].

Digital technologies engender prospects for active learning and engage learners in the online learning experience. Many pedagogical theories explain the role of technology in teaching and how learning takes place using digital technology. The most prominent is the notion that digital technology is a tool or medium to organize and impart teaching and learning activities by facilitating the communication of content and structure [9], [10]. Therefore, technology should be used meaningfully and actively by instructors to develop teaching plans [11]. The rapid growth of technology introduces new challenges making it difficult for educators to follow up with the changes and assess its effectiveness in online teaching and learning. Many studies focus on theoretical frameworks for integrating technology, but more focus is needed on the practical use of digital technology tools in the online classroom, particularly in higher education [12]. According to [8], the use of evaluation and participation tools positively impacted online learning and improved the instructor and student interaction. Instructors have used course quizzes as a teaching technique and a common assessment strategy for generations. The advancement of digital technology resulted in increasingly varied formats of quizzes [13]. According to [13], numerous research studies have found online and mastery quizzes and pre-lecture as a useful pedagogical strategy. Whereas the authors in the paper [14], focus on using online quizzes as a tool for formative assessment. Pre-lecture quizzes are used to assess the student's current knowledge level about the subject and improve student engagement. However, different studies have varied results concerning student performance [13]. According to [15], online quizzes were effective in the blended learning approach for pedagogy and students showed good performance in web programming. Many researchers have analyzed the benefits of online quizzes in higher education, and preliminary findings recommended that if these quizzes are used by students to test their knowledge rather than learning the material, they can improve exam performance [13], [16]. Some others found online quizzes to be an effective strategy for in-class quizzing [13], [17]. However, some studies found that out-of-class digital quizzes significantly impact perceptions toward learning and student engagement rather than student performance [13], [18]. Several studies have been published on the use of the game-based quiz platform "Kahoot!" in the classroom to examine its effectiveness through various factors, but few studies focused on its impact on online lectures [19]. Kahoot! is a game-based student response system that transforms the classroom into a game show temporarily where the game show host is the teacher, and the contenders are the students [20]. Kahoot! uses game elements (such as the use of points, audio effect) that affect student engagement, motivation, and classroom dynamics [21]. Therefore, the main motivation of this research study is to investigate for the first time the impact of Kahoot! on the learning curve in distance education.

Lacking active encouragement in video lectures, lack of interaction with the teacher and difficulty focusing on the course content are typical constraints and limitations that make self-directed online learning challenging for students [8]. These aforementioned challenges give rise to the need that motivates our research to find tools and methods that can encourage active learning and help to deliver and assess if the core messages of a course are understood by the students in an online class [8].

This research paper is organized as follows, Section 2 presents material and methods, including the related work, use of learning technology to mitigate the challenges in online lectures, comparative studies focusing on the game-based learning platform, and the research goal and research questions. Section 3 presents the experimental design. Section 4 presents the results and analysis. Section 5 presents the Discussion including findings concerning research questions and threats to validity. Finally, Section 6 concludes the article.

A. RESEARCH AIM AND RESEARCH QUESTIONS

Higher education learning in institutions worldwide has switched to an online mode due to the ongoing COVID-19 pandemic. This swiftly evolving situation is associated with numerous challenges in the learning process, alongside other challenges facing both the teachers and students. The interactivity between teacher/student and student/student started to fade once the classes merged, and the number of students within online classes increased to 150+ students per group.

This paper aims to investigate the use of a game-based digital quiz tool in a Human-Computer Interaction (HCI) course that switched to online mode, to assess the effectiveness of such technology in the online learning process. The online class was divided into two groups, with approximately 150 students in each group.

To ensure that the learning is acquired successfully, an experimental approach applied in two different iterations was conducted, where the first experiment aimed to check students' *engagement and interactivity* using Kahoot! and Google Form quiz platforms, and the second experiment endeavored to measure for the first time the *learning curve* using Kahoot! platform.

The following research questions are defined in order to achieve the aforementioned research goal:

- RQ1: How is students' engagement affected by the usage of online quizzing platforms?

The first research question investigates how the students' engagement changes from using a particular online quiz tool.

- RQ2: How is the interaction among students and teachers affected by using online quizzing platforms?

The second research question investigates how the students' interaction among teacher and other students are affected once using the online quiz tools.

- RQ3: How does the usability of different online quizzing platforms (simple vs. gamified) affect students' interactivity?

The third research question investigates how the students' interactivity is affected by the usability of the online quiz platform, where two different platforms are selected, the one characterised as a simple platform, whereas the other as a gamified platform.

- RQ4: How do online quizzing platforms impact distance learning during the quarantine experience?

The fourth research question investigates how the use of online quiz platforms impacts the participation of students, the activeness and emphasizes the impact on the students' quarantine experience.

- RQ5: Does the systematic use of the Kahoot! online quiz platform increase the learning curve of students?

The fifth research question investigates the impact of using Kahoot! as an online quiz platform in the learning curve of a Human-Computer Interaction course.

II. RELATED WORK

Researchers have highlighted several challenges and barriers associated with online teaching [8], [22] such as reduced motivation for active learning [23], [24], limitations in the interaction between student and instructor [8], [25], [26], and issues with software compatibility [8]. Most students are not very engaged in online lectures and videos and only focus on the part required for solving assignments. As the number of students participating in an online course increases, the interaction between students and the professor becomes a major issue, and email is not an effective solution. Moreover, many students face technical difficulties when attending online lectures or solving exercises because of different software versions or different types of operating systems [8]. The findings from the work of [27] showed the factors that most influence eLearning, online learning, or blended learning are: interactions between teacher, students and content, presence of instructor in an online setting, connections between designed offline and online activities and between campus-related and practice-related activities. According to a review by [28], the effectiveness of online instruction depends on the following: motivated instructor-teacher interaction, well-prepared instructors, well-designed course content, a feel of the online learning community, and rapid furtherance of technology.

[8] advocated usage of evaluation and participation tools in online learning to improve the interaction between the instructor and students. [8] conducted a case study implementing two methods (use of in-person review sessions and online evaluation tools) in an economic class to overcome the constraints in online teaching and found (based on students' performance and students' perceptions of the class) that the used methods had a positive impact on students' learning process and also improved student-teacher interaction. [13] combined traditional face-to-face meetings with an online quiz format for a small graduate course and found this blended instructional approach beneficial to stimulate classroom discussion and evaluate weekly course lectures. Numerous research studies recognize online quizzes as a useful pedagogical strategy [13], [29]. Reference [14] focused on the role of online quizzes as formative assessment tools that increases student-teacher interaction and improve instructional design. [29] aimed to analyze online quizzes' effectiveness on student performance with integrated use as a teaching and assessment tool. The results from five years of experimentation showed that online quizzes positively effect students' performance. Digital quizzes are tools that allow instructors to use electronic questions to develop higher-level assessments. Therefore, it is important to understand the relationship between such digital tools and learning outcomes [13]. However, there is a lack of research using these pedagogical tools to assess individual lectures [13]. Reference [12] highlighted the need to assess the practical use of technology tools in higher education online classes.

According to a survey by [6], advancements in internet technology are expected to increase the use of interactive games and multimedia in online teaching and learning. The game-based learning approach can aid the learning process by enhancing emotional states such as engagement [30]. One of the critical issues in higher education is understanding student engagement and the impact on learning performance. Therefore, it is essential to investigate the use of eLearning technology by students to contribute to eLearning design and support student engagement [31]. Since the game-based learning platform, Kahoot!, was publicly released in 2013, many studies on the effect of using Kahoot! for learning have been published [19]. The main conclusion from these studies is that Kahoot! has a positive effect on learning performance, classroom dynamics, students' and teachers' attitudes, and student anxiety. Some issues have also been identified, including technical problems, seeing questions and answers in the classroom, time stress, fear of losing, and hard to catch up on the scoreboard. However, there are very few studies of using game-based student response systems outside the physical classroom. A study by [32] explores the learners' perspective of using Kahoot! in an online synchronous English class. In this study, Kahoot! was run inside a university learning management system, allowing the teacher to share his screen with online students along with an online video stream of the teacher and a list of the students participating. The findings showed that both the learners and the teacher had a positive experience using the tool. Kahoot! helped the instructors to evaluate the learners' understanding of the subject matter and, by giving instant feedback to learners, the motivation and engagement of the learners were increased. The only other paper found on using Kahoot! outside the classroom is a paper that shares the experiences of a teacher providing a middle grades virtual classroom [33]. The paper describes how the teacher went from a somewhat

chaotic learning environment to an engaging virtual learning platform using tools like TikTok videos and playing Kahoot! over Zoom.

There have been several studies published similar to ours, focusing on related issues where Kahoot! was used in a physical classroom. The most notable and cited of these studies are experiments that are focusing on issues like the game experience, social effects, classroom dynamics, and the resulting student engagement and motivation [20], [21], [34], [35]. Similarly, there are several studies that cannot be classified as experiments but describe case-studies or surveys on the same topics [36]–[40]. In one of the experiments described in this paper, two groups were compared where the control group used Google Form Quiz, and the experimental group used Kahoot!. [41] describes a quasi-experiment examining the effect of Kahoot!, Quizizz, and Google Forms on concentration, enjoyment, perceived learning, motivation, and satisfaction. The main conclusion was that Kahoot! performed better than Quizizz, and Quizizz better than Google forms. Another topic of this paper is comparing the quiz experience to doing a paper quiz. [21] describes a quasi-experiment that compared the effect of using a paper quiz, a simple student response system, and Kahoot! had on enjoyment, motivation, concentration, engagement and learning. The main conclusion was that the game-elements in Kahoot! had a positive effect on enjoyment, motivation, concentration, and engagement compared to the two other approaches and no effect on learning. [42] present another quasi-experiment comparing the effect of using a paper quiz vs. Kahoot!, and it was found that using Kahoot! instead of a paper quiz had a statistically significant effect on learning and motivation. Also [43] experimented comparing the effect of using a paper quiz vs. using Kahoot!, where the main conclusion was that the exam grades were significantly higher for the group using Kahoot!. Finally, several studies investigate how using Kahoot! vs. other approaches affects the learning performance. The results of these studies show significant improvement on exam scores [44]–[46] and pre- and post-tests [34], [42], [47], [48].

As stated above, a number of studies tackled the idea of using game-based quiz platforms in the classroom to examine its effectiveness through various factors, but few studies focused their impact on online lectures and none of them the impact of systematic in-lecture quizzes in learning curve [19]. Therefore, the main motivation of this research study, is to investigate, for the first time, the impact of Kahoot! on the learning curve as part of online learning.

Our study distinguishes itself from existing research in that it is, the first experiment conducted in Higher Education Institutions that focuses on using the Kahoot! platform as an online tool to measure the learning curve using Kahoot! [19] and further includes investigation on the pandemic quarantine experience.

III. PARTICIPANTS AND DATA COLLECTION

In the first experiment investigating the students' engagement and interactivity, all participants were divided into two groups, i.e., the control group and experimental group. Two assessment quiz tools were investigated in this experiment. The control group (128 students) used the Google Quiz platform characterized by its simplicity, whereas the experimental group (129 students) used Kahoot!, a game-based learning platform.

As shown in Table 1, more students participated in the in-lecture quiz than in the overall experiment in both groups, since the in-lecture quiz was mandatory in the course. In contrast to that, the online surveys were optional for participation. In the survey, a total of 257 students participated. These participants are second-year graduate studies in the Computer Science. One year of study completed is prerequisite to enroll in Human-Computer Interaction, the course under study for this research. A total of 99% of them belong to the 18-25 age group.

TABLE 1. Participant composition in the first experiment.

Group	Number	Composition	In-lecture quiz	Survey
Control	128	39 Female / 89 Male	202	128
Experimental	133	33 Female / 100 Male	177	133

In the second experiment, measuring the learning curve using the Kahoot! platform, a total of 243 students participated (see Table 2).

TABLE 2. Participant composition in the second experiment.

Group	Number	Composition	pre-test	post-test
Experimental	243	75 Female / 168 Male	243	243

A. STUDY DIMENSIONS/ASPECTS

To define the study dimensions, or aspects within this research paper, the authors are inspired by the LEAGUE framework (Learning, Environment, Affective cognitive reactions, Game factors, Usability, UsEr). LEAGUE covers the core game-based learning elements in an integrated conceptual hierarchy [49]. This framework covers four levels: dimensions, factors, sub-factors, and metrics. Furthermore, as part of the dimensions level, the LEAGUE framework identifies: (i) Learning/pedagogical, (ii) Game factors, (iii) Affective cognitive reaction, (iv) Usability, (v) User and (vi) Environment, as key constituents of game-based learning evaluation.

Similar to [49], the study dimensions within this research paper focused on affective cognitive reaction (fun, engagement), game factor, usability, users (university students), the environment that includes setting (online quarantine experience), and technology type (tool-based quiz vs. paper-based classroom quiz).

Furthermore, after having collected the data, a ground theory approach is followed by the students feedback to extend the study dimensions for interpretation of the result [50] as follows:

1) Usability
   a) Simplicity - The design of the platform, presentation of the questions, and the transparency of technology to facilitate the user on achieving their goals in an optimal number of interactions with the platform.
   b) Accessibility - The necessary steps demanded to reach the goal (access the mini-test).
   c) Ease - The ability to interact easily with the platform (easy to learn).
   d) Efficiency - The optimal number of steps/ interactions within the platform for achieving users' goal.
2) Game experience
   a) Engagement - contain items related to students' engagement during the learning and teaching process.
   b) Timeliness - the quiz, specifically the questions had limitations on time.
   c) Untimeliness - Limitation on time only in the overall quiz, but not specifically in each question
   d) Competition - The approach of rewarding with extra points those students that scored earlier with correct answers.
   e) Interactivity with the platform - Having good interaction between students and the tool.
3) Interactive Teaching and Learning
   a) Interactivity between students and among professor and students - The idea of increasing the interactivity not only between students and the tool but also among professor and students.
   b) Teaching and Learning - The processes that facilitated knowledge acquisition, increased skills and gaining new experiences.
   c) Assessment and Evaluation - The processes related to the assessment of the learning process, and the instant evaluation from the platform.
4) Tool vs. paper-based classroom quiz - The different approach of having quizzes, in one dimension using several online quiz platforms to have the class quizzes, whereas in the other dimension, having the quiz printed in a paper, and as part of the on-campus classes with pen and paper.
5) Quarantine experience - the student and teacher experience of having the lecture and quizzes online.

B. INSTRUMENT

The designed survey contained 39 questions involving questions related to the main dimensions mentioned in Section III-A. Starting with questions related to the usability (9 questions), and continuing questions for game experience (9 questions), Tool vs. paper-based classroom quiz (4 questions), quarantine experience (12 questions), and five questions related to teaching/learning and socio-demographic aspects. Thirty-one of the questions use a Likert rating scale (scaling from 1 to 5), three closed-questions, and five single choice questions. The design of the questionnaire was inspired by the LEAGUE (Learning, Environment, Affective cognitive reactions, Game factors, Usability, UsEr) framework [49], while its reliability is checked using Cronbach's alpha. Cronbach's alpha resulted in 0.804, indicating good internal consistency in the responses [51].

C. PROCEDURE

In the first experiment aiming to investigate the students' engagement and interactivity in online classes, a 15 minutes in-lecture quiz was offered in the middle of the lecture. Students were also asked to fill out a survey once the lecture finished. The latter was optional, and only students who had approximately 15 minutes and were motivated, were encouraged to complete the survey (see Figure 1).

In the second experiment, as shown in Figure III-C, the authors continued only with the Kahoot! since the Google Form Quiz faced technical issues when students attempted to use the platform.

In discussion with all participants, the authors decided to use the Kahoot! platform every two weeks and in between weeks to use the standard interaction of professors asking questions and waiting for the voluntary answers from students.

For determining the learning curve in the second experiment, the following procedures within four months (one semester) were followed:

- In the initial phase, a 15 minutes pre-test was performed,
- Then the professor taught the specific subject in HCI,
- At the final phase, at the end of class, all students performed a 15 minutes post-test to gauge the knowledge capture process (measuring the learning curve).

In the initial phase, the pre-test is taken to determine the knowledge level of the students for the specific subject; actual instruction in the specific subject is offered to the students in the second phase; finally, in the third phase, students reflect upon their acquired knowledge from the second phase lecture.

D. DATA ANALYSIS

For data analysis purposes on the collected data, the SPSS program is used to compute the comparison between the group means using the t-Student test. For all the analyses, statistical significance was defined as $p < 0.05$. Furthermore, Python was used for computing mean (M), standard deviation (std), the distribution trend using skewness (Skw) and kurtosis (K_me), and visualising the data. Furthermore, the thematic analysis is used to model, analyse, and interpret the qualitative data collected through the survey in the first experiment [50], [52].

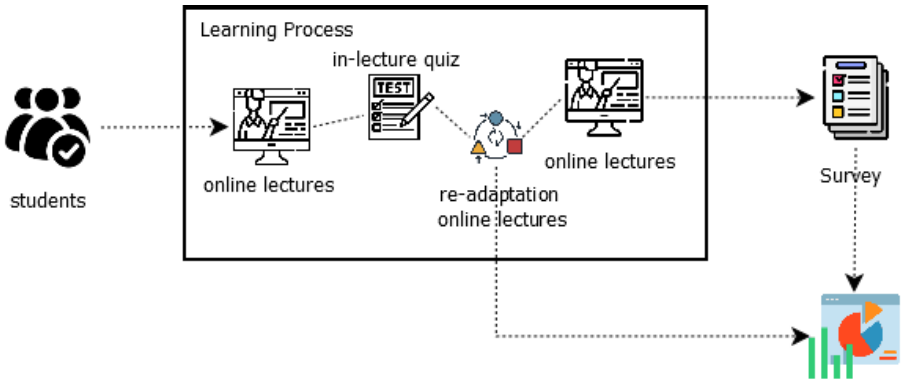

FIGURE 1. 1st Experimental Setup - Engagement and interactivity using two different online quiz platforms.

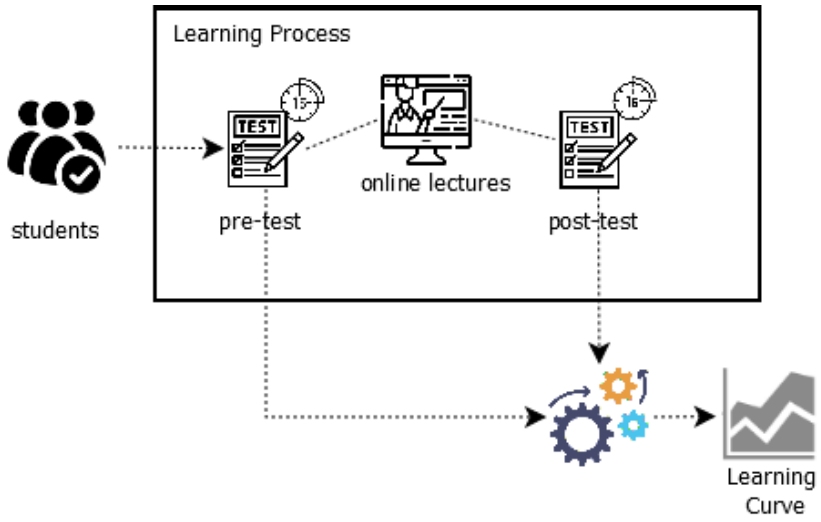

FIGURE 2. 2nd Experimental Setup - The measurement of the learning curve.

IV. RESULTS AND ANALYSIS

This section gives an overview of the generated results from the collected data for both experiments. We initiate the reporting with the first experimental results to research the students' *engagement and interactivity* and end up with second experiment results, which measure the *learning curve*.

A. FIRST EXPERIMENT RESULTS- RQ1 TO RQ4 RELATED TO ENGAGEMENT AND INTERACTIVITY

The whole lecture was organized online, and keeping the students engaged and more active virtually was challenging. Therefore, the first experiment targeted the engagement and interaction among professors and students in distance learning during the quarantine experience. Initially, the lecture started on a specific topic in HCI using the Zoom and BigBlueButton video conference platforms, and after covering the main learning objective of the specific topic, an in-lecture quiz using online quiz platforms was offered to the students to trigger their presence and keep them more engaged with the lecture.

Additionally, the authors were interested in making sure how far the students understood the lecture. The in-lecture quiz was performed using different tools, where the control group used Google Form Quiz, and the experimental group used Kahoot!. Since the Kahoot! platform has more gamification components, such as competition, music and bonus points, engagement, timeliness, the authors were curious to know whether these components would contribute to increased engagement of the students in the learning process and interactivity among the professor and students.

Figure 3 shows the results of the in-lecture quiz for both groups of students, using Kahoot! and Google Form Quiz. As shown in Figure 3, the second group of students using the Google Form Quiz performed better in the in-lecture quiz. These results could have been affected either because some of the first group students retook the in-lecture quiz in the second group (due to some interruption that they faced while taking the in-lecture quiz in the first group), or because this group is more knowledgeable.

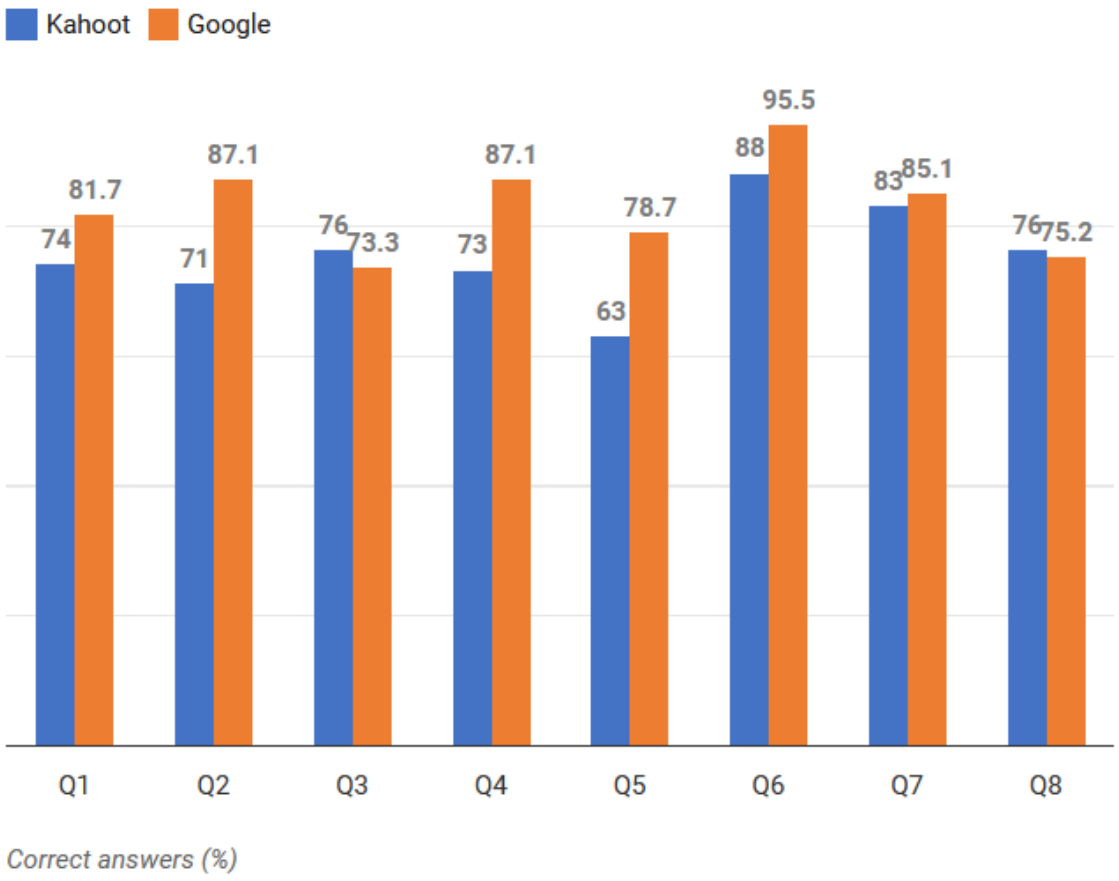

FIGURE 3. Results of students from the in-lecture quiz.

The in-lecture quiz results were used as input for re-planning the rest of the lecture, allowing the professor to focus on those questions where the students showed a higher miss-rate. This aspect of the experiment, proved highly beneficial in directing the lecture for maximum learning and increasing students knowledge of the material.

Having analysed the survey as the final process of the first experiment, the mean of the total Likert scaled questions of the survey depicted in Figure 4 shows that Kahoot! is rated slightly higher in regards to (i) Game experience, (ii) Tool vs. Paper-Based classroom quiz, (iii) Usability, and (iv) home/quarantine experience.

To conclude, concerning the survey results for the game experience dimension, the mean of the Likert scale for Kahoot! is 4.12 (out of 5), whereas for Google Form Quiz, 3.81 (out of 5).

This different trend also continued for the rest of the dimensions, in the Tool versus Paper-based classroom quiz dimension, Kahoot! the average rating is 3.9, compared to Google Form Quiz with 3.66, in the Usability dimension, Kahoot rated 3.41 compared to Google Form Quiz with 3.27, and finally, in the home/quarantine experience, Kahoot! average rating is 4.05, whereas Google Form Quiz 3.84.

Further, Table 3 lists the descriptive analysis from the used survey at the end of the first experiment, interpreted by the mean, standard deviation, standard error mean, the distribution trend by means of skewness (Skw), and kurtosis (Kme). Using kurtosis as a measure for tails of the distribution, we see that the concentration is, from -0.579 to.018, respectively from -0.675 to 0.591, claiming that we have a substantially skewed distribution.

The different rating trends resulting from the quantitative analysis between Kahoot! and Google Form Quiz incited the authors to continue with qualitative analysis of open questions, which gathered the feedback of the students about what they liked related to the specific technology that they used for in-lecture quizzes (Figure 3).

This is also supported by [53], claiming that to deepen the understanding of research participants' critiques, it is essential to analyze the qualitative data of the research. The analysis is inspired by the work that has been done by [50], [52], which followed a ground theory approach.

As shown in Figure 5, following the analysis procedures influenced by [50], [52], we came up with:

1) First column - student feedback raw data,
2) Second column - creation of study dimensions from the students feedback raw data and,
3) Third column - the aggregation of study dimensions into categories

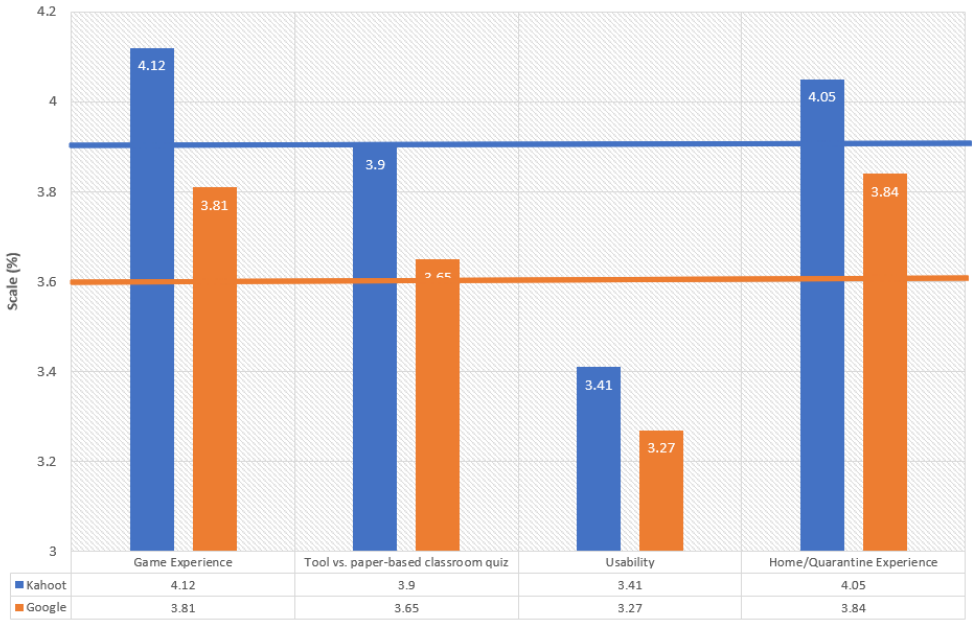

FIGURE 4. The comparison between the group of students that used Kahoot! and Google Form Quiz from the Likert Scale perspective.

TABLE 3. Likert scale and statistical description of the first experiment.

		Likert Scale (%)					Statistical parameters				
		5	4	3	2	1	Mean	Std. Deviation	Std. Error Mean}	Skewness (Skw)	Kurtosis (Kme)
Kahoot	Game Experience	55%	20%	12%	7%	6%	4.12	0.47598	0.04207	-.480	-.012
	Tool versus paper based classroom quiz	45%	21%	17%	9%	8%	3.9	0.37916	0.03351	-.579	.591
	Usability	41%	16%	12%	6%	25%	3.41	0.56819	0.05022	.018	.465
	Quarantine experience	47%	23%	23%	4%	3%	4.05	0.64369	0.05689	-.343	-.675
Google Quiz	Game Experience	45%	18%	20%	7%	10%	3.81	0.65967	0.05831	-.480	-.012
	Tool versus paper based classroom quiz	40%	19%	20%	9%	12%	3.66	0.43267	0.03824	-.579	.591
	Usability	37%	15%	13%	6%	29%	3.27	0.68078	0.06017	.018	.465
	Quarantine experience	40%	20%	28%	6%	6%	3.84	0.72291	0.0639	-.343	-.675

The students' feedback raw data is summed up and tailored to the context. The second step continues with the revised data to organize in study dimensions or aspects. Moreover, the set of study dimensions are reflected in the categories. The creation of categories results from analyzed study dimensions throughout several guidelines [54], [55]. The categories in Figure 5 and the aforementioned dimensions enabled us to interpret our findings with respect to the five research questions defined in Section I-A.

For simplicity of representation, in the first column in Figure 5, the similar context of students' feedback is merged. However, the frequency of occurrence of the specific concept within the students' feedback is reflected in the parameters of study dimensions, and cumulatively the parameters of all study dimensions are presented in the categories, respectively, in column three of Figure 5.

Furthermore, in Figure 5, the representation is encoded using colors: orange, blue, and black. The "blue" color represents the students' feedback for Kahoot! Platform, "orange" color for Google Form Quiz students feedback, and the "black" color infers that the feedback is similar from both platforms.

From the qualitative analysis presented in Figure 5, analyzing the parameters in the category column (third column), for "Interactive Teaching and Learning" and "Game Experience", the students' feedback favors Kahoot! with 46:29, respectively 38:9. Whereas for the Usability category, in

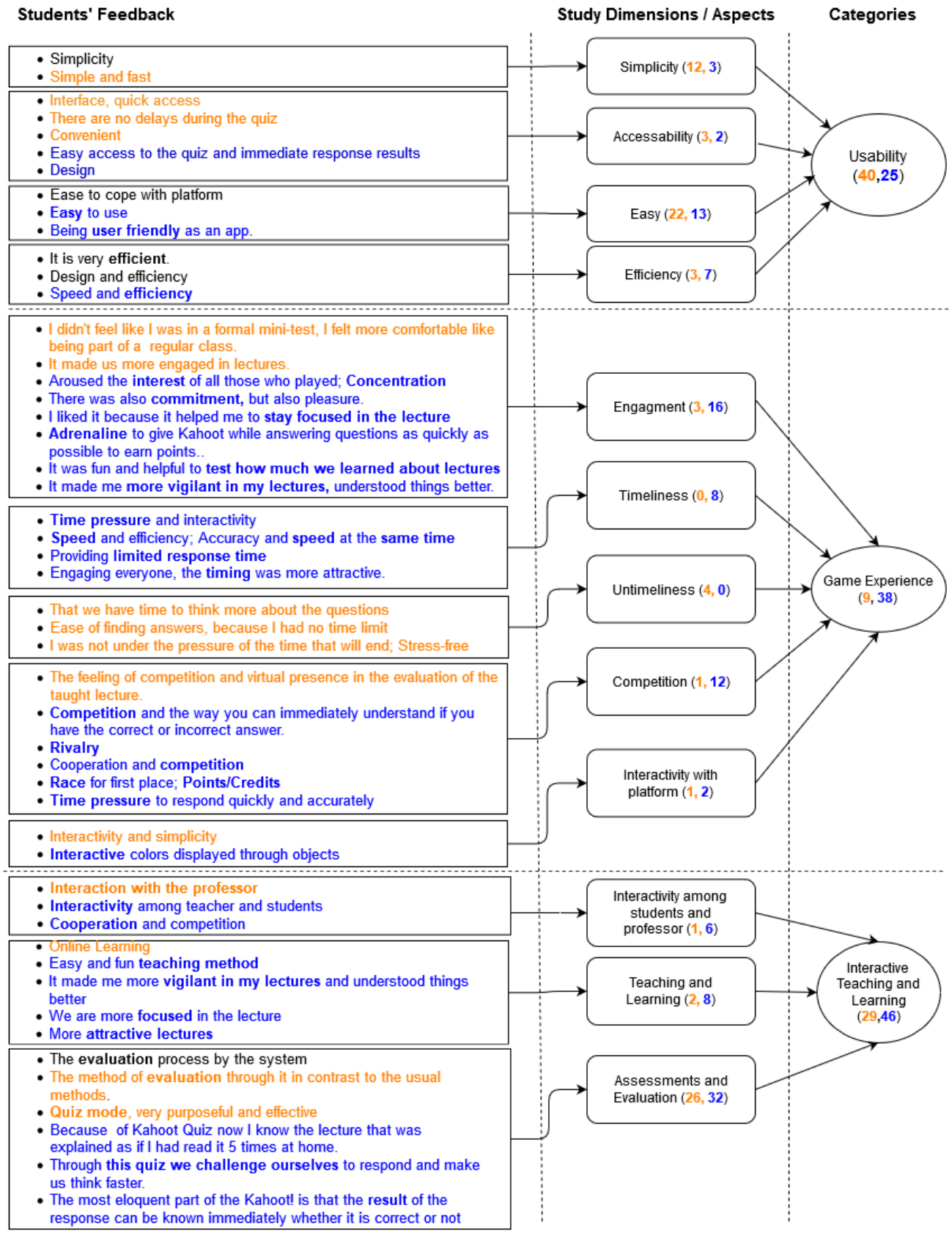

FIGURE 5. Qualitative analysis of students feedback.

contrast with the finding from the survey depicted in Figure 4, Google leads with 40:25.

B. SECOND EXPERIMENT RESULTS- RQ5 RELATED TO THE LEARNING CURVE

As mentioned in Section III-B, the second experiment continued with the Kahoot! platform, since no prior research of measuring the learning curve using this technology has occurred, and Kahoot! was favored from the students' experiences due to the gamification components.

To capture the learning curve of the students, two in-lecture quizzes were performed. The first in-lecture quiz (hereafter: pre-test) was performed at the very beginning while the second in-lecture quiz (hereafter: post-test) at the end of the lecture.

The pre-test aims to determine the knowledge level for the specific subject that will be presented, whereas the post-test tries to capture the students' knowledge level after participating in the lecture. Translating into academic language: testing endeavors to determine whether the lecture has successfully impacted learning outcomes within the classroom space. In the very beginning, the students were informed that all post-tests would be marked, whereas the pre-test solely aimed to measure the learning curve. Therefore the pre-test would not be marked and was optional to students.

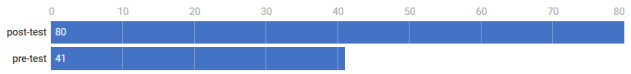

FIGURE 6. The mean of pre- and post-test results.

Figure 6 generally shows (mean in %) the lecture's impact on students' progress, specifically to the learning curve, whereas in Figure 7, it depicts the progress to each specific question.

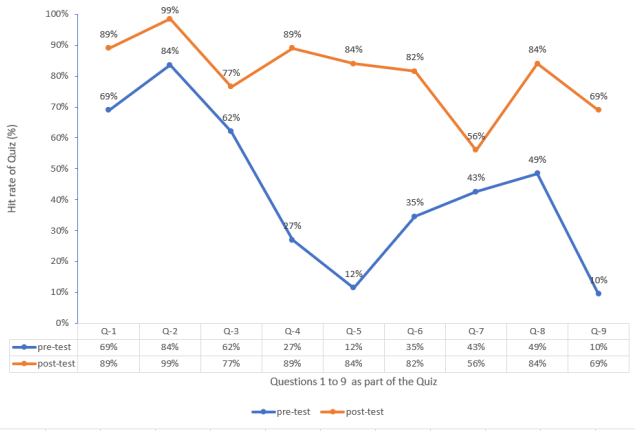

FIGURE 7. The results of each questions in pre- and post-test.

Usually, a new lecture starts with familiar concepts to students from the previous lecture, then dives into new concepts related to the given lecture, and the lecture is closed with practical cases. The same scenario is also reflected in the quiz, where the first three (3) questions are related to the first part of the lecture, continue with the questions related to newly elaborated concepts, and the last two (2) questions related to the practical cases.

Based on these factors, the results of new concepts were also affected. The first part of the in-lecture quiz (question 1-3) had higher correct answers than the second and third parts of the in-lecture quiz. For measuring the learning curve, this scenario was repeated in four (4) iterations, and the results for each pre- and post-test iterations are depicted in Figure 8.

Analysing Figure 8, the post-test results argue that the students were engaged and focused on the lecture. Especially when checking the result of the two final iterations, the students reached the post-test results above 80%.

Moreover, at the end of the course, the authors decided to create the fifth iteration of pre- and post-test combined with the number of questions (10) of those subjects that were quizzed in lecture and the rest of the questions (other 10) related to the subjects not previously quizzed in the lecture.

Furthermore, the result in Figure 9 shows that the correct answered achieved 73% on the questions that were related to the subjects performing systematic quizzes (every two weeks), compared to the questions previously only included in lecture when the teacher raised questions and waited for volunteers to answers, where the students answered correctly only 57.5%.

V. DISCUSSION

Switching from the on-campus classes into online classes due to the COVID-19 pandemic situation was the only choice in 2020. To initially cope with the online classes, the lecturers took the initiative to maneuver the situation using various online tools, until a higher level of University management took the steering in hand. They started to merge the groups (up to 150 students per group), and the classes were imposed in a one-way process. This situation reduced class dynamics, and consequently, interactivity between students.

Due to the low level of interaction, the lecturer felt that the students just logged in on the online platform and did not show any interest in participating in the online class discussion. The traditional manner of triggering the interaction between students and teachers and students by imposing a question and waiting for volunteers to discuss was no longer a viable option on its own. Due to the low interactivity, the lecturers could not know whether the competences of the specific lectures were absorbed or not by the students.

Having the arguments by [12] that today there is a need to assess the practical use of technology tools in higher education online classes and further emphasised by [13] the lack of research in using pedagogical tools for assessment of individual lectures, this research paper aimed to assess the effectiveness of such technology in the online learning process as part of a course that switched to distance learning. The authors during this experiment triggered the class

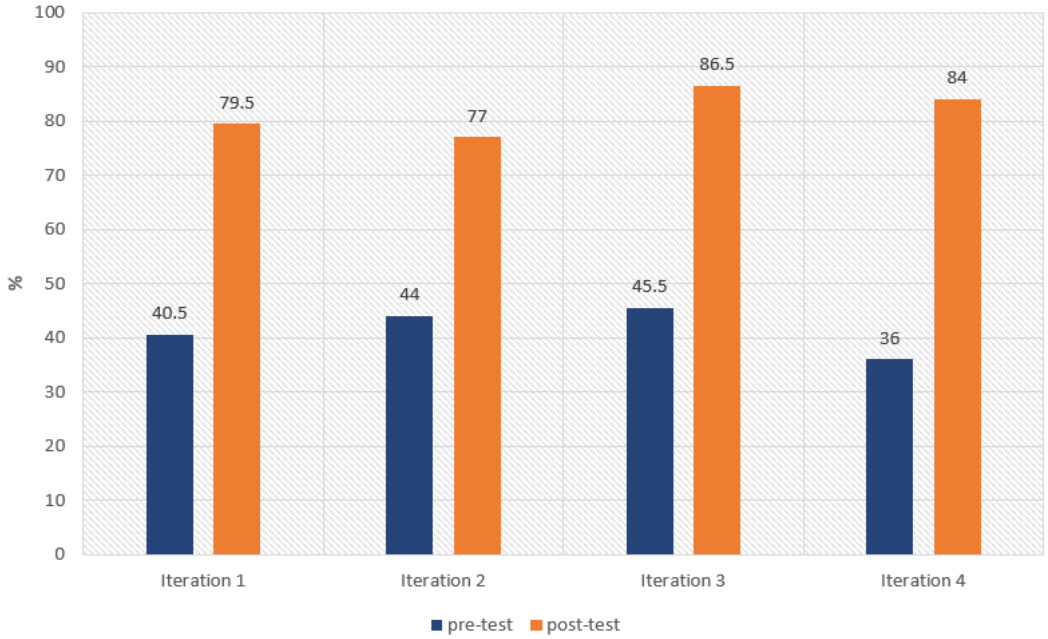

FIGURE 8. The learning curve among four realised iterations.

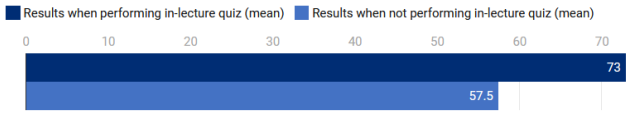

FIGURE 9. The comparison of results with and without performing in-lecture quizzes.

dynamics by using online quiz tools. Furthermore, they took the initiative to investigate students' engagement and interactivity while using these online quiz platforms and measuring the learning curve. Similar to [8], [13], [14], the findings show that using online tools contributes to the interactivity of a teacher and students and also facilitated performing assessments.

A. FINDINGS CONCERNING RESEARCH QUESTIONS

This section details and expands on concrete answers for each of previously stated research questions.

Research Question 1: Investigating how student engagement changes from using a particular online quiz tool, in Figure 4, expressed that the students favored Kahoot! platform due to its gamification component, including: competition, music, bonus points, engagement, timeliness - to name a few. The same approach is also validated from the qualitative analysis (see Figure 5), students expressed a correlated preference for Kahoot! by 38:9 (frequency of occurrence of the specific concept within the students' feedback) as part of the game experience category, which includes the aspects of engagement (RQ1) of students and interactivity.

Research Question 2: Inline with the latter preferences concerning interactivity among professors and students and students and platform (RQ2), the interactivity started to increase. The increased interactivity when using the online quiz platforms has also been specified in the qualitative data (see Figure 5), where the students linked frequent quizzes with higher interactivity. Additionally, from the empirical evidence, the interaction in online lectures using the traditional approaches was no longer a viable option, as aforementioned specified.

Research Question 3: Concerning research question 3, in Figure 4, Kahoot! is rated slightly better. However, when it comes to the analysis of qualitative data (Figure 5), the linking of usability with the Google Form Quiz platform has reached a ratio of 40:25, making Google Form Quiz dominant at this point (frequency of occurrence of the specific concept within the students' feedback). Moreover, returning to comment on the higher success rate of students in the in-lecture test, depicted in Figure 3, the usability could be linked to students' performance as well, this situation could be inferred as the student did not rush to give their answers in order to get higher scoring (no competition in Google Form Quiz) as students do in Kahoot! platform.

Research Question 4: In Figure 5, the quarantine experience (RQ4) using Kahoot! platform as an online tool to have online quizzes is rated 4.05 (out of 5) compared to Google Form Quiz with 3.84. Additionally, students emphasized that performing online quizzes in online classes during the pandemic quarantine time positively impacted their participation in online classes compared to other, quiz-less courses.

Research Question 5: The strategy of using online quizzes resulted in improved results, as stated in [13], [17]. The students performed 73% higher on those subjects where they had systematic online quizzes (RQ5) using Kahoot! platform,

compared to 57.5% to those subjects that did not have any online quizzes (see Figure 9).

To conclude, using the benefits of online quizzes in our experiment as part of the Human-Computer Interaction course resulted in improved class dynamics, as also claimed in [19]. Further, it resulted directly in students' engagement, interactivity and indirectly in students' exam performance as argued by [16].

B. THREATS TO VALIDITY

This section addresses the most critical threats to the validity of this study. The **Internal validity** concerns the degree to which an experimental design controls the extraneous variables [56]. The extraneous variables infer the causal relationships of the variables examined in a study, and influence and weaken the internal validity. Although our study is classified as a quasi-experiment, it is vital to consider the relevant internal validity concerns. There are mainly three relevant internal validity threats. *First*, the sample of the two groups used in the evaluation was not randomized. As mentioned in Section 2.2, the two groups were already formed in online classes, one designated as an experimental group using Kahoot and a control group using Google Quiz. However, both groups consisted of second-year students between 18 and 25 years old in the Computer Science department attending the Human-Computer Interaction course. The gender distribution of the two groups was relatively similar (see Section 2.2.1). Thus, there should not be a strong effect of selection bias. Also, there were no differences in how the two digital quiz platforms were used. For both groups, the in-lecture quiz was offered in the middle of the lecture, whereas students were asked to fill the survey (measuring usability, interactivity, game, and quarantine experience) once the lecture finished. However, it is possible that one group had more knowledgeable students than the other group, but since the focus of the first experiment was not the learning curve, we do not believe that these differences have had any significant impact on the results concerning students' engagement and interactivity.

Second, there was no control group in the second experiment. This was due to technical difficulties encountered in using the Google Quiz platform with many students. However, to mitigate this, we did compare the results for lectures in which Kahoot! was used to the lectures in which Kahoot! was not used. The authors decided to use the game-based quiz platform every two weeks and traditional lecture (the standard way by raising the questions from the professor and waiting for the voluntary answers from students) in-between weeks. Therefore, to compare results with and without performing in-lecture quizzes, the authors combined game-based (Kahoot!) questions and traditional lectures in the final pre-post test.

Third, it is potentially that a testing threat could have occurred if the pre-test affected the outcome of the post-test. Since the same questions were used in the pre- and post-test, this could have affected the post-test results. One could argue to use different questions in the pre and post-test, but we decided to use the same questions because we were interested to see if the in-lecture discussions were affected by it (as participants knew there would be a post-test at the end of the lecture) and we found students were more motivated and focused on understanding those questions during the lecture. It was also essential to take a pre-test to determine the students' knowledge level for a specific subject. However, for measuring the learning curve, this scenario is repeated in five (5) iterations with a large sample size, which counters the testing threat because results would be more sensitive to any variability in the outcomes.

The **External validity** of an experiment is related to generalizing. It focuses on whether or not a causal relationship holds for variations in persons, settings, treatments, and outcomes that were in the experiment and for persons, settings, treatments, and outcomes that were not in the experiment [57]; i.e., the degree to which the conclusion from a study would hold for other people in other places at other times. The results reported in this paper should apply to online digital quiz usage for teaching various subjects. However, we acknowledge that in the case of the learning curve, the results might not be transferable to any digital quiz and especially for non-game-based. The results presented in this study may be only relevant in the context of the use of Kahoot! or similar systems that provide game-like features (such as being competitive, having points and scoreboards, and use of audio-visuals).

The **Construct validity** concerns whether the methods measure what they are intended to measure [58]. It questions whether the sampling details can be fortified as measures of general constructs [57]. This study aimed to investigate the effectiveness of a game-based digital quiz tool in the online learning process. To answer the five research questions, we used a survey questionnaire and in-lecture quizzes. The context of this study (i.e., online lecture mode) made it challenging to use methods such as observation for data triangulation. Therefore we used two open-ended questions to triangulate the data collected from the questionnaire. We collected both quantitative and qualitative data. The quantitative data collected using the questionnaire covered the dimension inspired by the Game based Learning theoretical framework in [49] and Pearson correlation is used to check correlations within and between sets of variables (resulting in the significant value of < 0.05). The qualitative data focused on the open questions concerning students' feedback about what they liked about the specific online quiz platform. Therefore, the selected data sources are strong indicators (there are theoretical grounds and statistical evidence for expecting it to be related) to depict the effectiveness of game-based digital online quizzes. Although, it cannot be claimed that they give ultimate proof for all conclusions.

VI. CONCLUSION

This paper presents the findings of a four-month investigation on the use of a digital quiz in online classes. Two sets of

experiments are performed as part of the Human-Computer Interaction course within the Faculty of Computer Science and Engineering. The first set of experiments investigated the impact of online quiz platforms to measure students' engagement and interactivity during the quarantine experience. The second experiment measured the learning curve using Kahoot!, a game-based quiz platform.

At the beginning of the COVID-19 pandemic, there was limited advice for switching 100% to online classes. No one had envisioned that one day we will experience a situation where we are forced to switch 100% to online classes with no alternative at all. The switching process from in-campus classes to online classes was initially ad-hoc, and later on (after two weeks), institutions started to create tasks force at the institution and national level to lead the future transformation process and facilitate the online teaching and learning.

Transitioning to online-only classes, the professors experienced a decrease in students' participation and fading student engagement. Due to the lack of motivation (during the pandemic quarantine experience), students were very passive, and the lecture started to become one-way communication. Professors were left unsure on whether the planned learning outcomes had been reached and whether this way of teaching and learning was appropriate to continue in the upcoming weeks.

The initiative of the authors to integrate in-lecture quizzes in online classes transformed the situation. Students started to be more active, their participation increased and their engagement bettered, and also the students' learning performance. Involving two different platforms for performing the in-lecture quizzes (Kahoot! and Google Form Quiz) was not accidental. The authors were interested in investigating whether the technology could make any difference to the students' motivation and engagement during the online classes.

The research presented in this paper is driven by the LEAGUE (Learning, Environment, Affective cognitive reactions, Game factors, Usability, UsEr) framework, which influenced the study dimensions within the four months of research.

The results from the data conducted through the survey show that students favored Kahoot for the game experience dimension (the mean of the Likert scale for Kahoot! is 4.12 (out of 5)), and the same trend also continued for the majority of the dimensions (see Figure 4). However, from the qualitative analysis shown in Figure 5, Google Form Quiz is favored when talking about platform usability. Furthermore, results can be linked with students' in-lecture quiz performance shown in Figure 3, inferring that the usability of the platform can impact the students' quiz performance. Even though the findings indicate that the usability of the platforms can affect the overall students' performance, from the empirical evidence, students were more motivated to use platforms that are more game-oriented, and quizzes could be performed in groups instead of using those platforms where the students were driven by their own pace. Anecdotally, in general, it is fascinating that students start to complain when they have systematic in-lecture quizzes, however, they feel motivated to be part of any systematic in-lecture quizzes with game-based platforms.

In the second experiment, the measurement of the learning curve, our findings showed that the students performed significantly better in those subjects with systematic in-lecture quizzes (see Figure 9, 73% versus 57.5%).

Overall, concerning the LEAGUE framework study dimensions, students claimed that they had more fun (affective cognitive reaction) using Kahoot! platform due to the gamification components that it provides, such as competition, music and bonus points, to name a few. Further, they engaged and participated actively in the classes with systematic in-lecture quizzes. The ease of use and simplicity of the platform helped students stay focused on answering quiz questions within the lectures.

Having in mind that many educational institutions will continue with online classes, this study suggests the following takeaway points:

- Having systematic online quizzes impacts the students' engagement and motivation (see Figure 4), especially when using a game-based platform.
- The interactivity among professors and students increases when using systematic in-lecture quizzes in online classes (see Figure 5), where the systematic in-lecture quiz is linked with higher interactivity.
- Having systematic online quizzes impacts class dynamics.
- And finally, including the strategy of having systematic in-lecture quizzes in the teaching plans will impact the students' exam performance (see Figure 9).

REFERENCES

[1] C.-S. Li and B. Irby, "An overview of online education: Attractiveness, benefits, challenges, concerns and recommendations," *College Student J.*, vol. 42, no. 2, pp. 302–307, 2008.
[2] L. R. Kearns, "Student assessment in online learning: Challenges and effective practices," *J. Online Learn. Teach.*, vol. 8, no. 3, p. 198, 2012.
[3] M. Langford and C. Damsa, "Online teaching in the time of COVID-19: Academic teachers' experience in Norway," Centre Experiential Legal Learn., Univ. Oslo, Oslo, Norway, Feb. 2020.
[4] WorldBank. (2020). *Guidance Note on Education Systems' Response to COVID19 How Does COVID19 Impact Education?*. pp. 1–6. [Online]. Available: https://www.cdc.gov/coronavirus/2019-ncov/downloads/considerations-for-school-closure.pdf
[5] WorldBank. (Apr. 2020). *The COVID-19 Crisis Response: Supporting Tertiary Education for Continuity, Adaptation, and Innovation*. [Online]. Available: http://pubdocs.worldbank.org/en/621991586463915490/WB-Tertiary-Ed-and-Covid-19-Crisis-for- public-use-April-9.pdf
[6] K.-J. Kim and C. J. Bonk, "The future of online teaching and learning in higher education," *Educause Quart.*, vol. 29, no. 4, pp. 22–30, 2006.
[7] J. Keengwe and T. T. Kidd, "Towards best practices in online learning and teaching in higher education," *MERLOT J. Online Learn. Teach.*, vol. 6, no. 2, pp. 533–541, 2010.
[8] L. Peña-Lévano, "Personalizing online classes: The use of evaluation and participation tools," *Appl. Econ. Teach. Resour. (AETR)*, vol. 2, no. 2, pp. 51–58, 2020.
[9] R. Säljö, "Digital tools and challenges to institutional traditions of learning: Technologies, social memory and the performative nature of learning," *J. Comput. Assist. Learn.*, vol. 26, no. 1, pp. 53–64, 2010.
[10] D. Laurillard, *Rethinking University Teaching: A Conversational Framework for the Effective Use of Learning Technologies*. Evanston, IL, USA: Routledge, 2013.

[11] C. R. Graham, W. Woodfield, and J. B. Harrison, "A framework for institutional adoption and implementation of blended learning in higher education," *Internet Higher Educ.*, vol. 18, pp. 4–14, Jul. 2013.

[12] E. Alqurashi, "Technology tools for teaching and learning in real time," in *Educational Technology and Resources for Synchronous Learning in Higher Education*. Hershey, PA, USA: IGI Global, 2019, pp. 255–278.

[13] K. Beidler and L. Panton, "Incorporating the virtual into the physical classroom: Online mastery quizzes as a blended assessment strategy," *J. Interact. Technol. Pedagogy*, vol. 3, no. 3, May 2013.

[14] D. Cohen and I. Sasson, "Online quizzes in a virtual learning environment as a tool for formative assessment," *JOTSE*, vol. 6, no. 3, pp. 188–208, 2016.

[15] W. S. Ng and K. S. Cheng, "A collaborative blended learning approach for learning Web programming," in *Proc. Int. Conf. Inf. Commun. Technol. Educ. (ICICTE)*, 2018, pp. 49–58.

[16] T. Brothen and C. Wambach, "Effective student use of computerized quizzes," *Teach. Psychol.*, vol. 28, no. 4, pp. 292–294, Oct. 2001.

[17] D. B. Daniel and J. Broida, "Using Web-based quizzing to improve exam performance: Lessons learned," *Teach. Psychol.*, vol. 31, no. 3, pp. 207–208, Jul. 2004.

[18] M. G. Urtel, R. E. Bahamonde, A. E. Mikesky, E. M. Udry, and J. S. Vessely, "On-line quizzing and its effect on student engagement and academic performance," *J. Scholarship Teach. Learn.*, vol. 6, no. 2, pp. 84–92, 2006.

[19] A. I. Wang and R. Tahir, "The effect of using Kahoot! For learning—A literature review," *Comput. Educ.*, vol. 149, May 2020, Art. no. 103818.

[20] A. I. Wang, "The wear out effect of a game-based student response system," *Comput. Educ.*, vol. 82, pp. 217–227, Mar. 2015.

[21] A. I. Wang and A. Lieberoth, "The effect of points and audio on concentration, engagement, enjoyment, learning, motivation, and classroom dynamics using Kahoot," in *Proc. Eur. Conf. Games Based Learn.*, vol. 20, Academic Conferences International Limited, 2016, pp. 737–748.

[22] B. S. Horvitz, A. L. Beach, M. L. Anderson, and J. Xia, "Examination of faculty self-efficacy related to online teaching," *Innov. Higher Educ.*, vol. 40, no. 4, pp. 305–316, 2015.

[23] T. Drange, I. Sutherland, and A. Irons, "Challenges of interaction in online teaching: A case study," in *Proc. Int. Conf. E-Technol. Bus. Web*, vol. 3, 2015, pp. 35–42.

[24] C. J. Navarrette and R. A. Guthrie, "Challenges in teaching large online sections," in *Proc. AMCIS*, 2008, p. 377.

[25] S. Liu, K.-J. Kim, C. J. Bonk, and R. Magjuka, "What do online MBA professors have to say about online teaching," *Online J. Distance Learn. Admin.*, vol. 10, no. 2, p. 2, 2007.

[26] P. Shea, "Bridges and barriers to teaching online college courses: A study of experienced online faculty in thirtysix colleges," *J. Asynchronous Learn. Netw.*, vol. 11, no. 2, pp. 73–128, 2007.

[27] A.-M. Nortvig, A. K. Petersen, and S. H. Balle, "A literature review of the factors influencing e-learning and blended learning in relation to learning outcome, student satisfaction and engagement," *Electron. J. E-Learn.*, vol. 16, no. 1, pp. 46–55, 2018.

[28] A. Sun and X. Chen, "Online education and its effective practice: A research review," *J. Inf. Technol. Educ., Res.*, vol. 15, pp. 157–190, 2016.

[29] L. Salas-Morera, A. Arauzo-Azofra, and L. García-Hernández, "Analysis of online quizzes as a teaching and assessment tool," *J. Technol. Sci. Educ.*, vol. 2, no. 1, pp. 39–45, Mar. 2012.

[30] K. Pireva, R. Tahir, A. Shariq Imran, and N. Chaudhary, "Evaluating learners' emotional states by monitoring brain waves for comparing game-based learning approach to pen-and-paper," in *Proc. IEEE Frontiers Educ. Conf. (FIE)*, Oct. 2019, pp. 1–8.

[31] R. K. Shah and L. A. Barkas, "Analysing the impact of e-learning technology on students' engagement, attendance and performance," *Res. Learn. Technol.*, vol. 26, Dec. 2018.

[32] H. Uçar and A. T. Kumtepe, "Using the game-based student response tool Kahoot! in an online class: Perspectives of online learners," in *Proc. Soc. Inf. Technol. Teacher Educ. Int. Conf., Assoc. Advancement Comput. Educ. (AACE)*, 2017, pp. 303–307.

[33] A. Woods, S. Pettit, and C. Pace, "Quaranteaching in the time of Covid-19: Exemplar from a middle grades virtual classroom," *Becoming, J. Georgia Middle School Assoc.*, vol. 31, no. 1, p. 3, Jan. 2020.

[34] H.-T. Hung, "Clickers in the flipped classroom: Bring your own device (BYOD) to promote student learning," *Interact. Learn. Environ.*, vol. 25, no. 8, pp. 983–995, Nov. 2017.

[35] P. Tan and J. Saucerman, "Enhancing learning and engagement through gamification of student response systems," in *Proc. Amer. Soc. Eng. Educ.*, 2017, paper 18943.

[36] C. M. Plump and J. LaRosa, "Using Kahoot! In the classroom to create engagement and active learning: A game-based technology solution for elearning novices," *Manage. Teach. Rev.*, vol. 2, no. 2, pp. 151–158, Jun. 2017.

[37] E. Zarzycka-Piskorz, "Kahoot it or not? Can games be motivating in learning grammar?" *Teach. English Technol.*, vol. 16, no. 3, pp. 17–36, 2016.

[38] H. Bicen and S. Kocakoyun, "Perceptions of students for gamification approach: Kahoot as a case study," *Int. J. Emerg. Technol. Learn.*, vol. 13, no. 2, pp. 72–93, 2018.

[39] M. A.-A. Ismail and J. A.-M. Mohammad, "Kahoot: A promising tool for formative assessment in medical education," *Educ. Med. J.*, vol. 9, no. 2, pp. 19–26, 2017.

[40] S. A. Licorish, H. E. Owen, B. Daniel, and J. L. George, "Students' perception of Kahoot!'s influence on teaching and learning," *Res. Pract. Technol. Enhanced Learn.*, vol. 13, no. 1, p. 9, Dec. 2018.

[41] Y. Chaiyo and R. Nokham, "The effect of Kahoot, Quizizz and Google forms on the student's perception in the classrooms response system," in *Proc. Int. Conf. Digit. Arts, Media Technol. (ICDAMT)*, 2017, pp. 178–182.

[42] S. Wichadee and F. Pattanapichet, "Enhancement of performance and motivation through application of digital games in an english language class," *Teach. English Technol.*, vol. 18, no. 1, pp. 77–92, 2018.

[43] A.-L. Boboc, G. Orzan, I. Stoica, and C. Niculescu-Ciocan, "Gamification and game-based learning-a solution for romanian education system?" in *Proc. eLearning Softw. Educ.*, vol. 1, 2018, pp. 242–248.

[44] D. H. Iwamoto, J. Hargis, E. J. Taitano, and K. Vuong, "Analyzing the efficacy of the testing effect using KahootTM on student performance," *Turkish Online J. Distance Educ.*, vol. 18, no. 2, pp. 80–93, 2017.

[45] M. Esteves, A. Pereira, N. Veiga, R. Vasco, and A. Veiga, "The use of new learning technologies in higher education classroom: A case study," in *Proc. Int. Conf. Interact. Collaborative Learn.* Cham, Switzerland: Springer, 2017, pp. 499–506.

[46] Y.-H. Wang, "The effectiveness of integrating teaching strategies into IRS activities to facilitate learning," *J. Comput. Assist. Learn.*, vol. 33, no. 1, pp. 35–50, Feb. 2017.

[47] H.-T. Hung, "The integration of a student response system in flipped classrooms," *Lang. Learn. Technol.*, vol. 21, no. 1, pp. 16–27, 2017.

[48] E. G. L. Medina and C. P. R. Hurtado, "Kahoot! A digital tool for learning vocabulary in a language classroom," *Rev. Publicando*, vol. 4, no. 12, pp. 441–449, Sep. 2017,

[49] R. Tahir and A. I. Wang, "Codifying game-based learning: The league framework for evaluation," in *Proc. Eur. Conf. Games Based Learn.*, Acad. Conf. Int. Ltd., 2018, pp. 677–686.

[50] O. Hannula and O. Irrmann, "Played into collaborating: Design games as scaffolding for service co-design project planning," *Simul. Gaming*, vol. 47, no. 5, pp. 599–627, Oct. 2016.

[51] K. S. Taber, "The use of Cronbach's alpha when developing and reporting research instruments in science education," *Res. Sci. Educ.*, vol. 48, no. 6, pp. 1273–1296, Dec. 2018.

[52] M. Lichtman, *Qualitative Research in Education: A User's Guide*. Newbury Park, CA, USA: Sage, 2012.

[53] J. Creswell and D. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. New York, NY, USA: Sage, 2018.

[54] J. Nielsen. (Jan. 1995). 10 Usability Heuristics for User Interface Design. Nielsen Norman Group, Fremont, CA, USA. Accessed: 2017. [Online]. Available: https://www.nngroup.com/articles/ten-usability-heuristics/

[55] S. Arnab, T. Lim, M. B. Carvalho, F. Bellotti, S. de Freitas, S. Louchart, N. Suttie, R. Berta, and A. De Gloria, "Mapping learning and game mechanics for serious games analysis," *Brit. J. Educ. Technol.*, vol. 46, no. 2, pp. 391–411, Mar. 2015.

[56] J. P. Gall, M. D. Gall, and W. R. Borg, *Applying Educational Research: A Practical Guide*. London, U.K.: Longman, 1999.

[57] W. R. Shedish, T. D. Cook, and D. T. Campbell, *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*. Boston, MA, USA: Houghton Mifflin, 2002.

[58] C. Robson and K. McCartan, *Real World Research*. Hoboken, NJ, USA: Wiley, 2016.

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