QUIZZES VIA AUGMENTED REALITY ON LEARNING MANAGEMENT SYSTEM: A CASE STUDY OF MOODLE

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ABSTRACT

The different commercial and open-source LMSs do not support pre-built activities for students in Augmented Reality (AR). To solve this challenge, this work combines AR technology and the Moodle platform to enhance the capabilities to motivate students during the learning process. For this, we developed and configured an AR app to receive and solve a Moodle pre-built quiz by communication (using message swap) between Moodle, Vuforia, and Unity. The post-quiz questionnaire results show the satisfaction level of 40 students in higher education after taking a quiz via AR. A descriptive statistical analysis indicated that students' satisfaction was 4.6 on a 5-point Likert Scale. The research offers empirical evidence that taking quizzes through AR helps motivate students and improve Technology-Mediated Learning (TML) processes.

Keywords: *Augmented reality, LMS, Moodle, QR, Quiz, Test.*

INTRODUCTION

A conductive classroom environment is a process where teachers and students exchange knowledge gained through synchronous and asynchronous learning activities. In this process, the teacher expects active participation of students to evaluate their level of knowledge and skills acquired during the course topics. Thus, the effective learning process is based on interaction and active participation. However, students do not actively participate in the classroom, regardless of the methodology (Abdullah et al., 2012).

The classroom discussion is one of the most used pedagogical strategies to encourage student participation in learning activities. It has been studied from the philosophical, democratic, and technological points of view in various research (Dallimore et al., 2004). There are four types of student behaviors according to how they participate in classroom discussions: full integration, participation in the circumstances, marginal interaction, and silent observation (Liu, 2002). As a result, blended courses, whether face-to-face, online, or at a distance, use Technology-Mediated Learning (TML) to enhance the active participation of students during the learning process (Henrie et al., 2015).

Technology-Mediated Learning is an environment where students access learning materials and interact with their teachers using electronic devices such as computers, smartphones, and tablets. TML is compounded by different concepts and tools: Computer-aided/Assisted Learning (CAL), Computer-Mediated Communication (CMC), common computer-based production and presentation tools, and computer-supported search tools (Tetteh et al., 2020). Therefore, teachers and students use these tools at various stages of the learning and teaching process.

First, CALs are tools used for active communication asynchronously (e.g., email or newsletters) or synchronously (e.g., chat or video conference). Secondly, CMCs are multimedia tools commonly used in training processes. Finally, there are tools for production, presentation, and search (e.g., web browsers, newsletters, and others) (Shield, 2016). These tools are embedded (in different combinations) in various commercial and open-source e-learning environments.

There are different terms to describe learning environments: Managed Learning Environment (MLE), Virtual Learning Environment (VLE), Learning Management System (LMS), and Learning Content Management System (LCMS) (Pagani, 2009). Although different words describe learning environments, LMS is the most common.

There are several commercial and open-source LMSs supporting educational effectiveness in diverse fields of higher education, such as administrative sciences (Matei & Vrabie, 2013), medical (Zakaria et al., 2013), engineering (Garrote & Pettersson, 2007), and others. Commercial LMSs include Blackboard, Desire2learn, Scholar360, Teletop Virtual Learning Environment, and Angel Learning Management Suite, among others. On the other hand, Moodle, dotLRN/ OpenACS, Atutor, LON-CAPA, and Sakai are examples of the most popular open-sources LMSs (Kasim & Khalid, 2016).

However, comparative studies based on architecture, implementation, functionality, adaptation, cost, and usage in universities established that Moodle is the best platform to achieve educational effectiveness (Al-Ajlan, 2012). According to Río et al. (2018), active student participation in Moodle enhances academic performance in higher education.

Furthermore, Augmented Reality (AR) adds computer-generated input (graphics, audio, video) to the real-world video via cameras (Paul, 2018) mounted on smartphones, smart glasses, and other electronic devices. Azuma (1997) was one of the first to describe this technology. He explained AR as superimposing objects from the virtual world with the physical world, giving the user a sensation of coexisting in the same area. According to his work, AR technology has the following three characteristics: (a) Blends real world and virtual, (b) Interactive in real-time, and (c) Enabled 3D view.

Not only did AR enrich the user experience by representing the simulation of any complex process using 3D virtual objects (Keller et al., 2021), but it also helped to decide if the process failed or succeeded. Consequently, it is highly used in chemical experiments (Xiao et al., 2020), maintenance assistance (Konstantinidis et al., 2020), military applications, and others, but especially for training purposes (Sorko & Brunnhofer, 2019).

AR can be "triggered" by paper or objects (marker-based), GPS (location-based), motion tracking (dynamic augmentation-based), object recognition (complex augmentation-based), and others (Edwards-Stewart et al., 2016). A Quick Response (QR) code is a marker-based widely used to initiate the augmentation. For example, QR codes were used by different countries as a measure to track and reduce the spread of the coronavirus (Sharara & Radia, 2021).

Recently, AR has been described as a disruptive technology in the Fourth Technology Revolution (4IR or Industry 4.0). It can help develop efficient processes for digital transformation in industry and education (Winter, 2020). The 4IR is the intelligent interconnection between machines and industrial processes using information and communication technologies. The 4IR term was developed in 2011 by the German Federal Government, and it refers to the convergence and application of eight advanced technologies, including AR technology (Becker, 2020).

Currently, AR is being implemented in the aeronautics and general surgery areas. In aeronautics, aircraft operators perform maintenance tasks assisted by 3D models (Ceruti et al., 2019). In general surgery, AR offers specialists a hands-free approach, making the laparoscopic procedure more comfortable by avoiding poor posture (Zorzal et al., 2020). Another notable field AR is used in is emergency medicine (Munzer et al., 2019).

Nevertheless, research on AR's educational applications have the most scientific publications in the world, especially in science education, math, and educational technology areas (Karakus et al., 2019). Most of the studies focus on the impact of AR on students' motivation to learn because they do not participate actively in the classroom.

AR, likewise Moodle, enhanced the learning, motivation, and performance of higher education students in engineering (Restivo et al., 2014), natural sciences (Chiang et al., 2014), architecture (Sánchez Riera et al., 2015), and math (Aldalalah et al., 2019). After a group of students took a human biology course using AR, they were evaluated using different factors such as analysis, attention, confidence, and satisfaction. As a result, 14% of students expressed an increase in motivation (Khan et al., 2019).

PURPOSE OF THE PRESENT STUDY

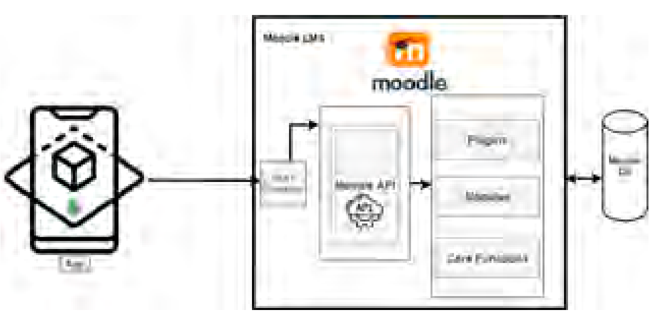
This work's purpose is to demonstrate how quizzes via AR on Moodle are performed and how to evaluate the students' level of satisfaction combining these technologies.

METHOD

System Architecture

To solve quizzes via AR on Moodle, we defined a 3-layer architecture system (see Figure 1). It was composed of a presentation tier, a business logic tier, and a data tier. We built the presentation layer using Vuforia and Unity. The business logic layer corresponds to a mobile web service API. Finally, the data tier returns information from Moodle's database which works with a MySQL.

Figure 1. 3 Layer architecture system



Moodle Configuration

In this work, we used MoodleCloud Version 3.9.1. First, the administrator must set up and enable a REST protocol (Owen, 2020) and a token for each specific user according to the standard way of using web services ("Using Web Services," 2021). This makes it simpler to send a quiz activity via a JSON message from Moodle to AR systems such as mobile phones or digital eyewear. Second, it is necessary to enable mobile web services to facilitate the systems to log in to Moodle and get information about quizzes by courses, quiz start attempt, quiz attempt data, quiz process attempt, quiz and attempt review, and quiz save attempt (Quiz settings, nd).

To enable the REST web service function from Moodle:

Log onto your Moodle as an Administrator.

- navigate to: Site administration > Plugins > Webservices > Manage protocols.
- enable the REST protocol.

To create a Token:

- go to: Administration > Site Administration > Plugins > Web services > Manage tokens.
- click on Add.
- select the created user and service.

To enable mobile web service:

- log into your Moodle as an Administrator.
- in Administration > Site administration > Mobile app > Mobile settings
- check "Enable web services for mobile devices."
- click Save.

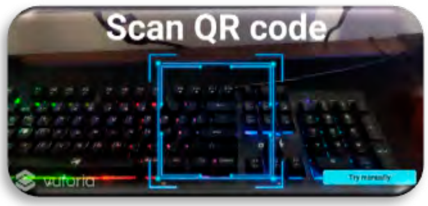
AUGMENTED REALITY

We used a QR marker to trigger the Moodle quiz in AR. The QR is an optical readable square matrix consisting of different areas that contain information such as positioning, data, timing, and more; every cell (module) of the matrix forms binary-coded data, and their combination creates a pattern (symbol). It is quickly decipherable in 360 degrees (any direction) because the position detection pattern offers a constant frequency ratio of black: white: black: white: black = 1: 1: 3: 1: 1

The position detection pattern is located at the three corners of the symbol, requiring at least two (regardless of orientation) to be optically readable by a line scanner or other device (Masahiro et al., 1995).

As previously mentioned, we encoded a QR code containing the Quiz URL information to allow the students to access it via hand-held devices (i.e., smartphones) or digital eyewear with integrated QR readers. Figure 2 shows the app's QR code reader.

Figure 2. *QR code scanning*



To create a QR code, you must obtain the quiz's URL information:

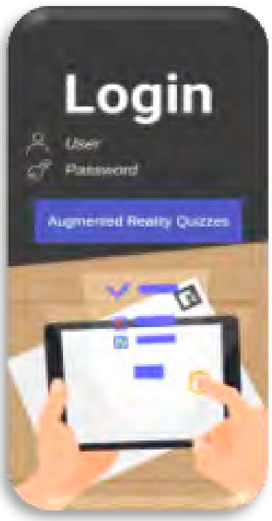
1. Log in to your Moodle account as a teacher.
2. Navigate to: Course.
3. Extract the course ID number from the URL, e.g., *http://yourmoodlesite.com/course/view.php?id=x*, where x is the course ID number.
4. Navigate to Moodle Quiz activity.
5. Extract the Quiz ID number from the URL, e.g., *http://yourmoodlesite.com/mod/quiz/view.php?id=y*, where y is the Quiz ID number.
6. Configure the URL to encode the QR code, e.g., *http://yourmoodlesite.com/x,y*, where x is the course ID number and y is the Quiz ID number.
7. Create a QR code with the URL obtained in step 6.
8. Print the code and place it in the classroom.

DEVELOPING AN AUGMENTED REALITY APP TO SOLVE MOODLE QUIZZES

We used the Unity platform to build the AR app and the Vuforia Engine SDK for recognizing images and objects to interact with spaces in the real world. We added a Vuforia engine to our Unity project to start the development; then, we set up the Vuforia Engine's features in Unity, as discussed in "Getting started with Vuforia Engine in Unity" (n.d).

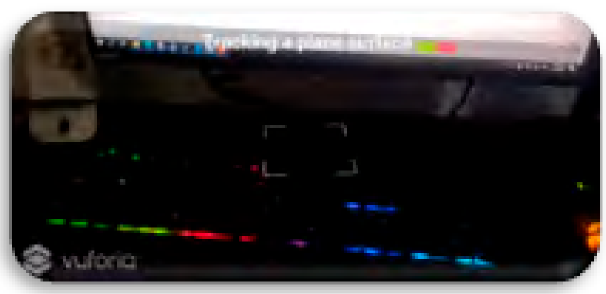
We configured a login form to grant student access to the Moodle site (see Figure 3). The login form sends the credentials from Unity executing a HttpClient.PostAsync method and dispatching a POST request to Moodle's URL as an asynchronous process (Microsoft, 2021). According to "Creating a Web Service Client" (2021), the Moodle REST server accepts the credentials as parameters. It then sends a token via JSON into Unity to access the Moodle quiz.

Figure 3. Login Screen



We included the capability to display the quiz on flat surfaces by including auto-detection ground-plane technology in the app. A student desk provides a perfect example. Figure 4 shows how the ground plane API detects, tracks, and finds surfaces using the smart terrain class. It performs a hit test consisting of shooting a ray onto a plane to calculate the device elevation relative to the plane (PTC. Inc, 2020).

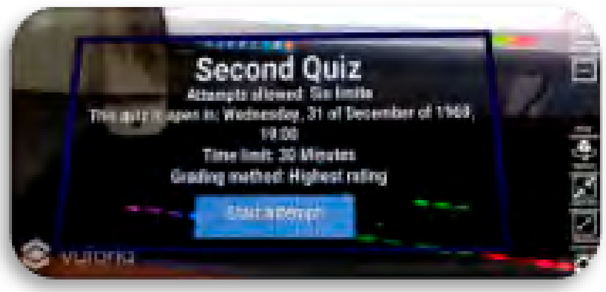
Figure 4. Plane surface



Once a flat surface is detected, a quiz introduction is displayed via AR on the smartphone. However, the quiz will not be available to students before the scheduled start time. Before starting the quiz, students can access important information (e.g., attempts allowed, time limit, grading method, etc.) configured on Moodle by the teacher.

We used a mobile web service called "mod_quiz_start_attempt" to configure a button that starts a quiz attempt (see Figure 5). The web service accepts a password (if required) as a parameter, and it returns the attempt ID, granting access to additional quiz information such as attempts allowed, time limit, grading method, and start time. In Moodle, this is done by startattempt.php. The script handles the new quiz attempt, submitting parameters, validating permissions for creating a new attempt, and starting a new preview attempt if required.

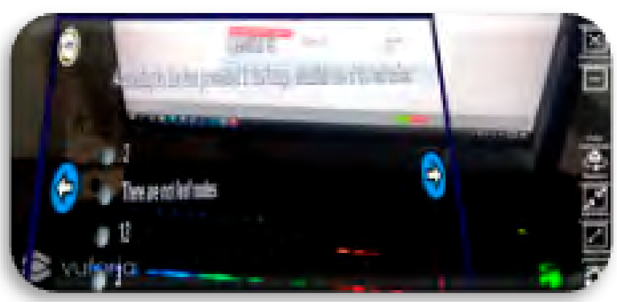
Figure 5. Quiz settings



We passed the attempt ID retrieved by mod_quiz_start_attempt web service into the get_questions_by_quiz API. It returns an array containing the quiz questions and active-user credentials (see Figure 6).

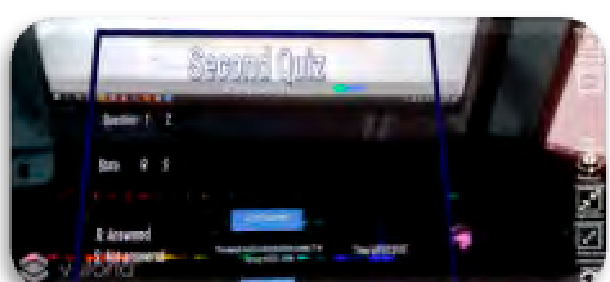
We configured a button with the mod_quiz_save_attempt web service to save the current quiz and question-answer pairs.

Figure 6. Quiz questions



Finally, we used the mod_quiz_get_attempt_review web service to review the information for the submitted attempt (see Figure 7).

Figure 7. Quiz attempt summary



RESULTS

The usability of the beforementioned AR app has been assessed by surveying over 40 higher education students who solved a quiz via AR. Afterward, we asked students to rate their level of agreeableness on each question using a 5-point Likert Scale (Strongly disagree, Disagree, Neutral, Agree, and Strongly agree).

The scale is a psychometric response tool to measure a person's perception about a specific declaration or question (Preedy &Watson, 2010). We selected the 5-point Likert scale because it is the most widely used and understood method for survey compilation. In this scale, respondents are not limited by rigid "yes" or "no" answers, allowing them to share their intermediate opinions. Their responses are rapidly quantified and used to make statistical or mathematical analyses. In fact, 90% of studies in clinical and health psychology in 2013 used some Likert-type scale because it is helpful to compare sub-groups, thus improving the validity of results. Consequently, the responders can take an undecided (neutral) option (Hartley, 2014).

In our work, the classifications of response were numerically coded as follows: 1 = Strongly disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly agree. We made a descriptive statistical analysis to determine the students' level of motivation while they solved the quiz via AR. The information gathered from the survey showed a mean score of 4.6 in-between range 4 (Agree) and 5 (Strongly agree) in the 5-point Likert scale.

We discarded Strongly disagree, Disagree, and Neutral answers because it only represented about 17.5%, while Agree and Strongly Agree responses corresponded to 82.5%, which indicated that the use of the AR app was satisfying for students.

Several investigators have discovered different results when applying AR to various academic subjects; for example, (a) Kaur et al. (2020) found that the mean score for the students' motivation level in an engineering course was 4.1, (b) Khan et al. (2019) found that the mean score for the students' motivation level in a biology course was 3.4, and (c) Di Serio et al. (2013) found that the mean score for the students' motivation level in a visual art course was 3.2. The 4.6 obtained by this study was coherent with 4.1 observed by the Kau et al. (2020) study.

Table 1
Frequency (F), Mean (M), and Standard Deviation (SD) for students' level of satisfaction.

Item	Question	F	M	SD
1	How similar was the experience of taking the quiz via Moodle web and the AR app?	35	4.4	0.49
2	How convinced are you with the use of a QR code for the activation of AR?	40	5.0	0.00
3	What was your level of motivation when solving a Moodle quiz via AR?	35	4.8	0.40
4	How pleased are you with the surface detection ability to display the quizzes via AR?	20	4.4	0.50
5	How simple was it for you to use the application?	33	4.4	0.49
6	How satisfied are you with the overall experience using AR?	35	4.8	0.49

Table 1 presents the Mean (M), Frequency (F), and Standard Deviation (SD) for questions that represent the students' enjoyment level. The maximum mean value was achieved by item 1 ($M = 5.0$) and item 3 ($M = 4.4$). The smallest mean value was obtained by item 4 ($M = 4.4$).

Regarding the item with the lowest F and M score (item 4), we can establish that AR is not the main reason for the low score. Only 20 out of 40 students indicated that the surface detection was a good option.

DISCUSSION

An AR mobile application has been created and developed to solve quizzes in Moodle via AR. It was tested by 40 computer science students, and the results showed that AR enriched the capabilities of Moodle. Our findings indicate that to connect AR technology with Moodle, it is necessary to use the standard web REST protocol and API-Moodle-Vuforia-Unity message exchange. As a result, most of the students were motivated to use the app.

Moreover, the launching time of quizzes using our AR app decreased by 75% in comparison to students typing the URL in the search engine.

As mentioned above, TML needs computers in the classroom to support the teaching-learning process between teachers and students. During it, students can either use a mouse or a keyboard to complete the quiz. Either method used to complete the quiz can transmit SARS-CoV-2 from student to student who may share these devices. Van Doremalen et al. (2020) indicate that SARS-CoV-2 is more stable on plastic surfaces and is detectable up to 48 hours after the keyboard and mouse (most of them are made of injected thermoplastic) become contaminated. Using the QR code to initiate and solve pre-build Moodle quizzes using AR devices could help prevent the spread of SARS-CoV-2 since infections can be acquired through surface transmission in the classroom.

The AR adds computer-generated input to the real-world scene via cameras mounted on smartphones, smart glasses, and other electronic devices. However, the students' comfort and therefore learning process performance is reduced because of using a smartphone. The use of a smartphone provides a small screen and requires the use of both hands. Therefore, future studies should focus on improving student comfort through technology such as smart glasses. The app's settings could be modified to recognize words and/or symbols (Dynamic Augmentation) written on the blackboard by the teacher to trigger the launch of the quiz on AR. Once the quiz is finished, the teacher could grade it using an AR device and analyze deficiencies in the teaching-learning process for the quiz topic. Finally, the app could help fight academic dishonesty during quizzes if the location-based option is enabled. The app detects the geo-location of the classroom and prevents anyone outside of it from taking the quiz.

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