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Proceedings of the World Conference on Education and Teaching
Vol. 3, Issue. 1, 2024, pp. 13-23
DOI: https://doi.org/10.33422/etconf.v3i1.460

ISSN: 2783-7807 online

Diamond Scientific Publishing

A Data-Driven Approach in Establishing Ideal Quiz Question Timings

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Abstract

In the realm of modern education, the integration of technology has transformed traditional assessment methods. This article explores the implementation of a data-driven approach to optimize quiz question timings, utilizing both a mobile and web application for student evaluation through multiple-choice questions. The study aims to enhance the efficiency of assessments by analyzing student responses and tailoring question durations based on data-driven insights. The research leverages two distinct platforms: a mobile application and a web-based system, both designed to facilitate seamless student engagement. Through these applications, students can access quizzes featuring multiple-choice questions, providing a comprehensive understanding of their knowledge and proficiency in various subjects. The focus of the investigation lies in harnessing the power of data analytics to refine the timing of each question, thereby optimizing the overall assessment experience. The findings from this study contribute valuable insights into the dynamics of student engagement and performance during assessments. By identifying optimal question timings, educators can create a more adaptive and personalized learning environment. This approach not only benefits students by aligning assessments with their cognitive processes but also aids educators in refining their teaching strategies based on real-time, data-driven feedback. Furthermore, the article delves into the technological aspects of the mobile and web applications, highlighting their user-friendly interfaces, secure assessment environments, and compatibility with various devices. The implementation of these applications reflects a commitment to modernizing educational practices while ensuring accessibility and inclusivity.

Keywords: quiz questions, e-learning, evaluation, question time, educational platform

1. Introduction

Assessment is a central element in the learning and teaching process. To effectively measure students' understanding and proficiency, teachers use a variety of assessment methods, and quizzes are one of the most common and widely used assessment methods. A lot of platforms allow teachers to use this type of assessment (Aldalur, et al., 2022).

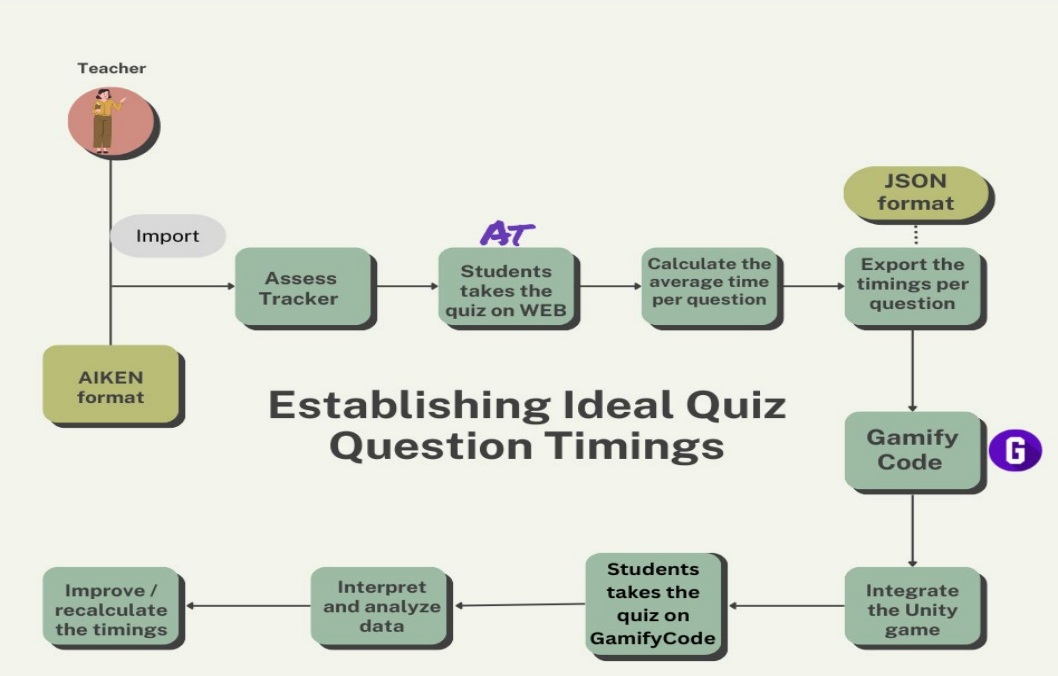
Quizzes are composed of a set of questions, either multiple choice or true/false, where students must select the correct option or determine the truth of a statement. This method has several notable advantages. First, quizzes are time efficient, both in terms of creating and correcting them (Laban, et al., 2022), (Laig Mendoza and Caramoan Lapinid, 2022). Thanks to their structured format, teachers can easily create quizzes and quickly correct them using automated assessment technologies (Mdlalose et al., 2022).

Second, quizzes are objective in assessment. The correct answers are clearly defined, thus removing subjectivity from the evaluation process. This makes quizzes an attractive option for standardized assessments where objectivity is essential.

Another advantage of quiz assessment is scalability. The questions can be used to assess a large number of students simultaneously without significantly increasing the correctional burden on teachers. In addition, the use of automated assessment systems allows for immediate results, which provide quick feedback for students.

However, quiz assessment is not without its disadvantages. One of the main disadvantages is the time needed for the student to answer the questions in the quiz, a lot of research has been done on how to calculate the time needed per question or per quiz.

Figure 1: General workflow for Establishing ideal Quiz Question Timings



This material describes a platform used to calculate the time required to answer a question. In order to verify this calculated time, a mobile platform was created to verify the questions that need to be answered in a specific time period. In this way, we create two platforms that are using the same set of questions. In the web platform, we calculate the necessary time per question and on the mobile application, using the calculated time per question, as shown in Figure 1.

2. Background and related work

Integrating technology into education involves facilitating key aspects of the learning process, including active participation in both group and individual settings, regular interactions, feedback, and connection to a professional network. Internet and e-learning technologies in education address a wide range of scenarios and directly contribute to the achievement of curricular objectives. Due to the continual technological growth of information and communication and the trend of globalization of education, computer-assisted instruction has undergone a true revolution throughout time.

E-learning represents the integration of information technology with the learning and evaluation processes. This field encompasses a broad spectrum of activities ranging from computer-assisted learning and evaluation to scenarios where the entire learning process occurs online (Topor and Vevera, 2023).

Users can access e-learning through a virtual learning environment. Its mission is to distribute content in digital format while also supporting the assembling of users into groups depending on their role in the educational environment via a web-based platform.

The use of e-learning in conjunction with information and communication technology has the potential to dramatically improve the educational process, according to research and experimental initiatives. It serves as a viable alternative to traditional learning methods and is gaining advantage in many educational institutions, due to the benefits of continuous learning and its versatility in the most varied businesses. Furthermore, according to professional studies, the use of it is steadily increasing (Dobre, 2010).

The expansion of the Internet has ended up resulting in a significant shift in the integration of Information and Communication Technologies (ICT) into education. Education has experienced the development of several software and services that improve teaching, learning, and cooperation as a result of ICT. It is well-known that the wise use of digital tools has the potential to improve educational quality. E-learning has transformed traditional educational concepts and methods, becoming an essential part of modern education.

Assessments are deeply encouraged in higher education in order to improve efficiency, knowledge acquisition, and academic achievement. While online education is an intriguing movement entirely, blended learning, which pairs online and in-person training, is the mainstream approach. Moodle and Canvas LMS, for instance, have acquired recognition in both face-to-face and online classes. To inspire and engage students, Learning Management Systems (LMS) increasingly include digital rankings and badges, with online testing becoming an expected component.

The immediate feedback that comes from online assessment aids student growth and self-improvement. Data analysis from e-learning platforms, which include large log files, assists in understanding student behavior, predicting performance, and converting instruction (Zamfiroiu et al., 2019).

Quizzes are becoming an essential component in university education, serving as a productive way of assessing students' knowledge and skills. These assessments have several benefits, including objectivity, scalability, and the capacity to examine a large number of students in a brief amount of time. Their significance originates from their power to effectively test subject comprehension and identify knowledge gaps while offering rapid feedback that improves performance. Learning management systems (LMS) continue to offer substantial resources for grid assessments in this context.

A couple of the most frequently used platforms are: Moodle (a popular LMS platform which is known for its versatility and wide grid testing characteristics as it offers a versatile framework during generating, maintaining, and administering quizzes, including the ability to develop multiple-choice questions and response types; Moodle also provides automatic feedback and in-depth analysis of exam results), Canvas LMS (another popular platform that easily deals with grid tests, providing an easy-to-use administration system for designing and distributing assessments, as well as the ability to customize and configure questions along with the way each one is evaluated). Canvas allows teachers to track and analyze results in real time in order to better adapt the educational program. Blackboard Learn is a platform that delivers a comprehensive collection of resources for designing grid-question tests, as well as the ability to schedule tests and provide automatic or manual feedback. It also has a powerful results analysis engine to evaluate student achievement.

These LMS platforms not only make creating and managing grid assessments quicker but also enhance the assessment and learning process by providing immediate feedback and extensive analysis, thereby contributing to the ongoing advancement of higher education.

Mobile learning has expanded considerably over the last decade: on the market, the number of applications in this area has grown significantly. Due to people's different preferences and interests, developers are trying to release more and more varied applications that support users in the learning process. Currently, there are m-learning applications that have different purposes: whether it's learning a new language, a new programming language, whether you want to learn to cook or skill development, the internet has a solution for each one. Research indicates that interactive learning is the most effective way to assimilate information in a short time. In recent years, developers of mobile learning applications have put more and more emphasis on the term "gamification". This concept brings learning through different games to the fore.

As far as gamification is concerned, this is a relatively new practice that has emerged in recent decades with the development of technology and increased interest in interactive games and experiences.

Gamification was originally used in business to encourage employees to improve their performance and be more motivated at work. Over time, it was adopted in a variety of fields including education, health, marketing and more. Gamification has been used in education to create more engaging learning experiences, encouraging active participation of students and motivating them to learn.

Gerard Christians, the author of the article "The Origins and Future of Gamification," underscored a critical aspect of gamification: instant feedback. This component holds significant importance in sustaining user engagement, regardless of their objectives within the application. Swift feedback serves as a potent motivator by promptly acknowledging users' actions and contributions. In his article, Gerard emphasized the fact that immediate feedback in gamification benefits both workplaces and educational platforms. It addresses the problem of infrequent performance reviews by providing instant input, aiding continuous improvement. This approach is particularly useful for tracking progress and engagement.

Duolingo is at the top of the foreign language learning applications that integrates the concept of gamification, gives instant feedback and ensure users over 40 different languages options (Education App, 2024). The general idea of the app is to learn new words and expressions in an interactive way based mainly on visual and auditory memory.

Learning the foreign languages that users choose is facilitated through various methods: correspondences between words, sound matching, word reproduction, translation, and

sentence completion (both written and spoken), as well as listening to the words. All these methods are presented in a fun and interactive manner that engages users to the extent that they forget they are using a learning app. The experience is structured like a game, where passing each level earns users experience points that accumulate. Users compete with each other based on these points. Additionally, a weekly ranking of the top players is displayed.

Elevate is a mobile application that integrates strategies such as gamification to enhance people's cognitive abilities (Dreimane, 2021), (Ćosić et al., 2022). The app consists of five distinct learning sections, the first being writing which includes many games designed to improve knowledge on punctuation, syntax, details and expressions. The second section focuses on speaking, offering games that improve diction, recall, clarity, and pronunciation. Third section is based on reading, centering on aspects like agility, connotations, associations, and reading speed. The last two modules are represented by mathematics, including mathematical operations, and memory games, used to help with concentration improvement, retention and synthesis.

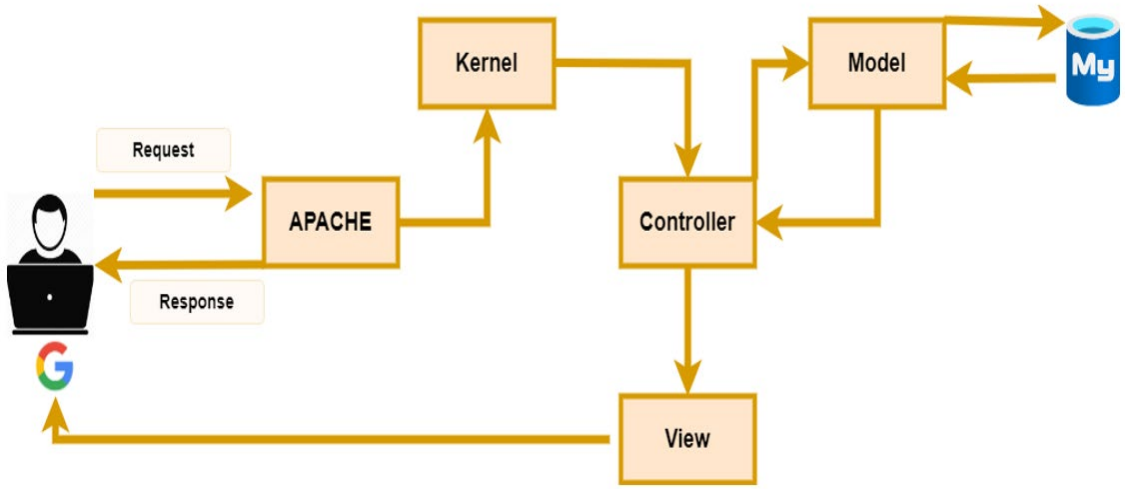
Elevate also has a study section on areas similar to those within the games. This section is dedicated to providing insights into enhancing learning efficacy, speaking with greater speed and coherence and knowing different math tricks or memorization techniques. The results are represented in the form of graphs, illustrating enhancement as users accumulate new knowledge. These visualizations are updated daily, keeping users informed of their progress over time.

3. Web platform used to measure the quiz question time

Assess Tracker is a web application targeting educational institutions that supplies its users with online assessment activities, as shown in Figure 2. Students are able to utilize it for filling out assessments in multiple choice format (for any of the disciplines) or open-answer format (for subjects consisting of programming languages).

The following technologies were utilized when building the application: PHP as the core programming language, Symfony framework, CSS, Tailwind framework, JavaScript Twig Template, and HTML.

Figure 2: Web application architecture (MVC model)



As expected, there are two categories of users utilizing this solution: students and teachers. Students must be allocated to the groups designated by the teachers who created those specific assessments in order to access the area dedicated to online assessment. Additionally, they gain access to a personalized area where they can view their exam history and final outcomes at any time. Teachers can also access the assessment reporting area to check assessment statistics. Assess Tracker also has a communication component that works as a chat system to encourage engagement. The uploading of the questions that constitute the part of the assessments is performed by the instructors, either by adding the questions independently or by importing them via an AIKEN text file.

Students receive quick feedback on their grades after taking the tests, which cannot exceed the time limits imposed by the teachers. They can also see the responses they thought were correct, as well as the actual correct answers. Afterwards, the teachers have access to the same information regarding the evaluation summary.

From this point forward, in addition to the customizable and accessible reports, teachers are also able to export specific reports, used to establish the ideal time required to complete the student assessments, which is the focal point of this paper.

Thus, by assessing the time necessary for students to complete, as well as the ratio between the time and the correctness of the submitted answers in the future, various approaches may be considered to improve the evaluation while also identifying the students' needs to deepen certain topics.

The next section is devoted to the report on the time spent completing the quizzes. In order to generate the time-spent report for a specific quiz, a series of steps are followed within the web application. First, a query is built using Doctrine's QueryBuilder. This query retrieves the required data, such as the quiz ID and question ID, then computes the average time spent on each question from within the supplied quiz. The query restricts the results to only include data linked with the specified quiz ID for optimal precision. The query is executed after it has been constructed, and the results are returned.

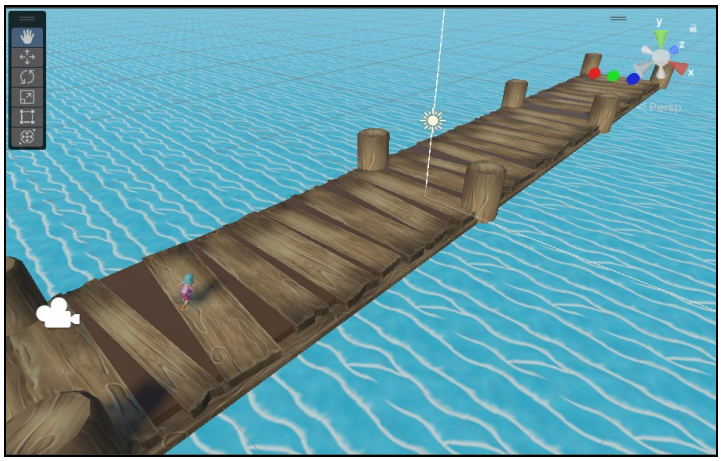
In fundamental terms, the process for generating the time-spent report for a quiz includes collecting quiz and question data as well as specific time-spent information. This data is organized into a downloadable report. In contrast, collecting comprehensive time-spent data for a quiz entail searching the database, aggregating specific data for each question, and delivering the results.

The result is translated into JSON format before being returned so that it can be further imported into the GamifyCode mobile application. As a result, for students who complete the quiz on the mobile app, the time will already be adjusted based on the information provided in the report.

4. Mobile app for quizzes

The mobile learning application is named GamifyCode, and as the name suggests, it offers users the opportunity to learn programming by incorporating elements of gamification. The implementation of GamifyCode involved several development environments, including Visual Studio 2022, Visual Studio Code, Android Studio, and the graphical video game creation engine Unity, Figure 3.

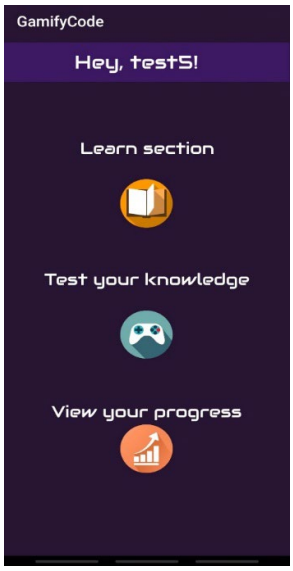
Figure 3:Unity Interface



In order to use the application, users are required to create an account, a step that proves essential for preserving their progress and incorporating their achievements into a ranking system. Authentication within the application is facilitated through the utilization of the service provided by Firebase, known as Firebase Authentication. This service, renowned for its robust data security, employs various methods of password encryption. Among these encryption methods, the most important is one-way hashing.

The application's menu is structured into four distinct sections. The initial section is devoted to both learning and houses a variety of courses spanning diverse programming areas such as Kotlin, Java, and Web programming. Each course offers the option to listen to its content, enhancing the learning experience, as shown in Figure 4.

Figure 4: GamifyCode app



The second section showcases the Unity Game, a 3D infinity gaming experience centered around an avatar that the user must control to move left or right across three paths. The objective of this game is to provide accurate responses to displayed questions. Each path features a coin bearing an answer option, requiring the user to guide the avatar toward the path with the correct answer. The third section displays a graph illustrating the user's scores,

enabling them to track their progress over time. Lastly, the fourth section is dedicated to showcasing a leaderboard of the top 10 highest user scores achieved in the game.

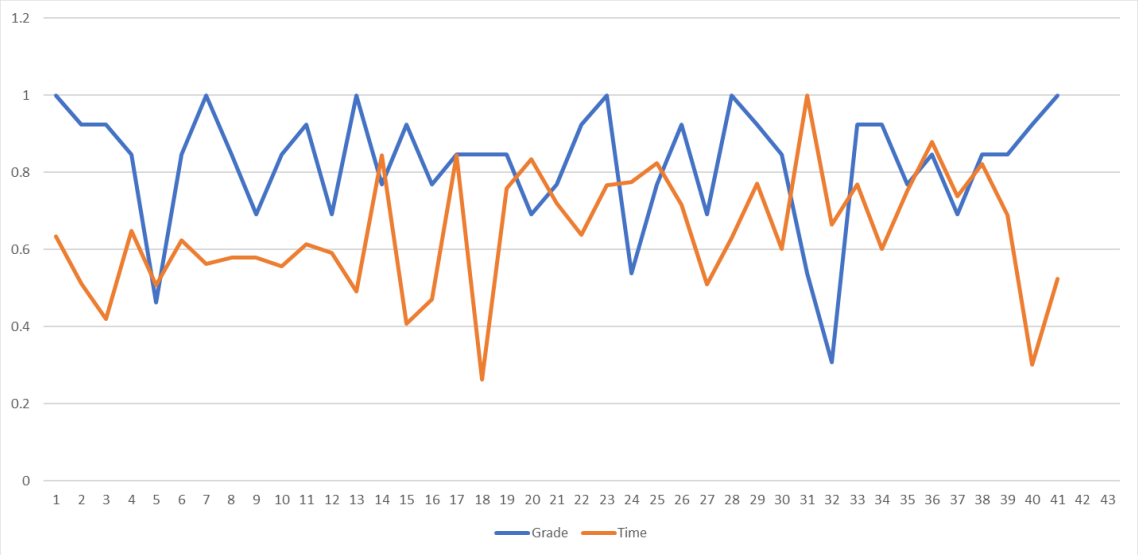
The Unity game is integrated into the Android application as a module called unity library, which is automatically generated by Unity during the game's export process.

To ensure the smooth functioning of this application, we developed a Node.js server that serves as a repository for the game's questions. By utilizing a POST request to the server, we incorporated the JSON document, which was generated by the Assess Tracker application, into the database.

5. Results and data interpretation

In order to demonstrate this functionality, a number of 42 students from Bucharest University of Economic Studies completed a quiz with 13 questions in the Data Structures course. The maximum response time for the test had been initially set at 10 minutes.

Figure 5:Time spent on question and grade for each student



In (Zamfiroiu et al., 2022) an analysis regarding the confidence of students in their response is made. Applying the same model on our responses for this set of students, we obtained the data represented graphically in Figure 5. All values are normalized in the interval [0,1]. We can observe that existing students obtained a big grade even though they did not spend much time on the quiz. It is important to note that these exceptions such as students numbered 18, 32 or 40 will influence the calculated time per question that will be used for the mobile app GamifyCode.

The overall duration of the test, as well as the time spent by each student on each question, were tracked using a JavaScript event and later handled in the application's backend.

According to the generated report, the approximate average time taken to answer a question was around 15 seconds, the average time to finish the quiz was 6 minutes and the average grade obtained was 8/10.

In the end, the time spent report from Assess Tracker was exported and loaded into the GamifyCode mobile application, as shown in Figure 6, where the students completed the test with the redefined time.

Figure 6. JSON Time spent per question caption


```
[
    {
        "id": 1,
        "questionName": "When we want to insert two elements in a scatter table and the two elements have the same hashcode:",
        "answerA": "delete the previous one and put the other one in its place",
        "answerB": "a collision occurs",
        "answerC": "an error occurs",
        "correctAnswer": "a collision occurs",
        "timeSpent": "18.3095"
    },
    {
        "id": 2,
        "questionName": "Which instruction correctly returns the dimension occupied by a pointer?",
        "answerA": "sizeof (void*)",
        "answerB": "int* (sizeof (int))",
        "answerC": "sizeof (void)+*pointer)",
        "correctAnswer": "sizeof (void*)",
        "timeSpent": "16.4286"
    },
    {
        "id": 3,
        "questionName": "How the end of a list is marked?",
        "answerA": "using character '\\n'",
        "answerB": "using character '\\0'",
        "answerC": "using a NULL pointer",
        "correctAnswer": "using a NULL pointer",
        "timeSpent": "7.6667"
    },
```


The average time spent per question by a student, calculated by the Assess Tracker application, plays an important role in enhancing user experience during the game. This valuable metric enables the GamifyCode app to approximate the time users typically take to respond to a question by utilizing this information, Figure 6.

Figure 7. GamifyCode app

The distance at which these coins appear can be tailored according to the average time needed for each question, ensuring a more engaging and enjoyable experience for the users, Figure 6. The students who took the quiz on GamifyCode app achieved the scores presented in Table 1. Some students were unable to takes the quiz on this app and for them the Assess Tracker web app was used. In this way we can improve the timings for quiz questions.

Table I. Obtained scores by students on GamifyCode

ID	USER	EMAIL	SCORE
1	user1	user1@gmail.com	110
2	user2	user2@gmai.com	70
3	user3	user3@yahoo.com	50
4	user4	user4@gmail.com	100
5	user5	user5@yahoo.com	110
6	user6	user6@gmail.com	20
7	user7	user7@gmail.com	40
8	user8	user8@gmail.com	90
9	user9	user9@gmail.com	100
10	user10	user10@gmail.com	130

6. Conclusions

Since it is widely recognized that the obsolete "one-size-fits-all" researcher strategy is inadequate for the advanced information society these findings have significant implications for individualized learning. In areas where they are performing poorly, students need to identify their own learning requirements and enhance their knowledge and skills in those areas. The first step in implementing effective strategies for individualized learning, to maximize each student's potential, is identifying these areas. The learner's profile will help the instructor decide what steps to take, such as recommending various learning resources, exercises, and assignments, or offering advice on how to boost confidence and grades.

The research conducted highlighted the benefits of mobile learning and the process of gamification in the learning process. The advantages of mobile learning are numerous, which is why an app specifically designed for beginners in programming has been created. This app effectively combines gamification, a process through which users can learn using game elements available to them. In this sense, we developed the GamifyCode application that provides programming courses divided by languages and areas of interest, also including a Unity game that ensures an optimal and efficient knowledge test, along with progress tracking reports within the game.

A future direction for quizzes involves introducing more precise analyses of the factors influencing student grades, such as: the time spent on questions compared to their difficulty and the scores obtained, or the grade in relation to the time spent on the question. Analyzing both the total time spent on each question and the overall scores received will provide a better understanding of student performance. As a result, it would be possible to determine whether students have assimilated the essential information.

Acknowledgement

The work presented in this paper is supported by the Core Program within the National Research Development and Innovation Plan 2022-2027, carried out with the support of MCID, project no 23380601, “Advanced research in the Metaverse and emerging technologies for the digital transformation of society”.

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