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MOBILE GAME APPLICATION FOR STUDENT KNOWLEDGE PRACTICE DEVELOPED WITH AN ARCHITECTURE USING DISTRIBUTED WEB SYSTEMS [1]

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Abstract: *Mobile devices are heavily popular among the current generation of students, who often express a desire to do fun activities, such as playing or consuming interactive content. According to studies, educational systems using gaming elements present an effective way to enhance the learning experience of students. This paper examines and analyzes the architecture of an online mobile educational game application for students, backed up by distributed web systems and intelligent educational systems. The properties offered by distributed web systems can be combined with intelligent educational systems to create a robust learning environment. This application combines gaming elements with educational content, providing interactive and personalized learning. The distributed architecture enables scalability and optimal application performance. Innovative approaches like this help create a more adaptable and attractive learning environment by encouraging regular and interactive learning.*

Keywords: *Distributed Web Systems, Intelligent Educational Systems, Mobile Application, Distance Learning, Gamification, Modern Education.*

INTRODUCTION

Numerous innovative teaching and evaluation techniques have surfaced in recent decades as a result of a significant shift in the educational paradigm. They place a strong emphasis on students' active participation in the educational process, which makes education more engaging and appealing. Students desire doing activities, which is observed with increased engagement when using embedded questions in recorded lectures (Meij & Böckmann, 2021). Similarly, microlearning methods enhance students' learning efficiency compared to traditional methods because students express a high desire to play or do activities, followed by watching videos (Mohammed et al., 2018). Game-based learning represents one of those contemporary techniques; it merges enjoyment with established in advance learning goals by using "serious games" to help students learn new information and abilities (Cheung & Ng, 2021).

A key component of digital learning platforms that enable customized and successful learning experiences is the utilization of digital technologies (Răceanu & Marian, 2023). Due to their advantages and low cost, especially in nations with poor technology adoption, devices like tablets and smartphones have become popular among instructors and students. Studies suggest that the successful use of technology and digital game-based learning in students' educational cycles improves their academica achievement (Coleman & Money, 2020).

The goal of incorporating gamification aspects into the educational process is to increase students' enthusiasm and engagement to a far greater extent, turning learning from a tedious task

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into an enjoyable and rewarding activity (Saleem et al., 2022). Meanwhile, the distributed design of the system guarantees scalability, flexibility, and resilience, enabling adaptation of the program to the constantly changing user activities for delivering an excellent user experience (Ileana, 2023). Game-based learning methods are recognized for their ability to create a balance between game and educational elements, a combination of entertainment and learning (Martinez et al., 2022).

The paper will explore an architecture and analysis of the implementation requirements. It will also look at the benefits and challenges associated with using a distributed architecture in the educational context (Johnson & Maddux, 2021).

EXPOSITION

Research by Troussas et al. examines the potential and difficulties of this innovative educational approach by examining the application of mobile and tailored game-based learning in higher education. The study explores how using mobile games to enhance learning might boost students' motivation and engagement levels. The article presents "Quiz Time!", an app that's designed to test and improve students' C# programming abilities. To give help tailored to each student's profile and educational needs, the program makes use of advanced modules, including a fuzzy logic-based learning model and a personalized recommendation generator. The assessment was conducted over the course of a semester at a university, confirming that collaboration and personalization may help students advance their level of knowledge by highlighting its pedagogical validity and positively impacting the learning process. The study emphasizes the need for more research on how to use game-based learning and mobile technologies to develop efficient, student-centered learning environments (Troussas et al., 2020).

Chen's research uses cognitive web services to look at how mobile learning is used in English higher education institutions. The article highlights the concept of cognitive web services, which are machine learning approaches created to assist in modifying teaching strategies to meet the objective of learning at any time. In addition, the display capabilities of mobile learning devices become a crucial determinant of attention and time required for skill acquisition. The experimental results show that the proposed method is more effective, with student performance rates of 92.11%, efficiency of 89.9%, teaching professionalism of 95.23%, error rate of 43.86%, English learning of 93.32%, interactivity of 92.5%, and learning flexibility of 94.86%. In the context of English higher education, the study emphasizes the need for a more dynamic and adaptable learning environment while outlining the benefits and drawbacks of mobile learning (Chen, 2022).

The work done by Sanchez-Sepulveda et al. evaluates the use of interactive technologies and educational games in architectural education. The study highlights how augmented and virtual reality technologies can work to improve students' spatial, motivational, and social skills. In order to develop immersive educational experiences, the researchers underline the value of working with others and the usage of digital platforms. According to the research they looked at, using educational simulations and serious games can boost students' academic achievement and engagement (Sanchez-Sepulved et al*.,* 2020).

Using a dynamic approach to analyze the topic of e-learning, the existing literature reveals numerous publications containing a wide variety of keywords. For this empirical study, the "Scopus" database was used, and its search engine facilitated the data collection process. The analysis focused on documents published between 2018 and 2024, especially in the field of computer science. The obtained results were processed using the VOSViewer application, which allowed the clear identification of keywords relevant to this topic, generating a graphic representation based on a keyword cluster network, as illustrated in Fig. 1. The dataset contained 194 keywords, with a relevance criterion that a keyword must appear in at least two papers. Consequently, 21 keywords met this requirement.

Distributed web systems are software architectures that enable the sharing of resources and services over the Internet. They are composed of multiple distributed components that interact with each other, facilitating access to data and functionality from different locations and providing the best experience for the user (Ileana, 2023).

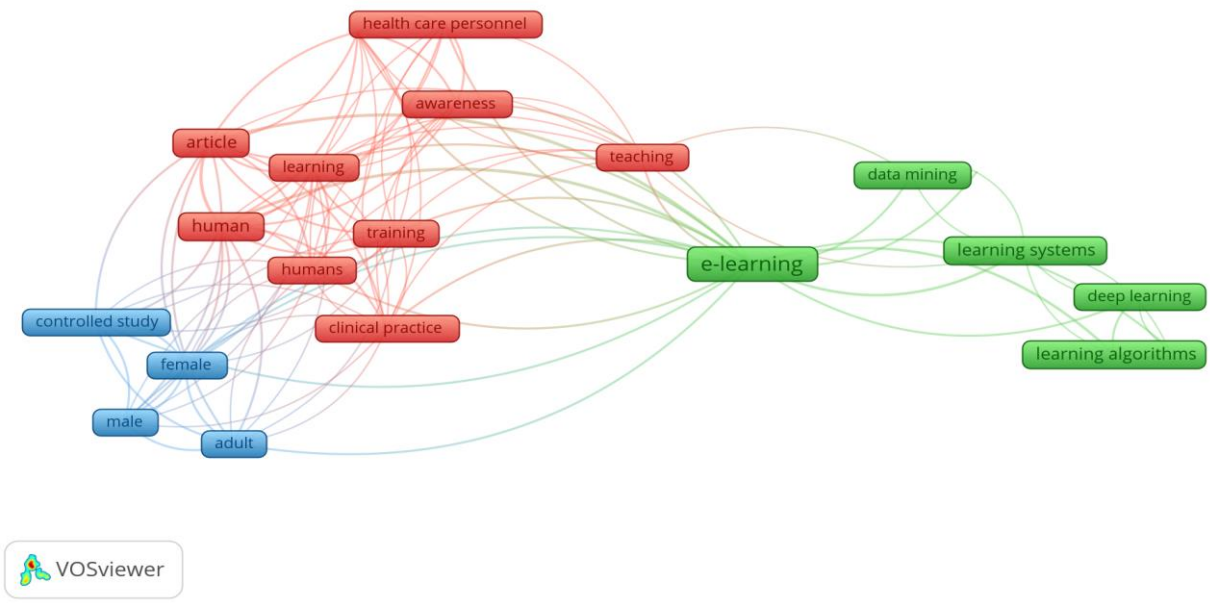

Fig. 1. A graphical keyword map for the search term "e-learning"

Efficiency and flexibility are properties of distributed web systems that are determined by several key characteristics. The most crucial of them is scalability, which makes it possible for systems to scale to accommodate higher user or request volumes by adding more nodes. Another crucial characteristic is reliability, which ensures users may access services even in the event of a node or component failure. Interoperability across various components and services is extremely important because it facilitates sharing information between them, regardless of the underlying technology. In addition, the systems' flexibility enables them to be adjusted to meet the particular requirements of applications. Resource sharing provides users with access to distributed data and functionality. When these characteristics combine together, robust, effective solutions that satisfy contemporary user needs are produced (Van Steen & Tanenbaum, 2017).

Typical web systems facilitate online learning through popular platforms such as Moodle and Blackboard. They provide access to educational resources regardless of where the student is located. They are widely adopted by higher educational institutions, even companies, and in addition to them, external communication tools such as Zoom, Microsoft Teams, and others, which allow virtual meetings and interactive discussions, are used more often, making collaboration between students and teachers more accessible (Bezovski & Poorani, 2016). Hinting towards integration of similar tools into a web educational system created using the combined features of distributed web systems and intelligent education systems.

The increasingly accessible educational resources available through the Internet offer new opportunities and flexible use of study materials, thus promoting a more accessible education for all those who want to increase their level of expertise in a certain area. Personalized learning is another important feature of intelligent educational systems, as modern technologies such as Bayesian networks can adapt content to the skill level, needs, and personality of each student through personal modelling (Tlili et al., 2023). Online assessments represent another major advantage, they provide immediate feedback in real time, making the learning process more interactive and thus efficient (Popescu, Ileana & Bold, 2024). Automated assessment and evaluation in similar systems used for practicing fundamental programming courses show mixed results when reaching advanced topics solutions to overcome these impediments are sought (Skalka & Drlik, 2020).

The diagram in Fig. 2 illustrates the architecture of the distributed web system combined with an intelligent educational system and a mobile game. The diagram is divided into two sections, the first section "What is seen" and the second section "How it works." This diagram

illustrates the flow from game development to student interaction with it, showing how data flows through various components, ultimately reaching teachers who monitor progress and grades.

On the end user side, the student uses a smartphone from any location to access the game that tests his knowledge. The teacher uses a laptop to view students' status, performance, answers, and manage their grades. On the technical side, the game is created using an existing game engine available on the market. A requirement for the game is to be cross-platform, therefore, the game has to be compiled and distributed for the two major smartphone operating systems – Android and iOS. Once the game is downloaded on a smartphone, it requires internet access to communicate with the remote server. Once a connection is established, the game communicates via the Internet with the API, which does load balancing for the distributed server. The server infrastructure consists of two servers (Server 1 and Server 2) connected by a local area network (LAN), managed by API. Those servers access database servers based on traffic and API management to create the game experience. Table 1 shows two example usage scenarios, one for the student (Scenario 1) and the other for the teacher (Scenario 2).

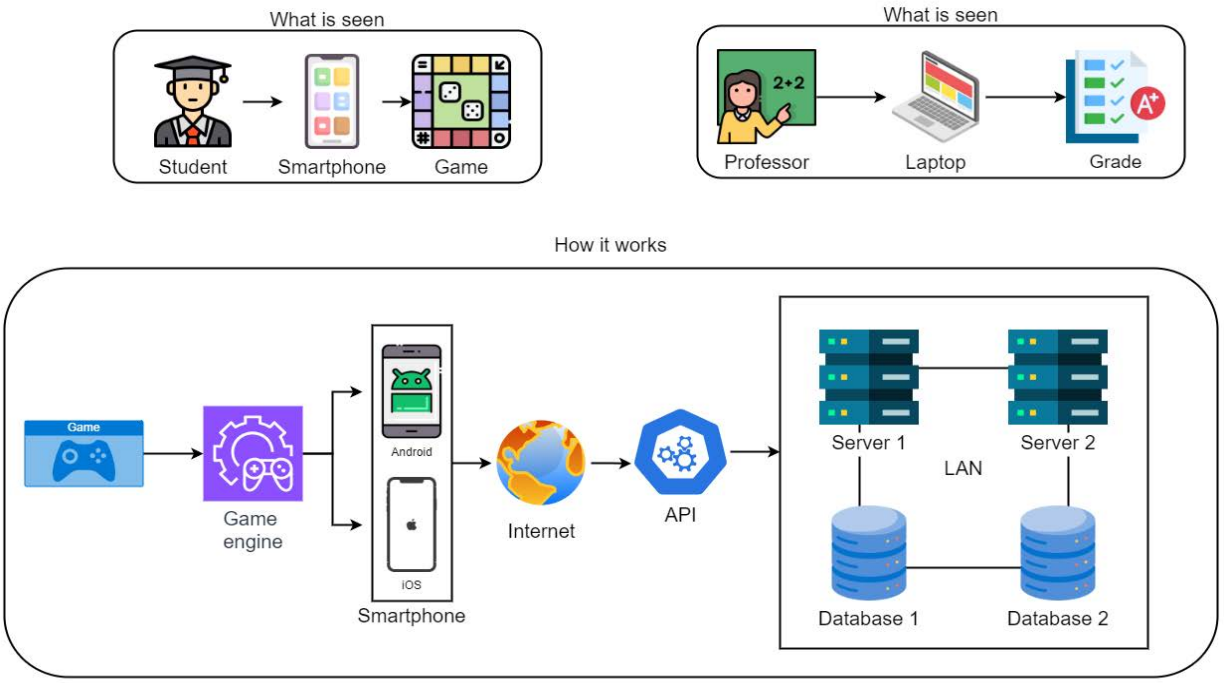

Fig. 2. Architecture for Distributed Intelligent Educational Web System using a mobile application

Table 1. Example usage scenarios

Scenario 1	Scenario 2
(Interactive learning for students)	(Assessment and tracking by teachers)
Background: Alice is a 2nd year college student who uses the educational app on her smartphone to learn object-oriented programming.	Background: Prof. Bob is Alice's teacher and wants to check his students' progress in computer science.
1. Alice downloads the app from the app store directly to her smartphone; 2. She uses her student account username and password received from the college to log in to the application; 3. She selects the course or laboratory from which she wants to test her accumulated knowledge; 4. Alice goes through the levels of the game, and	1. Prof. Bob opens his laptop and logs into the web platform of the educational application. 2. He accesses the student evaluation section; 3. The platform extracts the data from the databases through the servers and the API;

in an interactive way she practices the notions of programming; 5. The obtained performance is sent to the server through the API; 6. The data is stored in the database to be analyzed later by her teacher; 7. Ana receives instant feedback about her progress directly on her smartphone.	4. Prof. Bob can see each student's performance in detail, including time spent on each problem and correct/incorrect answers; 5. He notices that Alice is having difficulty with certain concepts and decides to provide additional educational resources.

Sample screens of the game can be seen in Fig. 3. The mobile game features many specifically designed game levels to match a generalized question type (i.e., multiple or single choice, ordered or unordered list, and others). They are gamified presentations of the educational test questions and answers that teachers uploaded in the database. When a student starts a game, random questions from the pool of the chosen topic get loaded, after which a random game level is chosen based on the type of question. A large pool of game levels provides novelty that helps engagement and learning, while the teacher only creates questions and answers and sets their type.

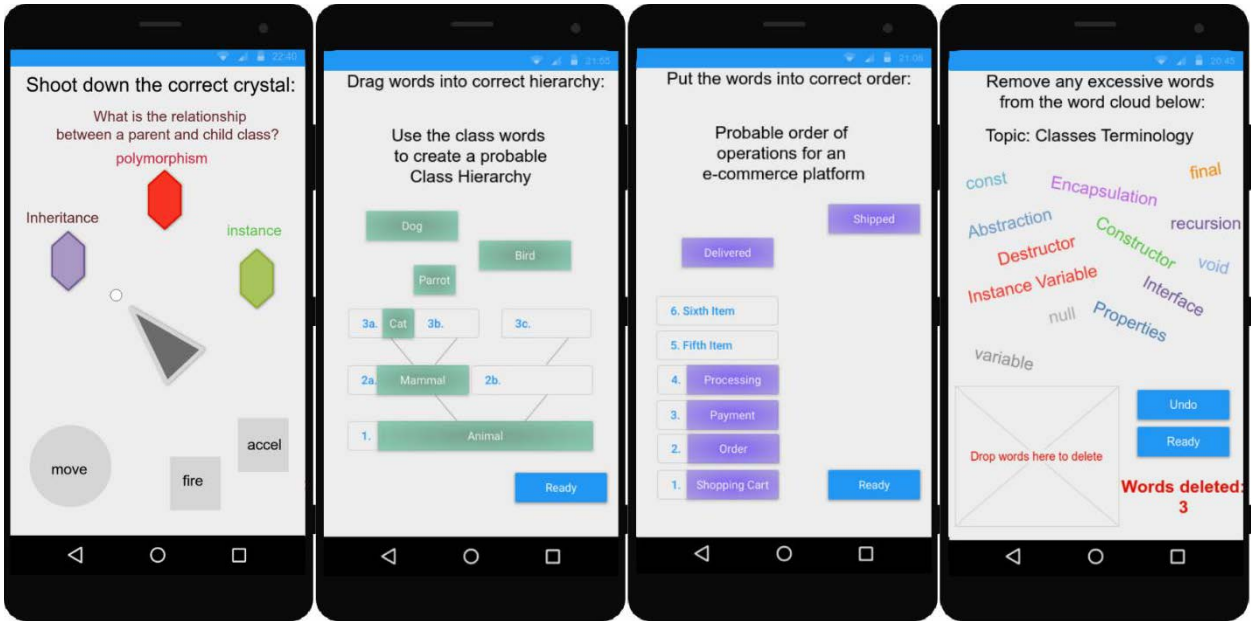

Fig. 3. Sample screens featuring some game levels with questions for object-oriented programming

Table 2 presents a detailed analysis of the advantages and disadvantages of using educational apps. On the one hand, they bring significant benefits, such as increased accessibility and the ability to provide immediate feedback, facilitating the teaching-learning process. On the other hand, there are also certain limitations, among the most important being: technology dependence and challenges related to customization and accessibility, which can affect the effectiveness of such digital learning tools in various study contexts.

Table 2. Advantages and Disadvantages of Using Educational Apps

Appearance	Advantages	Disadvantages
Accessibility	Students can access tests anywhere and anytime using their smartphones.	Internet access and compatible devices can be a problem for students in disadvantaged areas.
Immediate feedback	Students get immediate feedback, helping them catch mistakes and learn faster.	Automated feedback may not be as detailed or personalized as that provided by a teacher.

Tracking progress	Teachers can easily monitor each student's progress and identify areas where improvement is needed.	Dependence on technology systems can lead to problems in the event of a server failure or outage.
Personalization	Tests and learning materials can be adapted to the level and needs of each student.	Full customization requires additional time and resources for setup and maintenance.
Efficiency	Reduces the time required for manual correction of tests and their administration.	There may be a learning curve for teachers and students in using the app effectively.
Economy of resources	Reduces the need to use paper and other physical materials, contributing to sustainability.	The initial costs for application development and implementation can be high.
Involvement	Educational apps often include interactive elements that make learning more engaging and enjoyable for students.	Dependence on apps, especially games, can reduce students' motivation to use traditional learning methods or materials.
Differentiation	It can facilitate collaborative learning through features such as joint projects or group activities.	If not all students have equal access to and actually use the technology, collaboration tools can be ineffective.
Accessibility for special needs	For students with special needs, apps can offer features such as text-to-speech or text magnification.	Not all educational apps are optimized for students with disabilities, this could limit their use.
Data collection	It enables the collection of extensive data on student performance, which helps in personalized learning analytics.	There may be concerns about the security of student data and the privacy of their data when using educational applications.
Globalization	Students access resources and peers worldwide, which enhances their educational experience.	Cultural differences and language barriers could limit the effectiveness of some global educational resources.

CONCLUSION

In conclusion, the development of a mobile application based on intelligent educational systems, using a distributed architecture of web systems, represents a significant opportunity for the improvement of the educational spectrum. By combining traditional educational content with modern intelligent educational technology and game elements, such an application provides an active and effective platform for strengthening students' knowledge. The distributed architecture enables handling an expanding user base while preserving a smooth user experience.

Such a tool is encouraging regular and interactive learning since it can track progress, offer immediate feedback, and personalize learning paths. Those benefits contribute not only to improving access to education but also to creating a more adaptable and attractive learning environment. As the educational landscape evolves, such innovative approaches are essential to make learning more effective for contemporary students around the world, whether they want to learn on campus or from anywhere, through the mobility provided by such an application.

A mobile educational application featuring gaming elements and modern educational technology not only boosts student engagement but also encourages a dynamic and interactive learning environment. Consequently, this technology offers an improved level of learning and promotes online connection and collaboration while simultaneously modernizing traditional learning methods and opening up new opportunities for distance learning.

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