

IoT Game-based Learning Model in Education

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Abstract—The subject of this paper is the development of a game-based learning model based on the Internet of Things (IoT). The main problem discussed in the paper is to investigate the possibility of implementing a game-based learning model in an interactive educational environment that will increase student interest and enhance learning outcomes. The developed model will be based on ubiquitous computing technologies and integrate IoT, mobile, and augmented reality technologies. The proposed model integrates with existing components of the educational infrastructure. As part of the model evaluation, testing and measurement of relevant parameters that affect the effectiveness of the proposed model was carried out.

Keywords - edutainment, Internet of Things, mobile technologies, augmented reality, smart learning environments

I. INTRODUCTION

The development of the Internet of Things (IoT), mobile technologies, and augmented reality has contributed to innovations and new methodologies in education, such as developing smart educational environments, focusing on ubiquitous and active learning, and adapting learning to individuals [1].

The mobile age has made digital content part of everyday life and brought even more changes to the learning context, such as a focus on blended learning and the introduction of augmented reality and the Internet of Smart Devices as part of the teaching process [2]. Modern education requires learning on the go, anywhere and anytime, in physical or virtual environments. [3].

Augmented reality combines different computer technologies and provides the user with a unified worldview. Studies have shown that using augmented reality in education improves learning outcomes [4], [5].

Introducing educational games into smart classrooms creates an activity-filled learning environment where students can learn through play without the constraints of an actual classroom [6]. Students will be more interested in learning by presenting knowledge in a game format [8]. In order to implement smart educational environments into existing learning methods, it is necessary to base them on core values such as ethics and transparency [8].

The paper's research subject is developing a game-based learning model based on the Internet of Things (IoT). The research aims to develop a learning model through play in an interactive educational environment that will increase students' interest and improve learning outcomes. The developed model is based on ubiquitous computing technologies and the integration of IoT, mobile, and augmented reality technologies.

The primary research objective in this paper is the development of a game-based learning model based on the Internet of Things. Different models and implementation approaches for IoT-based game-based learning systems are defined. The paper proposed a new methodological procedure for learning through play based on the application of the Internet of Things.

II. BACKGROUND

Smart environments can be adapted to specific needs. Smart environments adapted to education are equipped to enhance the learning process from a technological perspective [9]. Smart learning environments enable the safe use of current technologies in the transfer of knowledge [10]. "Smart learning environments refer to a ubiquitous, personalized and intelligent system that is context-aware, capable of providing high levels of motivation, engagement and intelligent feedback for a better learning experi-

ence" [11]. By enabling communication between devices, smart educational environments offer quick and easy access to classroom distance learning material [12].

Koper, 2014 outlines the requirements for creating smart play environments [13]:

- digital devices are added to physical learning locations;
- digital devices detect the location and context of students;
- digital devices improve the physical learning environment with additional digital learning functions;
- digital devices monitor students' progress.

Learning through play is a learning method realized by applying games in the teaching process that improves attitudes and approaches to learning and allows students to have fun during the learning process [14]. Many studies have shown that digital game-based learning positively impacts motivation, attitude, student engagement, and performance [15]. Learning through play facilitates students to learn by using games as a medium, activating motor and cognitive sensors [16].

Educational games are games that contribute to the education of the player [17]. Educational games include not only those created as such but also those that only secondarily expand the knowledge and abilities of the contestants. [18]. It can be said that any game that helps players develop is actually educational [19]. Games help improve competitors' abilities, primarily cognitive and the ability to react and make quick decisions. However, at a higher level, educational games help to master certain areas, complex concepts, or other teaching elements within which they are implemented [20].

The combination of the IoT ecosystem with educational games is called Smart Educational Games. Smart educational games are tools that can solve real-world problems in any domain where game technology can help [21], [22]. In an interconnected IoT ecosystem, educational games could collect and analyze data from players' physical environments and present it to the user to provide better insight into player behavior. Using player behavior data allows game developers to improve the game, provides more robust conclusions about game-related research, and helps the industry tailor in-game content to match player satisfaction, among other things [23]. Research into the application of sensor technologies has highlighted gamification as an area of high potential. It allows sensor-based data to make recommendations to users, creating a smart solution [24].

The Internet of Things can be used to enhance learning through play. The physical aspects of the Internet of Things contribute to students' interaction and hands-on experience. Maintaining games within the IoT system makes it possible to simulate real situations and measure the players' adaptation to the environment [25].

Technologies such as augmented reality and their application in digital educational games have the potential

to motivate students [26]. Augmented reality provides the user with a unique view of the world created as a combination of physical and virtual. The combination is created by combining the real world in which the user is located and computer-generated virtual scenes. It is an interactive environment where reality is enhanced with real-time virtual objects [27]. By analyzing the literature, it was observed that using educational games with augmented reality elements in teaching activities leads to an increase in learning efficiency. Other benefits include increasing student motivation and interest, improving communication and interaction between participants, and a higher degree of satisfaction after learning. [28].

Learning through play using technology in a smart learning environment enables students to acquire knowledge and develop cognitive and social skills [29]. The benefits and needs of serious games require implementing advanced technologies in smart environments to improve the learning process. Games in smart environments are interactive and capable of automatically tracking and collecting data on student activities [30]. Learning through play provides students with a fun, interactive, and challenging learning experience. In addition to the transfer of knowledge, students can practice the practical application of acquired knowledge, test themselves, and measure their progress [31]. This type of learning provides students with a contextualized and personalized learning environment that meets the individual needs of different students [32].

Modern educational games are created using advanced technologies, and their implementation requires appropriate technical conditions. The technical characteristics of smart educational environments serve as the initial infrastructure for implementing educational games. Some of the benefits of smart environments are access to the Internet and intranet; various sensors that can help play the game, and interfaces that facilitate the implementation process itself. If it is about smart classrooms, there is an additional advantage, integration with existing learning systems. The advantages of applying learning games in smart environments can be divided into the following categories [33]:

- Collecting data about students and the game process;
- Adapting the game to students;
- Overview of achieved results and competitions;
- Interaction with the game system.

III. MODELING

Modeling a smart educational environment for learning through play is a way to connect the services of the Internet of Things, mobile technology, and educational games into a unique system that improves the learning process in higher education. The proposed model of education in smart educational environments includes the following components: the framework of the learning system through the game, the architecture of the smart environment, the software infrastructure of the smart environment, testing knowledge through games, the integration of the components of the

Internet of Things with the e-learning system.

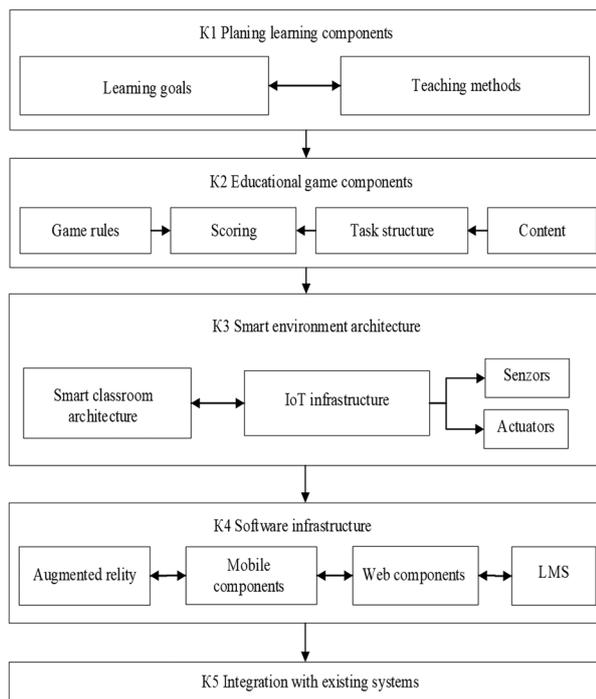


Figure 1 Model structure

The first step in planning the model is defining learning goals and outcomes. The success of the learning model is measured based on the efficiency and effectiveness of the knowledge transfer process, maintaining student motivation and achieving learning outcomes [34]. Smart educational environments, IoT, and augmented reality have a wide range of potential effects on student motivation and learning outcomes.

Here is a summarized, but not exhaustive, list of possible goals related to students and learning:

- greater interest in the field of study;
- higher level of motivation during learning;
- higher level of communication and cooperation with other students and professors;
- better learning outcomes.

When creating a teaching plan that would meet the mentioned goals and enable the achievement of the required learning outcomes, it is necessary to follow the revised Bloom's Taxonomy [35]. Before the lesson, it is necessary to make a lesson plan. The lesson plan should include the content that will be taught during the lesson. The content includes professor's lectures (presentation of knowledge), practical teaching (application of knowledge), and testing. In addition to classic lectures, it is necessary to prepare learning material that is always available to students through systems integrated into a smart environment. After planning and preparing the materials, designing games for application and testing is necessary. At this stage, it is necessary to consider the environment's current technical and technological capabilities. Based on the present IoT devices and implemented software, planning each task

individually and combining them into one game is necessary. The tasks depend on the application technologies, and it is necessary to create standardized tasks for easier classification and implementation. The components used in the tasks must be designed according to the principle of mutual communication and communication with other system elements.

The initial hypothesis of the application of educational games in education is the influence on student motivation [36]. A higher level of engagement and commitment is achieved by implementing solutions that require user interaction. If the medium of knowledge transfer is also fun for the user, better results were observed during knowledge testing compared to the control group. [37].

Depending on the goal of the game and the area of the teaching material, it is necessary to choose the type of game to be created. According to the type of game and the objectives of the test, it is necessary to define the rules of the game. The number of players that will make up one team should be defined if it is a team game. The game should test students' knowledge, so it is necessary to define whether the testing is time-limited for one attempt to solve, the method of scoring tasks, the flow of tasks that can be random or sequential, and the way of interaction between tasks, participants and the learning system.

According to the type of study material and technical limitations, it is necessary to choose the type of game that will be used. After choosing the type of game and creating the framework, it is necessary to divide the game into meaningful parts that will be separately designed and implemented, so-called tasks. The task tests one domain of knowledge from the subject of study. It is necessary to define the necessary teaching material, technical equipment, and, if the task is solved by physical presence in the environment, the execution location. Each task must have the characteristics of communication with the system and with users and must meet the criteria of fun character and valid transfer and testing of knowledge.

Students learn how to solve complex problems in an ideal educational game environment. The game's problems usually start easy and become progressively more difficult as the player's skill develops. Students are motivated to learn because learning occurs through the process of theorizing, examining, thinking, and drawing conclusions about the simulated situation depicted in the game. Objectives are clear, and information is made available to players to achieve each objective [38].

When researching learning through play, two types of outcomes were observed, changes in learning outcomes and changes in interest and motivation. In addition to measuring the success of knowledge transfer, it is also important to check players' satisfaction with a given game. For games to be interesting and accessible to users, it is necessary to define a user experience model. Factors affecting the experience are grouped into the following categories [39]:

- Engagement,
- Purpose of the game,
- Interaction and
- Possibility of learning.

IV. RESULTS

The designed system was evaluated in the Internet of Things course of graduate studies in the Information Systems and Technologies department of the Department of Electronic Business at the Faculty of Organizational Sciences, University of Belgrade. In the course, students learn the basics of internet technologies of intelligent devices. The course was implemented in the form of mixed learning using the Moodle system.

The research was conducted at ELAB during the spring semester of the 2017/2018 school year. Year, on a sample of 24 undergraduate students who attended the Internet intelligent devices and Mobile business courses. All respondents were between 20 and 25 years old; 29.2% were men, and 70.8% were women.

All students who attended the course consented to participate in the research. During the 3-month course, students have exercises in which they discover new elements and participate in group projects that require weekly evaluation. The game was presented during one of the lectures during the semester. The purpose of the research and instructions for using the software were explained in the presentation. The first step was filling out the questionnaire. After filling out the questionnaire, two tests followed. The first was a written test, and all students did it simultaneously. The second test was realized through the presented software and hardware. Due to technical limitations, the second test was done in groups. Both tests had the same tasks. In the game, the tasks are given in a random order. Students did not have an insight into the accuracy of the solutions to the tasks until both tests were completed. In this way, the influence of the first test on the second was avoided. After the two tests, students were asked to complete a second questionnaire.

The results show that the time needed to solve the game is significantly longer than the time to solve the written test ($t = 29.37$, $p < .05$). Students achieved better results in the game compared to the results of the written test, which leads to the conclusion that this type of game-based learning and assessment can be incorporated into regular activities. A positive observation is that more students passed the IoT test. A possible explanation is that some students struggle when taking written tests, and using active learning methods is easier. Detailed results were published in [40].

V. CONCLUSION

This paper aimed to develop a game-based learning model based on the Internet of Things. Using a mobile

educational game based on ubiquitous computing and the Moodle learning system, it is proposed to expand the formal learning process by abandoning the concept of traditional classrooms and moving to learn through interaction with the environment. The main contribution of the research is a defined approach to learning through play in smart learning environments based on the Internet of Things to increase students' interest. The presented approach can be used both as a learning activity and a tool for testing students' knowledge.

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