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Development of an educational game based on IoT

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Abstract - Internet of Things (IoT) in combination with game based learning offers new possibilities to improve teaching and learning. This paper presents an example of using the IoT in education through the creation of an educational interactive game. An educational game based on the IoT has been developed. The developed system aims to motivate students to acquire and enhance knowledge in the field of IoT. The system is composed of a mobile application that serves as a controller for students, an administrative tool in the form of a web application used by the teachers, a set of assignments implemented within a smart educational environment, and a collection of web services used for integration of software components. The system is integrated with Moodle learning management system. The evaluation has been conducted at the Faculty of organizational sciences, University of Belgrade, during the Summer school in Internet of Things. A group of seven students played the game, solved the knowledge test, and gave their opinions on usefulness, ease of use, ease of learning and satisfaction with the developed system. Results show that the game has a positive effect on students' knowledge and attitudes, and therefore is suitable for application within a blended learning environment.

Keywords - Internet of Things (IoT); game-based learning; smart learning environments.

I. INTRODUCTION

The rapid development of information technologies and Internet leads to new forms of education and learning. Numerous innovations in modern e-education lay in the fields of smart educational environments and Internet of Things (IoT) applications [1]. There is an obvious ubiquity of using smart technologies in education, as well as increasing interest of the academic community for research in this field. The main idea is to achieve a level where smart devices and applications are not considered as a distraction but as an integral part of an educational blend [2, 3].

A smart learning environment is made of objects that can communicate, interact, compute, and make decisions [4], in a way adapted to the needs of educational processes [4]. At the same time, they present a comfortable environment for teaching and learning. Smart environments are developed using the technologies of the IoT [5, 6]. In education, IoT enables the application of modern Internet and mobile technologies, which leads to a more active approach to learning. In this way, we can develop environments and tools that enable students to learn more efficiently, with an increased interest, compared to traditional methods of education [7].

Although the literature presents a number of researches related to the application of smart technologies in the classroom, there are not many of them giving examples of the game-based learning in a smart environment fully integrated into the educational process. In this research, we try to

This paper is a revised and expanded version of the paper presented at the XVI International Symposium INFOTEH-JAHORINA 2017 [26].

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contribute to filling this gap by developing a game within a smart learning environment integrated with educational services. The developed environment is equipped with various sensors, devices, and software that support the learning process. In a "treasure hunt" type of game, students are testing their knowledge on the Internet of Things and learning new things in a fun way. The whole process is integrated and supported by Moodle LMS.

II. LITERATURE REVIEW

A. Educational games

Many studies have shown that alternative and modern approaches to teaching yield better results [8]. Some of the techniques that have been recently looked into are the use of modern technologies in the form of teaching tools and the use of edutainment in the teaching process. The studies have shown that because of their strong beneficial impact on learning and willingness of students to accept them, educational games find themselves used more frequently [9, 10]. Educational games have been used by teachers for a long time, more specifically, the subset of educational games that use physical objects - physical educational games [11]. With the advances in technologies, especially mobile and Internet technologies, and their increased availability, it is easier to develop and use mobile educational games [12]. Internet of Things (IoT), defined as a network of both physical and digital objects that are connected with each other via standardized protocols, has made it possible to bridge the gap between the physical objects used in traditional games and digital objects used in new games and enable communication between them [13]. Using new technologies to change traditional types of games and adapt them to new trends makes them more

interesting to newer generations and increases their effects [14]. With the development of 3D games, we can see a rise in their popularity over the 2D type [15]. Another new way of making these so-called hybrid games is with the implementation of augmented reality [16]. All these technologies are helping teachers to create ubiquitous educational environments and to adapt them to characteristics of the educational process or to students' needs [17].

Games attract the attention of those that play them and keep them focused on the task at hand [18]. Their fun character is the source of their potential for education [19]. Games lead players (students) to complete goals that have been set while generating feedback and tracking their progress for teachers. Of course, not any game can be an educational game, even if it possesses educational content. The key is game design. It is necessary to design a game in such a way that will drive the players to immerse themselves and test their knowledge to their fullest capabilities [20-22].

There are several parameters that can be used to evaluate the quality of an educational game:

- Acceptability: the level of completion of the learning goals;
- Challenge: the level of motivation;
- Clarity: the level of understanding;
- Interactivity: the level of interaction between the student and the game;
- Reward: it enables the student's satisfaction after the completion of goals.

B. Smart learning environments

Many classrooms today are connected to the Internet and have the advanced technological equipment, such as tablets or interactive boards. This type of classroom is called the smart classroom [23]. Smart classrooms possess the equipment and technology to support blended learning, a combination of the traditional face to face system of learning and the virtual, off-site approach, creating a flexible and motivating environment. These classrooms are the ideal place to implement educational games as they meet the necessary technological requirements. Smartphones and tablets are present in smart learning environments, so the learning can happen anywhere [24].

By using mobile and IoT technologies, smart classrooms surpass the physical limitation of a traditional classroom [25]. However, smart classroom services need to be integrated with other learning services, such as learning management systems [26, 27].

III. DESIGN

A. Project requirements

During the course of our research, we have set out to design and develop a tool that would help turn learning into an interesting and motivational experience. This goal can be achieved in a form of an educational game based on IoT technologies. The game tests the knowledge of a subject and like the teaching process is divided into lectures, the test too must be split into smaller parts. To correctly measure the students' mastery over the subject curriculum, the game is split into so-called tasks. The tasks each represent a lesson of

the course and test the knowledge of the field of study of said lesson. During the game's time limit, students receive tasks one by one, in random order, and can only proceed to the next task after entering the solution to the current problem [28].

B. Architecture

The architecture of the developed system is shown in Fig. 1 [29, 30]. The system is composed of a mobile application that serves as a controller for students, an administrative tool in the form of a web application used by the teachers, a database and a collection of web services to transmit data as well as a smart environment that includes on-site equipment (hardware and software) for each task. Communication between components is realized through the use of web services, RFID tags, and QR codes. User management and grading are interconnected with Moodle LMS.

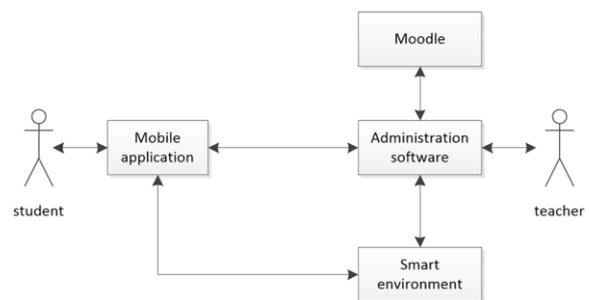


Figure 1. The architecture of the game

Mobile application

The mobile application is the player's gateway into the complex system of the game. It is the only way to interact with the physical objects necessary to solve tasks as well as the only interface that receives tasks from the server. In order to accommodate a wide range of task types, it uses task metadata to adapt to the current type and generate only the capabilities necessary at the moment. It does this by being split into modules that are used as building blocks to form a whole during the loading of a new task, as seen in Fig. 2. The application can be divided into two parts, the Vuforia part, that enables the use of augmented reality, and the Android part that facilitates everything else.

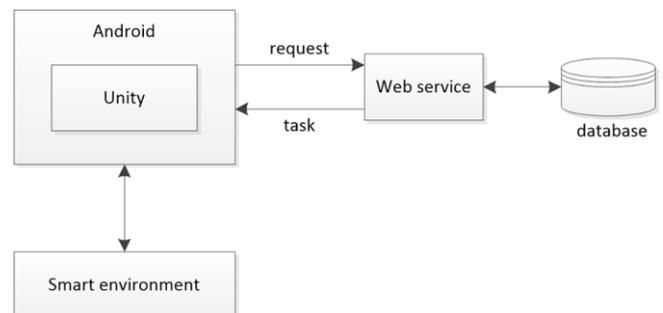


Figure 2. Mobile application structure

Administration software

The administrative tool is used by teachers to organize tests (playing of the game), to create new tasks or modify existing ones, review achieved results for a given student and grade

them. In Fig. 3 we can see the screen used for creating a new task.

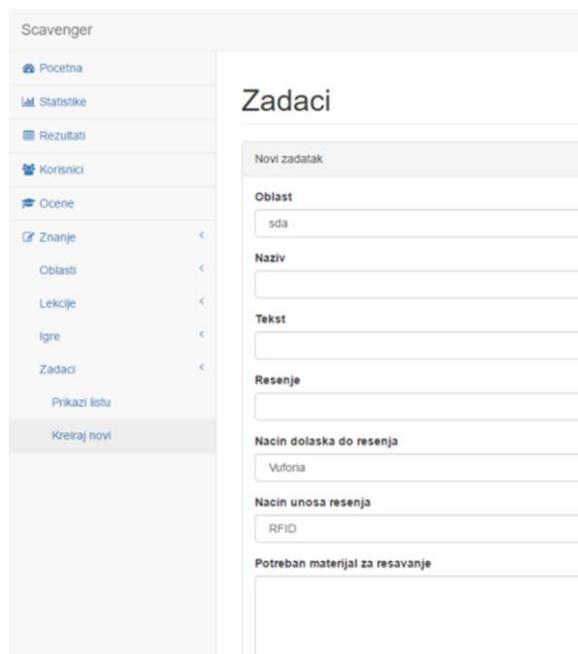


Figure 3. Task creation screen

The administrative application is implemented through the use of PHP programming language and Laravel 5.3 framework. It also contains all the web services that are available to clients via the mobile app. All the data is stored in a MySQL database. Both the database and software are stored inside a virtual machine hosted in a cloud environment. The VM is a basic server installation of Centos 7 OS with Apache and other necessary services installed. By having the server on the Cloud, it is possible to enhance it by adding more bandwidth, processing power and memory, in order to solve any bottlenecks that may occur.

Smart environment

To successfully implement the game, it is necessary to do it in a smart learning environment. This environment includes workstations on multiple locations and equipment for students.

Student's equipment is a single device and the necessary software installed on it. The device is an Android handheld smart device, either a mobile phone or a tablet. The student is handed the fully prepared device at the start of the game. After receiving the controller, the student logs in with their Moodle account and proceeds to play the game by going to the first task location.

Workstations are equipment present on site for each task. If the task is envisioned to be solved with the aid of external factors and devices, then all the necessary hardware and software must be set. Since the game is played in multiple locations, they are scattered throughout the envisioned playing field. An example of a workstation schema is displayed in Fig. 4.

Location of each task can be anywhere, in the classroom, in the faculty building, or outside. For example, a task can be related to measuring the temperature, and the equipment can

be placed in a classroom. Or, a task can be related to plant watering, so the workstation will be placed in the garden.

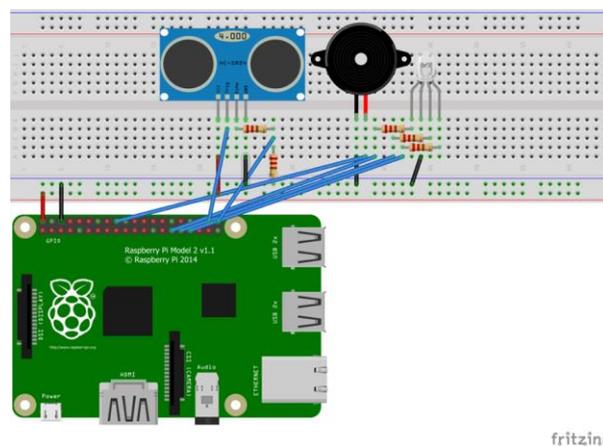


Figure 4. An example of a task physical system

All the implemented tasks are related to studying the field of the IoT and its applications:

1. A system for measuring temperature and air humidity. The student connects to the system using the mobile device and sets the parameters of the system according to the requirements.
2. A system for light control. The student connects to the light control and sets the lights as required for the task.
3. A system for movement detection. A movement is detected using a sensor, the LED screen shows the information, and a timer is started. In a defined time, the student is required to perform an action defined in a task.
4. A system for measuring the distance. An ultrasonic sensor is used to measure the distance and shows the measured value on a LED screen. The student is required to do a movement that will cause the reaction of a sensor, as defined in the task.

Besides the equipment necessary for solving tasks, each location is equipped with:

- Wireless Internet. Components communicate through a wireless network.
- Hosting service. Each location has its own local database and services necessary for the hosting and realization of a specific task.
- RFID system for monitoring the progress of the students.
- The system that informs students about their progress. The yellow color is used to note that the system is in the ready state, waiting for a student to come. The red color is used to note that a system is performing an action, and no interaction with a student can be done at this time. The green color is used to signal the student that they can perform the required action.

Moodle integration

Moodle integration has been realized in the form of authentication, in both the mobile and administrative applications. Another call to the Moodle service is activated after the game ends. The client application sends the achieved results to the server for professors to grade with the help of the web application. After the grades have been set, they are set as Moodle assignment scores.

C. Game scenario

In the beginning of the game, the user receives the handheld device used as a controller, logs into their Moodle account, presses the button to start the game and receives the first task. After starting the game, the timer begins the

countdown. The screen shows the text of the current problem. The job of the student is to go to the location specified in the text of the task and follow the provided instructions to find the solution to the given problem. The solution is then inputted into the console. If the answer is correct, the solved task is registered as completed and the student will not receive it again. In the case that the answer is incorrect, the task remains in the scope of possible assignments for the next iteration. After the time limit expires or all the tasks have been solved, the student has completed the game. The results are scored based on the number of solved tasks and the remaining time, if there is any, and the student is graded accordingly. As previously stated, the game is played in iterations, as shown in Fig. 5 [18, 19].

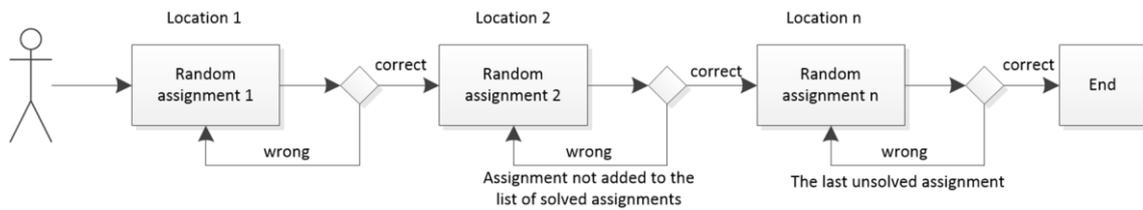


Figure 5. The game scenario

The student starts the game from a starting point, where they get the first task. Among the received information is the location of the task, name, and text of the problem that must be solved and all the necessary metadata that the mobile application uses. Metadata is used to generate user interfaces that the player sees, such as the way of inputting the solution (keyboard, RFID tag, QR code) as well as the level of difficulty of the task. After solving the first task, they get a clue to reach the next location, where a workstation with the second task is located. This repeats until the last assigned task is solved. There is no direct penalty for solving a task incorrectly as it might be received and correctly solved at a later point in the game, however, the time required to redo it decreases the acquired points at the end of the game (as the remaining time is part of the grade). Another potential penalty occurs if the player cannot correctly finish a task even after multiple attempts. In this scenario, not only is the utilized time deducted from the score, so are the points that each completed task brings. Since not all tasks are of the same difficulty, they cannot be scored in the same way, so the final score is calculated based on the remaining time and the sum difficulty level of each successfully completed task. The detailed game process is displayed in Fig. 6.

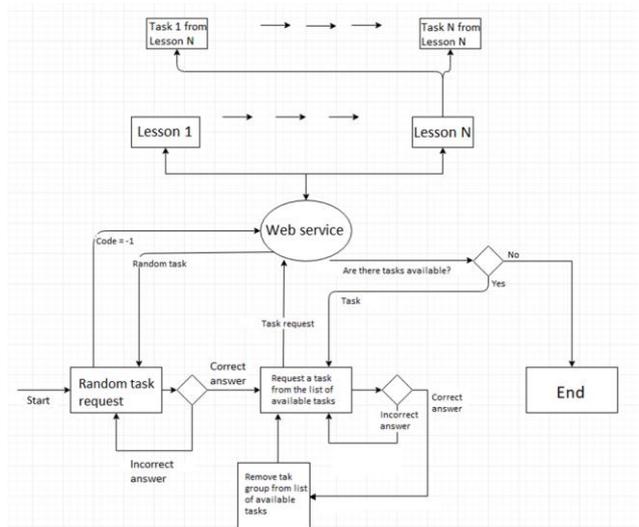


Figure 6. Task overview

Throughout the game, the student can review the solved assignments. After completion of all the assignments, or after the time has elapsed, the score that student achieved is calculated, shown to the student, and inserted into the administration application and Moodle.

D. Assignments

A schema of the assignment is shown in figure 7. The displayed assignment is called Plant watering. The student is required to solve the Python function shown on the screen. The result of the function is the required humidity level of the plant.

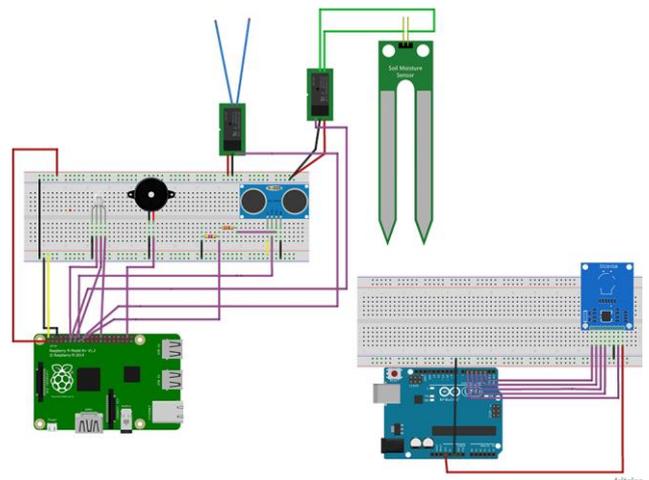


Figure 7. Plant watering diagram

Based on the task metadata, the mobile application will, alongside all the other views, also show the view with the current humidity and a button activate the water pump and increase it to a point. At any moment the student can interact with another part of the workstation, the RFID tag generator that will create and transmit a code to the mobile application. This code represents the solution of the task and if the humidity level is as required at the moment of the button click, the generated code will be correct. Based on the validity of the code, the task is marked as completed or left as a possible option for all next iterations during the current game. After typing in the code, the student receives the next task, if there is one still left unsolved.

Another example of a task is named Distance sensor. This task also tests the knowledge of the Python programming language and is an alternative to the previous one. It is possible and even recommended, to create more than one for each given lesson. During the game a student can only solve one task per lesson, so all the tasks that belong to the same group are automatically removed from the selection pool for the next turn. The aforementioned example displays the python function whose result is the distance that one needs to block an ultrasonic distance sensor to receive a code needed to continue forward. The current distance is displayed inside a view of the mobile application alongside a button to generate the code (Fig. 8). The validity of the code is tested in the same way as the first example, but instead of receiving it from an RFID tag, the code is shown on the mobile application screen.

A special kind of task is the Vuforia type. It uses augmented reality to display models of key IoT elements that overlap with corresponding images in the real world. They can be in the format of displaying basic elements or even entire IoT infrastructures across their schemas with the goal being to either recognize the model or discover a missing element from the system. As an example, we have a task in which we have to recognize a system with a certain 3D model, in this example a Raspberry Pi (the end screen can be seen in Fig. 9). The player will receive this task and go to the specified location. On site, they will encounter 3 sets of printed image – QR code pairs. His assignment is to activate the Vuforia mode of the game and scan each image in turn. The images are incomplete IoT schemas that become complete with the models that are shown on the screen when the image is in camera view. After finding the model specified in the text of the assignment all that is left is to return back to the main application mode and scan the correct image's accompanying QR code.



Figure 8. Task text and helper page



Figure 9. Vuforia task example

IV. RESULTS

For the evaluation of the developed game, a pilot testing was organized at the Faculty of Organizational Sciences, University of Belgrade, within the Department of Electronic Commerce (e-lab) during the Summer School attended by undergraduate 4th-year students. The goal was to test the efficiency of using the developed game while learning about the Internet of Things. The research was conducted in accordance with the code of professional ethics. All students willingly agreed to contribute to this research.

The research involved 7 students who attended the IoT course. All students solved a classic test consisting of 10 questions, which tested their knowledge in IoT. Another form of testing was done with the help of the developed game. The game consisted of three tasks: two from the Vuforia group and one Python task. The aim of the research was to compare the results achieved by the students solving the classical test with those obtained by solving the IoT test. After the completion of both tests, students completed a survey where they expressed their satisfaction with this kind of work. The survey was prepared using a standard USE survey [12], tailored to the specific needs and objectives of the testing. The survey itself was divided into 3 sections, the first one having 31 questions related to the application, its usefulness, ease of use, ease of learning, and satisfaction of students in solving tasks using the given application. The second part of the questions in the survey concerned the satisfaction of solving each particular task within the mobile application, while in the third part of the survey students were expected to give their opinion regarding the negative and positive aspects of using the application. The survey provided a five-point response scale (I fully agree, partially agree, I cannot decide, partially disagree and completely disagree).

Within the classical test, students had different types of questions: 1) choosing the correct answer, for example: recognize the Raspberry device on the picture, recognize the schema with the motion sensor, etc. 2) matching concepts with offered answers, 3) solving the given function, 4) open answer type, 5) Python code.

Each student received a mobile phone on which a mobile application was installed. Their tasks were to launch the application, log in to the Moodle system, and press the button in the displayed menu - launch the game. The system then selected one of the tasks randomly. If the student does not solve the exact task, they have the ability to re-test within a given time again. After the expiration of the time or after solving all the tasks, it was necessary to press the button "finish the game". Two of the offered tasks were Vuforia type. The student had the task of reading the text on the screen of the mobile phone, then going to the assigned location from the task. Within the application, it was needed to move the screen to the right and click on the scan, then select the option specified in the text of the task and position the device so that the image is visible on the camera. The students needed to select a 3D model that matched the task's solution, double-click the "back" button, move the screen to the right and click on the scan. The device had to be positioned to see the QR code corresponding to the selected model. Another type of task was the Python task. It was necessary for the student to read the text, go to the specified location, and move the screen within the application to the right. The next step was to block the distance sensor so that the measured distance corresponds to the Python function found in the text of the task, and the current distance was visible on the mobile application screen. Then they needed to click on the "Solution" button, read the message that appeared and close the window. The last step was to move the application screen to the right, enter the read message into the displayed field, and click "Submit".

Finally, students who participated in the research filled in the questionnaire, answering questions about the application itself. In the given survey, students expressed their opinions on

the application, but also answered questions that were related to satisfaction in solving each of the three questions asked.

Participants of the research expressed their positive opinion when it came to solving tasks through the game, from the standpoint of the usefulness, the ease of its use, the ease of learning, and the satisfaction of this kind of acquiring new knowledge.

A. Knowledge test results

Table 1 shows the results achieved on the knowledge tests. The results of the IoT test are significantly better than the results achieved by the students by solving the classical test. It also shows us that the standard deviation is 1.95, which tells us that a large number of students achieved the maximum number of points from the IoT test and that on the other hand, there were two students who achieved lower results.

TABLE 1. TEST RESULTS

	N	Average grade	Std. dev
Standard test	7	7.14	0.69
IoT test	7	8.85	1.95

B. Students' opinions

Usefulness of the application

Table 2 shows the students' opinion on the usefulness of the application when solving the task. In matters related to the usability of the application all students stated that they fully or partially agreed that the application was useful. Even 85.71% were fully or partially in agreement that the application helped them to be more efficient, and 71.43% said that it allowed them to be more productive.

TABLE 2. USEFULNESS

Question	% Strongly agree (score = 5)	% Agree (score = 4)	% Neutral (score = 3)	% Do not agree (score = 2)	% Strongly disagree (score = 1)	Mean score	Standard deviation
It helps me be more effective.	28.57	57.14	14.29	0.00	0.00	4.14	0.60
It helps me be more productive.	28.57	42.86	28.57	0.00	0.00	4.00	0.71
It is useful.	57.14	42.86	0.00	0.00	0.00	4.57	0.49
It gives me more control over the activities in learning.	42.86	42.86	14.29	0.00	0.00	4.29	0.70
It makes the things I want to accomplish easier to get done.	14.29	42.86	42.86	0.00	0.00	3.71	0.70
It saves me time when I use it.	0.00	42.86	57.14	0.00	0.00	3.43	0.49
It meets my needs.	0.00	28.57	71.43	0.00	0.00	3.29	0.45
It does everything I would expect it to do.	28.57	28.57	42.86	0.00	0.00	3.86	0.83

None of the issues related to the usefulness of the application were answered by anyone who did not agree with these issues.

Nobody replied that they fully agree that their use of the application saves time and that they fit their needs. On these two questions, there were also the most undecided students, 57.14%, or even 71.43%. This means that although they agreed that the application was useful, after a conducted survey, they were not convinced that it responded to their needs and saved them time. This should be taken into account

when designing the future improvements of the developed game.

In the further stage of research work, and the development of application games for educational purposes, answers of students' who could not decide on the usefulness of the application need to be analysed with more details, and improvements need to be made in terms of productivity, time savings, easier tasks, needs, and expectations.

Ease of use

After solving tasks with the help of the game, the students also expressed their ease of using the application. In general, students have declared that the application is easy to use. They fully agreed that the application is easy to use and useful for

students, and 100 percent confirmed and fully or partially agrees that it is easy to use, it can be used without difficulty and that it takes a few steps to achieve the goal. Table 3 shows the students' opinion on ease of use of the application.

TABLE 3. EASE OF USE

Question	% Strongly agree (score=5)	% Agree (score=4)	% Neutral (score=3)	% Do not agree (score=2)	% Strongly disagree (score=1)	Mean score	Standard deviation
It is easy to use.	85.71	14.29	0.00	0.00	0.00	4.86	0.35
It is simple to use.	100.00	0.00	0.00	0.00	0.00	5.00	0.00
It is user friendly.	100.00	0.00	0.00	0.00	0.00	5.00	0.00
It requires the fewest steps possible to accomplish what I want to do with it.	28.57	71.43	0.00	0.00	0.00	4.29	0.45
It is flexible.	42.86	42.86	14.29	0.00	0.00	4.29	0.70
Using it is effortless.	42.86	57.14	0.00	0.00	0.00	4.43	0.49
I can use it without written instructions.	57.14	14.29	14.29	14.29	0.00	4.14	1.12
I don't notice any inconsistencies as I use it.	28.57	14.29	42.86	14.29	0.00	3.57	1.05
Both occasional and regular users would like it.	14.29	42.86	42.86	0.00	0.00	3.71	0.70
I can recover from mistakes quickly and easily.	14.29	28.57	57.14	0.00	0.00	3.57	3.57
I can use it successfully every time.	71.43	14.29	14.29	0.00	0.00	4.57	0.73

Answering questions related to the practical confirmation of the ease of use, students in the high percentage expressed their indecision, which came in conflict with their very clearly defined attitudes that the application is easy to use.

Thus, 28.58% were undecided or partly did not agree that they could use the application without instructions, and even 57.15% were undecided or partly did not agree that there was no inconsistency in the use of the application. At the same time, 42.86 % of the student was indecisive about whether this application would appeal to regular or casual users, 57.14% can quickly and easily correct the error while using the application, and 14.29% and whether it could be successfully used next time.

Such a collision between the general views that the application is easy to use and their attitude that they cannot decide on a few issues in this area is a dilemma that should be removed in future works, whether it is subjective uncertainties or objective misunderstanding of the functioning of the application.

Ease of learning

The students almost did not have any dilemma and indecision that the application was easy to learn. Table 4 shows the students' opinion on how easy it was to learn to use the application. Namely, all students replied that they easily remembered and learned how to use the application. In addition, all students confirmed that they fully or partially agreed that they quickly learned to use the application and that they quickly became skillful in its use.

TABLE 4. EASE OF LEARNING

Question	% Strongly agree (score=5)	% Agree (score=4)	% Neutral (score=3)	% Do not agree (score=2)	% Strongly disagree (score=1)	Mean score	Standard deviation
I learned to use it quickly.	85.71	14.29	0.00	0.00	0.00	4.86	0.35
I easily remember how to use it.	100.00	0.00	0.00	0.00	0.00	5.00	0.00
It is easy to learn to use it.	100.00	0.00	0.00	0.00	0.00	5.00	0.00
I quickly became skillful with	71.43	28.57	0.00	0.00	0.00	4.71	0.45

Satisfaction

Table 5 shows the students' perceptions of how satisfied they are with the given application. In whole or in part, 100% of students stated that they are satisfied with the application, that it is useful and that it is pleasant to use. No one replied that it partially or completely disagreed with any of the questions and attitudes about satisfaction with the application.

However, 28.57% of the students could not decide whether the application worked out how they wanted it and whether it was wonderful, and 14.29% could not decide whether to recommend the application to friends and whether it was fun use and learn with the help of the application.

TABLE 5. SATISFACTION

Question	% Strongly agree (score=5)	% Agree (score=4)	% Neutral (score=3)	% Do not agree (score=2)	% Strongly disagree (score=1)	Mean score	Standard deviation
I am satisfied with it.	71.43	28.57	0.00	0.00	0.00	4.71	0.45
I would recommend it to a friend.	42.86	42.86	14.29	0.00	0.00	4.29	0.70
It is fun to use.	57.14	28.57	14.29	0.00	0.00	4.43	0.73
It works the way I want it to work.	14.29	57.14	28.57	0.00	0.00	3.86	0.64
It is wonderful.	42.86	28.57	28.57	0.00	0.00	4.14	0.83
I feel I need to have it.	57.14	42.86	0.00	0.00	0.00	4.43	0.49
It is pleasant to use.	71.43	14.29	14.29	0.00	0.00	4.57	0.49

C. Satisfaction with solving each of the three tasks

Within the survey, students also responded to their satisfaction when solving all three tasks with the help of the application.

Regarding the first two tasks, the answers are quite similar and generally positive, while in the third task they showed a much higher degree of indecision. At the first and second tasks, all students declared that they were completely or partially more entertaining to solve the task with the help of the application.

Also, in the first task, one hundred percent declared that they had enough time to solve it. That the first task easy to learn partially or completely agreed 85.72%, while for 71.43 % partially or completely it was easier to solve the task with the help of the application. In part, or completely, 71.43%, regarding the first task, they did not agree that they prefer the classic test for solving this type of tasks.

In relation to the second task, one student said that she had the feeling that she was controlling the situation while solving the task, and that the task was easy to learn. According to 85.72%, they had enough time to solve the task, and it was easier to solve with the application. They completely disagreed that they prefer the classic test for solving tasks of this type 42.86%, but there was 28.57% of those who could not decide on that matter.

When answering questions about the third task, 28.57% could not decide on the question whether the task is easier to solve with the use of the application, whether it is boring, or whether they prefer classic test for solving tasks of this type. At the same time, as much as 42.86% could not decide if they had the feeling of controlling events while solving the task and whether it was a pity that there were no more tasks of this kind.

These answers indicate either that the third task was uneven compared to the first two in terms of its weight and complexity, or there was a lack of understanding among the individual students when using this application in solving this task.

D. Opinions about the application

After completing the coursework, students expressed their opinion on the positive and negative aspects of the application. Table 6 shows these opinions.

As the most positive aspects, they stated: ease and simplicity, fun and futuristic, interactivity, interest, ease of learning, and virtualization.

According to the answers, the most negative aspects were: QR code is not well scanned, the application had some bugs, it was a bit slow, and the design was bad. All these issues are to be addressed in the future work.

TABLE 6. STUDENTS' COMMENTS

Positive	Negative
Simplicity and ease of use	QR code not scanning well
It is fun and futuristic	Possibilities of bugs
Interactivity	Slowness, bugs
Interesting	Bad design, slowness
Easier learning	Memory requirements
Virtualization	

V. CONCLUSION

This paper presents a model of an interactive game based on the Internet of Things. The game has been developed at the Faculty of organizational sciences, University of Belgrade. The goal was to motivate students to learn about IoT and smart environments.

The evaluation was conducted within the Summer school course Internet of Things with a small group of students. The results have indicated that this type of game has a potential for application, that it is considered useful and fun by the students, and that it contributes to their knowledge. In addition, the evaluation has shown the directions for improving the application before its wider use in the educational process. Besides improving the technical aspects of the system, future work will be directed towards the development of a higher number of tasks, further integration with Moodle and complete technical and educational evaluation of the system.

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REFERENCES

- [1] O. Migilino, A. Di Fernando, R. Di Fuccio, A. Rega, C. Ricci, "Bridging digital and physical educational games using RFID/NFC technologies", *Learning in smart environments*, vol. 10, pp. 92-106, 2014
- [2] D. Stojanović, Z. Bogdanović, N. Nedeljković, "Upotreba mobilnih tehnologija u srednjoškolskom obrazovanju", *Zbornik radova XLIII simpozijum o operacionim istraživanjima SYM-OP-IS*, pp. 71-74, 2016
- [3] P. Mikulecký, "Smart Environments for Smart Learning", *DIVAI 2012 9th International Scientific Conference on Distance Learning in Applied Informatics*, ISBN 97880-558-0092-9, pp. 213-222, 2012
- [4] D. Cook, S. Das, *Smart Environments: Technology, Protocols and Applications*. Wiley-Interscience, 2005, ISBN 0-471-54448-5.
- [5] S. Song, X. Zhong, H. Li, J. Du, F. Nie, "Smart Classroom: From Conceptualization to Construction," in: *Proceedings of the International Conference on Intelligent Environments*, pp. 330-332, 2014.
- [6] Đ. Knežević, M. Despotović-Zrakić, A. Labus, I. Jezdović, A. Ivković, "Pametna učionica: Razvoj pametnog novogodišnjeg osvetljenja", *Infoteh-Jahorina 2016*, pp. 649-652, 2016
- [7] X. Pei, X. Wang, Y. Wang and M. Li, "Internet of Things Based Education: Definition, Benefits, and Challenges", *Applied Mechanics and Materials*, vol. 411-414, pp. 2947-2951, 2013.
- [8] K. Simić, M. Despotović-Zrakić, A. Labus, M. Radenković, Z. Bogdanović, "Model infrastrukture obrazovne institucije zasnovan na Internetu inteligentnih uređaja," *Infoteh 2015, Jahorina 18-20. mart 2015*. ISBN 978-99955-763-6-3, pp.681-685.
- [9] A. Labus et al, "Enhancing formal e-learning with edutainment on social networks", *Assisted Learning Journal of Computer*, John Wiley & Sons Ltd *Journal of Computer Assisted Learning*, vol. 31. no. 6, pp. 592-605, 2015
- [10] L. MyounJae, "Secure game development for IoT environment", *J Comput Virol Hack Tech*, pp. 126-130, 2016
- [11] M. Pivec, O. Dziabenko, "Game-Based Learning in Universities and Lifelong Learning: "UniGame: Social Skills and Knowledge Training" Game Concept," *J. UCS*, 10, 4-16, 2017
- [12] J.C. Burguillo, "Using game theory and Competition-based Learning to stimulate student motivation and performance", *Computers & Education* 55, pp. 566-575, 2010
- [13] L. Ly-yi, Z. Yan-lin, "The Application of the Internet of Things in Education", *School of Education Science, Northeast Normal University, Changchun*, 2010
- [14] F. Xiang, J. Xin, "Research on the standards for the Internet of Things in education", *Journal of East China Normal University*, 2012
- [15] F. Tiejun, "Study on the Remote Experimental Teaching Management of Modern Education Technology", *Journal of Northeast Agricultural University*, 2007
- [16] M. C. Kooops, I. Verheul, R. Tiesma, C. de Boer, R. T. Koeweiden, "Learning Differences Between 3D vs. 2D Entertainment and Educational Games", *Simulation & Gaming*, vol. 47(2), pp.159-178, 2016
- [17] H.-H. Liou, S.J.H. Yang, S. Y. Chen, W. Tarnq, "The Influences of the 2D Image-Based Augmented Reality and Virtual Reality on Student Learning," *Journal of Educational Technology & Society*. Jul2017, Vol. 20 Issue 3, p110-121. 12p.
- [18] E. De La Guía, M. D. Lozano, V. M. Penichet, "Interacting with Objects in Games Through RFID Technology", *Radio Frequency Identification from System to Applications*, Dr. M. I. B. Reaz (Ed.), InTech, DOI: 10.5772/53448. [Online]: <https://www.intechopen.com/books/radio-frequency-identification-from-system-to-applications/interacting-with-objects-in-games-through-rfid-technology>, 2013.
- [19] M. Begg, D. Dewhurst, H. Macleoad, "Game-Informed Learning: Applying Computer Game Processes to Higher Education", *Innovate: Journal of Online Education*, Vol. 1, Iss. 6, Art. 6, pp.1-7, 2005
- [20] M. Griffiths, "The educational benefits of videogames", *Education and Health*, Vol. 20 No.3, pp. 47-51, 2013
- [21] Gros, "Digital Games in Education: The Design of Games-Based Learning Environments", *Journal of Research on Technology in Education*, 2007, 40(1), pp. 23-38
- [22] K. Kiili, "Digital game-based learning: Towards an experiential gaming model", *Internet and Higher Education*, Vol. 8, pp.13-24, 2005
- [23] M. Papastergiou, "Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation", *Computers & Education*, vol. 52, no. 1, pp. 1-12, 2009.
- [24] C. O'Driscoll "Smart Classroom Technology," *Advances in Technology, Education and Development*, Wim Kouwenhoven (Ed.), ISBN: 978-953-307-011-7, InTech, DOI: 10.5772/7925, 2009
- [25] C. Shen, Y. Wu and T. Lee, "Developing a NFC-equipped smart classroom: Effects on attitudes toward computer science", *Computers in Human Behavior*, vol. 30, pp. 731-738, 2014.
- [26] L. Petrović, I. Jezdović, Z. Bogdanović, M. Despotović-Zrakić, "Razvoj edukativne igre zasnovane na Internetu inteligentnih uređaja", *Infoteh, Jahorina Vol. 16*, pp. 506-509, 2017.
- [27] S. Yue, M. Naoki, M. Hiroki, I. Toru, S. Yuanchun, "Open Smart Classroom: Extensible and Scalable Learning System in Smart Space Using Web Service Technology", *IEEE Transactions on Knowledge and Data Engineering*, vol. 21, no. 6, pp. 814-828, 2009
- [28] X. Pei, X. Wang, Y. Wang and M. Li, "Internet of Things Based Education: Definition, Benefits, and Challenges", *Applied Mechanics and Materials*, vol. 411-414, pp. 2947-2951, 2013.
- [29] S. Aslan, O. Balci, "GAMED: digital educational game development methodology", *Simulation: Transactions of the Society for Modeling and Simulation International*, vol. 91(4), pp. 307-319, 2015
- [30] L. Petrović, D. Stojanović, A. Labus, Z. Bogdanović, M. Despotović-Zrakić, "Harnessing Edutainment in Higher Education: an example of an IoT based game", *The 12th International conference on virtual learning, Sibiu, Romania-Europe*, pp 318- 324, 2017



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