Practical Evaluation on Serious Games in Education*

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Abstract— **The arrival of the new learning methodologies is in response to the reality: new generations should learn in a different way. The so-called "Millennials" are looking for another kind of stimulus. Discussions for modernizing the curriculum include various solutions to retain students' attention and, in order to ensure that teachers learn how to act with a critical attitude, they will be confident and with the developed creative skills that they will need for success in the professional world in the future. The game based learning is more than providing educational games to students, it is about changing students' access to learning and their learning approach: the goal is to enjoy the learning process itself. This paper presents a methodological tool based on an evaluation framework for integration of digital games into education (MEDGE), expanded by adding additional information from the students, MEDGE+. The evaluation framework is used on three different approaches to the educational content: robot, micro: bit and playing quiz Kahoot. MEDGE+ presents better tool for the teachers in order to follow the student's interest when choosing appropriate educational games in the teaching process.**

Keywords—Serious games, critical attitude, games evaluation framework

I. INTRODUCTION

Today, the teacher abandons the role of a central figure, becomes a leader who guides the students through the learning process, enabling more learning styles, so that the student can move forward with his\her learning pace [1]. Students, on their part, use technology for communication, searching and finding information, expanding social experiences, and enjoying computer games on a daily basis [2]. The digital games (on their phones or computers) are played by students with a lot of energy and enthusiasm. This commitment is a challenge for the teacher - the learning process can be done through computer games. Students have transferable skills to share online research and access to many digital texts in a number of contexts. If digital literacy is encouraged throughout the teaching program, using positive language is necessary. By making such changes in the language teachers use, with the goal of becoming closer to their students' language, the students themselves will feel closer to the teachers and will understand the learning material more easily [3]. Technology offers a wide range of opportunities for developing learning experiences across a wide range of topics. If digital literacy is promoted through the curriculum, a positive language is required. By changing the language that teachers use, in order to be closer to the students, then the students themselves will feel closer with the teachers and will easily overcome the material.

II. RELATED WORKS

Confidentiality should be able to ensure that the data is only available to authorized users during the process and that it is not interfered by unauthorized people. Privacy is the most important security item in IoT because many devices can be integrated into IoT. It should be ensured that data received with a measuring device does not provide secure information to neighbouring devices. To ensure this privacy, advanced techniques and others, including key management mechanisms, should be developed and used [2].

It is essential to use wireless data transmission and to encrypt the information transferred between the nodes in order to keep it confidential. The most appropriate encryption algorithms and adequate key management systems are required to secure this data [3].

Wireless sensor networks have a large number of trust-based intrusion detection systems (IDS) that are used to defend against attacks. However, the effectiveness of IDS decreases in IoT due to the large amount of data produced in a short time. Meng et al. [4] proposed a Bayesian-based trust management method that incorporates traffic sampling into IDS under a hierarchical structure [5].

James King of Lulea University created an IoT network in his work in 2015 within the local network. Arduino used it as a gateway and collected and encrypted data from different devices and sensors. The encryption algorithm used is the Advanced Encryption Standard (AES) with both 128-bit and 256-bit key length [6]. Mahmudur Rahman, Bogdan Carbunar and Umut Topkara from Florida International University collects instant values from devices such as stopwatch, heart rhythm tracker and moisture meter used in fitness studies and transmits the IoT device to a web server remotely. In this study, FirstBeat is used as an encryption algorithm and Arduino Uno device is used as an IoT device. It also belongs to the IoT device from the webserver by taking the coordinate data, we can track the point we are at via GPS [6].

III. BACKGROUND

With carefully selected concepts and accompanying pictures that create a pleasant and creative atmosphere,

children learn more easily through various activities of games and tasks. The games often have a fantastic element that intrigue players and engage them in learning activities [4,5,6].

But in order to apply games in teaching, more conditions need to be met. According to the UNESCO framework, teachers should use educational (serious computer games) in education, preferably in accordance with the application of the teaching experience [3]. Teachers should have the following competencies:

- Using the Internet for online research;
- Using tools for making text and spreadsheets, making presentations;
- Using communication and collaboration tools such as emails, video conferencing and social networks;
- Application of ICT sources for curriculum development;
- Interest in continuing upgrading and improving the teaching content they teach and their teaching skills;
- Knowledge of the subject they teach to be appropriate for the age of the students;
- Have managerial and organizational skills;
- Knowledge of strategies that will help the student to gain in-depth knowledge such as:
    o Learning Collaboration;
    o Problem-based learning;
    o Project-based learning;
    o Activities based on project development;
    o Games and simulations;
    o Research experiments;
    o Case study;
    o Exercises;
    o Mentoring;
    o Evaluation.

What conditions should the school have in order to introduce educational games in teaching? The answer to this question divided in two parts:

- Provided technical equipment in the classroom and
- Teachers have to have appropriate digital competencies.

The word "competence" means knowledge or expertise in a given area [7]. Accordingly, digital competence is the ability to track, analyse, evaluate, generate and transmit information in digital format. This applies to desktops, laptops, smartphones and similar devices. Regarding the discussion of this term, there are various attempts to define definitions that are in use, as well as a few related names for it, such as information, the Internet or media competence. A person who is digitally competent will have more interlinked skills: knowledge of the basic principles of computer hardware, computer networking skills, the ability to engage in online communities and social networks. By digitizing human knowledge and developing digital technologies (mass production of devices that have access to the Internet). We can conclude that a digitally literate person will have practical knowledge of hardware and software, but also different kind of knowledge that they did not have in the last century. Computer literacy is often considered today as the ability to use the computer programs for some less complex practical tasks or the ability of individuals to effectively use the computer. Digital competence, or in other words, digital literacy, is considered to be as important today as reading and writing. Digital devices are starting to be used from an increasingly young age, but this does not help much young people to develop the skills they need for further personal and professional upgrading. Digital competence is far more than just accepting new technologies and using social media in order to create some content.

Today, digital literacy is almost equally necessary to attain personal and professional ambitions. It allows seemingly complex tasks to be performed in a much simpler and more efficient way and with better results. It is necessary to focus attention on the way the students use devices in extracting knowledge.

Digitalization and inroads have already led to major changes in our daily lives and our world in terms of information and work. However, these numerous changes have not yet become clearly visible and understandable to us. For this reason, it is particularly important to pay attention to large volumes of new information and to all innovations. To do this, it is necessary to have a sufficiently high level of digital competence.

As far as the technical equipment of the schools is concerned, as a first requirement is that there is an Internet connection and at least one laboratory with a certain number of computers, preferably connected in a local network. Possession of additional tools and equipment can greatly enrich hours with certain activities. The LEGO Mindstorm EV3 Robot [8] and micro:bit tools [9] are used in practical case studies.

IV. THE CASE STUDY

In order to conduct this evaluation, the evaluation framework for integration of digital games into education (MEDGE) was used [10], expanded with two new questions, thus MEDGE+.

The following questions were answered by several professors at the "Jane Sandanski" High School:

- Is the game easy to use? (EASY)
- What is the educational goal of the game? (VAL)
- Does the game adapt to educational goals? (ADT)
- Pleasure / acceptance of the game by students? (QoE)
- What is the teacher's subjective opinion about the game? (SUB)
- What is the motivation of students to adopt the material? (MOT)

In order to achieve better motivation for the students when applying serious games, two questions were added, where the students were asked the following questions (MEDGE+):

- Through the game, I will easily overcome the material (EL);
- Through the game, my motivation for material adoption (MS) will increase.

The following scale of responses was offered:

I totally agree (5). I agree (4), I am neutral (3), I disagree (2), I completely disagree (1).

A. Case Study 1 - LEGO

A class in high school using a memory game (with the help of the LEGO Mindstorm EV3 Robot) [8].

Teaching unit: One-dimensional arrays;

Type of lesson: lecturing;

In order to get the students interested as much as possible on this thematic unit, a memory game in Python was used through simulation of robotic games. Preparing for this guide: LEGO Mindstorm EV3 Robot is the tool used for this game. A robot with specific parts is built in the instructions for building the LEGO Mindstorm Education Core Set. The goal and the game is to build the main body for the robot (base unit) and the color sensor.

Effects

Computer Science (Python) - This lesson will help students understand the use of an array, from an abstract concept to a point where they actually understand how the color storage works in random order. Students will be introduced to the random functions used to generate colors.

Exercise

Create a program that will put random colors in sequence, and then the robot will repeat (express) the order of colors. The student must remember the colors and show colors on the card to the robot sensor in the same order as given. In the end, the robot announces whether the study of time wins or not.

Reflection

Students learned how to store colors in arrays and to check if the generated colors are the same as shown in front of the sensor. They can also make different versions of this program by counting a score and saving other type of data. Based on a poll conducted after playing this game, the following results were obtained, given in the Fig1:

	EASY	VAL	ADT	QoE	SUB	MOT	EL	MS
robot	2,5	3,4	5	3,8	4,4	4,6	4,4	4,1

Fig. 1. Review of robot responses, MEDGE+

B. Case Study 2 - KAHOOT

Teaching unit: Basics in programming with C++ Type of lesson: Kahoot quiz to check the acquired knowledge on the topic Introduction to programming in C ++.

Kahoot [11] is a formative learning tool that uses quizzing technology, discussions and surveys. The principle of work is basically a game in which the whole class participates in real time. For the preparation of this class, a quiz with 10 questions was developed, which examines the gained initial knowledge in programming in C ++, which is necessary to start programming the simplest tasks in C ++.

Exercise

Students get the link and join the game.

Reflection

The class with Kahoot was filled with excitement and euphoria like no previous one. The competitive spirit was at the highest level. After the quiz was conducted, questions that were incorrectly answered were discussed. The students asked after each teaching unit (or at least after completing a theme) to have a time dedicated to competing with the Kahoot Quiz. Based on the conducted survey after playing this game, the following results were obtained, given in the Fig2:

	EASY	VAL	ADT	QoE	SUB	MOT	EL	MS
Kahoot	4,6	5	5	5	4,7	5	4,8	4,7

Fig 2. Review of Kahoot responces, MEDGE+

C. Case Study 3 - MICRO:BIT

A class in high school using a micro:bit [9] to verify acquired knowledge of algorithms with a branched structure.

Teaching unit:

Algorithms and programming;

Type of lesson:

Algorithms and their representation. In order to hold this lesson, the OOU Sando Masev Strumica was visited, where, with the help of the British Council, the school owns 30 micro:bit devices [12]. At this class, the application of the algorithm with a branched structure was presented, realized practically with the micro:bit device.

Exercise The acquired experiences were used for introduction into the branch structure. Other approaches were introduced to explain algorithms with a branch structure. The students were able to solve other examples.

Reflection

By using the micro:bit, the programming becomes clearer, closer and more attentive to the students. The survey by MEDGE+ has produced the table in Fig 3.

	EASY	VAL	ADT	QoE	SUB	MOT	EL	MS
micro:bit	4,3	5	5	4,5	4,2	5	4,8	4.5

Fig.3. Review of micro: bit responces, MEDGE+

The evaluation methodology MEDGE+ produces the net presented in Fig.4. It gives graphical representation of the game/tool acceptance in the three case studies.
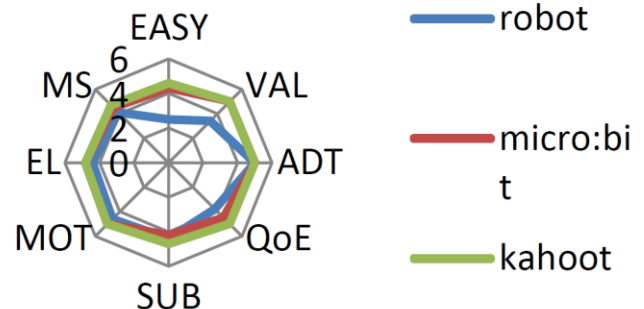

Fig4. Evaluation of the explored games with MEDGE+

V. DISCUSION

In this part a discussion of the three case-studies is given. At the lesson of one-dimensional strings, the good sides were: greater interest and curiosity towards something new, resulting in increased interest in learning and interest in research through additional sources for the new concepts. The negative sides were that the use of robots in teaching requires additional costs, one robot is a not enough for a group of 24-30 students. Another point is the programming language - in order to use the robot in the teaching process, another programming language was needed, and not the one that is studied in the regular classes. The good sides in the realization of classes using the Kahoot quiz for repeating the material for the basics of programming were: initiating a competitive spirit, raising awareness of teamwork, getting quick results for the correct answers and showing greater interest in understanding the reasons of choosing the wrong answers. Also, all students answered the same questions at the same time and there was no fear of consequences if wrong answer was submitted.

In the third case study, the algorithms for a branched structure with micro: bit was introduced. The positive side was this new approach to learning algorithms. It was more interesting to the students because of the visualization and the ease of use. One disadvantage of using micro:bit in high schools is that following the curriculum, micro:bit can be applied only at the beginning of the programming courses because the latter material is more complex.

VI. CONCLUSION

The introduction of games in IT teaching is a very positive experience [13,14,15], but of course, the realization of each of these serious games and tools has positive and negative aspects.

In this paper, following the evaluation methodology [10], MEDGE+ was introduced that can give even more insight when choosing an appropriate educational game in the teaching process. We have explored three case studies, and used the MEDGE+ methodology to measure the acceptance of the given games and tools.

The performed analysis was done over three different games: robot simulation, Kahoot and micro:bit coding. It showed that all three activities positively influenced the process of adopting new knowledge and knowledge testing, while the greatest satisfaction and motivation according MEDGE+ achieved the quiz Kahoot. The extension of the methodology [10] considered the inclusion of the student's opinion, contributing to the teacher's decision which games/tools should be chosen in the educational process.

The use of games in teaching obviously has many advantages, and as a future work, more examples of games and tools will be evaluated using the information provided by MEDGE+.

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