Recommendation Systems Supporting the Educational Procedure: the Case of Grifobot

Vassilis Poulopoulos, Manolis Wallace, Panagiotis Kokkinos, Marina Lantzouni
Knowledge and Uncertainty Research Laboratory
University of the Peloponnese
Tripolis, Greece
vacilos@uop.gr, wallace@uop.gr, p.kokkinos@uop.gr, lantzouni@sch.gr

***Abstract*—As we enter a novel era for education, the need for adaptation of both students and their teachers to the modern educational procedures arises. Using technology in education and especially games as a learning tool has gained attention throughout the years but it seems the time has come for it to be applied on large scale. Under these circumstances, we have designed and implemented "Grifobot" an online Game-Based Learning platform. Grifobot was initially designed to provide an entertaining learning tool, but pivoted and changed to become a recommendation system that can support the educational procedures. In this paper, we present the main idea of the recommendation system and the first results of its experimental evaluation.**

***Index Terms*—educational procedure, recommendation systems, modern education, grifobot**

I. Introduction

The educational procedure as a whole has gained attention during the first months of 2020, due to the "lockdowns" applied in many countries worldwide, as a precaution measure against the COVID-19 pandemic. Several educational systems – including Greece's – were forced to apply, in a matter of days, distance learning procedures. The political decisions were the ones that directly affected the social, economical and cultural aspects of our lives, leading students to face a new educational process.

While the use of novel technologies in education is a research field that flourishes for decades, still, many teachers and educators have difficulties adopting them. In fact, a large number of educators avoid the usage of technology, as it is not directly supported by the educational systems in several countries. Researching the state of the art in the combination of technology and education, reveals that the discussion remains the same for more than 30 years. In 1987, Seymour Papert – the father of LOGO – wrote about "computer criticism vs technocentric thinking" in an attempt to analyze the different points of view between "technologists" and "humanists" [1]. He furthermore analyzed how a specific computer programming language (LOGO) can be used as a cultural building material, and not as a conservative educational policy. The discussion was not about the use of technology at school or not, but on how to successfully adopt the technology and how to teach it in the classroom. Ten years later – more than 20 years ago – Fabry and Higgs performed research on the barriers of effective use of Technology in Education [2]. They concluded that despite the existence of the infrastructure, there were still persistent barriers to overcome, including not only the lack of sufficient computer units for the students, but most importantly the lack of technical support, and inadequate professional development. At the same time, research on the effects of technology integration in education on the attitudes of teachers and students, revealed that in 1995 the U.S. Congress Office of Technology Assessment reported that "helping teachers effectively incorporate technology into the teaching and learning process is one of the most important steps the nation can take to make the most of past and continuing investments in educational technology"; which lead to the conclusion that for more than 25 years countries were trying to adopt technology in education [4]. On the other hand, from the very past [3] till nowadays [5] [32] [33] the question remains the same: what is the attitude of educators towards technology in education?

Technology has emerged during the last decades, offering a wide variety of solutions to several sectors, education included. There is a considerable amount of literature regarding the available tools and how they can be used in the classroom. It is important to focus on educators who are not technology-related, as they are the ones that are reluctant in using digital tools in class. Throughout the last - many - years there is a keyword repeating itself in the research in the field ICT and Education: "new technology tools". Researchers and educators keep collaborating in order to generate novel tools that can be used during the educational procedure. Starting from the very early ages (1980s), videos, images and sounds progressing to today's tools for synchronous and asynchronous communication, technology can play an important role in a classroom. Tools for asynchronous education include multimedia, online data (encyclopedias), web forms (tests), forums; while tools for synchronous educational procedure lead mainly to teleconference platforms and online chats. In parallel there is a number of tools - not necessarily related to classrooms, but directly related to the educational procedures - that use serious games in education leading a field often referred to as Game-Based Learning [36]. A large number of EU projects (as well as EU calls for funding) are directly related to Game-Based Learning. EU-funded projects like NAVIGATE, GUINEVERE, Beaconing, Mobile Game-Based Learning and SIG-GLUE are only some of the projects that have as their

 ISBN: 978-1-68558-020-9

main scope Game-Based Learning and serious games.

In this paper, we will present Grifobot, an online educational game created during the COVID-19 lock-down in order to educate and entertain primary school students, which turned out to be a very successful tool that was finally altered and enhanced to become a teacher's supporting tool. The initial problem-solving-using-code tool (the first version of Grifobot) was changed in order to include recommendations for automated or supportive education. This online game is a proof that a paradigm shift in education is possible, and that both students and teachers can adapt to such unexpected situations, if they are provided with the appropriate tools.

The rest of the paper is structured as follows. Section II presents related work in the field of educational games and recommendation systems, while Section III presents the architecture of Grifobot. Section IV presents the experimental evaluation of the online game and Section V concludes with future remarks.

II. Related Work

Game-Based Learning is a research field that has gained attention since the early years of modern pedagogical systems formulation. John Magney wrote back in 1990 that "Game-Based Teaching is a relatively recent addition to the formal curricula of schools and colleges", but still he recognizes Game-Based Learning as a procedure that can lead back to examples from the past (e.g., war games) [7]. Although the game procedures are recognized as a learning procedure for more than 30 years, it is the evolution of technology that provided more assistance and infrastructure to both students and educators in order to apply them in the classroom. A similar outcome is described in [9], stating that computer games may create a new learning culture. Gee focuses more on video games and their "ability" to be ideal for learning [34].

From the early 2000' Prensky noted that students need motivation in order to successfully learn [8]. Students often refer to their educational system and procedures as "boring" or "dry", as the same researcher states. He also expresses his certainty that a combination of learning and the motivation of games is exactly what the learners need.

Trying to define what consists of the first part of the research field "game" is usually assumed as a digital game, but it is not always the case [12]. In [13], the game is described as "a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome", which is sufficient for the involvement of gaming procedures in the educational procedure. But what is this "game" all about in a classroom? Kili recognizes four main aspects of Game-Based Learning (GBL) [10]. It is all about *Motivation* [14], *Player Engagement* [15], *Adaptivity* [16] and *Graceful Failure* [17].

An analysis of the role of games in education, and how they can be used, or even the exact models for each class or lesson is nowadays a multi-disciplinary field of research including several different proposals that cover a very wide variety of educators' and students needs [18] [19] [20] [21]. In parallel, there is literature that criticizes the use of video-games as a learning tool [22].

A number of EU-funded projects are related to the GBL and "serious" games field as the European Commission provides financial tools for the combination of education and technology. "Gaming Horizons" [23] is a project funded by the European Commission under the Horizon 2020 research and innovation programme. Its scope is to democratically open up new areas of public value for the games industry as a whole, beyond sectorial distinctions between "leisure" and "serious" games. Navigate project [24] is an Erasmus+ project that intends to apply an innovative approach based on digital gaming to increase competences on information literacy (IL), starting from higher education students in Humanities. BEACONING - that stands for Breaking Educational Barriers with Contextualised, Pervasive and Gameful Learning - is another EU-funded project that focuses on 'anytime anywhere' learning by exploiting pervasive, context-aware and gamified techniques and technologies, framed under the Problem-Based Learning approach [25]. ProActive project [26] and SIGGLUE project [27] as part of the Lifelong Learning EU funding scheme, explore paths of the usage of technology for learning and life-long learning, while a number of projects are exploring the combination of technology and education [28] [29] [30] [31].

Grifobot is a prototype attempt to empower the use of technology in education aiming to facilitate educators in evaluating the skills and level of their students, and to help them to recognize the weaknesses of their class and adjust their educational procedure accordingly.

III. Grifobot

Grifobot is an online game that was designed and implemented within a very short period of time as its scope was entertainment and education during the COVID-19 lockdown. The game's name is a compound bilingual word made up from the greek word $\gamma\rho\iota\phi os$ meaning riddle, connundrum, and the word bot.

Its initial version was very simple and focused on maths, language and literature. The game consists of a square board (5x5) with cells. Each cell is either empty, blocked or has a quiz as presented in Figure 1.

The students have an avatar with an initial position. The scope of the game is to solve as many quizzes as possible, guiding the avatar from question to question trying to find the shortest path. Each time a correct answer is given, the avatar must move to the correct cell using code. Giving the wrong answers means missing the quiz and points. The "code" was actually a process of finding the steps that lead from the current position to the position of the correct answer.

A. The Game

The game is simple to use and easy for the students to learn. Each student is registered to the system recording his/her grade. According to the grade, the system presents boards with questions on maths and literature. The students have to find the

 ISBN: 978-1-68558-020-9

correct answer and guide their avatar to the cell for the next question. They are instructed to use the shortest path through their way to the questions as this procedure is the one that helps earning the most points.

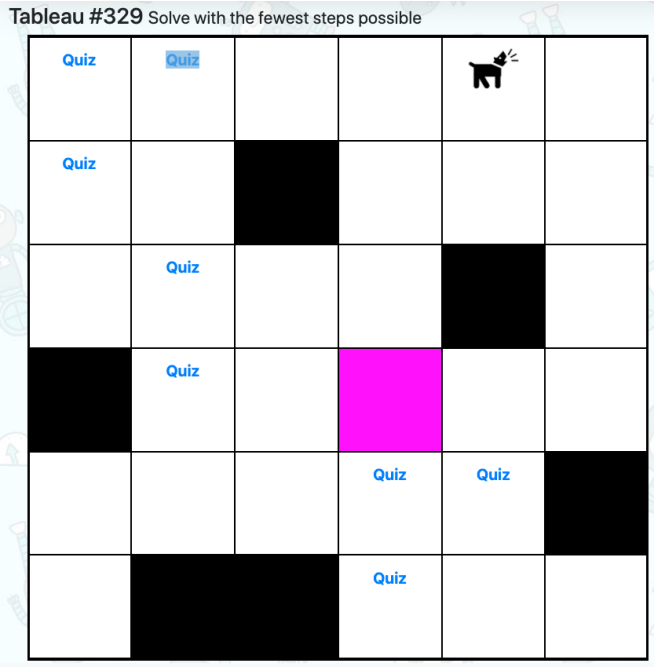


Fig. 1. Board of Grifobot's initial version.

B. The idea of the recommender version

Grifobot had gained enough attention and had undergone three major changes, and it was already interactive enough to perform the next step, which was adding features that will make Grifobot an educational tool for the teachers. The questions were separated into categories and sections, and were assigned a difficulty level. The role of the teacher was added to the back-end of the system and a new dashboard was designed for them. Each teacher could create his/her own class and create questions and quizzes for each class. The quizzes could have categories (e.g., maths, geography, history), sections of categories (e.g., maths/fractions, history/Trojan War, etc.) and a difficulty level of each section in a range of one to ten (1..10). Furthermore, the quizzes (categories and sections) were "sequenced"; meaning that the section fractions was placed after the section integer numbers. The students were able to follow a specific category and section (with the guidance of their teacher) and start the quizzes. According to their progress the system was able to recognize their strengths and weakness and either progress to the next difficulty level and the next section, or repeat the procedure until the student is strong enough to progress. In case a student remained weak, the system could downgrade the level. The teacher is aware of the students' progress and is able to know the strengths and weaknesses of each one.

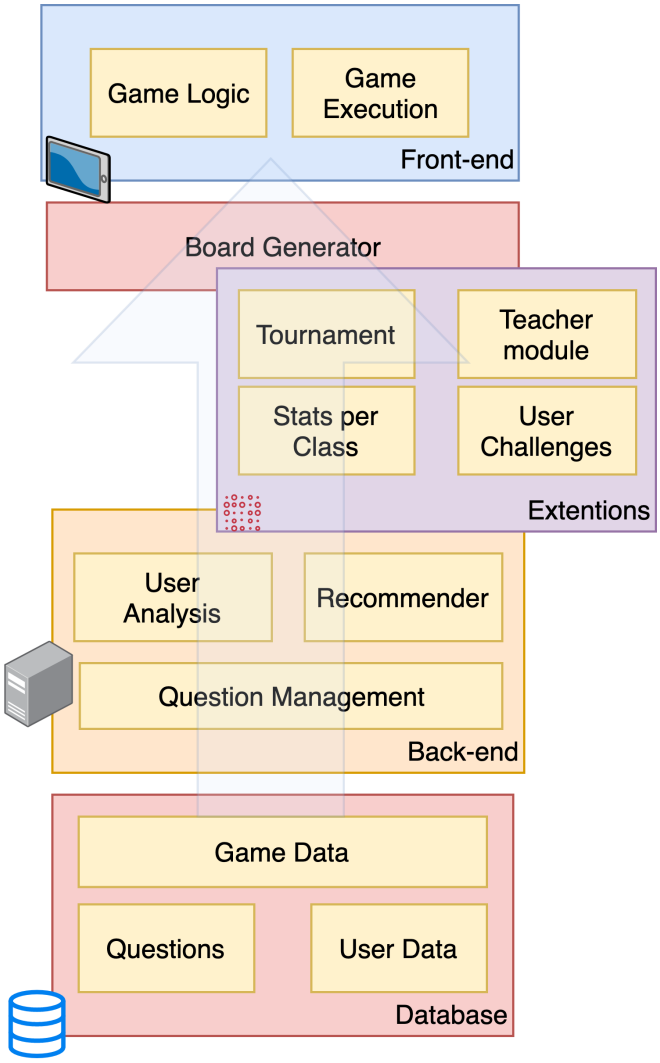


Fig. 2. System architecture.

C. Architecture

The system architecture follows the classic client-server model, having the game logic both in the back-end as well as in the web-based front-end. The system has several levels of discrete tiers while it is built-in open standards in order to easily adapt add-ons and useful extensions (Figure 2). The basis of the system is a database layer that stores information about the games and the users and stores the pool of questions to be answered. Each question has a number of metadata including category, section, level, type of answer, accompanying images, correct answer, possible answers, book reference and explanation. According to the type of procedure that an educator wants to follow the respective fields can be filled with data. By filling the complete set of metadata, the student is be able to see the correct answer, to get some assistance from the system, to find a book reference so that she or he can search for the correct answer.

The question management module is responsible for handling all the information related to the questions and answers.

 ISBN: 978-1-68558-020-9

The main back-end features include - apart from the question management - the parts of the user management as well as the recommender system. User management module stores information about the system users, educators, students and system administrators. The user data include information that is useful system-wise (student grade) and classroom-wise. In the latter we can find information about what kind of questions are answered (category), what is the level for each category, in which level the student shows strengths and weaknesses, and general data including playing duration, number of boards solved and more.

Grifobot is designed and implemented on Laravel framework [6] and its main code engine can be found on Github [**?**]. A board generator is the final module of the "back-end" as it includes a mechanism to create a non-blocking board, selecting the appropriate type of questions, size of boards and graphics. The output of the board generator is a web-standards object and specifically it is JSON formatted code. This selection is made in order to decouple the procedure of board creation to the end-device. The rest of the game-logic is upon the client-side implementation and is also available on the open game repository.

This implementation helped us create a totally different look and feel for the recommender version of the system without having to change anything related to the code or logic, just by altering the client side styling. This was selected in order to attract the students to use the system (Figure 5).

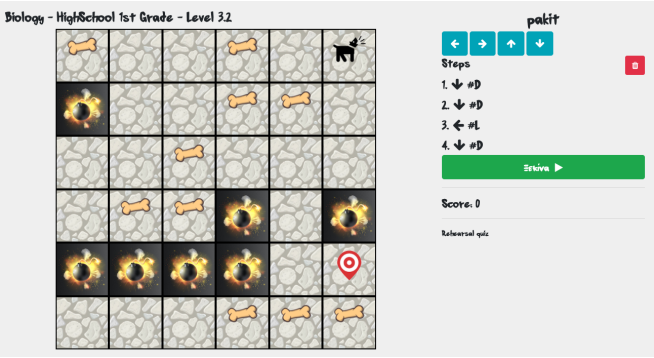


Fig. 3. Board used by the recommender system.

D. Recommendation System - Assisting Educators

The recommendation system is built as a main part of the system, as the whole system pivots towards this direction. The recommendation system follows a two step procedure in the students' evaluation. The first step is the identification of the students' capabilities through an assessment procedure. The second step includes iterations over a number of questions, in order to locate the weaknesses and strengths of each student.

The system uses different subject categories, topics in categories and difficulty levels of a specific topic within a category. For each of the topics the questions can be assigned a level; for example the question 1+1 is of lower level, compared to the question 6+3 (within the same topic).

1) System Initialization: The assessment procedure on a particular category, starts by selecting random questions from the lower level of the first topic. If the questions are answered correctly and quickly, the assessment procedure raises the level. If top level in a topic is reached the next topic is selected. If a student is not able to reach the top level the assessment procedure stops. The combination of topic/level indicates the progress of the user. For example, if a user manages to complete all the questions up to the third topic second level, then its progress within the Grifobot system is 3.2. The system records this number as the current level of the user for the specific category.

The assessment provides information to the teacher on the level of understanding of the student or for the whole classroom. This step is performed, when students enter a new category, in order to determine his/her overall status. It is also helpful for the educators in order to recognize the level of understanding of their classroom.

2) Main procedure: According to the progress recognized from the initialization procedure, a student can start performing exercises on his/her current level. The system keeps providing questions from the current level, while giving clues and tips related to techniques or useful information to help the students find the correct answer. A level is considered to be "completed" when a user is able to find solutions for more than 75% of the questions without using system tips and clues. If all levels of a topic are completed, then the user is able to progress to the next topic. Finalizing the whole set of topics means that the user has "mastered" the current category.

E. The system as a tool

The system can be used throughout the year as it offers several positive aspects for both the students and the educators. First of all, talking about a "serious" game with scoreboard among the students of the same classroom it motivates the users to play and learn, it engages the students with the current gaming procedures, its support and help on error mechanism provides graceful failure and it helps the educators adapt on the needs of the classroom. It is both a tool for revision and a tool to recognize the weaknesses of students or the classroom. So, it can be helpful in order to personalize the teaching procedure for groups of students or even sole students.

IV. System Usage

With the help of educators from primary and secondary schools in Greece, the system was tested in a real environment and more specifically the tests were performed during the period of lockdown (due to COVID-19) using Grifobot as just an educational game to play.

45 students participated in the game consisting of 7 topics with 3 levels, in the category of Maths. This would make the system having the levels 1.1 to level 7.3. An assessment procedure was initiated in order to define the level of each student. As the procedure was initiated almost in the middle of the year the assessment concluded to the graph presented in Figure 4. A first outcome was that the majority of the students

 ISBN: 978-1-68558-020-9

could reach up to topic 4 level 3 (22 students), while an almost equal amount (20 students) could reach levels 4.1 or 4.2. This indicator helped the educator realize on which specific point in the theoretical part of the lesson he/she could focus and progress.

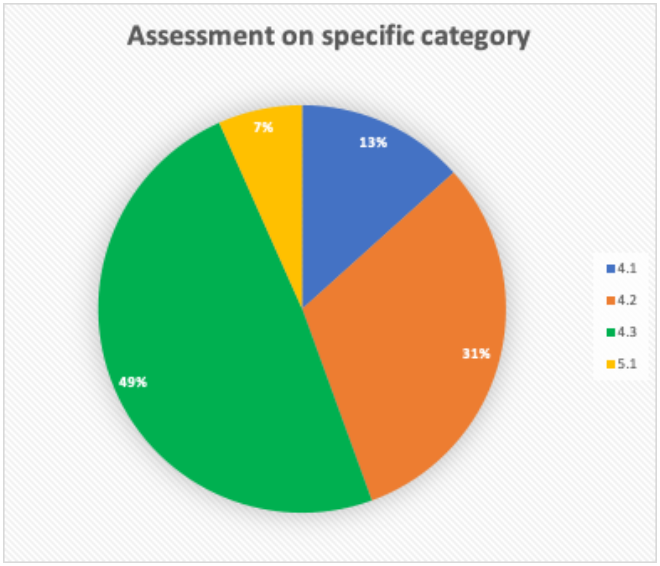
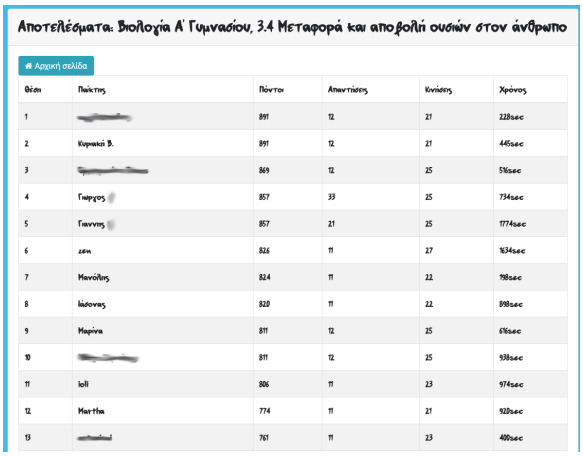


Fig. 4. Assessment of students.

The students keep "playing" with the system as it would present their score in a table per topic and level (Figure **??**), a part that they really enjoyed and engaged them (according to their comments). The parts that students enjoyed most - according to their comments- were on the one hand the game itself and the fact that they would be able to watch the scores within the classroom and on the other hand the fact that when they were unable to provide the correct answer, they were guided by the system in order to locate the correct answer in their books.


Αποτελέσματα: Βιολογία Α' Γυμνασίου, 3.4 Μεταφορά και αποβολή ουσιών στον άνθρωπο

Αρχική σελίδα

Θέση	Παίκτης	Πόντοι	Απαντήσεις	Κινήσεις	Χρόνος
1	[redacted]	891	12	21	228sec
2	Κυριακή Β.	891	12	21	445sec
3	[redacted]	869	12	25	516sec
4	Γιωργος	857	33	25	734sec
5	Γιαννης	857	21	25	1774sec
6	zan	826	11	27	1634sec
7	Μανώλης	824	11	22	198sec
8	Ιώαννας	820	11	22	898sec
9	Μαρίνα	811	12	25	676sec
10	[redacted]	811	12	25	938sec
11	loli	806	11	23	974sec
12	Martha	774	11	21	920sec
13	[redacted]	761	11	23	400sec

Fig. 5. Sample results table.

The system was tested during the difficult period of the lockdown, as such, the students were more "on their own"

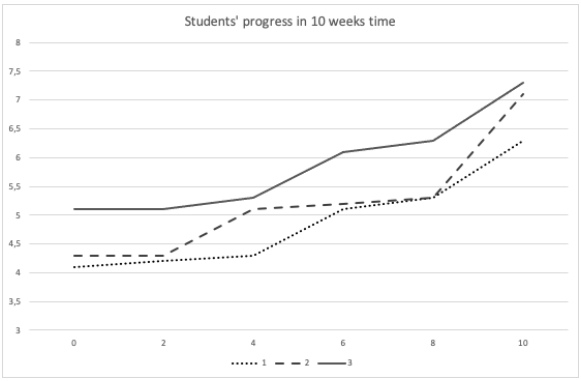


Fig. 6. Students' progress in 10 weeks time.

when reading and progressing rather than under the strict supervision of their educators. Under this circumstance, the system could monitor their progress in a 10 weeks time period that they used the Grifobot recommender system. It is clear that all the students managed to make even a small progress with the majority of them (more than 70%) being able to progress more than 2 topics in average.

Figure 6 presents a comparison of the different levels of students progress. The solid line represents students that scored higher during the assessment, the dashed line represents students with medium (to lower) scores while the dotted line represents students with the lowest score. It is obvious that the system was able to record their progress through time and helped the teacher realize during the 6-8 weeks that there is a difficulty in progress for a number of students which was inspected quick enough in order to progress better during the last 2 weeks.

V. Conclusions

As GBL gains more and more attention and while technology becomes a part of our educational systems, Grifobot introduced a novel educational culture, combining a "serious" game with the educational procedure. We performed a detailed analysis on the importance of gaming within the classroom and by recognizing the problems that both students and teachers face we built Grifobot.

Grifobot, an online platform that was created during the lock-down due to COVID-19 virus, was constructed in order to support students of the preliminary schools revise their lessons. A system that turned out to become a recommendation system that can support the educational procedure within a classroom. The usage of the system can help gain the four main aspects of game-based learning: motivation, engagement, adaptability, graceful failure, as well as empower the teachers with a tool to analyze the strengths and weaknesses of their classrooms; and thus their lessons' outlines.

We presented experimental results of the system's usage within a real classroom and how this provided evidence to the educators about the progress that the class is able to make according to the curriculum.

 ISBN: 978-1-68558-020-9

The system - being at an experimental phase of application in classrooms - is a live organization changing frequently, adapting to educators' and students' needs and is enhanced with novel and innovative features in order to cover the excessive demands that young people have.

Some of the features to be applied in the next versions include advanced graphics interface in order to further enhance children's engagement, create a mobile application instead of mobile friendly web application, construct an adventure game that will further enhance the coding part of the system and create a double-interface API in order for game developers to be able to create add-ons that can easily be connected to Grifobot platform.

An important aspect of the system is the ability to support several different levels of education. As the core of the system remains the same (solving problems), the accompanying environment can be adapted to the needs of students. An experimentation of the system that is being conduct the last year is examining whether a system like Grifobot, can be applied to University Students with non-technical background. The idea is that students mainly of humanities can benefit from a system that could be used as a recommender system, in order to monitor their progress, and be a tool for assessment, while in parallel being able to compete and learn soft-skills related to algorithms and sequential coding procedures.

ACKNOWLEDGMENT

The work was partially funded by ARTEST project (project no. 618802-EPP-1-2020-1-DE-EPPKA2-CBHE-JP. ARTEST Project is co-funded by the ERASMUS+ Programme of the European Union.

REFERENCES

[1] S. Papert, Information technology and education: Computer criticism vs. technocentric thinking. Educational researcher, 16(1), pp. 22-30, 1987.

[2] D. L. Fabry and J. R. Higgs, Barriers to the effective use of technology in education: Current status. Journal of educational computing research, 17(4), pp. 385-395, 1997.

[3] C. P. Gressard and B. H. Loyd, Validation studies of a new computer attitude scale. AEDS Journal, 19(4), pp. 295-301, 1986.

[4] R. Christensen, Effects of technology integration education on the attitudes of teachers and students. Journal of Research on technology in Education, 34(4), pp. 411-433, 2002.

[5] L. N. Tabata and L. K. Johnsrud (). The impact of faculty attitudes toward technology, distance education, and innovation. Research in higher education, 49(7), 625, 2008.

[6] Laravel, the PHP Framework for Web Artisans. http://laravel.com (last accessed June 2022)

[7] J. Magney, Game-based teaching. The Education Digest, 55(5), 54, 1990.

[8] M. Prensky, Digital game-based learning. Computers in Entertainment (CIE), 1(1), pp. 21-21, 2003.

[9] D. A. Norman, Things that make us smart: defending human attributes in the age of the machine, 1993.

[10] K. Kiili, Digital game-based learning: Towards an experiential gaming model. The Internet and higher education, 8(1), pp. 13-24, 2005.

[11] J. P. Gee, What video games have to teach us about learning and literacy. Computers in Entertainment (CIE), 1(1), pp. 20-20, 2003.

[12] J. L. Plass, B. D. Homer, and C. K. Kinzer, Foundations of game-based learning. Educational Psychologist, 50(4), pp. 258-283, 2015.

[13] K. Salen, K. S. Tekinbaş, and E. Zimmerman, Rules of play: Game design fundamentals. MIT press, 2004.

[14] S. Hidi and K. A. Renninger, The four-phase model of interest development. Educational psychologist, 41(2), pp. 111-127, 2006.

[15] A. I. Abdul Jabbar and P. Felicia, Gameplay engagement and learning in game-based learning: A systematic review. Review of educational research, 85(4), pp. 740-779, 2015.

[16] R. Azevedo, J. G. Cromley, D. C. Moos, J. A. Greene, and F. I. Winters, Adaptive content and process scaffolding: A key to facilitating students' self-regulated learning with hypermedia. Psychological Test and Assessment Modeling, 53(1), 106, 2011.

[17] W. Hoffman, AI and the Future of Cyber Competition. Center for Security and Emerging Technology. https://cset.georgetown.edu/publication/ai-and-the-future-of-cyber-competition, 2021.

[18] C. Y.Chang and G. J. Hwang, Trends in digital game-based learning in the mobile era: a systematic review of journal publications from 2007 to 2016. International Journal of Mobile Learning and Organisation, 13(1), pp. 68-90, 2019.

[19] A. Theodoropoulos, Framework for the effective implementation of alternative teaching methods for informatics, PhD Thesis, Fac. of Economy, Management and Informatics, Dept. of Informatics and Telecommunications, 2017.

[20] A. Theodoropoulos, A. Antoniou, and G. Lepouras, How do different cognitive styles affect learning programming? Insights from a game-based approach in Greek schools. ACM Transactions on Computing Education (TOCE), 17(1), pp. 1-25, 2016.

[21] I. Antonellis, C. Bouras, and V. Poulopoulos, Game based learning for mobile users. In 6th International Conference on Computer Games: AI and Mobile Systems, 2005.

[22] M. Ronimus, K. Eklund, L. Pesu, and H. Lyytinen, Supporting struggling readers with digital game-based learning. Educational Technology Research and Development, 67(3), 639-663, 2019.

[23] Gaming Horizons project. Alternative Framings for a new role of gaming in education and society. GA 732332, https://www.gaminghorizons.eu/ (last accessed June 2022).

[24] Navigate EU project. Information Literacy: A Game-based Learning Approach for Avoiding Fake Content. ERASMUS+ Project 2017-1-BG01-KA203-036383, https://www.navigateproject.eu/ (last accessed June 2022).

[25] Beaconing EU project Breaking Educational Barriers with Contextualised, Pervasive and Gameful Learning. GA 687676, https://beaconing.eu/ (last accessed June 2022).

[26] ProActive EU Project. Fostering Teachers' Creativity through Game-Based Learning. Lifelong Learning Programme. 505469-LLP-1-2009-1-ES-KA3-KA3MP

[27] I. Antonellis, C. Bouras, V. Kapoulas, and V. Poulopoulos, Enhancing a web-based community: the case of SIG-GLUE. International Journal of Web Based Communities, 2(1), pp. 112-130, 2006.

[28] Engage, Enhancing teachiNG And learninG English in a digitalized world https://www.euprojects.gr/en/portfolio-items/engage/ (last accessed June 2022).

[29] ID GAMES - Co-Create assistive games for people with Intellectual Disability to enhance their inclusion. https://www.euprojects.gr/en/portfolio-items/id-games/ (last accessed June 2022).

[30] Skills-Up. Online education focused on talent development, career development and soft-skills of the unemployed. https://www.euprojects.gr/en/portfolio-items/skillsup/ (last accessed June 2022).

[31] DIGITART - Digital Systems for a Smart Approach to ART https://www.euprojects.gr/en/portfolio-items/digitart/ (last accessed June 2022).

[32] J. Tondeur, A. Forkosh-Baruch, S. Prestridge, P. Albion, and S. Edirisinghe, Responding to challenges in teacher professional development for ICT integration in education. Journal of educational technology society, 19(3), pp. 110-120, 2016.

[33] R. Scherer, F. Siddiq, and J. Tondeur, The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. Computers Education, 128, pp. 13-35 (2019).

[34] J. P. Gee, Good video games+ good learning: Collected essays on video games, learning, and literacy. Peter Lang, 2007.

[35] Grifobot Main Engine Repository, https://github.com/vacilos/grifobot (last accessed June 2022).

[36] R. Dörner, S. Göbel, W. Effelsberg, and J. Wiemeyer, Serious games. Cham: Springer, 2016.

 ISBN: 978-1-68558-020-9