# Which is better for learning: a web-based educational application or an educational game?

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***Abstract*—Last decade, the integration of information and telecommunication technologies into education has changed the processes of teaching and learning. There are many formats of educational applications that range from simple online tutorials, tests and drill and practice software to integrated web-based educational applications and educational games. So, the following question arises: Which kind of educational software and applications is the most effective and suitable? For answering the above question, in this paper, we present a comparative evaluation between a web-based educational application and an educational game that teach the programming language HTML. Both applications include the same learning material. A group of learners used the two applications for experimental evaluation. We observed and recorded the learners' reactions, preferences and opinions. The observation-experimental data from the usage of the two applications help us to conclude about the educational application that is more likable, offers motivation and engages learners in a higher degree to the learning process. The evaluation results are presented and discussed..**

***Keywords—educational applications, educational game, e-learning, evaluation***

## I. INTRODUCTION

The advent of computers and the constant evolution of technology have led to the use of new and advanced teaching methods. These methods are based on the development of educational software, the primary purpose of which is to help the student to improve her/his knowledge of a particular subject [1]. Teachers also benefit from having the ability to monitor student progress, assess their performance, and encourage them to continue their efforts. An educational application can incorporate multimedia components such as images, videos, and audio, providing a tempting aesthetic environment that can keep the student engaged. Also, the student can study and solve exercises at her/his own pace through the trial and error method, thereby improving her/his self-esteem and self-confidence [2].

An educational application can be classified into one or more types based on some criteria. For example, depending on the target platform, an educational application can be window-based (desktop), web-based or mobile application. Web-based applications require Internet access so that they can be accessed at any time and from anywhere. They are independent of the operating system since it is sufficient to use a browser to execute them. They are usually connected to a database, which, especially for education, can contain a large amount of information related to the learning objectives. the main advantage of a web application is that it is a source of knowledge that is available any time at any place [3]. Also, teachers can register educational material and monitor student performance.

Another category of educational software is educational games. Educational games are mainly educational applications framed by a gaming environment. Many researchers support the use of educational games in the learning process as their fascinating character keeps the player's motivation high. Some of their abilities are to 'release' the student's way of thinking and help to learn a skill while playing [4-8]. An educational game can be available on the web.

The principal differences between a conventional web-based educational application and an educational game concern the structure and the process of the learning. Particularly, a conventional web-based application includes seperately sections for the theory, the practice and the assessment. Furthermore, a user of a conventional web-based applications follows the conventional way of learning: firstly, s/he reads the theory, then s/he practices and finally s/he assesses her.his knowledge. On the other hand, a user of an educational game learns while palying. S/he plays a game following the game's plot and trying to win a prize or to complere a mission. During the game playing s/he learns a knowledge domain answering to questions, solving puzzles or quizzes e.tc.. Her/his aim is to answer questions and solve quizzes correctly in order to proceed to the game and gain. Therefore, s/he tries to obtain the required knowledge. In an educational game, ussualy, the theory is presented as clue or instructions in order to be able to solve the available quizzes.

Many researchers have evaluated and demonstrated the usefulness and benefits of both educational applications in general, and educational games in particular [9-11]. However, there is no comparison between these two categories in order to conclude as to which of the two may ultimately be more beneficial. For this purpose, we developed two educational systems: a web application and a web game for learning HTML. Therefore, both systems are accessible from everywhere and, also, they use the same learning material and the same assessment exercises. The only difference is that in the first system the student only deals with the educational content, while in the second system s/he plays the game and deals with the educational part only where this appears in the game context. Bearing in mind this clear separation between the two systems, the work leads to conclusions about students' preferences that can be useful for additional future work.

## II. Related work

In literature, there is a large number of educational applications in general and educational games in particular. Many researchers have conducted evaluations and have highlighted the benefits that educational applications offer during the learning process. Evaluations usually involve two issues: the learning outcomes and usability of the application [12]. The first subject emphasizes the educational component, such as the organization of teaching material and student performance. The second issue examines how convenient and easy to use it is the educational program.

Each research may aim to evaluate the application from the perspective of a different type of user. Nikiforidou Z. and Pange J. [11] developed an application that exploits the probability theory to conclude the capabilities of preschool children. The evaluation of the application was carried out from the perspective of the teachers with the help of questionnaires. The authors analyzed the answers of the teachers and concluded that the application is useful in educational practices. Also, they have calculated the Cronbach Alpha index, which has highlighted the credibility of the results.

Sanchez R.P., Bartel C.M, Brown E., and DeRosier M. evaluated Adventures Aboard the S.S. GRIN, an educational application that helps students develop their social skills [13]. In this case, students in the US who attended grade 3 through 5 participated in the evaluation process. The students took part in an online evaluation survey, answering questions based on the 5-point Likert scale, which were classified in categories usability, likeability, and psychosocial distress. The evaluation has shown that the application can raise positive results in terms of behavior and emotional status of students.

Kularbphettong K., Kedsiribut P., and Roonrakwit P. developed a web-based educational application that is used to improve the knowledge of the Java programming language, utilizing the Mastery Learning Technique [3]. They highlighted the advantages of a web application in general, such as the ability to learn an object at any time and in any place or the information sharing and students' collaboration. Both instructors and students responded to questionnaires to measure their satisfaction with the usability of the system. The evaluation produced positive results, although it was at a preliminary level.

Many evaluations have also been conducted in the field of educational games. Najdi S. and Sheikh R. E. followed the descriptive method to estimate the influence of educational games on student attitudes in the case of chemistry learning [14]. The evaluation was also made using a questionnaire, consisting of 22 questions based on the Likert scale. Also, the researchers successfully tested the validity and reliability of the results.

Riemer V. and Schrader C. used a pre-test and two primary studies to compute the attitudes, perceptions, and intentions of students to learn an object through educational games in general [15]. The evaluation was conducted by examining the three most popular types of educational games: quizzes, simulations, and adventure games. The results of the evaluation revealed positive attitudes, positive cognitive attitudes but also various emotional perceptions, depending on the type of game.

Researchers conducted a systematic bibliographic review to highlight the positive effect of games in the process of learning objects of computing education [9]. Through a sample of 3617 articles, they identified 112 of them suitable for their work. The review has shown that the factor most evaluated is learning. Also, in the majority of cases, pre-tests and post-tests are used to compare the student's level of knowledge before and after playing the game. Other factors that are often evaluated are user experience, usability, educational aspects, and motivation. Some surveys do not choose a specific factor to evaluate, but they value the quality of the games as a whole, leaving open questions about students' perception of them.

The above are some examples of literature that highlight the positive effects resulting from the integration of educational applications in the learning process, whether these applications are games or not. Each evaluation may consider a different factor, and this is even more pronounced in the case of games due to their additional target to entertain the student. Also, there is no defined assessment method although it is common to use pre-tests, post-tests, and questionnaires.

Especially in the case of games, some evaluations take into account their type. However, a question that has not been asked is what type of educational software generally users prefer. This research responds to a similar question by performing a comparative evaluation between two specific types of educational software: a web-based application and an educational game. The two applications are used for learning HTML, host the same educational material and they provide the same quizzes and tests. The results of the evaluation are exciting as they reflect the users' preferences depending on the category in which they are located.

## III. Description of The Systems

Both systems, which are described below, have been developed in the Software Engineering Lab of the department of Informatics of University of Piraeus, Greece, and are used internally for educational and research purposes.

### *A. Educational Game*

The educational game used in our research is an escape game called "HTML Escape Game". "HTML Escape Game" is an online adventure game, meaning it requires a computer with Internet access and a browser. Hence, the requirements for using either the game or the web-based educational application are precisely the same. The only element that differentiates is the educational environment in which the user is browsing.

The student assumes the role of the game hero, imprisoned in a multi-room building and a large courtyard. The hero can tour the rooms, collect objects, combine objects, chat with non-playable characters (NPCs) and give them objects (Fig. 1). Each NPC assigns the hero a small mission. Most missions are about searching and finding objects that characters need for some reason. Every time the hero completes a mission, he receives an object as a reward. Rewards are always necessary for the continuation of the mission of the hero as they are objects used in other missions. For example, in a room, there is an older adult who has lost a music disc. If the hero finds the disc, the old man rewards him with a stool. The hero uses the stool in the courtyard of the house to be able to reach a lemon high on a tree.

Subsequently, he puts the lemon in cold soda and gives it to a thirsty NPC. In this way, the story continues until the hero manages to escape.

However, some NPCs are not interested in an object but want to examine the student's knowledge of HTML. These NPCs assign the hero quizzes of questions (Fig. 2). Questions are of four types: single-choice, multiple-choice, fill-the-blanks, and sorting. Furthermore, the questions are classified into one of the following difficulties: easy, medium and difficult. If the hero answers correctly to an adequate number of questions, the character rewards him accordingly. That is, the reward differs depending on the success rate. If the success rate is high enough, the hero gets the maximum reward. For example, there is an NPC in a warehouse, that assigns a quiz to the hero. If the hero completes the quiz with a high rate of success, the NPC leaves, and the hero is free to pull down a heavy object tied to the ceiling. If the hero manages to get the weighty object, he may use it to complete another mission. If the success rate is satisfactory but not high enough, the object is too heavy, and the hero cannot lift it. Then in another room, a muscular NPC appears and assigns a new quiz to the hero. This repetitive quiz contains questions appropriately selected in order for the student to overcome the shortcomings identified by the system in the previous quiz. In the iterative quiz, the student must respond successfully with a high rate of success so that the powerful NPC can offer his help by lifting the heavy object.

*Figure 1: The environment of the game*

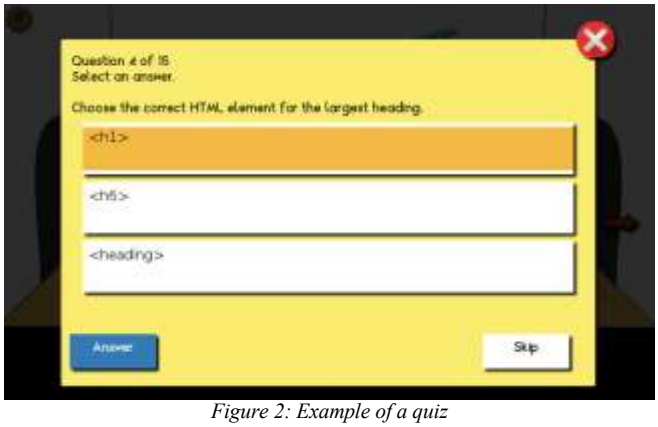


*Figure 2: Example of a quiz*

Similar examples exist in other parts of the game. Therefore, when the player has an excellent quiz performance but not as much as possible, the game implicitly runs a process that alters the script by adding new characters, puzzles, objects, and even rooms. The game's adaptivity is designed to keep the player more engaged and to increase his motivation and entertainment. In this way, s/he will take part in additional exercises containing questions tailored to the weaknesses determined by the system, in order to overcome them. We have to mention that the theory part of the learning material is provided in a web-platform, that the user-learner has to visit it before starting the game.

### *B. Web-based educational application*

The web-based educational application that we used in our research is called "web-tutor for Html", and it is an original integrated e-training environment for teaching programming concepts and the HTML programming language. The particular educational application offers personalized e-training in HTML programming language. The learning material of the "web-tutor for Html" is broken down into several domain concepts that are organized into chapters and lessons (Fig. 3). Furthermore, the web-tutor for Html" offers personalized tests that include four types of exercises: 1) true/false exercises; 2) multiple choice exercises; 3) fill in the gap space exercises, where the student fills in a symbol or a command in order to complete a program; and 4) exercises in which users put certain parts of a program in the right order. The application offers each particular learner the domain concepts and tests that are confronted with her/his knowledge level and learning abilities and needs. For informing the learner for her/his progress and learning level offering her/him personalized tutoring, the "web-tutor for Html" uses adaptive hypermedia [16]. It accompanies each domain concept with an icon and a characterization that informs the particular student about her/his current knowledge level.


*Figure 3: A sample of the learning material*

### *C. Web services and Interoperability*

As mentioned above, the two applications present the same learning material and the same exercises. In this way, the evaluation produces more accurate results as the environment, and the user interface offered by each application (application execution requirements, educational content tailored to the student's needs) are precisely the same. However, how does the

same educational content and projection of the same exercises are promoted to each application?

As one can conclude, both applications are connected to the same database that hosts all HTML material. However, to avoid developing source code in both applications, which selects the appropriate educational material by using the same rationale, we implemented a tool that utilizes the technology of Web Services (Fig. 4). By using the latter, it is not necessary to implement the same functionality for each application separately. Additionally, Web Services provide methods that each external application can call, receive the appropriate response (usually in XML or JSON format) and manage it as desired [17-20]. The methods incorporated in our web-services tool are depicted in Table I. An indicative example of a quiz display call method is illustrated in Figure 5.


*Figure 4: Utilization of the web-services tool from both applications*

TABLE I. THE WEB SERVICES METHODS

| Action | Description |
|---|---|
| Student registration | It creates a student account/profile in the system. |
| Student authentication | It authenticates the student. It returns a token used for further transactions with the student. |
| Quiz creation | It creates quizzes for a specific HTML lesson. |
| Retrieve knowledge level | It returns the student's knowledge level, as calculated after completing a specific quiz. |
| Retrieve quiz | If the quiz is not complete, it returns the current question. If the quiz is complete, it returns the student's success rate and the answers submitted. |
| Submit answer | It receives the student's answer to a quiz's current question. |
| Retrieve answer's correctness | It returns if the user's answer to the current question is correct or incorrect. |
| Skip current question | It skips the quiz's current question. It returns the next unanswered question. |

The projection of the same educational material in both applications is evident in the following example: suppose a user starts a new quiz through the 'HTML Escape Game' but not complete it. If s/he then uses the 'web-tutor for Html, s/he will continue the same quiz that started through the game. Hence, each application knows each time the whole history of answers submitted by the student and the evolution of the corresponding knowledge level. The way each application exploits this information (e.g., the game extends its scenario), is relevant to the application, not the web-services tool.

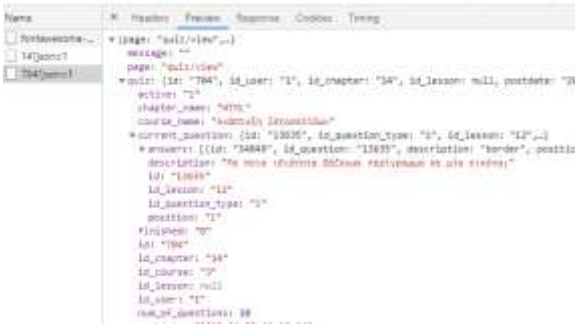

*Figure 5: Example of retrieving quiz question in JSON format*

## IV. COMPARATIVE EVALUATION

Evaluation is a crucial process for concluding the results, success and the significance of scientific work. There are several evaluation techniques. The most common evaluation methods are questionnaires and experiments. Considering the above, we conducted a comparative evaluation between the two different presented kinds of educational environments (game and web-based application). We gave both applications for using in real conditions to students of a postgraduate program, and we observed their behavior and reactions during the learning process. Also, we asked the learners' opinion about the presented educational applications through a questionnaire.

For the needs of the evaluation process, a group of 65 students of a postgraduate program in the field of Informatics of the Department of Informatics in the University of Piraeus, were asked to use both environments (the educational game and the web-based educational application) for learning the programming language Html. The group consisted of learners, who have different backgrounds and ages. All students had attended lessons of HTML in class for one month before using the two educational applications. They used the presented applications over a three-week period. More specifically, 32 learners (group A) out of 65 started to learn HTML using the educational game ("HTML Escape Game") and 33 learners (group B) out of 65 started using the web-based educational application ("web-tutor of Html"). Learners of both groups could switch between the two applications by continuing their learning process from where they were left using the same training material at any time. Once s/he switches platform, it is possible to switch back to the other application again. A learner can switch from one application to the other as many times as s/he desires. At the end of 3 weeks, learners were asked to complete the questionnaire that is depicted in Table II. The questions of the particular questionnaire are close-ended based on a Likert scale with the responses ranging from "Unsatisfactory" (1) to "Excellent" (5). All 65 users were asked to answer the particular questionnaire for both educational applications.

The results of the evaluation showed that both educational applications-environments are significant, each one for other reasons. In more details, from the 32 learners, which were asked to start the learning process using the game, 3 quitted the

learning process entirely, 19 preferred to complete the learning process using the game, and the rest 10 preferred to complete the learning process using the "web-tutor for Html". A learner completes the learning process, when s/he has answered successfully all the quizzes-tests of the application. Furthermore, from the 33 learners, which were asked to start the learning process using the "web-tutor for Html", 2 quitted the learning process completely, 19 preferred to complete the learning process using the game, and the rest 12 preferred to complete the learning process using the "web-tutor of Html". In other words, from group A: 59.38% of students continued to use the game and 31.25% of students chose to complete the learning process using the "web-tutor for Html", and from group B: 36.36% of students continued to use the "web-tutor for Html" and 57.58% of students chose to complete the learning process using the "HTML Escape Game" game. Therefore, 5 students (7.69%) in total quitted the process, 58.46% of students preferred to complete the learning process using the game and 33.85% of students preferred to complete the learning process using the "web-tutor for Html". Consequently, there is a clear preference for the educational game.

TABLE II. THE QUESTIONNAIRE

| | Questions | Answers (circle one for each question) 1: unsatisfactory 2: Improvement needed 3: meet expectations, 4: exceeds expectations 5: excellent | | | | |
|---|---|---|---|---|---|---|
| Q1 | How much did you like the application? | 1 | 2 | 3 | 4 | 5 |
| Q2 | How easy is it to navigate to the application? | 1 | 2 | 3 | 4 | 5 |
| Q3 | Is the learning goal clear? | 1 | 2 | 3 | 4 | 5 |
| Q4 | Rate the organization of the learning material. | 1 | 2 | 3 | 4 | 5 |
| Q5 | Do you like to use the particular application for learning the knowledge domain about HTML programming? | 1 | 2 | 3 | 4 | 5 |
| Q6 | Does the application motivate you to participate in the learning process? | 1 | 2 | 3 | 4 | 5 |
| Q7 | Does the application contribute to the increase of your engagement in the learning process? | 1 | 2 | 3 | 4 | 5 |
| Q8 | Rate the application's feedback to your learning performance at each interaction with it. | 1 | 2 | 3 | 4 | 5 |

Also, we observed the times that each student switched between the two applications and we calculated the mean times that they used the "HTML Escape Game" and the "web-tutor for Html" until they completed the educational process. For example, if a learner needed to interact with both applications 12 times in total, in order to complete the educational process (i.e. to answer successfully to all the available quizzes-tests) and s/he choosed 3 times to interact with the "web-tutor for Html" and other 9 times to interact with the "HTML Escape Game", then s/he used 25% the web-educational application and 75% the educational game. Then, we compared the average of times that the two applications were used by those, who completed the learning process using the "web-tutor for Html" (group 1), and by those, who completed the learning process using the "HTML Escape Game" game (group 2). The results are depicted in Fig 6. From these results, we can conclude that each learner needed, almost, the same number of tests-tries (by switching from one application to the other) to decide which educational environment s/he likes most.

| | group | Number of learners | Avg times of use |
|---|---|---|---|
| use_of_game | 1 | 22 | 24,1059 |
| | 2 | 38 | 75,4792 |
| use_of_web | 1 | 22 | 76,3486 |
| | 2 | 38 | 24,5208 |

*Figure 6: The average time of switches to each application*

Furthermore, from the students' answers to the questionnaire (Table III), we can understand the reason for their preferences. As we notice, learners like more to learn during gaming, since the scenario of the educational game motivates them to participate in the learning process and engage in it. However, sometimes they deal with difficulties that concern the navigation into the game, which make them distract from the learning goal. That is a reason for some learners prefer a classical-structured web-based educational application, which has a more evident learning goal, provides more organized and structured learning material and gives a more clearly feedback to learners.

TABLE III. THE RESULTS OF THE QUESTIONNAIRE

| Questions | "HTML Escape Game" | "Web-tutor for Html" |
|---|---|---|
| Q1 | 3.43 | 2.93 |
| Q2 | 3.78 | 4.15 |
| Q3 | 3.72 | 4.36 |
| Q4 | 2.86 | 4.12 |
| Q5 | 3.43 | 2.93 |
| Q6 | 3.78 | 2.63 |
| Q7 | 3.73 | 2.63 |
| Q8 | 3.32 | 3.85 |

## V. CONCLUSIONS AND FUTURE WORK

In this paper, a comparative evaluation of two different educational applications that offer the same learning material was presented. In particular, we provided an educational game and a web-based educational application to 65 students to use them in real conditions for learning the HTML programming language. Then, we observed and recorded the learners' reactions, preferences, and opinions to conclude about the educational application that is more likable and suitable for

learning. The evaluation results showed that there is a clear preference for the educational game since it motivates the learners more and increases the degree of their engagement in the learning process. However, the precise structure and organization of the learning material and the tutoring process of a classical web-based educational application, which are asked by a significant number of learners, are, usually, absent of an educational game. Therefore, the solution for a friendly and competent learning environment that motivates the student is the existence of an integrated educational environment that includes a variety of educational applications (for example educational game and tutorial and a classical tutoring application).

Considering the above, in our future work, we aim to build an authoring tool that will allow to different kind of digital and e-learning applications to share the same learning material and identify the same learners' profiles. In such a way, a learner will be able to use at the same time more than one educational application for learning a particular domain concept, taking advantage of all the benefits of the different applications. Furthermore, we are going to assess if educational games are more efficient for some disciplines or cognitive subjects and conventional web-based educational applications suit better for other disciplines or cognitive subjects.

## REFERENCES


[1] Z. Stanisavljević-Petrović, Z. Stanković, and B. Jevtić, "Implementation of Educational Software in Classrooms–Pupilś Perspective," *Procedia - Social and Behavioral Sciences*, vol. 186, pp. 549–559, 2015.

[2] L. Cairns and M. Malloch, "Computers in Education: The Impact on Schools and Classrooms," *Education in the Asia-Pacific Region: Issues, Concerns and Prospects Life in Schools and Classrooms*, pp. 603–617, 2017.

[3] K. Kularbphettong, P. Kedsiribut, and P. Roonrakwit, "Developing an Adaptive Web-based Intelligent Tutoring System Using Mastery Learning Technique," *Procedia - Social and Behavioral Sciences*, vol. 191, pp. 686–691, 2015.

[4] J. Martí-Parreño, A. Galbis-Córdova, and M. J. Miquel-Romero, "Students attitude towards the use of educational video games to develop competencies," *Computers in Human Behavior*, vol. 81, pp. 366–377, 2018.

[5] N. Padilla-Zea, F. L. Gutiérrez, J. R. López-Arcos, A. Abad-Arranz, and P. Paderewski, "Modeling storytelling to be used in educational video games," *Computers in Human Behavior*, vol. 31, pp. 461–474, 2014.

[6] P. Molins-Ruano, C. Sevilla, S. Santini, P. Haya, P. Rodríguez, and G. Sacha, "Designing videogames to improve students motivation," *Computers in Human Behavior*, vol. 31, pp. 571–579, 2014.

[7] G.N. Yannakakis, J. Togelius, R. Khaled, A. Jhala, K. Karpouzis, A. Paiva, and A. Vasalou, "Siren: Towards Adaptive Serious Games for Teaching Conflict Resolution," Proc. Fourth European Conf. Games Based Learning, 2010

[8] N. Konstantinou, , I. Varlamis, and A. Giannakoulopoulos, "The use of 3D virtual learning environments in the learning process", in 5th International Conference in Open and Distance Learning, 2009.

[9] G. Petri and C. G. V. Wangenheim, "How games for computing education are evaluated? A systematic literature review," *Computers & Education*, vol. 107, pp. 68–90, 2017.

[10] J. Derboven, B. Zaman, D. Geerts, and D. D. Grooff, "Playing educational math games at home: The Monkey Tales case," *Entertainment Computing*, vol. 16, pp. 1–14, 2016.

[11] Z. Nikiforidou and J. Pange, "Teachers' evaluation of preschool educational software: the case of probabilistic thinking," *Procedia - Social and Behavioral Sciences*, vol. 9, pp. 537–541, 2010.

[12] S. Coomans and G. S. Lacerda, "PETESE, a Pedagogical Ergonomic Tool for Educational Software Evaluation," *Procedia Manufacturing*, vol. 3, pp. 5881–5888, 2015.

[13] R. P. Sanchez, C. M. Bartel, E. Brown, and M. Derosier, "The acceptability and efficacy of an intelligent social tutoring system," *Computers & Education*, vol. 78, pp. 321–332, 2014.

[14] S. Najdi and R. E. Sheikh, "Educational Games: Do They Make a Difference?," *Procedia - Social and Behavioral Sciences*, vol. 47, pp. 48–51, 2012.

[15] V. Riemer and C. Schrader, "Learning with quizzes, simulations, and adventures: Students attitudes, perceptions and intentions to learn with different types of serious games," *Computers & Education*, vol. 88, pp. 160–168, 2015.

[16] P. Brusilovsky, "Adaptive Hypermedia for Education and Training," Adapt. Technol. Train. Educ., p. 46, 2012.

[17] F. Halili and E. Ramadani, "Web Services: A Comparison of Soap and Rest Services," *Modern Applied Science*, vol. 12, no. 3, p. 175, 2018.

[18] Y. Syu, J.-Y. Kuo, and Y.-Y. Fanjiang, "Time series forecasting for dynamic quality of web services: An empirical study," *Journal of Systems and Software*, vol. 134, pp. 279–303, 2017.

[19] J. Tihomirovs and J. Grabis, "Comparison of SOAP and REST Based Web Services Using Software Evaluation Metrics," *Information Technology and Management Science*, vol. 19, no. 1, 2016.

[20] G. Katsionis and M. Virvou, "Personalised e-learning through an educational virtual reality game using Web services," *Multimedia Tools and Applications*, vol. 39, no. 1, pp. 47–71, 2007.