Validating a Model of Smart Service System, Supporting Teachers to Create Educational Maze Video Games

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***Abstract* - Intelligent technologies can encourage the design and implementation of personalized learning solutions. In traditional school settings, teachers still hesitate about how to use educational video games in class. In this context smart services can support teachers to design personalized and adaptable learning games by providing more data-enabled, user-centered and context-oriented recommendations. The paper presents the smart service concepts and explores their role in improving teachers' capacity to design educational video games. It steps on the platform APOGEE to construct educational enriched maze video games and proposes a smart service validation model, which is verified and tested. The paper starts with a short introduction of the pilot smart service system, based on the APOGEE platform. After that, it analyzes the existing platforms that teachers can use for learning game creation. Next, a validation model of the smart service system is presented. The validation process is explained in detail, covering two testing rounds with 9 lecturers and 15 students. The discussion part verifies that the proposed smart service pilot implementation can efficiently support teachers to conceptualize educational maze video games.**

Keywords - smart service, educational video games, learning gamification, validation

I. INTRODUCTION

Intelligent systems in educational context can support teachers to improve the general design of personalized learning process, focusing both on the learning outcomes and on the learning delivery [1]. Especially after the pandemic, teachers are increasingly expected to deliver challenging and enjoyable "phygital" learning solutions, combining activities both in the physical and in the digital space [2]. By providing more data-enabled, user-centered and context-oriented assistance, intelligent systems such as smart service platforms can facilitate design of the effective and efficient gamified learning experiences [3]. In the same time, implementing games in the classroom settings is widely discussed as student' oriented approach, ensuring student' engagement and satisfaction, improving learners' creative, critical and problem-solving skills [4]. However, the main reason for the low adoption of educational video games in class still remains the low involvement of teachers in video game design, the lack of adaptation strategies to fit in the classroom learning scenario and the dominant misconceptions about game-based learning among teachers [4, 5].

The present research aims to outline the testing and validation of a pilot implementation of a smart service design model for supporting teachers to build educational video games. By comparing and discussing existing approaches for design and development of educational video games, the model of the smart service platform is implemented in the framework of the APOGEE platform (http://www.apogee.online/). More specifically, the current research proposes a two-step testing and validation process, exploring how low-code smart service model can facilitate and engage teachers, lecturers and non-IT professionals to build 3D educational maze video games on the APOGEE platform.

The paper is structured as follows. The first part makes a short overview of the main problems for applying game-based learning in class, making a brief summary of the popular learning games platforms and the key features to support teachers as game-designers. Next, the APOGEE platform and the smart service model are presented, exploring their approach and characteristics to support teachers to design complex and personalized learning games. The fourth part describes the smart service platform validation model, analyzing the quantitative data and qualitative outcomes obtained from the participants during the testing sessions. At the end are outlined the future work and next stages of smart service platform for assisting teachers in their efforts to create educational video games.

II. BACKGROUND RESEARCH

A. Study Background

Although the advantages of Game-based learning (GBL) and educational video games in literature reviews [6], teachers in general still hesitate to implement educational computer games in their teaching practice. The benefits for using educational video games are identified as presenting an immersive process, where students acquire knowledge during the play. Furthermore, GBL can be applied in various subject areas to improve student motivation, facilitating knowledge acquisition,

behavior change and developing high-order skills such as creativity, critical thinking and problem-solving skills [7].

To support teachers for adopting GBL in their teaching practice, some authors as [8] recommend a practical matrix, addressing six main aspects of the GBL implementation, covering: 1) teacher' own motivation to use GBL, 2) learners' needs and specifics, 3) game content and features, 4) practical classroom settings, 5) design of learning scenarios, 6) GBL results evaluation. All these aspects demonstrate that applying GBL in educational design is a complex issue and learning game design covers only one minor part of all tasks that teachers have to consider before implementing GBL.

As a short summary of the main difficulties and barriers for teachers to implement games and GBL proposed in [9] focus on: 1) the time for learning game development; 2) the limited resources for game creation; 3) the costs and efforts to produce learning games; 4) the lack of direct impact to the learning process; 5) the lack of support from schools and/or parents. As barriers for teachers can be cited as well the inadequate technology support, the lack of supporting materials and best practices for using games for learning, and the lack of time [3]. In addition, many in-service teachers still are not using English and prefer local or translated software game design platforms and GBL supporting materials.

B. Smart Services and Intelligent Systems

The smart services are intelligent systems, usually explored in the framework of industry automation and Industry 4.0 and can refer to terms: smart product-service systems and cyber-physical systems [10, 11]. Built on data-analysis, interactive interfaces and personalized configurations, smart services can be used interchangeably with "smart web services", "intelligent services", "intelligent product-service systems", and others. Therefore, smart services can be defined as "real-time, user-oriented, adaptable and context-oriented services, delivered within networked systems and platforms "[12]. Smart services can be applied to facilitate different educational processes and can cover different learning scenarios [3]. By delivering data-enabled, user-centered and context-aware recommendations and automatic configurations, smart services can assist teachers to better understand students' needs and to improve their learning experiences. Supporting teachers to conceptualize and design educational video games for learning can engage them in the design of more complex and interactive designs.

In the context of education, smart services can be applied in different perspectives: on educational level, on school level, on class level, on teacher level, and on student level. Furthermore, smart services can facilitate learning personalization and learning adaptation, assisting teachers to apply various approaches that can be realized through the use of technological means [13]. Focusing on the practical aspects, smart services have to address the 4C [14]: 1) connectivity "improving access to people, devices, and educational environments"; 2) collection "of (study-related) data"; 3) computation of "key factors, influencing learning and student satisfaction"; 4) communication "within or through technology-equipped education device and environment for increasing value co-creation between students, teachers, and other stakeholders" [14].

C. Exploring Game Design Features of Popular Educational Video Games

Before exploring more sophisticated models to assist teachers to easily create and implement educational video games and GBL in their teaching practices, a short overview is provided for some popular GBL solutions. The outlined game platforms in table 1 are among the most used and recognized game platforms by local teachers, identified in teachers' surveys, interviews and discussions. The list of GBL platforms in table 1 is not exhaustive and its goals are mainly to illustrate and analyze the most common approaches to assist teachers in the design of educational games.

Table 1. Summary of popular learning games platform features.

Learning platform	Game elements	Teachers' support
Kahoot!	Online quiz	2D quiz; predefined templates examples;
Genially	Interactive presentations, quizzes	2D games, combine off-line/online elements, pre-defined games & example;
Learning Apps	Puzzles, quizzes	2D games, examples, pre-filled templates, multiple languages;
Scratch	Programming games	2D game, online editor, examples, gallery;
H5P.org	Interactive exercises	Puzzles, pre-filled examples; integrated with Moodle;

Furthermore, some screenshots of the game platforms are provided on fig. 1, focusing to outline the game designing process. It should be noticed, that most of the game platforms support 2D puzzles and interactive learning activities. The most popular type of games covers quizzes and presentation-type display (Kahoot!, Genially). Most of the game platforms provide examples of the games that can be used as pre-filled templates, that users can modify and adapt with own learning content (learning apps, h5p). Additionally, some of the platforms support online drag and drop visual editors, along with examples of exercise scripts, that teachers can directly explore in their class activities (scratch). Most of the games can be played with a school computer equipment (computer and projector), some of the games allow students to use their own hand-held devices such as mobile phones and tablets (Kahoot!).

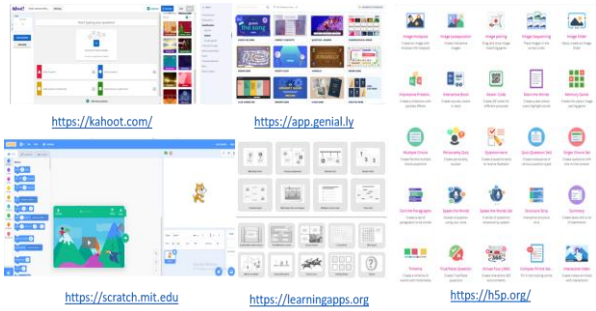

Figure 1. Screenshots of the popular learning game platforms supporting GBL, as described in table 1.

Among the key problems with these models can be summarized as follows:

- Neither of the game platform provides information and guidance how teachers can apply games or GBL in the design of their learning scenarios.
- The process is not interactive, it usually imitates some common approach (building presentations).
- Teachers have to learn how to design the games in every specific game platform (as lock-in factor).
- Dominant 2D puzzles and video games can be easily performed with traditional means (and not need digital platforms);
- Language support (most of the GBL platforms are on English)
- Lack of support for learning personalizing and adaptation of the games to the students' needs.

III. The APOGEE Video Maze Game Platform

The APOGEE platform for construction and generation of rich educational video maze games is based on the Unity editor and supports the design of educational 3D video mazes enriched with mini-games [15]. The enriched maze video-games are defined as a maze 3D video game with multimedia learning content presented within the maze halls on learning boards and within personalized and adaptive puzzle mini-games of various types, embedded into each hall [15]. The APOGEE platform supports design of personalized and adaptable learning experiences as the mini-games could be tailored to the end user profile. The learning content can also be personalized upon the player/learner model attributes such as demographic characteristics, demonstrated outcomes, learning/playing style, and emotional status and further adapted to the learning scenario.

To facilitate teachers to create educational video games in the APOGEE maze design platform, a pilot model of smart service platform is designed. The main objectives of the smart service platform are to support teachers, non-IT professionals and experts, parents and students to design educational video games. Based on recommendations, dynamic data statistics and best practices, teachers can not only learn how to design adaptable and personalized maze video games but improve their GBL skills and gain experience from others.

The process for building educational games in APOGEE starts with submission of an XML document, formally describing the maze, the mini games and the learning content. There game designers should describe all game elements, combining text, images, and audio files, together with the mini-games placed in the maze halls. In these settings, teachers have to describe and upload all the features of the educational video game – such as the number of halls, the structure of the maze, the learning panels, and the mini-games.

Thus, in order to facilitate and support teachers for game design process, a pilot low-code solution is provided. This pilot Smart Service platform, described in [16] aims to propose an alternative approach for teachers to design and structure educational games, providing additional information about GBL, learning scenarios, learners' preferences and some additional statistics [16]. On this platform, the APOGEE game design process is structured on three main parts. The first part introduces the general parameters of the video game, the second is dedicated on game halls design and the third part allows teachers to make a request for game generation. Every hall in the maze is separately generated, including all elements such as educational panels and mini-games. A special page explains types of the mini-games supported in the model, highlighting how they can be adapted and used to personalize student experience. There, teachers just have to fill out several interactive Google forms, making an easy step-by-step approach, selecting answers, and uploading game elements. When the files are submitted, users receive by mail a link to their data, allowing them to make multiple revisions and modifications. The process is highly iterative, requiring many versions and modifications, before completing the final version for a game generation [16].

A. *Smart Service Platform Validation Model*

A detailed validation process is organized to ensure that smart service model platform can efficiently support teachers and end-users, observing their experiences and interest to create and implement educational video games in class.

To validate the model of the pilot smart service platform, a two-step validation process is organized. The testing of the design and delivery of the smart service prototype is made via two workshops: with teachers/ tutors and with students/teachers-to-be. The quantitative data are collected via online questionnaire, and the qualitative data are obtained from semi-structured interviews and discussion, focusing on the concepts of interactivity, personalization and further modification of the platform to support educational video games.

B. *Methodology for Validating the Pilot Smart Service Platform*

In order to test and validate the pilot smart service platform, there are investigated the following indicators of success. Focusing on the needs of the educators to support the game creation processes, the factors of success are based on the matrix of Ney et al. [8]. Based on the self-reported data and external observation, a smart service system for supporting teachers to design educational video games should improve:

1) the teacher's own motivation to use and create educational video games: to what extent the developed system has supported and improved the teachers' understanding and interest for creating educational enriched maze video-games.

2) the needs and specifics of the learners: to what extent the smart system has improved the teachers' understanding of the needs of the learners and the possibilities for personalization.

3) the game content and features: the what extent the educators can easily create and understand approaches to design game and learning content, including as well content for the minigames.

5) design of learning scenarios: to what extent the system improves the understanding of the role and place of games in the learning process.

6) evaluation of the results of game-based learning: to what extent the teachers understand how they can evaluate the learning outcomes of the players.

The only indicator listed in the model of [8], which is not explicitly considered in the presented model, is (4) the practical classroom settings, since the pilot implementation of the system does not address issues related to technological characteristics, practical and logistic challenges for the actual implementation of the developed games in the classroom settings.

In addition to these indicators, complementary features are the practical parameters of creating educational video games. For example, these consist of: time for the first draft and the final version of the game development, dedicated resources and efforts for game design, the satisfaction of the process, the models to link educational games with the learning process and the opportunities for group work and interaction with other teachers.

C. Practical Settings of the Validation Process

The smart service system pilot implementation and the models for creating personalized and adaptive games were validated and tested in practice on two separate settings. All validation activities took part in December 2022 and followed the same procedure.

1) Validation on the e-Creha Tutors' Workhop

First, the testing and validation round was organized with the participants of the e-Creha project workshop (https://www.ecreha.org), taking place on December 9, 10 and 11, 2022 in Sofia. The Tutors' workshop was dedicated on the design and use of educational games and games-based learning approaches, and was closely related with the tasks of the Bulgarian team - development of four educational maze video games on the climate change and the preservation of the architectural heritage. A total of 15 university professors and lecturers from Bulgaria, Italy, Turkey, France and the Netherlands took part in the Tutors' workshop.

Within the Tutors' workshop settings, participants created a pilot educational game by using the tools and instruments, provided in the smart service system. They have to select and define the learning objectives, the learning content and the mini-games for an educational video game. Provided with initial concepts notes and texts for the maze video games, in a participative manner, tutors defined the first draft of the game design within less than 2 hours. Based on the delivered learning content, the first draft of the game was ready for testing, generated only for several hours after this session. This way, tutors tested the game on the third day of the seminar, and then they were asked to provide structured feedback by filling a questionnaire. A more detailed insights and qualitative data were collected within the group discussion and final feedback session.

The feedback questionnaire included a total of 17 questions, out of which 14 questions concerned the game creation process and 3 questions addressed the satisfaction with the workshop. In total 8 participants out of 15 attendees completed the structured questionnaire.

Considering the collected quantitative data, after the workshop the attitude of educators for creating content for computer games is improved fig.2. (before seminar: mean 3,5; st.dev:0,92; after the seminar: mean 4,75; st.dev: 0,46), Likert scale (1 min.-5 max., 3 neutral). Tutors appreciated the working process with the smart service platform as rather easy, including submitting the content in structured forms. As the easiest functionality for tutors is to fill the ready templates and the ability to upload additional files. The selection of learning objectives and the design of the learning content were identified as the most challenging tasks for the game development process.

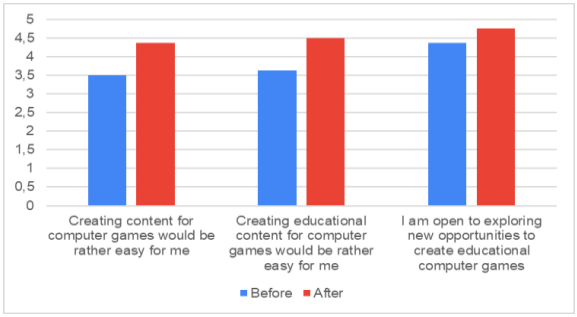

Figure 2. The tutors' attitudes for game design before and after the workshop.

In terms of game personalization approaches, the tutors highlighted that they would apply learning personalization approaches mainly considering the learners' age/ grade, their preferred learning and playing styles, and the level of interest in their specific discipline. All of the respondents stated that additional statistics for learners' preferences, recommendations for good practice, teacher and learner experiences, and individual preferences are to a large degree useful when designing and using educational video-games.

The open-ended questions revealed that the process of developing educational games, using smart-service platform is easy for teachers, they see the potential to create educational games and better understand appropriate approaches for game use and development. One of the participants noted that the workshop motivated her to explore more game-based learning approaches in her own field - architectural design. More research is needed to identify how different type of games and

gamification approaches can be applied in different subjects and discipline areas.

2) Validation with University Students

The second experiment for testing and validating the pilot smart service system was organized with students, enrolled in the BSc teachers' program at Sofia University. The main task for the students was to make an educational video game, by selecting and systematizing learning content according to the chosen topic, including texts, images, diagrams, and audio content, and to define the content of the selected puzzle minigames. They had to complete the task for two to three learning hours, providing learning and game content (including texts and multimedia files such as audio and images, processed to fit the system requirements) for the game development.

Within this experiment, three testing games were successfully designed and developed by the students - a game dedicated to learning styles (the VARK game), a game on Geography, and a game for Triangles. All of the games are operational, can be easily up-graded and adapted to a specific situation and learners.

After the experiments, 15 students filled the same questionnaire for their experience evaluation. The conclusions are that students easily navigated the smart service system, they understood well how to generate an APOGEE video-game, and they received enough additional information about the benefits of using computer games in the educational process.

When comparing data between tutors and students, it can be identified (fig.3), that students are somehow more critical and demanding for using more visual video-game creation technologies comparing to the educators. This can be explained by the fact that university students are better prepared to learn from visual tutorials and they are better adapted to use learning-by-doing systems and technologies.

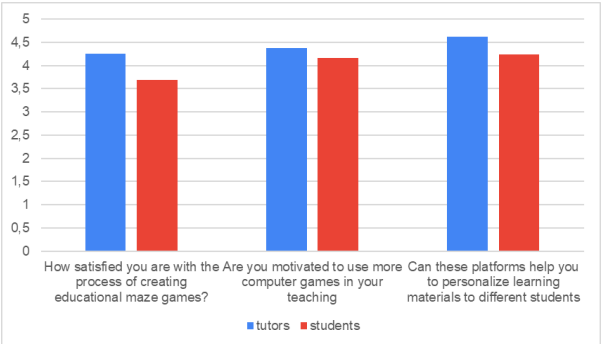

Figure 3. Comparing the attitudes of tutors and students on game design process.

The evaluation of the students' quantitative and qualitative feedback shows that the creation of educational three-dimensional maze video-games is both interesting and in the same time challenging for them and requires a totally new mindset and way of thinking. Some of the students who worked independently encountered difficulties in understanding how to proceed with the APOGEE gaming platform and could not finish their games.

IV. Discussion

The objectives of the selected smart services are to support teachers, providing additional functionalities to improve the effectiveness and efficiency of the learning process. In this perspective, smart services can facilitate teachers to create more interactive, personalized and differentiated digital game solutions, better assessing and adapting them to the individual characteristics of the learners.

From user experience perspective, it is important to underline that both tutors and students had positive attitude for the smart service platform seminar. Most of them enjoyed the participative process of working with the system, collaborating with their peers, thinking about best gamification approaches and its visual representation. Reducing stress on learning a new computer system for game design allowed both teachers and students to dedicate more time and efforts to specify appropriate learning and game content and learning objectives and to focus on mini-games experiences. After playing the games, students became even more motivated to investigate how to use GBL approaches in class.

The general outcomes of the validation demonstrated that the proposed smart-service system model supports the fast and smooth design and development of an APOGEE 3D educational maze game. This experiment for validation session demonstrated that a group of non-trained university lecturers and students succeeded to create several fully functional three-dimensional enriched maze video-games on the platform APOGEE for just few hours of work. It allowed participants to: (1) easily understand the concepts of game-based learning and APOGEE maze game design elements; (2) identify learning goals and objectives of the educational games; (3) provide in participative manner didactic content for the game design, including texts, images and sound, as well as to structure mini-games content (4) identify models and strategies for learning personalization, supported by the APOGEE platform.

V. Conclusion

The most important factor for introducing GBL on practice is to make the process of game design enjoyable, efficient and satisfactory for teachers. By reducing the stress from using a new platform, both students and tutors gained confidence and interest to design and use more educational video games. Further, it is recommended that game design platforms should support more participative approaches for users, allowing them to work in groups, to share experiences, data and learning analytics on best practices for learning scenarios and learners' preferences and to allow interactive and multistage development process.

Acknowledgment

The research leading to these results is partially based on the outcomes of the APOGEE project, funded by the Bulgarian National Science Fund, Grant Agreement No. DN12/7/2017 and supported by the Erasmus+ e-CREHA project, Number: 2020-1-NL01-KA203-064610.

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