

TEACHERS NEED PLATFORMS FOR CONSTRUCTION OF EDUCATIONAL VIDEO GAMES

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Abstract

At present, digital games are applied in education as a highly interactive visual media able to incorporate knowledge, didactic tasks, and virtual objects in an appealing and interactive way. For a massive penetration of educational video games into the learning process, teachers and educationalists do need simple and affordable software platforms for the easy construction and generation of such games in their subject area, in a straightforward way without any needs of programming. For greater both effectiveness and efficiency, constructed games for education should adjust their features such as task difficulty, object speed, learning content, and audio-visual effects depending on the outcomes and the emotional state shown by the player. Thus, players would be able to improve their skill levels, cognitive abilities, and general performance. The paper presents a case study aiming at the identification of user needs of platforms for construction of educational video games, developed within the scope of the project APOGEE (smArt adaPtive videO GamEs for Education). It outlines the stages of the conducted case study and the specifics of the questionnaire, in addition to presenting some of the initial results from the survey. Further, we make a statistical analysis of key findings and discuss both the meaning and importance of the obtained data. In conclusion, the research summarizes collected from respondents during case study and survey the recommendations concerning the functionality of the platform for the generation of smart adaptive video games for education and proposals for didactic mini-games.

Keywords: user needs, educational video games, platform, generation, GBL, APOGEE.

1 INTRODUCTION

Serious games intended for school education can be considered as a tool for learning at the intersection between formal and informal educational settings [1]. For this form of education, the main motivation is the desire of the students who want to improve their knowledge. This form of learning can be viewed as informal as well as unconscious. It is usually voluntary that is a crucial factor for its success. Educational computer games appear to respond to changes in society – its digitalization and need of innovations in classical education [2]. At present, the major challenge to identify the way for easily constructing various educational games that offer informal education in many subjects. Thus, the need for platforms that are user-friendly and support teachers even without specific programming skills to create such games is growing [3].

The game-based learning (GBL) is based on the idea that man constantly learns through interactions with variable visual environments. This form of training is often is considered as vague, because it is seen as leisure, fun activity. But in fact, for example, training simulators, some medical and military applications that help to gain skills and knowledge that are very specific and often hard to acquire another way. The same concept can be applied to any area of science [4]. GBL can fundamentally reshape not only the form of education but also its content and understanding of the role of students and teachers throughout the education process [5].

Nowadays, digital games are applied in education as a highly interactive visual media able to incorporate knowledge, didactic tasks, and virtual objects in an appealing and highly interactive way. Modern game-based learning has proven advantages over classical teaching in a classroom - it motivates students to play an active role in the learning process and, hence, to learn in an immersive and effective way. While playing educational video games, learners obtain both long-lasting knowledge and practical skills in an enjoyable way. For a massive penetration of educational video games into the learning process, teachers and educationalists do need simple and affordable software platforms for an easy construction and generation of such games in their subject area, in a

straightforward way without any needs of programming [6]. For greater both effectiveness and efficiency, constructed games for learning should adjust their features such as task difficulty, object speed, learning content, and audio-visual effects depending on the outcomes and the emotional state shown by the player [7]. Thus, players would be able to improve their skill levels, cognitive abilities, and overall performance.

The paper presents a case study aimed at the identification of user needs of platforms for construction of educational video games, developed within the scope of the project APOGEE (smArt adaPtive videO GamEs for Education). As the project goal is the creation and practical validation of an innovative open software platform for building smart and adaptive video games for education by teachers, in order to identify and understand the user needs, the project the team conducted a special case study addressing these needs. The case study was designed as a two-stage process:

- 1 First, we conducted structured interviews with teachers and educationalists in order to embrace their vision about both the types and usage of educational video games applicable to their subject and, next, about the functional requirements for the future online platform for construction, customization, and automatic generation of such games;
- 2 Second, we conducted an online survey applying a special questionnaire having 21 items addressing the types and the use of educational video games, together with the functional requirements for the platform.

The paper outlines the stages of the conducted case study and the specifics of the questionnaire. As well, it presents some of the initial results obtained from filling in the questionnaire, together with an initial statistical analysis of obtained data. Next, it provides a discussion on both the meaning and significance of the presented data. Finally, the paper concludes with some meaningful suggestions about the types of educational games found important for learning and, as well, about the features of the future platform for construction and automatic generation of smart and adaptive video games for education.

2 MOTIVATION

This section of the paper outlines our motivation to start the APOGEE project and, in particular, to conduct the case study about teacher needs of platforms for construction of educational video games. For this purpose, the sections first present a short review of the previous research in the field and, next, a comparative analysis of existing software platforms for construction of educational games.

Two crucial issues need to be solved to enlarge the use of educational games in the school practice: a high production cost [8] and a lack of enough free and customizable platforms for the automatic creation of such games [3, 6]. The massive inclusion of GBL can be facilitated vastly by providing tools for rapid video game construction. The open or free platforms for generation of educational games offer the possibilities to the creation of end products suitable for any specific curriculum. Answering to this need, this paper presents a software platform for automatic generation and easy customization of educational video games maze. The maze is defined in a declarative way including a description of its structure and properties.

GBL penetrate widely in the schools in many countries during the last decades, but there are still some obstacles in front of the massive use of games in the education. The GALA Roadmap [8] identifies several main obstacles and open questions, listed here:

- high development cost – educational games have a specific purpose, so their users are limited;
- less attractiveness than commercial games;
- the hard transition between instructional and game design – it has to achieve conformity the game mechanics with the learning mechanics;
- assessment issues – a shortage of effective tracking the learners' progress parameters;
- application of psychological theories in the design of adequate realistic non-playing characters (NPCs);
- the need of a reference framework – a correlation of different pedagogical paradigms to serious game mechanics.

The ten key impediments to applying games in the education are identified by Shapiro [9]. He emphasizes on three crucial technological obstacles embarrassing the extensive application of educational games: the cost of purchasing; difficulties in finding appropriate for a specific curriculum video game; and uncertainty about the ways of their applying into the teachers' practice [10].

2.1 Background works

Despite the proved benefits of GBL, this innovation in education is still hampered by different kinds of obstacles. One of the most significant obstacles is the shortage of free tools and platforms for creation and customization of educational games by teachers and non-IT specialists. The available simple educational games oriented to traditional classroom goals [9] are not sufficient for the universal massive use of GBL. Heading to this direction, generators of simple 3D video maze games with a different type of rooms and tunnels [3] with built-in learning content and cognitive tasks are designed. A framework for describing and analysing games is proposed by the Game Ontology Project [11], including game interfaces, rules, goals, and entity manipulation, that can be an effective base for a game generation. Game assets should be described in a similar way like the RAGE (Realising an Applied Gaming Eco-system) [12] asset metadata model related to the applied games domain.

In order to be more efficient, the modern video games should personalise their parameters (task difficulty, object speed, learning content) according to the outcomes and emotional state of the player. This gives the player the opportunity to make many meaningful choices depending on their skill levels, cognitive abilities, emotions, and performance [13]. The gameplay should be adapted to the context of individual player applying specific player's model. Tracking and measuring the human behaviour performed by player-centric modelling allows adapting the game by researchers and game designers according to some features of the player such as playing style, player's emotions and affect, and player's skills [ibid]. The ADAPTIVES (ADAPTive player-centric serious video gaMES) holistic player-centric model proposes an identifying the playing skills, cognitive outcomes, emotional state, and playing/learning style and applying them for dynamic adaptation of game mechanics, dynamics, and aesthetics [14]. This model was applied in several adaptive educational games and was proved that brings benefits on the effectiveness, immersion, and educational playability.

Recent video games usually include virtual players (NPCs) that can be personal assistants answering questions or doing tasks for the player or opponents [15]. The intelligence chat bots as a part of a chat room are well accepted by real players in the form of NPCs in the games. The answering to questions appears first in role-playing games [16] but it is appropriate also for any game having NPCs. Smart NPCs should provide adequate answers to the player's questions, especially to those within the thematic domain.

2.2 Educational game development platforms

Labyrinths are one of widely used in entertainment games, as they offer the player selection of several action options while presenting interactive content. Thus, they gain popularity as very suitable for interactive educational games and recently become frequently used in GBL [3, 6, 17]. In Table 1 there is presented a comparison of some of the popular platforms for the automatic creation of games. All the platforms are compared to the Maze Builder tool that is at the base of the developed platform for the construction of intelligent adaptive video games for education proposed in the project APOGEE. To make this comparison we choose, some of the most significant criteria from the viewpoint of teachers without programming skills, who will be the intended end user. Despite the technical requirements – the platform where the games are played (important for more wide use), we analyse the functionalities provided to users without programming skills (the opportunities user to configure, adapt and upgrade the game) and some other criteria as follows:

- Platform for which is generated game – desktop, Web-based, mobile, or console;
- Dimension type of the-game – 2D, 2.5D, or 3D;
- Game engine – used by the generated games;
- Need of programming language in the process of creation of games;
- Learning resources within the game – for example slides, test questions for opening doors or for proceeding further in the maze, image puzzles, etc.;
- Personalisation – for example changing font, colours of text and background, adding sound and visual effects, etc.;

- Openness of platform – the code is available for modifications or is locked;
- Price – free, trial or paid solution (possible academic discounts).

It should be taken into account that some of free versions of platforms have limited core features. Table 1 presents a comparison of platforms for automated creation of educational games.

Table 1. A comparison of platforms for automated creation of educational games.

Solution Criteria	Quandary¹	Qedoc Quiz Maker²	ADAPTIMES [14]	Kahoot³	ADOPTA [18]	Maze Builder [6]
Platform distribution	Web	Desktop	Desktop	Web	Web	Desktop
Type	2D	2D	3D	2D	2D	3D
Game engine	None	None	None	None	None	Unity 3D
Need of programming skills	No	No	Python	No	Java, OWL	No
Learning resources	slides, test questions	slides, test questions, learning games	slides, test questions, arranging images	test questions, discussions, trivia games	logic and word games	slides, test questions, arranging/ finding 3D objects
Personalisation	images, music, video, fonts	images, font, sound effects	textures, rooms	videos, images, diagrams	game patterns, custom game components	textures, images, music
Open code	No	No	Yes	No	Yes	Yes
Price	Free	Free	Licensed	Free	Free	Free

3 THE APOGEE PLATFORM FOR AUTOMATIC GAME GENERATION

In this section, the maze builder platform for an automatic game generation, developed within the APOGEE project is presented. The project objective is to design and create an open software platform for the construction of smart and customizable 3D video labyrinth games with intelligent virtual players (smart NPCs) and to validate it by practical experiments with creating prototypes of games in a complex and content-rich teaching domain. Here are presented the requirements for the platform, considerations for the design and some results from the conducted survey. The essential quality requirements for the platform are identified as follows:

- The generated video games to be portable to different target platforms;
- The Maze Builder platform is planned to be usable by non-IT specialists (like a substantial part of the teachers.) To design as simple as possible user interface and the process of creation to be automated;
- The adding of new game objects and script components should be easy. For this reason, the platform is designed as a free open-source application to the Unity 3D editor and the code is available for future extensions;
- The platform is easy to maintain, as it is not implemented for a specific version of the game engine and it should work well with future releases of Unity 3D with minor or no modifications;
- The Maze Builder platform relies on the high-performance qualities of the Unity 3D game engine. Its scripts need to be efficient and free of any large time or memory consuming code.

¹ <https://www.quandarygame.org/>

² <http://qedoc-quiz-maker.software.informer.com/>

³ <https://kahoot.com/>

The platform and methodology for the easy creation of smart adaptive educational video maze games by non-IT specialists will be applied using the following innovative features:

- The metadata-driven approach for maze creation will be supported by visual graph construction of the maze, declarative game description, and semantically structured representation of artefacts;
- Using a Unity3D-based maze builder for automatic generation of the educational labyrinth;
- The customizable adaptation control engine will apply physiological measurements and analysis of facial expressions for managing adaptation of game mechanics, dynamics, and audio-visual effects;
- An intelligent agent will provide appropriate answers to player questions during game sessions.

The APOGEE platform will enhance the current desktop version of the Maze Builder by abilities for online generation of educational mazes runnable in Unity 3D and embedding mini-games of various types such as rolling balls to predefined places or objects in the maze rooms, finding, collecting and sorting of hidden objects, solving tests for unlocking doors, etc. APOGEE will take a metadata-driven approach for maze creation supported by an online visual graph editor. The editor will allow visual graph construction of the maze, declarative game description, and semantically structured representation of artefacts. On the other side, APOGEE plans to develop a customizable adaptation control engine that will apply physiological measurements and analysis of facial expressions for controlling adaptation of game mechanics, dynamics, and audio-visual effects. Finally, an intelligent agent embedded into virtual computer players will provide appropriate answers to player questions during game sessions.

The APOGEE platform for online construction and generation of educational maze games is planned to be usable by teachers and educationalists who are non-IT specialists. For that purpose, the user interface is designed as simple as possible and the process of creation is highly automated. However, it is crucially important to understand user needs and requirements to the functionalities of such a software platform for online construction and generation of educational maze games. With this regard, the authors proposed a methodology of a survey aiming at understanding these user needs.

4 METHODOLOGY

Within the scope of APOGEE project⁴ we conducted structured interviews and quantitative survey by specially developed online questionnaire, both aimed to identify the needs of schools teachers and educators of software platforms for the construction of educational video games, including the generation of educational video maze games, in which the didactic material is presented in a thematic (modular) way by means of canvases with text, graphic content, and audio materials for each hall, together with various types of learning tasks. Structured interviews were started with a demonstration of a prototype of educational maze game generated by the APOGEE platform and related to the Bulgarian medieval history. It was intended to introduce teachers to educational maze games, their objectives, and structure. Based on the presented game we made a discussion focused on the identification of the user needs of educational video games and free platforms for their creation. The issue was studied from the perspective of the teachers predisposed to apply GBL to enhance the traditional teaching process in Bulgarian elementary schools.

The survey aims at exploring the needs of teachers (usually without programming skills) both for platforms for the creation of intelligent educational video games and such games itself. In order to explain the essence of an educational maze games, the survey provided a brief video demonstration of an educational game named “Asenevtsi”⁵ about the history of the creation and strengthening of the second Bulgarian kingdom, generated with the APOGEE platform for Unity 3D. Next, teachers were asked to fill an online questionnaire consisting of 21 questions that reflect user needs identified by conducted structured interviews. It refers to two areas: (1) Applicability of educational video games (14 questions), and (2) Platform usability (7 questions). As our goal is to measure respondents’ attitudes and opinions with the more precision, we choose Likert five-point scale type questions. For a better analysis of findings, we also include questions for identifying teachers’ profile and experience with ICT

⁴ <http://apogee.online>

⁵ <https://youtu.be/ml9NwiZOrB0>

and computer games. Another group of questions explores the application of educational computer games in teaching practice and the readiness of respondents to take part in the development of such resources. Further, we examine the teachers' views on the preferred types of mini-games that have to be built-in the maze video games to effectively support achievement of various pedagogical goals during the teaching process. An essential part of the survey also is the identification of the respondents' views and preferences to functionality and interactions with the platform for creation and adaptation of video games.

5 RESULTS

This section outlines the results obtained by the structured interviews and, next, presents some initial results obtained from the online survey.

5.1 Structured interviews

The experimental work on the project APOGEE includes a case study focused on the identification of the user needs of platforms for development of educational video games for Bulgarian primary and low secondary schools. The users are both teachers and educationalist who are eager to create custom educational video games and use them in their teaching practice to support knowledge acquisition. The user needs were studied according to the viewpoint of the teachers who do not have specific programming skills.

The experimental setting of a structured interview with primary and elementary school teachers was a seminar aimed to introduce to teachers the concepts of the project APOGEE and to demonstrate the "Asenevtsi" prototype of an educational video game. The main goal of prototype was to demonstrate functionalities and sample learning tasks that are integrated. About 15 educators took part in structured interview and propose many practical ideas about the development and construction of games. Some of them are as follows:

- to make the platform user friendly, easy operating;
- to make a graphic visual interface of the platform for creating educational video games;
- to record and limit the time for questions answering;
- to record the player's results and the reached position in the game when exit;
- to change the questions or tasks at each entry into the game (by a random selection);
- to collect bonuses in accordance with the difficulty of the question in order to stimulate students;
- to make an online ranking of the participants;
- to make a competition multi-player version of the game;
- to develop tool for editing and upgrading games already created;
- to generate mobile versions of the games.

All these constructive suggestion are useful and will be at the base of planning and developing the game platform. Moreover, the structured interviews contribute to construct more precise questionnaire aimed to in-deep exploring teachers' needs and requirements to the platform for creating educational video games. Further, they help us in selecting appropriate questions that could address both to the teachers and school students.

5.2 Survey results

Until present, 148 teachers from Bulgarian primary, secondary and high schools have participated in the online survey. Their profiles are represented in fig. 2 (left). In the survey invitations, there was no special preference for teachers of given subject. About a quarter of all the respondents appeared to be teachers in primary schools (teaching all the subjects), while near 30% reported teaching mathematics and informatics. The right chart of fig. 2 provides the distribution of the answers to Question 3: "Do you use or plan to use educational video games in the classroom?". Though only a fifth of the teachers reported using educational video games in the classroom, the majority of them plan to apply such games in teaching.

With our next questions, we try to address the appropriateness of educational video games to the school levels. Table 2 presents a comparison between the statistics mean (M), standard deviation (SD), and standard error (SE) about the answers to Question 6: “Are the following types of educational games eligible for the primary school?” and Question 7 “Are the following types of educational games eligible for the secondary course?” (both having a 5-level Likert scale from “1 – Definitely no” up to “2 – Definitely yes”). The differences are both negligible and not statistically significant (p-value is greater than 0.05). The same goes for the high school.

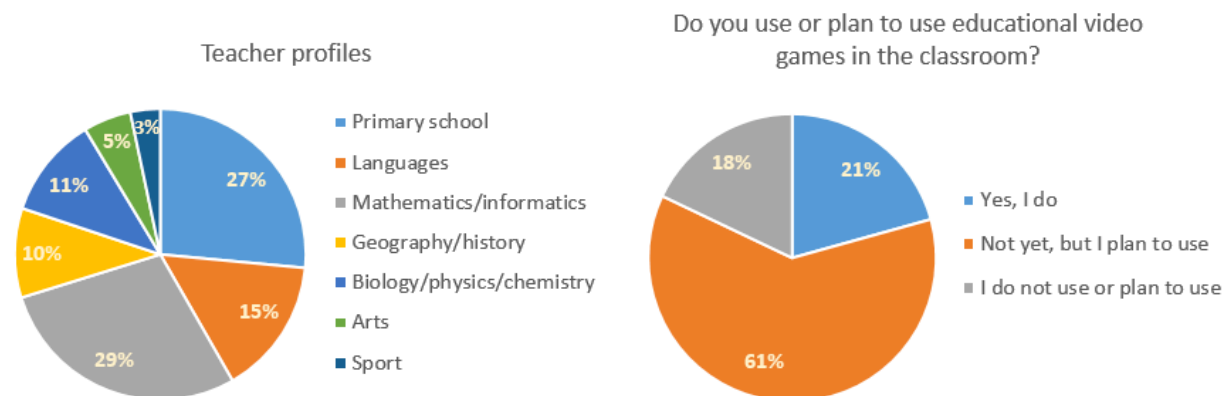


Figure 2. Teacher profiles (left) and usage of educational video games in the classroom (left).

Therefore, we can conclude that according to teachers the interactive environments (e.g., virtual museums), logical and board games, and educational mazes are the most eligible games for schools.

Table 2. Appropriateness of educational video games to primary and secondary school.

Statistic Games	Primary school			Secondary school			Difference b/n M	
	M	SD	SE	M	SD	SE	Diff.	p
Simulators	3.5809	1.1389	0.0977	3.6667	1.0557	0.0930	-0.0858	0.2072
Adventure	3.8913	1.0786	0.0918	3.8015	1.1329	0.0990	0.0898	0.2053
Social games	3.8162	0.9978	0.0856	3.9084	0.9723	0.0850	-0.0922	0.1787
Exercise Games	3.5185	1.1772	0.1013	3.4609	1.1426	0.1010	0.0576	0.3609
Shooting Games	2.4737	1.3404	0.1162	2.5276	1.3323	0.1182	-0.0539	0.8038
Virtual environments	4.0638	1.0903	0.0918	4.0846	1.0118	0.0887	-0.0208	0.9131
Puzzles, logical and board games	4.2286	0.9844	0.0832	4.1221	0.9529	0.0833	0.1064	0.1749
Educational labyrinth	4.2319	0.9225	0.0785	4.1364	0.9473	0.0824	0.0955	0.1929

As far as the APOGEE platform is going to generate educational mazes enriched with various types of mini-games, we asked teachers (Question 8, 5-level Likert scale) at which extent such educational video labyrinths are appropriate for the age groups of learners in pre-school, primary school, secondary school, high school, higher school, and those practising continuing education. Fig. 3 reveals that such video mazes are found by teachers as mostly suited (with M between 3.5 and 4) for the primary, secondary, and high schools, i.e. for learners aged from 6-7 up to 18-19 years.

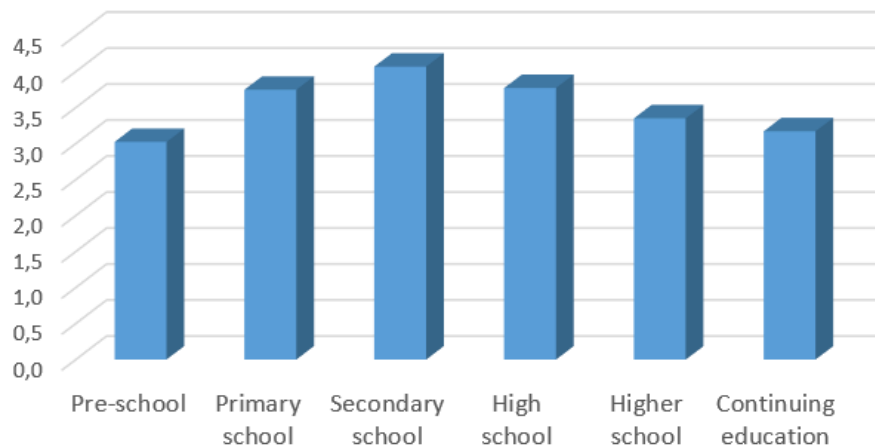


Figure 3. Results about appropriateness of educational video labyrinths for different age groups.

Question 9 asked about the suitability of educational video games labyrinths for training on different subjects such as mathematics, natural sciences, languages, social sciences, and IT and vocational training. Fig. 4 show the numbers of teachers voted about each subject with values between 1 (definitely not) and 5 (definitely yes). We see they regard these games suited for all the subjects but mostly for natural and social sciences, and mathematics.

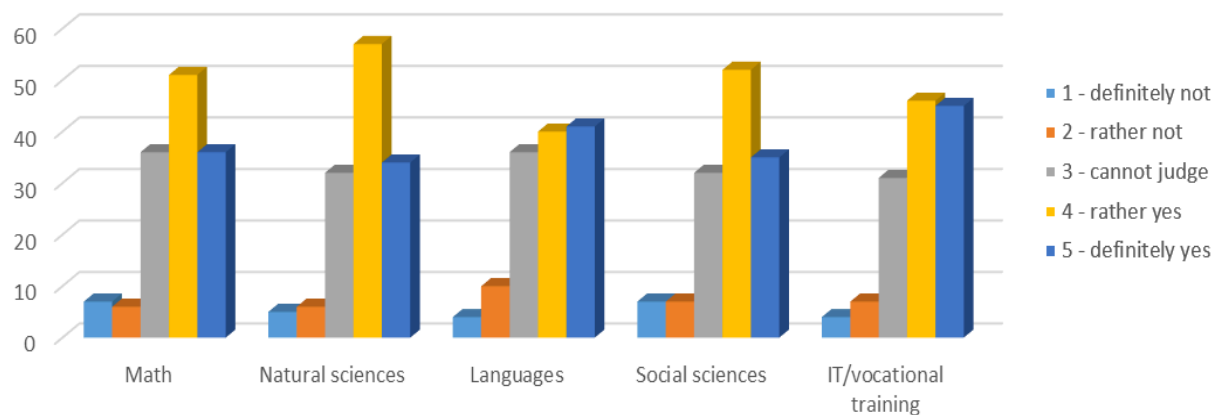
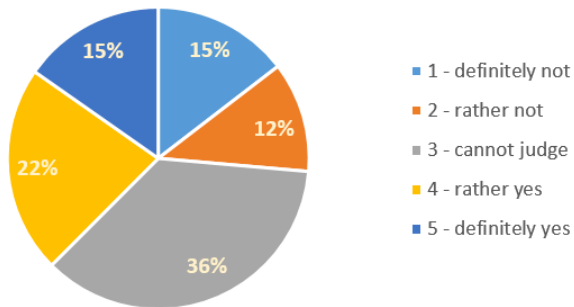


Figure 4. Results about appropriateness of educational video labyrinths for different subjects.

The present version of the APOGEE Maze Builder supposes defining educational video mazes by a formal document (in XML), while the future versions are going to support a Web-based graphical editor for intuitive description of the maze, with further generation of the XML description file. So Question 15 asked teachers if they are able to describe educational video games-labyrinths by manually creating a text document that is used to automatically generate the game. Fig. 5 (left) reveals that only 15% of all of them could to this without any problems. Next, question 16 asked: "Instead of manually creating a text document template, would you prefer to describe easily an educational video game labyrinth in a graphical online editor, followed by an automatic game generation?". The chart in fig. 5 (right) shows that a half of them do prefer such an option, while 30% are not sure about that but could try it.

Answers to Question 15



Answers to Question 16

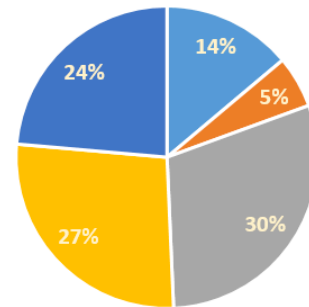


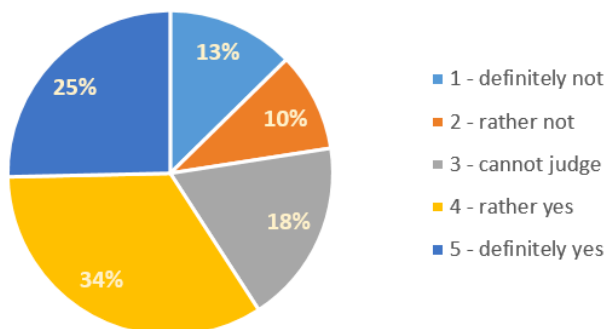
Figure 5. Answers to Question 15 (left) and to Question 16 (right).

Next, we asked teachers about their opinion regarding usage of virtual computer players and adaptation in educational games:

- Question 17: "Do you consider that the generated educational video games should include virtual players to help the learner and answer his/her questions in the subject area?".
- Question 18: "Do you consider that the generated educational video games should be dynamically adaptable in terms of player's outcome?".

The charts represented in fig. 6 provide an eloquent evidence about the preferences of teacher to educational games having both virtual computer players and adaptation according to the player's outcome – about 2/3 of all the teachers approve considering that very positively.

Answers to Question 17



Answers to Question 18

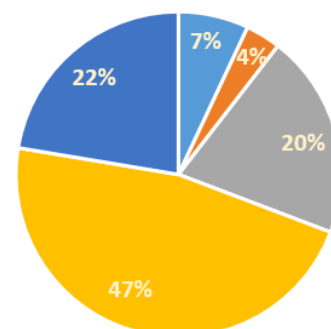


Figure 6. Answers to Question 17 (left) and to Question 18 (right).

6 CONCLUSIONS

Educational computer games offer the change of didactics and teaching methods as well as an entire transformation of the education process [4, 15]. The transition from the traditional pedagogue to innovative game-based learning seems to be started. Gamification as a modern teaching method is already a trend that changes the role of teachers and students' way of learning. As GBL is an appropriate approach for engaging learners in difficult concepts or enhancing student motivation through competition, so many teachers try to employ educational games in their practice [10]. Nevertheless, only a few of them succeed in creating their own games usually because of lack of required knowledge. This hindrance can be overcome by providing a user-friendly, specially designed for users without programming skills platform for the development of educational video games [2, 5]. Thus, we are motivated to start the project that aims to provide a solution to this problem.

In the further work on the project, we will take into account the teachers' recommendations that they share in the questionnaire. The respondents proposed many mini-games, and elements to be included in the maze game, as follows:

- to design various skill levels and the players to be greeted for accomplishing them;
- to take into account the time for passing levels in the final result in order to stimulate the competitive spirit of the students;
- to develop an interface for plug-in of innovative devices like adding controllers for operating in an virtual or augmented reality;
- students to participate in the process of game creation as a part of their IT education;
- to add other types of mini-games, for example:
 - crossword games both for numbers and words (when a task is solved properly, a word or sentence to be obtained);
 - placing missing objects on a map;
 - arranging objects according to size or position in space;
 - math chains;
 - finding objects by their properties, related words or definitions;
 - adventure games with collecting artefacts for passing the levels;
 - connecting images with text;
 - enigmas and puzzles.

All these features of the mini-games embedded into the rooms of the educational maze are expected to enhance the smart and adaptive labyrinth games constructed and generated by the APOGEE platform.

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