DIDACTIC MINI VIDEO GAMES – STUDENTS’ AND TEACHERS’ POINT OF VIEW

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Abstract: Computer games are used more and more often in education. Their application in the learning process brings a lot of benefits and advantages compared to the classic form of teaching without the use of new technologies. Some of the more sophisticated games can include a variety of smaller ones, which supplement their functionality. In this article are described in detail the mini-games, which will be part of a 3D educational labyrinth game. They include: quiz, 2D puzzle, solving a Wordsearch Puzzle, rolling balls, shooting on moving inanimate objects, etc. The characteristics of mini-games are considered, and they may be mandatory or optional. The opinions of students and teachers regarding their preferences for the mini-games and the results are studied and compared. Surprisingly, according to the survey, teachers show a more positive attitude towards educational games than students. The APOGEE project aims to create a platform for automatically generating an educational 3D labyrinth game that can be easily used by teachers, even if they are not IT specialists. Thus, they will have the opportunity to choose the right mini-games and the necessary training material.

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Introduction

Lately, computer games find wider and wider application in education. Their application in the learning process brings a lot of benefits and advantages compared to the classic form of teaching without the use of new technologies (BinSubaih, 2009; Mat Zin et al, 2009; Waters, 2009).

Computer games themselves are also constantly developing and acquire new functionalities. The early games were two-dimensional, whereas today 3D games are widespread. Virtual, augmented and mixed reality (VR, AR, MR) are also widely used for fun as well as learning. Some of the most popular sources of VR applications and games are ClassVR platform (<http://www.classvr.com>); Expeditions app (<https://edu.google.com/products/vr-ar/expeditions>) and Unimersiv platform (<https://unimersiv.com>). In addition to the change in visuals, games are also changing in complexity: offering personalization of content, dynamic adaptation (Bontchev & Vassileva, 2017) in the course of the game and can include intelligent virtual players. Many different game genres are emerging with each one finding fans among users of all ages.

To meet students’ preferences, developers of educational games need to create a large variety of them. In addition to the required learning material, they should also encompass many game genres in order to hold the attention of adolescents. It’s also recommended that teachers take part in their development since they have the necessary experience with the target group and can present the learning material in a way that’s understandable for students. The main objective of that is the teachers’ knowledge in the area of information technologies.

The APOGEE project (<http://apogee.online>) is created aiming to meet these requirements and needs of the education system. The development of a platform for automatic generation of labyrinth games in which learning material can be embedded is planned as part of the project. The platform will have a simplified interface in order for it to be used even by teachers not possessing in-depth IT knowledge. Various mini-games can be embedded in the labyrinth halls, presenting parts of the learning material. The possibilities of these types of games for teaching primary school students are presented in paper by Terzieva (2018). A labyrinth game containing information about the development of carpet making in Bulgaria is described in work by Bontchev & Panayotova (2017).

Mini-Games into the Labyrinth Halls

The platform-generated video game labyrinths will have one main objective: the players go through all the labyrinth halls and accomplish all required game tasks in such a way that they complete the game (reaches the final screen), collecting the maximum number of points (i.e. to achieve a maximum result).

At the same time, these video game labyrinths can have mini-games of different types built in the labyrinth halls and which represent the educational tasks. This sets a number of specific goals for each of these embedded video games that need to be accomplished to complete the mini-game and fulfil the learning task.

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Types of mini-games

Here are presented examples of the types of three-dimensional mini-games that can be embedded in the labyrinth halls:

Answering a question in order to unlock a door to another hall in the labyrinth

The player has to approach the door and read the question to open it (Figure 1). He/ she sees the predefined answers and has to choose the correct one. If the typed number corresponds to the correct answer, the player receives a message to click on the door to open it. If the answer is wrong he/ she can choose another answer. Before the player gives a new answer, a certain time has to pass that is necessary for the player to read the needed information on boards (images) hanged on the hall's walls.

Figure 1: Answering a question for unlocking a door

Source: Author

Responding to several questions in order to unlock a door to another hall

The player answers a number of questions from a quiz, and in order to open the door he/ she has to collect a certain number of points. Information about answers to the questions can be found in various forms (texts or content in mini-games) in the present room. The questions in the quiz are selected especially for the certain player. If the quiz fails (i.e., the required number of points is not collected), the player can respond again after a certain amount of time has passed. As with the first game, the needed information can be found in the hall.

Unlocking the door by solving a 2D puzzle

The door to the next room can also be opened by arranging an automatically generated 2D puzzle with a learning image. Its content can be personalized by the gender and/ or age of the player.

Solving Wordsearch Puzzles (word soup)

The word soup will be able to be personalized to the players according to their observability. The words can be arranged in rows or columns (for the more observable players also by diagonal), with directions: from top to bottom and from left to right (for the more observable players – in all directions). The words are selected from the learning content automatically or by the teacher.

Composing a word using given letters

The player receives a given set of letters, out of which he/she has to compose a word/collocation, related to the learning material. The correct answer has to be given in a certain amount of time and its complexity may be adjusted according to the age and knowledge of the players (personalization of these parameters).

Rolling balls marked with text or images to certain items or positions on the floor

There are several balls in the room that are marked with text or an image of the studied matter. The player has to roll them to certain places or labelled rings on the floor (Figure 2). Upon reaching the corresponding place or object, the ball stops moving. The task is successfully completed when all or a certain number of balls have reached their definite end position.

Figure 2: Rolling balls certain place on a map or to labelled rings

Source: Author

Detection of visible semi-transparent objects in order to obtain points

There are a number of semi-transparent objects in the room that a player needs to find (Figure 3). If the task is not set as mandatory, they can give extra points or items to be used in other small games within the main game. The objects are thematically related to the study material and can be selected automatically (from a database) or set by a teacher.

Figure 3: Finding a semi-transparent object

Source: Author

Detect invisible objects hidden in larger visible ones by moving large objects

There are a number of transparent objects in the hall that are hidden in larger visible ones and the player has to find them out. They can also give extra points or be items that can be used in other mini-games within the main game. As with the previous game, subjects are thematically related to the material being studied and can be automatically selected or assigned by a teacher.

Collecting and grouping the found objects by a common feature

Here the player can use the items that are collected from the previous two games or use other (provided especially for this game). Objects should be grouped according to a common feature. Personalization can be realized by setting different difficulty groups of features. It can also be done according to players' gender and/or age.

Memory development game

The game is played by providing a group with an even number of cards or tiles. The cards match in pairs, with different types of matches possible: identical images; image and attribute; or related objects. The player opens them two by two attempting to open a pair of matching cards. If the open cards are a pair, they remain open (or disappear), and if they do not match they are hidden and the player has to open another two cards. The game ends when all the matching pairs of cards are found.

Shooting moving inanimate objects

Students like games involving shooting (see section 3.2 and table 1), but in order to avoid the element of violence and aggression, the objects on which they shoot are inanimate. In the halls, there are balloons with a load attached to them, and the player has to hit them with a bow to get the item. These items are related to the learning material and can be used in different ways to further mini-games or just to bring

points. In this case, personalization may be related to the speed of the balloons or the height at which they are flying (i.e., the distance).

The following activities are not mini-games, but are mandatory elements of the labyrinth game or can be optional (help from a virtual assistant player or a smart virtual player who extracts knowledge from the Web in the subject area):

Getting help from a virtual assistant player without asking: He/she cannot answer questions but can give predefined information, thematically related to the subject area.

Asking questions to a smart virtual player who extracts knowledge from the Web in the subject area of the game: The player types a question and the smart virtual player searches the answer in the Web. After finding the information on trusted websites he/ she answers the player's question.

Walk through the labyrinth using an interactive map showing where the player currently is.

Characteristics of the Mini-Games

Each mini-game has a different characteristics that will be described below. These game-tasks can be:

Mandatory for execution - the player cannot continue the main labyrinth game (i.e. exit from the current hall and enter another) if he/ she does not accomplish the given mini-game (i.e. does not solve the given learning task).

With optional execution – the player can continue the main labyrinth game (i.e. exit the current hall and enter another) if he did not accomplish the given mini-game (i.e. did not solve the given learning task). Such optional mini-games can be played at a later stage in order to increase the score or not to be played at all.

With the purpose of easier generation and gameplay, the following restrictions are imposed: 1. In a labyrinth hall, there may be a maximum of one copy of each type of mini-game. 2. Mini-games do not have a time limit for playing, but playing time left to the end of the main game (i.e. solving the learning task) brings points to the player. 3. In multiplayer mode, each player sees his or her own individual instance of a mini-game - this limitation is set so that each player can solve all mini-games available in the labyrinth (instead of one player solving the mini-game and then rest cannot do so).

Results and Analysis

The APOGEE survey was conducted with students and teachers from different schools in Bulgaria. It included a procedure for sending online invitations to teachers and a request for assistance to regional education authorities by posting a notification on their websites. The study also included seminars with teachers and students.

Methodology

The purpose of the surveys is to explore the experiences of teachers and students and the perspectives for the use of educational video games in class. The study may include variables that are based on the nature of the curriculum, focusing on specific learning outcomes. It is also necessary to clarify the factors influencing perceptions and actual use of video games in schools. This study aims to identify the main parameters to be taken into account when designing, developing and adopting video games for training.

An online questionnaire on the creation of educational video games by non-IT specialists and their use in teaching was created to conduct the survey with teachers from the primary and secondary educational stage in the Bulgarian schools in the country and abroad. Similarly, a questionnaire was developed for understanding the students' attitudes towards the use of educational video games in the learning process. The texts of the two surveys are available on the project site: <http://apogee.online/news.html>

When comparing the opinions of students and teachers in the next two sections the questions aimed at students are denoted with an S (665 respondents) and those aimed at teachers with a T (208 respondents). Answers are graded according to the Likert scale where 1 means "Definitely no" and 5 means "Definitely yes".

Teachers' and students' preferences for the type of games

In the questionnaire, students responded to questions about their preferred types of games for fun and learning. Questions are formulated as follows: S7. "Do you like playing the following types of video games?" / S15. "What kind of learning games would you prefer to play?" The results are presented in Table 1. According to the results, the most preferred type of game for adolescents is FPS (First Person

Shooters), followed by simulators and action/adventure games. Students also like to play sports games, labyrinths and puzzles (including logic and board games). Surprisingly, the least preferred games for fun are games on social network sites.

Table 1: Comparison of the students' preferences to the type of games for fun and learning

	S7			S15				
Type of games	M	SD	SE	M	SD	SE	Diff.	P
Sports / Exergames	2.68	0.0848	0.0033	3.13	0.0653	0.0026	0.45	0.00000
Action / Adventure	2.91	0.0766	0.0030	3.59	0.0994	0.0040	0.68	0.00000
Puzzle/ Logic / Board	2.68	0.0933	0.0037	3.23	0.0732	0.0029	0.55	0.00000
Social games	2.46	0.0990	0.0039	3.33	0.0847	0.0034	0.87	0.00000
Simulators	2.96	0.0716	0.0028	3.32	0.0745	0.0030	0.36	0.00001
Games for shooting	3.33	0.1054	0.0041	3.26	0.0741	0.0029	-0.07	0.42776

Source: Author

According to students, all types of games are suitable for learning with the most preferred being the action/adventure type. Results show that most game types are preferred for learning purposes rather than for fun. The only exception is the shooting games with a minimal difference (3.33 and 3.26). For almost all types of mini-games the results are statistically significant with $p < 0.05$ (calculated with T-test). The only exception is the shooting games ($p = 0.43$), the results being more heterogeneous here and differences in students' opinions are essential.

These results show students' readiness to utilize games in their learning process. This conclusion suggests the need for creating a larger number of various games for learning purposes. This need gives ground to researchers to include a variety of mini-games in the main game. However, the final decision about which mini-game will be included in every automatically-generated game will be made by the teacher who describes it.

Table 2 shows the results from the comparison of answers given by students and teachers about their preferred game types for fun and learning. The questions are the following S15. "What kind of learning games would you prefer to play?" / T6. "Are the following types of educational games appropriate for school students?"

Table 2: Comparison of the teachers' and students' preferences to the type of games

	S15			T6				
Type of games	M	SD	SE	M	SD	SE	Diff.	p
Sports / Exergames	3.13	0.0653	0.0026	3.47	0.0877	0.0066	0.35	0.00086
Action / Adventure	3.59	0.0994	0.0040	3.77	0.1137	0.0085	0.19	0.05863
Puzzle/ Logic / Board	3.23	0.0732	0.0029	4.10	0.1477	0.0110	0.87	0.00000
Social games	3.33	0.0847	0.0034	3.88	0.1283	0.0096	0.55	0.00000
Simulators	3.32	0.0745	0.0030	3.70	0.1119	0.0084	0.37	0.00011
Games for shooting	3.26	0.0741	0.0029	2.58	0.0654	0.0050	-0.68	0.00000
Interactive museums	3.04	0.0618	0.0025	4.11	0.1504	0.0112	1.08	0.00000
Labyrinth	3.12	0.0628	0.0025	4.18	0.1597	0.0118	1.06	0.00000

Source: Author

Surprisingly, teachers evaluate different types of games' potential higher than students. The most preferred types of games for learning according to teachers are puzzles (logic and board games), educational labyrinths and interactive museums. Right here are the biggest differences between the opinions of the two groups of respondents (from 0.87 to 1.08). On the other hand, the most unwanted type of game for teachers is shooters. The difference in opinion with students is also significant - 0.68. Here again the T-test shows that the results are statistically significant with $p < 0.05$ for all mini-games, except for Action / Adventure (0.059).

Teachers' and students' preferences to the included mini-games

Teachers' and students' preferences to the included mini-games in the main maze-game are presented in table 3. The questions are defined as follows: S18. "Educational video games-labyrinths should also include the following types of mini-games:" / T13. "Is it appropriate that educational video games-labyrinths include the following types of mini-games:"

Table 3: Comparison of the teachers' and students' preferences to the type of included mini-games								
Mini-games	S18			T13				
	M	SD	SE	M	SD	SE	Diff.	P
1	3.32	0.0851	0.0034	3.95	0.1532	0.0109	0.63	0.00000
2	3.27	0.0867	0.0035	3.82	0.1394	0.0100	0.55	0.00000
3	3.19	0.0807	0.0032	3.77	0.1312	0.0095	0.57	0.00000
4	3.32	0.0880	0.0035	3.85	0.1370	0.0099	0.53	0.00000
5	2.97	0.0788	0.0032	3.58	0.1316	0.0096	0.61	0.00000
6	3.12	0.0805	0.0032	3.66	0.1443	0.0104	0.54	0.00000
7	3.09	0.0809	0.0032	3.67	0.1307	0.0094	0.58	0.00000
8	3.12	0.0890	0.0036	3.95	0.1567	0.0112	0.83	0.00000
9	3.08	0.0790	0.0032	3.50	0.1149	0.0084	0.42	0.00001
10	3.16	0.0792	0.0032	3.81	0.1395	0.0100	0.66	0.00000

Source: Author

In order to shorten the table, only the numbers in brackets appear in the table. Some of the mini-games discussed in section 2.1 are included after the dissemination of the questionnaires and for that reason are not presented in the table.

The suggested mini-games and elements of the main game for evaluation by the two groups of users are the following:

- Answering a question for unlocking a door to another room in the labyrinth (1)
- Answering several (tailored for the specific user) questions for unlocking a door (2)
- Unlocking a door by arranging a two-dimensional puzzle (chosen from images related to the studied material) (3)
- Interactive map of the labyrinth, showing where the player is located at the moment (4)
- Rolling of balls with an image or text on them to predetermined places or objects on the floor (5)
- Discovering visible semi-transparent objects for obtaining points (6)
- Discovering invisible objects, hidden in bigger visible ones by moving the latter (7)
- Collecting and grouping the found objects according to common criteria (8)
- Getting help from an assistant player (9)
- Asking questions to a smart virtual player who can answer questions, connected to the game topic (10)

Students give the highest evaluation to the mini-game which contains answering a question to open a door and using an interactive map of the labyrinth. The game with rolling a ball, on the other hand, received the lowest evaluation by the adolescents. Two reasons for this are most probable: they do not appreciate the educational element of matching one object with another or have difficulty manipulating the ball.

Teachers also give their opinion on which mini-games are suitable for learning purposes. They give their highest evaluation to collecting and grouping objects by a common criterion and answering a question to open the door to the next hall. The least wanted game element is the smart virtual player. The reason for that is probably their suspicion that this will make students' tasks too easy and the learning objectives will not be met.

As in the previous section, teachers show a more positive attitude towards learning games. The biggest difference is with the game containing collecting and grouping objects by a given criterion (0.83) and the smallest – for receiving help from a smart player (0.42). For all studied game types the results are statistically significant, with $p < 0.05$ (calculated with T-test).

Conclusion

Adolescents use many different types of games in their leisure time. Some of them, however, still cannot get used to the fact that computer games can also be used for learning purposes. In contrast to students, teachers realize the engaging power of games and show readiness to include them in their work. At the same time, a need arises for the creation of a large number of various computer games. On the one hand, they will have to be able to cover to a great extent the learning material by subject and age, and on the other, to include a large variety of genres in order to meet the needs of adolescents.

The platform developed in the APOGEE project aims to meet this need for various games. The inclusion of varied mini-games meets students' demand for games of different genres. It is foreseen that teachers can easily use the platform, even if they are not IT specialists. In this way, they will have the opportunity to choose the right mini-games and the necessary training material. Another advantage of automatically-generated games is the possibility for personalization in the choice of learning material and the way of presenting it on one hand, and on the other, the dynamic adaptation of the game to the specific player according to his/her style of playing, emotional condition and results achieved.

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References

- APOGEE – smart adaptive video Games for Education, Accessed 11 January, 2019. Retrieved from: <http://apogee.online>
- BinSubaih A., Maddock S., Romano D. (2009). Serious Games for the Police: Opportunities and Challenges. Special Reports & Studies Series at the Research & Studies Center (Dubai Police Academy). Accessed 10 August, 2019. Retrieved from: https://staffwww.dcs.shef.ac.uk/people/S.Maddock/publications/BinSubaihEtal2009_special_report.pdf
- Bontchev, B. and Panayotova, R., (2017). Towards Automatic Generation of Serious Maze Games for Education. *Serdica J. Computing*, Vol. 11, No 3, pp.249–278. Accessed 10 August, 2019. Retrieved from: https://www.researchgate.net/publication/333118847_Serdica_Journal_of_Computing_TOWARDS_AUTOMATIC_GENERATION_OF_SERIOUS_MAZE_GAMES_FOR_EDUCATION
- Bontchev B. and Vassileva D., (2017). Affect-based Adaptation of an Applied Video Game for Educational Purposes. *Interactive Technology and Smart Education*, vol. 14, no. 1, pp. 31-49. DOI: <https://doi.org/10.1108/ITSE-07-2016-0023>
- ClassVR platform. Accessed 11 January, 2019. Retrieved from <http://www.classvr.com>
- Expeditions app. Accessed 11 January, 2019. Retrieved from <https://edu.google.com/products/vr-ar/expeditions>
- Mat Zin, NA, Jaafar, A & Yue, WS, (2009). Digital game-based learning (DGBL) model and development methodology for teaching history, *WSEAS Transactions on Computers*, vol. 8, no. 2, pp. 322-333. Accessed 10 August, 2019. Retrieved from: <https://pdfs.semanticscholar.org/0128/1d0d54d0766964fab29ccef0206f11be87.pdf>
- Terzieva V., (2018). The Potential of Educational Maze Games for Teaching in Primary Schools. *Proceedings of the 11th annual International Conference of Education, Research and Innovation ICERI2018*, November 12-14, Seville, Spain, IATED, ISBN:978-84-09-05948-5, ISSN:2340-1095, pp. 2480-2489. Accessed 10 August, 2019. Retrieved from: <https://library.iated.org/view/TERZIEVA2018POT>; DOI: <https://doi.org/10.21125/iceri.2018.1542>
- Unimersiv platform. Accessed 11 January, 2019. Retrieved from <https://unimersiv.com>
- Waters, A., (2009). Serious Games for Students in Healthcare: Engaging a Technically Inclined Generation. *Canadian Journal of Nursing Informatics*. Vol. 3, No. 4, pp 16-27.