EXPLORING PUZZLE-BASED LEARNING FOR BUILDING EFFECTIVE AND MOTIVATIONAL MAZE VIDEO GAMES FOR EDUCATION

Albena Antonova[1], Boyan Bontchev[2]

[1]CIST at Sofia University "St Kl. Ohridski" (BULGARIA)
[2]FMI at Sofia University "St Kl. Ohridski" (BULGARIA)

Abstract

Puzzles are popular learning instruments and teachers easily adopt them in class, raising students' motivation and engagement. Furthermore, puzzle-based learning has many advantages for developing complex transversal skills. Therefore, the APOGEE (*smArt adaPtive videO GamEs for Education*) research project exploits puzzles as building blocks for supporting teachers to generate personalized and adaptable rich educational maze video games. The present study aims to explore puzzles-based learning strategies for constructing personalized and adaptable educational video maze games within the APOGEE video game platform. The paper proposes a model for adapting puzzle games both to the educational context and to the end-user profile. First, an overview of the puzzles and puzzle-based learning concepts is made, leading to a model of educational puzzles-games taxonomy. Then, there is suggested a taxonomy of puzzle games based on five criteria for their classification. The next part explores the development process of APOGEE puzzle games, including tailoring to the player/learner profile considering learning context and end-user profile. In the end, selected ten types of educational APOGEE puzzles are defined regarding their abilities for personalization and adaptation. Finally, the authors reflect on the main strengths, weaknesses, opportunities, and threats for applying APOGEE video games in class and their role as a student-focused education instrument.

Keywords: Puzzle-based learning, maze games, educational experiences, personalization.

1 INTRODUCTION

While complex video games technologies and game-based learning approaches attract the attention of practitioners and researchers, the literature for digital puzzle-based learning remains modest. Historically, the types of puzzle games exist since the antiquity, depicted on the halls of the Egyptian pyramids or taking part in the mythology and legends (the Knossos labyrinth). Through the centuries, puzzles engaged and entertained people, and today, some mathematical and logical puzzles help training artificial intelligence algorithms. In educational settings, puzzles are popular learning tools and teachers easily adapt them to specific learning context or discipline [1], challenging and entertaining students and puzzle solvers [2].

The present research aims to explore puzzle-based learning and puzzles as building blocks of personalized and adaptable rich maze video games. In the framework of the platform APOGEE[1] (*smArt adaPtive videO GamEs for Education*), the advantages of puzzle-based learning and puzzles will be applied for designing and generating rich maze video games for education [3, 4]. Ten different types of puzzles are going to be integrated within the APOGEE video mazes. By selection of specific learning scenario, the APOGEE platform will allow teachers to design personalized and adaptable educational video maze games. The personized instance of the puzzle game will be created applying the static characteristics of the learner profile such as age, gender, school year and learning and player style, while the dynamic adaptation of the difficulty will be realized using the dynamic profile properties like player skills and outcomes, demonstrated in the game.

The paper is structured as follows: the first section makes an overview of the puzzles, puzzle-based learning and puzzle taxonomy including puzzle types and elements, and reflecting on their impact on learning. The second part presents the platform APOGEE and its functionality for supporting teachers to generate adaptable and personalized educational video games. Next, we propose a taxonomy of puzzle games based on five criteria for their classification. Then, the APOGEE games process and models for game building, game personalization and adaptation are defined. There are explored

[1] http://apogee.online/index-en.html

personalization and adaptation strategies within ten types of puzzles and mini-games. The discussion part defines the main strengths, weaknesses, opportunities, and threats for further adoption of APOGEE rich adaptable video-maze games. Finally, the last section outlines the next steps and further work for puzzle-based learning adaptation and personalization.

2 OVERVIEW OF PUZZLE-BASED LEARNING

2.1 Defining Puzzles Games

Commonly, puzzles are defined as single-player games or rule-based systems that are enjoyable to play [5]. Puzzles represent a large variety and types of playful activities, usually referred as a “game, a problem or a toy” that asks the player to find a solution by applying a specific set of rules. The player or the puzzle solver needs ingenuity, logic, knowledge or patience to find the right solution.

Strictly, puzzles are not games [6], as they are static and single-player, simple and non-social [7]. Therefore, unlikely to games and other play activities, puzzles do not require winning over a competitor and do not exploit socialization elements. The problem solving is the central puzzle mechanic [8] and finding the solution is intrinsically motivating, both aesthetically pleasing and satisfying for the player [5]. According to Steven Clontz [9], a puzzle is any question or problem, which meets two important conditions:

- to be designed in a way entertaining the puzzle solver;
- to have a well-defined solution.

Therefore, first, puzzles as any other forms of play should be entertaining and engaging. For this purpose the following three factors should be considered: the puzzle’ novelty, the puzzle’ challenge (not too easy, and not too hard), and the puzzle trick [8]. In puzzles, the fun is derived primarily from learning, from decoding, memorizing and applying specific skills to progress, as puzzle games generate fun primarily from problem-solving [10].

Second, players should find one or several well-defined solutions, resolving a logical or conceptual challenge, often within a specific time limit or in combination with other game elements or actions. Puzzles are "mentally challenging" [11], and can be integrated into action or adventure games, used as building blocks of more complex games.

In computer games classifications, puzzles are specific sub-class of video games. They are typically played in series, presenting a variation of a particular theme. This common theme can include pattern recognition, logical follow-up, or understanding of the process. The puzzles have a simple set of rules, and the game space is limited within a spatially defined structure such as board, net or other closed structure. Players should solve a puzzles-type challenge before winning and moving to the next level and the game difficulty increase gradually. In some puzzle games, the difficulty of the levels can vary.

As already discussed, puzzles vary considerably by type and by elements. Some authors as [9] categorize the puzzle into the following genres: mechanical puzzles (such as jigsaw puzzles, nail puzzles, or Rubik’s cubes and snails); logic puzzles (like Sudoku, nonograms, and logic grids); math puzzles (formal or narrative), word puzzles (e.g. crosswords or letter soups); trivia (a variety of various puzzle types including mixed types); riddles (though they do not fit to the puzzle definition given over); and pattern puzzles (like finding the next number in a sequence, or removing the number/figure that does not follow a pattern). Obviously, some popular puzzle genres are not included in this categorization, such as matching puzzles (tile matching like *2048* or *Tetris* and other falling block puzzles); memory games (like reconstruction of positions of figures after observing them for a short time); observation puzzles (e.g. to find the differences between two pictures); hidden objects puzzle (like *Black Box* or *Minesweeper*), and advancing blocks puzzles (where player has to prevent some moving blocks from reaching the opposite edge of the board).

Furthermore, by slightly extending the definition above, riddles and construction puzzles can be considered as puzzles, that may have one or several well-defined solutions, or may have many and unknown solutions. Escape rooms can be considered as well as specific sub-class of puzzle or maze games, even if played by a team. The participants have to solve different challenges in order to find well-defined solutions and to escape from specific physical or virtual space within a certain time limit. It is important to note that they can contain both real and virtual tasks and challenges [12].

2.2 Puzzle-Based Learning

Puzzles are widely used in an educational context as they involve the development of many transversal skills such as critical thinking, logical thinking, pattern recognition, unstructured problem solving and others. In this context, it is interesting to note the long-term observations of [13, 14, 15, 16] who developed puzzle-based learning courses in order to build complex skills such as critical thinking and problem-solving. Exploring many empirical studies in different educational contexts, the authors underline how puzzle-based learning builds on critical thinking, motivating learners to solve complex and unstructured problems [14]. Many real-life problems can be explored as large-scale puzzles, and puzzle-solving skills can be referred to as business-related skills [16]. The aim of puzzle-based learning is to develop critical thinking skills and approaches to effectively solve real-life problems [15]. In its general meaning, solving real-world problems requires three categories of skills: to address uncertain and changing conditions, to apply domain-specific knowledge and methods, to apply critical thinking and to implement common problem-solving strategies.

More specifically, [14] suggests that educational puzzles should conform to four main principles: to be general (following universal rules), to be simple (to remember easily the rules), to evoke the Eureka moment (to challenge the player) and to be entertaining (to engage the player). The two main principles of the puzzles are the Eureka moment and the entertainment (or fun). The Eureka moment involves a sense of frustration, relief (when the puzzle is solved) and reward [ibid]. Without entertainment elements, solving the puzzle may become boring and the interest in solving it can wane.

Among other differentiating features of the puzzles [17], are that they are self-contained (all information for solving the puzzle is supplied within it), and that puzzles usually do not address specific subject or knowledge domain, but rely on common principles and knowledge. By comparing puzzles to mathematical problems and tasks, [17] claim that solving puzzles and problems can help students to adopt novel and creative approaches, to make choices, to develop modelling skills, to develop tenacity, to practice pattern recognition, reducing problem situations to exercises. Hence, [18] explores the following functional roles of educational video-game puzzles such as:

- an instrument for presenting/delivering learning content,
- an incentive for additional intellectual activity,
- an instrument for learning assessment,
- a model for transferring features to other context or areas of action.

These features allow puzzle video games to become an appropriate tool to support learning processes. The focus of puzzle-based learning is the development of transferable and domain-independent skills [16]. In addition, it enhances introspection and reflection, addressing an abstract level and pattern of thinking to create key skills and knowledge such as critical thinking, logical thinking, and analytical capabilities [19]. Puzzles encourage building problem-solving by lateral thinking, analytical skills, memory skills, pattern recognition, abstraction, creativity, and engagement. Further, successful, fun puzzle games very carefully control the pace with which challenges are introduced chronologically (i.e., the learning curve) throughout a players interaction with the game.

2.3 Puzzle Games Taxonomy

There are different video game classifications, proposed in the research and practitioners' literature, outlining different models, characteristics and elements. In order to build a taxonomy of puzzle games, we have first to set criteria for their classification. We suggest several such criteria, as follows:

I. Criterion 1: *the puzzle problem* - a puzzle presents one main problem and has one (or, sometimes, several) well-defined solutions (s), requiring specific skills. The problem solution may be either close-ended (i.e. fixed, with a prearranged end, known in advance), or open-ended (i.e., unrestricted).

a) Close-ending puzzles have a predefined solution and may be:
   - Finding puzzles:
     - Find-by-exploration: observing and searching at the playing area for an existing (sometimes hidden) item/object or pattern;
     - Find-by-thinking: finding/discovering some items/objects or patterns, such a logical decision (like in matchstick puzzles, math puzzles, or in cryptograms), or answer to a question;

- Find-by-remembering: observing and memorization of a given situation (objects or patterns) – e.g., discovering differences, matching tiles, often requiring a faster execution of a task;

- Arrangement puzzles:
  - Ordering dispersed items/objects in a predefined uni-/two-/three-dimensional sequence – like 2D/3D jigsaw puzzles, card puzzles (like *Solitaire* and *Freecell* puzzles, or sequences of pictures related to each other in time or zoom order, etc.
  - Classification of items/objects/traits – the player has to sort the puzzle items into categories, forms, colours, etc., e.g. to sort the country names by the content where the country is located;
  - Association of items/objects/traits – the player needs to associate some items with others, based on specific rules (identical items, similar items, or inverse items).

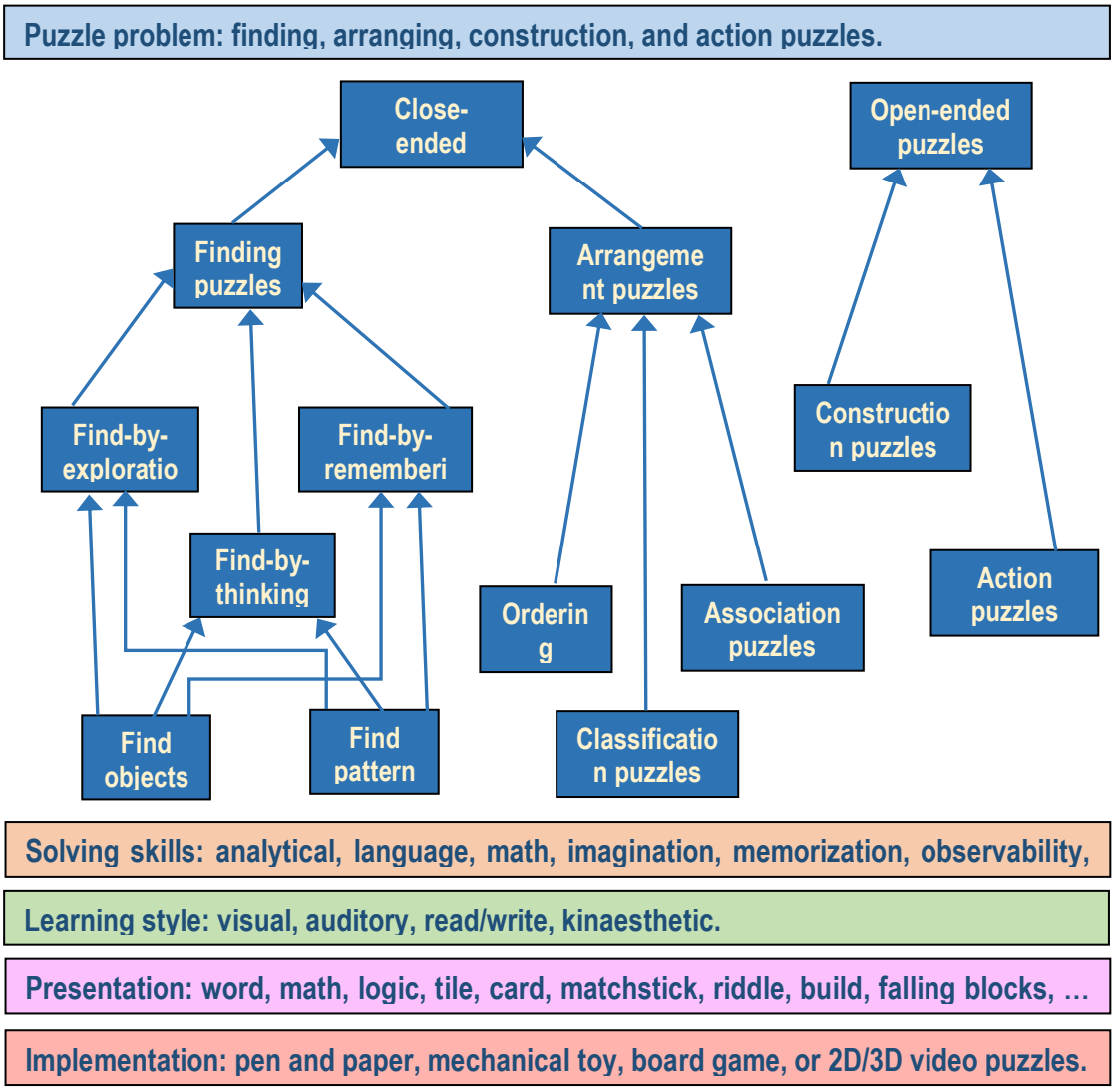

Figure 1. Puzzle categorization.

b) Open-ending puzzles may imply a construction process or dynamic actions:
   - Construction of new objects by existing items/objects (ordered or dispersed) - unlike ordering puzzles, these puzzles have no predefined and known to the player goal, i.e. a sequence/ordering of the items, building the puzzle, therefore, the player is free to use them as he/she finds for appropriate; examples here could be stick puzzles, many tiling puzzles and, as well, some mechanical puzzles;

- Fast dynamic actions for matching/shooting/grabbing moving items, usually, for a limited time - for matching or destroying them, or restricting them at the playing area; like the construction puzzles, the action puzzles may include other puzzle sub-types of arrangement and finding puzzles.

II. Criterion 2: *the type of skills* required for solving the puzzle problem - the solution may require analytical/language/mathematical/imagination (lateral thinking) skills, memorization, observability, and/or speed and dexterity.

III. Criterion 3: *the learning style* the puzzle is appropriate for - as far as puzzles are a means for learning, an important criterion should be the learning style that the puzzle addresses best. By means of Fleming's model of so-called VARK learning styles [20], learners are identified by their individual preference for visual learning (like pictures or movies), auditory learning (by listening to music or lectures), reading and writing (textbooks or notes), or kinaesthetic learning (by movement and experiments).

IV. Criterion 4: *the puzzle representation* – the same problem (e.g., finding synonym words) may be presented in several ways, like a word puzzle, as a set of riddles, as a tile matching or a logic puzzle.

V. Criterion 5: *the puzzle implementation* – the same puzzle can be provided as various physical implementations, such as solution for pen and paper, a mechanical toy, or a video game. For example, a Black Box is an abstract board game for one or two players, that can be played with pen and paper, with game board and pieces, on the Emacs text editor, or as a custom 2D/3D video game.

We exclude the puzzle solving time from the classification criteria, as far as each puzzle may have or not a restricted time for solving. In fact, time restriction is one of many implementation features and might be imposed for any type of puzzle. Fig. 1 presents puzzle categorization by the five criteria, given above. Each specific puzzle can fall in one or more of the categories, split by the puzzle problem, solving skills, and learning style. At the same time, any given puzzle instance has one presentation and one implementation.

3 PERSONALIZATION AND ADAPTATION OF THE APOGEE PUZZLE GAMES

The concepts of puzzle-based learning will be applied in the APOGEE research project [3, 4]. The APOGEE software platform aims to facilitate non-IT professionals like teachers, to generate rich educational maze video games, containing different types of puzzles and mini-games. Among the main features of the APOGEE maze video games is their capacity to adapt and personalize learning content, taking into account both the learning context and the end-user profile characteristics.

3.1 The APOGEE Personalization and Adaptation Process

The process of the APOGEE game personalization and adaptation takes three main stages (figure 2). During the first stage, the game designer (teacher, educational expert) explicitly defines the learning scenario, based on the learning context. The platform APOGEE supports six learning scenarios [21], and each of them can cover specific types of puzzles. The teacher can select the most appropriate types of puzzles among the suggested for each scenario, assuming the learning content, the learning context and the general demographics of the learners (their age, background knowledge, and others). In addition, teachers will be able to set puzzle variances in order to make the educational game more engaging and motivating, based on students' last achievements and preferences.

On the second step, every end-user (student/player) defines explicitly its profile within the system. By responding on an initial set of quizzes and self-reporting tools, the end-user completes its static profile, including gaming and learning preferences. Based on this static profile, the game engine create a personalized instance of the video maze game for every specific learner. Furthermore, the game engine calibrates the main puzzle game mechanics and elements such as speed, time and constraints.

Lastly, during the play, the maze game engine collects data (dynamic profile) of the end-user, reflecting his or her game performance and in-game experience. Based on the dynamic data from the user performance, the game engine can calibrate the play variations including both the learning content within the puzzles (the level of difficulty), as well as the game mechanics (to keep his attention). The dynamic profile data, generated during every play experience are stored in the system, serving as a source for analytical services for the teachers and game creators.

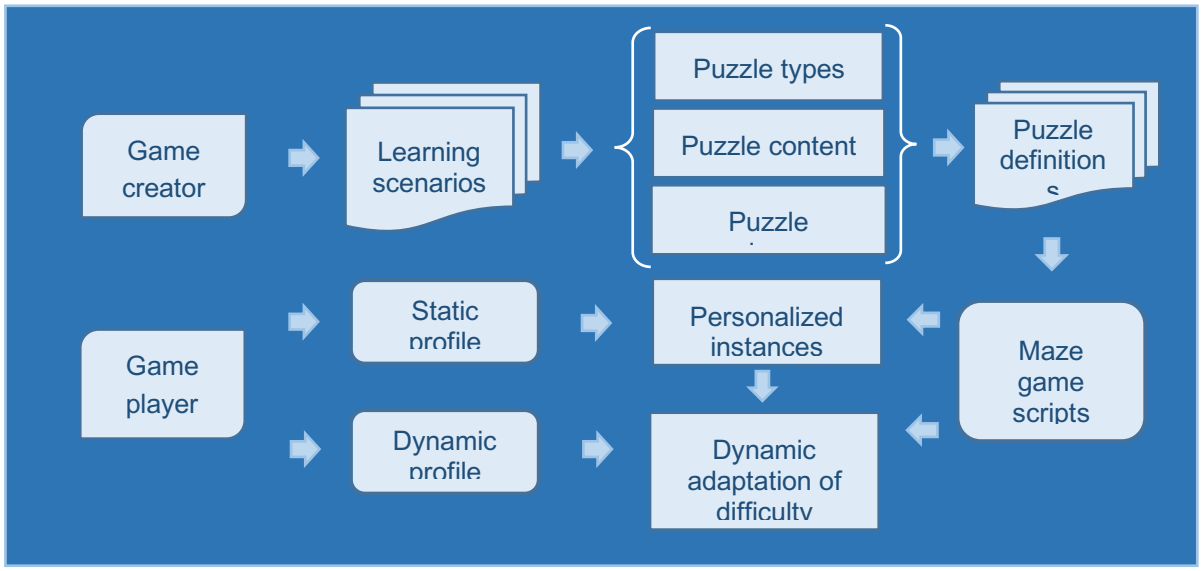

Figure 2. The process of puzzle design, personalization, and adaptation.

3.2 APOGEE Personalization and Adaptation Models

The main function of the APOGEE maze game is to serve as an educational instrument, adapted to the learning context and to the end-user needs and preferences. In the section below, we will outline the main models for puzzle games personalization and adaptation.

3.2.1 Game Creator: Design Scenario and Context

The APOGEE personalization and adaptation is made first by the game creators (teachers), who take into account various characteristics of the learning context and content and, as well, set specific puzzle variances. The puzzle variances, defined by the teachers, can include:

- The didactic content complexity – basic; medium; expert - it is supposed to be different for learners of different age, having a different learning style, or demonstrating different learning outcomes;
- The didactic content structure – the content may appear in short consecutive paragraphs or as a continuous text;
- The puzzle type's presentation and features: image, sound, text, or video;
- The presentation of the didactic content – by changing the font, size, color, etc.;
- The game mechanics such as speed, time and constraints for specific learning task

3.2.2 End-User Static Profile: Learner and Player

The end-user static profile reflects his or her personal characteristics. The end user defines them explicitly in the game system by completing directly his or her profile or by responding on additional pre-set quizzes. Even if static elements can change over time, they do not depend on the player experience with the system. They can include demographic characteristics (age, gender), learning profile attributes such as school year, learning style; and playing profile attributes and preferences, such as playing style and player expertise.

The static profile of the end-user determines the personalized instances of the maze video game. Based on the end-user preferences as learner and player, the maze video game scripts will generate a personalized version of the maze with puzzles types and characteristics. This way, the didactic content of the game will be personalized both to individual learner' age, learning outcomes, specific learning style and preferences, and to his playing style and expertise.

3.2.3 End-User Dynamic Profile: In-Game Experiences

The game adaptation follows the player in-game experience, taking into account his/her game performance, emotional status, and engagement. As puzzle mini-games embedded into the maze halls may have different difficulty and/or audio-visual parameters, they can dynamically change, following

some properties of the player model such as the playing style and outcomes. For example, according to the player model, the game engine can change dynamically some features of the puzzle game mechanics like:

- The mechanic difficulty of solving the puzzle – e.g., by varying the number and forms of tiles constituting a 2D image puzzle, or tailoring the velocity in a shooting mini-game embedded into a hall of the maze;
- The audio-visual features of the puzzle mini-games embedded into the maze – such as illumination, contrast, sound volume, sound tempo, etc.

Therefore, the puzzle mini-games embedded into the maze can have a different dynamic adaptation to the playing process, changing the game difficulty based on in-game experience and game results. The collected data of dynamic adaptations can serve for further analytical tools and recommendation services for teachers.

3.3 APOGEE Puzzle Games

The APOGEE maze video game will support and contain the following types of puzzle games [3] – finding puzzles (G1, G2, G6, G7, G9), arrangement puzzles (G3, G4, G8) and action puzzles (G5, G10). More specifically, the types of puzzle games planned to be included in APOGEE maze halls are as follows:

- G1. Answering a question about unlocking a door to another hall in the maze;
- G2. Answering several questions (a quiz) about the didactic content presented in the hall;
- G3. Arranging a 2D puzzle, which is automatically generated from an image;
- G4. Solving a 'word soup' puzzle (search specific words in rows, columns, or diagonals) – in all directions;
- G5. Rolling balls marked with both text and image to:
  - certain positions on the map shown on the floor;
  - certain objects (e.g., rings) located on the floor in the hall.
- G6. Detection of visible translucent objects;
- G7. Detection of invisible objects hidden in larger visible objects by moving the large objects;
- G8. Ordering and classification of found objects by specific feature;
- G9. Memory development game – the player has to remember and match equal colours, images, or texts;
- G10. Shooting on moving objects (e.g. balloons with a 3D didactic objects attached to them).

All the puzzle types provide opportunities for personalization and adaptation, however, in very different ways. The table below presents some possible ways of introducing personalization and adaptation into the ten puzzle games.

Table 1. Personalization and adaptation of APOGEE puzzle games.

	Personalization of the puzzle	**Adaptation of the puzzle**
G1	Asking an open/closed question with a specific difficulty	Changing the question difficulty; setting a variable time limit
G2	Asking questions with specific difficulty; select the true answer among the variable number of wrong answers	Changing the question difficulty; setting a variable time limit
G3	Choice of puzzle content and number and form of the building items	Rotation and movement of the building items
G4	Changing the letter grid size and the words	Showing/hiding a list of the searched words; Variable number of words/complexity
G5	Changing the number of balls and positions	Showing/hiding positions and their titles

G6	Changing objects' number, size, and type	Changing objects' visibility; variable difficulty of objects (common/domain specific)
G7	Changing objects' number, size, and type	Showing hints for the hidden objects, association rules and patterns
G8	Changing the type of objects and degree of complexity	Showing hints for ordering/classification; association rules and patterns
G9	Changing the matching criteria (image to the same image/text/form/etc.)	Setting a variable time limit; association rules: same/similar/opposite
G10	Changing object types	Changing the velocity, acceleration, and size of the objects

4 DISCUSSION

Puzzle-games are widely used in school education; they are domain-neutral, develop critical and logical thinking and makes the learning process more interactive and enjoyable. By facilitating teachers to create adaptable and personalized puzzles-based maze educational video games, the APOGEE project aims to develop new school education instruments for students' focused and personalized instruction.

The main strengths of the APOGEE puzzle games include: low learning curve, easily adaptable to existing educational practices, to specific learning domains and learning scenarios in class, an interactive instrument, supporting personalized and adaptable student' focused instruction, easy to implement in different educational context (classwork, homework, study visits, and others), puzzles are integrated within a thematic maze. On the other hand, the main weaknesses of the APOGEE puzzle games consist in a lack of support of sophisticated game mechanics (as commercial video games), lack of in-game socialization (all the puzzles are single player games), and support of a limited number of interactive activities.

The APOGEE puzzle games provide several main opportunities. First, the APOGEE puzzles can be explored in various formal and informal learning scenarios in schools, supporting building transversal skills. A large set of learners' specific data will be generated, supporting analytical instruments and improving teachers' efforts for students' personalization. Furthermore, the APOGEE personalization and adaptation strategies can be integrated within other e-learning systems such as MOOCs, as well in e/m-learning and blended learning solutions. Last, but not least, the design of the puzzle-games scenarios can improve teachers' collaboration, knowledge sharing among teachers, and promotion of best practices.

The main threats of the wider implementation of the APOGEE puzzle games include:

- lack of teachers' motivation and capacity to use it (lack of knowledge, time, will, administrative school support);
- administrative restrictions (for example, using mobiles in class);
- lack of students' interest toward playing educational puzzle video games;
- resistance to new educational practices;
- problems with efficient player-centric personalization and adaptation.

5 CONCLUSIONS

The present research aims to outline the main strategies and functions for personalization and adaptation of the APOGEE supported puzzle games. Puzzles-based learning allows the development of complex, transversal skills, which rank high for the professions of the future. Puzzles prove to be effective and efficient learning instruments, easily applied to specific formal and informal educational practices. However, further research will outline which are the main factors, enabling teachers to practically implement and use APOGEE learning video games in class, as well as which personalization and adaptation strategies will prove more effective and efficient for raising students' skills and motivation. Further, data statistics and analytics will allow teachers and researchers to explore patterns that are more successful and recommendations for puzzle games use. Hence, applying both learning and gaming analytics will allow us to realize a more effective and efficient personalization of the learning content and dynamic adaptation of the game difficulty for the puzzle types planned to be implemented.

ACKNOWLEDGEMENTS

The research leading to these results has received funding from the APOGEE project, funded by the Bulgarian National Science Fund, Grant Agreement No. DN12/7/2017.

REFERENCES

[1] J. Hill, Ray, C. K., Blair, J. R., & C. A. Carver Jr. “Puzzles and games: addressing different learning styles in teaching operating systems concepts”, In *ACM SIGCSE Bulletin*, vol. 35, no. 1, pp. 182-186, 2003.

[2] J. Hamari, Shernoff, D. J., Rowe, E., B. Coller, J. Asbell-Clarke, & T. Edwards, „Challenging games to help students learn: An empirical study on engagement, flow, and immersion in game-based learning”, *Computers in human behavior*, *54*, pp. 170-179, 2016.

[3] E. Paunova-Hubenova, “Are the School Teachers Ready to Start Using Smart Adaptive Video Games for Education?,” *Proc. of the 13th INTED Conf.*, 11-13 March, 2019, Valencia, Spain, IATED, ISBN: 978-84-09-08619-1, ISSN: 2340-1079, pp. 5191-5199.

[4] V. Terzieva, “The potential of educational maze games for teaching in primary schools”, *Proc. of ICERI’2018*, Seville, Spain. 12-14 November, ISBN: 978-84-09-05948-5, pp. 2480-2489. DOI: 10.21125/iceri.2018.1542., 2018.

[5] G. Kendall, A. Parkes, & K. Spoerer, “A Survey of NP-Complete Puzzles”, *International Computer Games Association Journal*, 31(1), pp. 13–34. 2008.

[6] V. Karhulahti, “Puzzle Is Not a Game! Basic Structures of Challenge”, *Proc. of DiGRA Conference*, 2013.

[7] S. Kim, “What is a puzzle”, In *Game Design Workshop: A Playcentric Approach to Creating Innovative Games*, pp. 35-39, 2008.

[8] A. Rollings, & E. Adams, *Fundamentals of Game Design*. Prentice Hall, 2006.

[9] Steven Clontz, *Puzzles*, personal blog. Retrieved from https://clontz.org/puzzles/.

[10] J. Melero, J., Hern, D., & J. Blat, “Towards the support of scaffolding in customizable puzzle-based learning games”, Proc. of *2011 International Conference on Computational Science and Its Applications,* IEEE, pp. 254-257, 2011.

[11] C. Linehan, G. Bellord, B. Kirman, Z. H. Morford, & B. Roche, “Learning curves: analyzing pace and challenge in four successful puzzle games”, Proc. of *The first ACM SIGCHI annual symposium on Computer-human interaction in play*, ACM, pp. 181-190, 2014.

[12] M. Wiemker, Elumir, E., & Clare, A. “Escape room games”, *Game-Based Learning*, *55*, 2015.

[13] Z. Michalewicz, & Michalewicz, M. *Puzzle-based learning*. Hybrid Publishers, 2008.

[14] N. Falkner, Sooriamurthi, R., & Michalewicz, Z., “Puzzle-based learning: The first experiences”, Proc. of *20th Annual Conference for the Australasian Association for Engineering Education*, 6-9 December 2009: Engineering the Curriculum (p. 138). Engineers Australia, 2009.

[15] Z. Michalewicz, Falkner, N., & Sooriamurthi, R., “Puzzle-based learning: An introduction to critical thinking and problem-solving”, *Decision line*, 42(5), pp.6-9, 2011.

[16] N. Falkner, Sooriamurthi, R., & Michalewicz, Z., “Teaching Puzzle-based Learning: Development of Transferable Skills”, *Teaching Math. and Comp. Science*, 10/2, pp. 245-268, 2012. Retrieved from https://cs.adelaide.edu.au/~zbyszek/Papers/tmcs-2.pdf.

[17] M. Badger, Sangwin, C., Ventura-Medina, E., & Thomas, C. “A guide to puzzle-based learning in STEM subjects”, *University of Birmingham: National HE STEM Programme*, 2012.

[18] C. Steinkuehler, & Squire, K., *Videogames and learning*. Cambridge handbook of the learning sciences, pp.377-396, 2014.

[19] B. Law, “Puzzle Games: A Metaphor for Computational Thinking”, Proc. of *European Conference on Games Based Learning* (pp. 344), Academic Conferences Int. Ltd., 2016.

[20] W. L. Leite,, M. Svinicki,, & Y. Shi, “Attempted validation of the scores of the VARK: learning styles inventory with multitrait–multimethod confirmatory factor analysis models”, *Educational and psychological measurement*, 70(2), pp. 323-339, 2010.

[21] A. Antonova, B. Bontchev, “Designing Scenarios for Personalized Learning: Enabling Teachers to Apply Educational Video Games in Class”, *Proc. of EDUTE’2019*, 25-27 May 2019, Rome, Italy, WSEAS 2019 (in print).