Educational Video Game Design Using Personalized Learning Scenarios

Boyan Bontchev(✉), Albena Antonova, and Yavor Dankov

Faculty of Mathematics and Informatics, Sofia University "St Kl. Ohridski", Sofia, Bulgaria
{bbontchev, a_antonova, yavor.dankov}@fmi.uni-sofia.bg

Abstract. Educational video games are considered interactive, user-oriented, and motivating learning instruments, allowing delivery of tailored learning experiences. Designing and implementing adaptive and personalized educational video games can become a suitable tool for teachers in student-centric learning. In this context, the present research aims to outline how mini puzzle games adaptable to the individual learner and proactive learning scenarios can help teachers to adopt enhanced strategies for game-based learning, based on students' personalization and adaptation. The paper presents design approaches for adjusting educational video mazes to both individual and group student models, which are based on personalization and adaptation. It describes how basic learning scenarios can be personalized once at the level of the maze game by selecting puzzles appropriate for a given individual student and, next, inside each of the puzzles. While the personalization of the learning content and its structuring and presentation is realized statically, a dynamic adaptation of both the content difficulty and gameplay is suggested according to observable changes in student properties during playing the game. Both the personalization and adaptation of the maze containing puzzles are specified by XML descriptions, which are used by different software instruments for building the whole game and for analyzing the outcomes of its playing. There are discussed the design principles of personalized maze games allowing teachers and educators to create and apply their educational games.

Keywords: Game design · Personalization · Learning scenarios · Analytics

1 Introduction

Educational video games can support learning process adaptability and personalization, allowing teachers to design and adopt learner-oriented teaching strategies [1, 2]. Considering student needs, learning style, and preferences of each learner in the class [3], educational video games can assist teachers to apply flexible instruction scenarios. Thus, educational video games represent interactive platforms for innovative pedagogical practices, embracing learner-based and personalized teaching approaches [4]. In this way, by exploring different adaptation approaches, we would be able to identify how teachers can apply personalization and adaptability in game-based learning scenarios [5], based on adaptable mini-puzzle games in the class [6].

© Springer Nature Switzerland AG 2020
O. Gervasi et al. (Eds.): ICCSA 2020, LNCS 12254, pp. 829–845, 2020.
https://doi.org/10.1007/978-3-030-58817-5_59

Thus, the present research aims to outline how educational video games personalization and adaptation can be achieved via mini puzzle games and proactive learning scenarios, for supporting student-oriented and tailored learning. More specifically, the research determines the following approaches for educational video game adaptation and personalization, including:

(1) educational maze games generated automatically by the APOGEE (smArt adaPtive videO GamEs for Education) platform [7] and containing various mandatory and optional puzzle mini-games;
(2) learning objects embedded into the maze and the mini-games contained in the maze halls; and
(3) game-based learning scenarios designed for both the maze and embedded mini-games.

The present research will discover how the educational video-game platform-APOGEE will support adaptivity [8] and personalization [9], supporting teachers first to section puzzle mini-games for learners with a specific profile and, next, to link, structure and represent learning content inside mini-games by enhancing personalization of the overall game-based learning process. The selected puzzle mini-games and linked learning content inside each mini-game will be automatically presented to each learner having a specific profile. The learner profile includes static and dynamic properties about age, gender, learning goals, initial knowledge, learning/playing style, and others, determined before starting the game on the base of a self-report.

The paper is structured as follows: first, the authors outline the main approaches for learning adaptability and personalization, taking into consideration the learning scenarios for designing and implementing educational video games in the class [5]. Then, by investigating the common elements of various puzzle mini-games that can be embedded within the maze game generated by the APOGEE platform, there are identified common patterns and characteristics of these mini-games. Next, simplified tools and methods are identified to support personalization within every educational mini-game, reflecting as well for relevant pedagogical methodologies and in-class learning practices. Considering that one of the objectives of the APOGEE platform is to enable teachers to design and develop their own-generated educational games, new approaches for supporting them to apply learning personalization are proposed. In the conclusion section, the paper discusses the main challenges faced by teachers in the process of implementation personalization strategies in-class, combining adaptable educational video games and innovative teaching methods.

2 Related Works

Both interactive and reactive to learners, educational video games facilitate the inclusion of adaptation mechanisms in games and in the learning process as a whole. Even more, adaptation is one of the key features of educational video games. As discovered in [10, 11], adaptation affects the quality of the educational experience, allowing the learning environments to cater to students with different learning styles, different levels of initial knowledge, and different expectations and objectives. Further,

personalized and adaptive educational video games can motivate usage, increasing user acceptance, and user identification within and outside of the game [11, 12]. Providing personalized experiences, educational video games facilitate achieving the targeted positive outcomes, allowing users to make progress in a motivating and rewarding manner.

Adaptability and personalization are often discussed interchangeably in-game literature [8, 11]. Discussing the main differences among the most popular terms, [12] determines that *adaptability* is the ability for changing some properties of the system to the needs of a user group or environmental context. The term *customization* reflects the act of changing the system (more often concerning appearance or content of the system) by explicit user intervention. *Personalization* explains how the system responds to specific user groups' demands depending on the user profile. Personalization can either be achieved manually or automatically by tailoring the content, appearance, or any other aspect of the system according to the needs and preferences of given user groups. Customization is often used interchangeably with the term personalization, but there is a subtle difference. In many cases where personalization relates to automatically individualized experiences, meaning that a system is configured or adjusted implicitly without interaction by the user, customization relates to manual, explicit adjustments and choices made by the users to optimize their experience. *Adaptivity*, on the other hand, means an automatic adjustment of the game features over time (e.g., changes in technical parameters or content level and presentation) conforming dynamic changes in the individual user model. In this context, the adaptivity of educational games content can mean the dynamic adjustment of learning paths, the dynamic creation of game content, or its adaptation to changes in the learner model observed while playing the game.

As stated in [12], adaptive games recognize and comprehend the players' interactions and intelligently alter themselves to adapt to the in-game goals of their players, improving the gameplay experience. Adaptive games typically require two-type methodology – player modeling and content generation (adaptation) [11]. The five components of personalized learning, as identified by Miliband [4], include personalized learning assessment, effective teaching, and learning strategies, curriculum entitlement and choice, school organization, and building a strong partnership beyond the school. Thus, the ultimate goal of an adaptive educational game is to support users to achieve progress towards individual learning goals.

2.1 Learning Scenarios for Educational Video Games

Learning scenarios represents a pedagogical method for developing a set of activities and their sequence (learning paths), enabling students to acquire skills and knowledge. There can be identified with different design guidelines that support the integration of adaptive games in online education environments [11, 13]. More specifically, learning scenarios define the main activities, roles, learning structure, and environment context–location, resources, tools, and services [12]. Learning scenarios define both the role of the students and what they have to accomplish as a set of learning activities to attain the expected learning outcomes. On their turn, learning outcomes usually are defined in terms of skills [14], knowledge, and competencies that learners will develop as a result

of performing specific learning activities. Learning scenarios can support adaptability and personalization by adding/removing puzzles, changing which objects are in each room, adding/removing elements, skipping parts of the game, and others [8, 12].

Taking into consideration the three basic learning theories–behaviorism, cognitivism, and constructivism, Huo [15] proposes the following six categories of game scenarios. This way, the game scenarios related to the behaviorism theory cover *instruction*, or guidance of gameplay and knowledge acquisition, and *cultivation* – reinforcement of existing knowledge. The cognitivism theory supports *organization*-structured and interrelated knowledge, and *application* – assessment and application knowledge. And the constructivism theory discovers *experience*, or personalized experience-based learning and *adaptation*, or accommodation to the player individuality.

Considering that learning scenarios reflect the specific learning context, they have to define where and how specific learning activities and instruments will be integrated into the general learning process. Therefore, designing specific educational video game learning scenarios, teachers have to be able to structure several learning paths within the video games that will correspond to specific learning objectives. The six learning scenarios for adopting educational video games in class, as identified in [5] can combine six models (LS1-LS6). This way, the first scenario (LS1) explores an introduction game, where learners have to experience and get introduced to new learning content. Then, the second learning scenario is experiential game LS2, reflecting the experience-based learning cycle of Kolb [16]. The third learning scenario–LS3 involve students to gain an in-depth understanding of one specific knowledge domain by applying advanced cognitive models and strategies. Then, the testing game LS4 aims to facilitate students' learning process by designing dynamic and competitive testing experiences. Summary game scenario LS5 explores the overall knowledge domain, this time focusing on the most important contextual knowledge. Finally, interdisciplinary game scenario LS6 aims to connect the new knowledge domain to other disciplines, allowing learners to get a better understanding and perspectives of the links and connections within the learning content.

2.2 Design Approaches for Personalized Video Games for Education

The six learning scenarios defined in [5] for designing educational video games can be tailored according to specific characteristics of the individual student model. Concerning the nature of the student model properties, the tailoring process includes two important issues [16]:

A. Tailoring features of an educational video game based on some static properties of the group student profile such as age, gender, learning goals, special education needs, learning style, or personality traits. This type of tuning is known as a *macro-level adaptation* [17] and is accomplished before game starts;
B. Adjusting features of the video game according to some dynamic properties of the model of an individual student changing during the playing session, like effectiveness (shown learning outcomes as score and acquired knowledge or skills), efficiency (time and effort for achieving the score), and emotional state (recognized

emotions and arousal during the play process). This type of tuning is known as a *micro-level adaptation* [17] and is implemented during the game-based learning process.

On the other hand, depending on the specifics of the game features tailored to the model of the student, two other main groups can be distinguished [18]:

I. Tailoring learning features of the educational game like the personalization of learning content incorporated into the game (including the degree of detailing and level of difficulty), content structuring and presentation at game levels, feedback to learners, and others;
II. Adjusting playing features of the game such as a dynamic difficulty of tasks; selection of specific mini-games, quests, and tasks; changes of audio-visual effects (i.e., sound volume or rate, illumination, and image contrast); adjustment of help and behavior of non-player characters (NPCs); tailoring of game mechanics, etc.

Personalized learning scenarios deal with tailoring learning features of the educational game (group I) aiming at better learnability of the game. The adjustment of a learning scenario can be implemented as a *static personalization* of learning content based on relatively constant properties of the student model (group A). For this purpose, static model properties are to be received from the student through self-report (usually before the playing session) or to be estimated during playing by methods like linear regression [18]. On the other hand, adjustment of a learning scenario can be realized as a *dynamic adaptation* of both the content difficulty and gameplay according to observable changes in some student properties during playing the game (group B). It this case, dynamic changes in student properties should be measured during the playing session (e.g., by measuring effectiveness and efficiency) or inferred through appropriate metrics (like emotion recognition based on facial analyses or psychophysiological measures [8]).

3 Personalized Learning Scenarios for Educational Mazes

3.1 Educational Maze Games with Puzzles

In the last decades, many video maze games were designed for free gaming for both fun gamers and learners. Thanks to their orientation on various activities involving interactions and assessments, playing with educational labyrinths and mazes were proven as an efficient game-based learning approach for developing problem-solving competencies [19], higher-order abilities (e.g., reasoning, evaluation, decision making) [20], and literacy skills [21].

The concept of rich educational video maze was coined in [22] as a 3D single-player maze video game able to provide didactic multimedia content presented inside each hall/room the maze not only on learning boards but as well within various mini-games. These mini-games represent puzzles of different types and are embedded into maze rooms or halls by the designer of the maze game simply by selecting the puzzle type and setting its position at a maze hall, learning content, and customization parameters. The game creators can define and customize the maze game and the

puzzles embedded into it through predefined XML templates or using a graphic editor that generates an XML description of the whole game [23]. Next, this XML description is applied by the APOGEE platform to create automatically the rich educational video maze using the Unity environment.

The puzzle mini-games may have mandatory or optional completion. Mandatory puzzles available at a maze shall need to be completed for the player to advance to the next hall, while optional puzzles are played for fun and for gaining knowledge, skills, and points. Each puzzle belongs to one of the following groups [22]:

- Questioning puzzles – focused on solving a single problem for unlocking a door or answering a collection of questions (quiz);
- Searching puzzles – aiming at finding translucent or hidden objects, or matching identical or interrelated items in puzzles such as "word soup" or card-matching memory game;
- Arranging puzzles – asking for assembling a 2D image from parts having different shape or size, or for sorting/classifying objects according to specific criteria;
- Action puzzles – for example, shooting at flying balloons with attached 3D educational objects and, next, collecting the fallen objects.

Completing a puzzle mini-game means solving a learning task and adds some points to the player score. As well, it may bring to the player some game objects for being used further in the game. Next to puzzles, the rich educational maze provides intelligent virtual players (NPCs) able to help the player in solving the puzzles and to reply to questions about the learning domain [22].

3.2 Personalized Learning Scenarios for Maze Games with Puzzles

A rich educational video maze created through the APOGEE platform may contain various 2D or 3D puzzle mini-games of questing, searching, arranging, or action type, distributed at the maze halls according to the structure of the didactic material. The game creators (teachers or instructors) can adjust both the learning and playing features of a maze game according to the static and dynamic model properties of individual players, as explained in Sect. 2.2. Thus, a rich educational video maze may involve static personalization and dynamic adaptation of the learning content presented on the learning boards or in the puzzles embedded into the maze halls. In this way, each of the six learning scenarios for designing educational video games [5] (outlined in Sect. 2.1) can be tailored according to the specific characteristics of the individual student model. At *maze level*, the personalization may be achieved by the game designer simply by selecting types of puzzles suitable to the properties of specific learners such as age, gender, learning goal (introduction to the subject, a game with experiments, detailed study, assessment game, summarization, or intersectional game), or learning styles. The results of a representative online survey [23] revealed the level of appropriateness of each puzzle type according to the age, gender, and playing style of the students. As well, at the macro-level, the game designer can set some features of each maze hall, such as which are the mandatory puzzles for specific student properties, a threshold of the minimum total score for unlocking a door to the next hall, and others.

At *puzzle level*, the personalization may be accomplished by customizing the learning content and its structuring and presentation at all the levels for each puzzle game appropriate to the same student properties together with the initial knowledge (none, beginner, intermediate, or advance) of the individual player, with respect of the chosen learning scenario. Customization of learning content for each level (if any) of a puzzle game is possible by changing the default settings of the puzzle and adding specific textual, graphic and/or audio content to be presented in that puzzle. Different types of puzzles [22] may have common settings as didactic contents included in a puzzle or a threshold of the score for completing a given level and, on the other hand, different customization features depending on their specific context, for example:

- For questioning puzzles – customization of question type (open or closed), difficulty and complexity; the number of answers in a quiz; hints and feedback;
- For finding puzzles aiming at discovering something by exploration, thinking, or remembering – setting the number, criteria, positions, and type of objects/words/cards in finding objects/word soup/card-matching games;
- For arrangement puzzles involving ordering, classification, or association of items/objects/traits – customization of number, shape, and size of pieces, together with criteria for arranging/classifying them. Figure 1 presents a screenshot of such a puzzle game integrated into the maze and focused at an arranging of history pictures of Bulgarian kings in time order built on the years of their coronation;

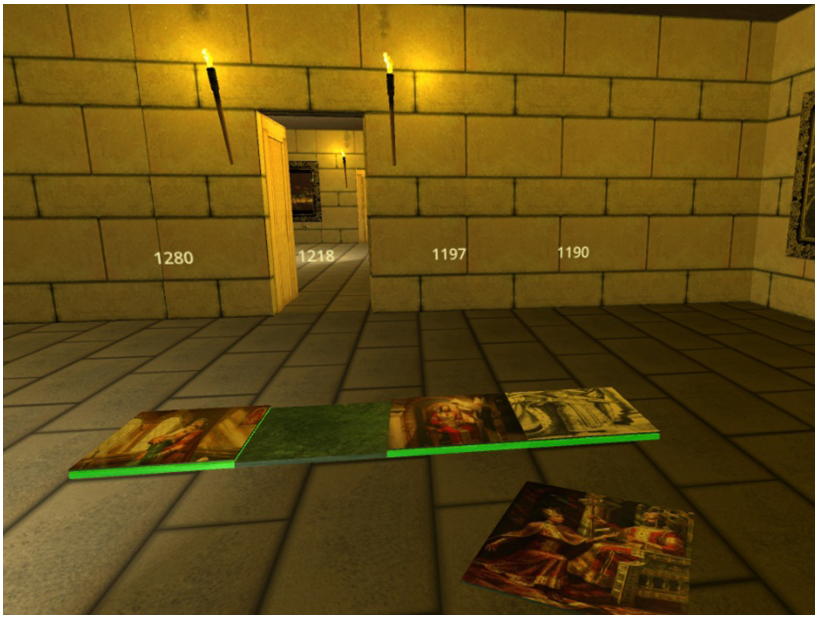

Fig. 1. Screenshot of the "Arrange me!" puzzle game.

- For action puzzles requiring dynamic actions for matching/shooting/grabbing moving items, usually, for a limited time – setting the number, size, and type of objects for shooting, together with dynamics of the shooting process.

The personalization of the learning content and its structuring and presentation at the levels for each puzzle game is realized statically, by providing customization settings in the XML description for each puzzle game. Besides that, static personalization, the APOGEE platform is planned to provide a dynamic adaptation of both the content difficulty and gameplay according to observable changes in some student properties during playing the game, such as learning outcomes, efficiency, and emotional state. The dynamic adaptation will be achieved through machine learning or statistical analysis, however, its customization will be provided in the XML puzzle description.

4 Design of Personalized Educational Maze Games

4.1 Software Instruments for Educational Video Game Design

The conceptualization and development of the APOGEE instruments are based on previous research by the authors [23, 24]. Figure 2 presents the instruments and processes in the APOGEE software platform for the generation of educational video games. The platform consists of two main groups of instruments. These are *Assistive Instruments* and *Analytics Instruments.*

In the APOGEE platform, Analytics instruments enrich the platform with the ability to analyse data. This category includes *Learning Analytics*, *Gaming Analytics*, and *Analytics for users*. These tools provide stakeholders with a wide range of analytics capabilities that they can use. Analytics tools "*link what the user needs to what is available as data*" [25]. Thanks to Analytics, users can make various analyses of available data, visualize data results, extract valuable information and knowledge from data, and make informed strategic decisions. Analytics tools perform the analysis of all the available data on the platform and evaluate the design of the designed, generated, and played games by users. For that reason, the instruments in the Assistive instruments' category are directly related to Analytics instruments.

The software tools that help manage the design of personalized video games are those in the category "Assistive instruments". These include *Design Management Instruments* and *Game Design Validation and Generation instruments*. These tools manage the design, its validation, and subsequently the generation of a valid educational video game.

As shown in Fig. 2, users who intend to use the APOGEE platform for educational video games, must first go through "Registration, Authentication Process". The platform checks whether a given user has a registered account or not. If the user is not registered on the platform, it is necessary to create a personal profile for the user. The platform accounts are divided into three categories, each with its rights and limitations. These are *Student Profile*, *Game Creator Profile*, and *Admin Profile*.

If a user is logged in with a *Student profile* on the platform - he/she has three options to choose from. These are *Play Games*, *View Analytics*, or *Exit* the platform. In

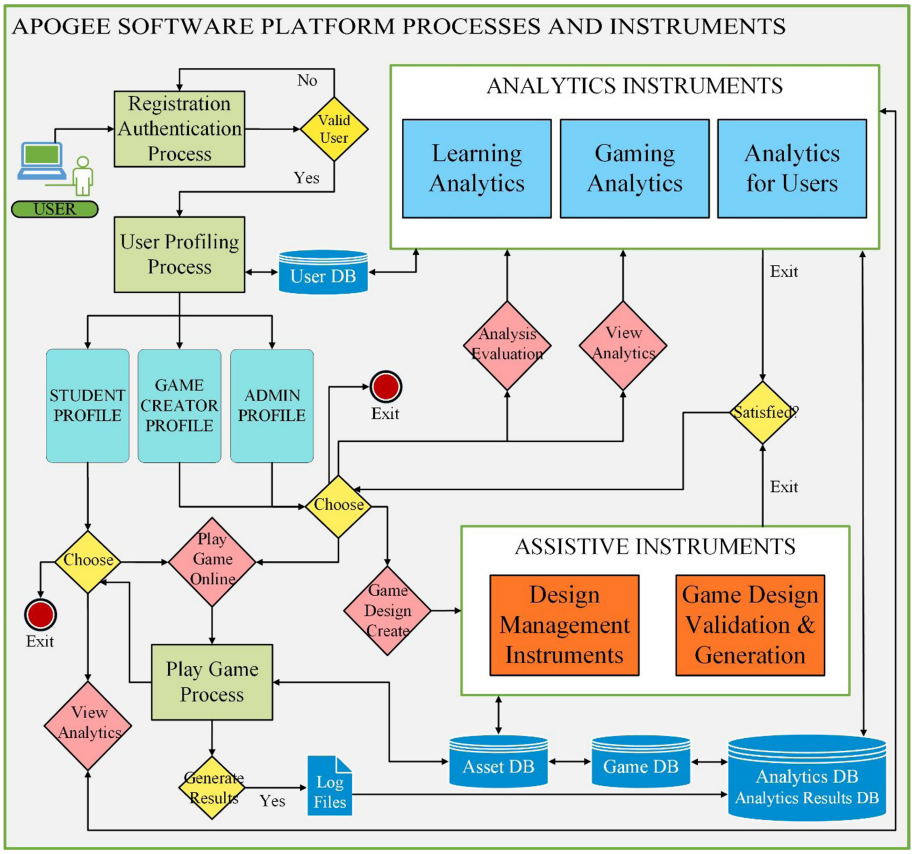

Fig. 2. APOGEE software platform process and instruments.

the Play Games process, the user plays a designed and generated game from the APOGEE platform. Upon completion of the game/learning process, data is generated in the form of log files for the various users' game sessions. These log files are stored in the Analytics database and are processed by tools in the Analytics Instruments category. In View Analytics, the user chooses to use Analytics capabilities to visualize data to the users. Thanks to this, the user can visually monitor the data about their results from game sessions played, statistics, personalized metrics, etc.

All available data is stored in the platform database. The main categories are *Asset DB*, *Game DB, Analytics DB and Analytics Results DB*. All data is interconnected and used by Analytics Instruments to process, analyse, and visualize data to the user.

Platform users who have *Game Creator* and *Admin* profiles can take advantage of the full range of capabilities provided by the APOGEE platform. They have the right to use both categories of Assistive and Analytics instruments. When logging in as a valid user with a Game Creator or Admin profile, he/she has the choice (depicted as diamonds on Fig. 2) of: 1) *Play Games*; 2) *View Analytics*; 3) *Analysis and Evaluation*; 4) *Game Design Create Processes*. Similarly, in (1) and (2) these users use the rights

granted to the Student Profile. By selecting (3) Analysis and Evaluation, users with Game Creator and Admin Profile accounts can take advantage of the full range of features provided by Analytics Instruments. These tools will be followed by the completion of work and return to the starting position for choosing an activity. In the fourth choice (4) Game Design Create process, the user chooses to design an educational video game for its purposes. The designer or creator of educational games uses the capabilities of Assistive Instruments.

4.2 Management of Maze Games Design Process

The category "Assistive Instruments" enables the user to use the tools designed on the APOGEE platform to manage the design, its validation, and the generation of educational video games [24]. Based on the application of the proposed taxonomy developed in [24], in this paper, we further develop Fig. 3, representing the process through which the user navigates to use the various instruments from this category. As mentioned in the previous section, users with Game Creator or Admin privileges are allowed to use these tools.

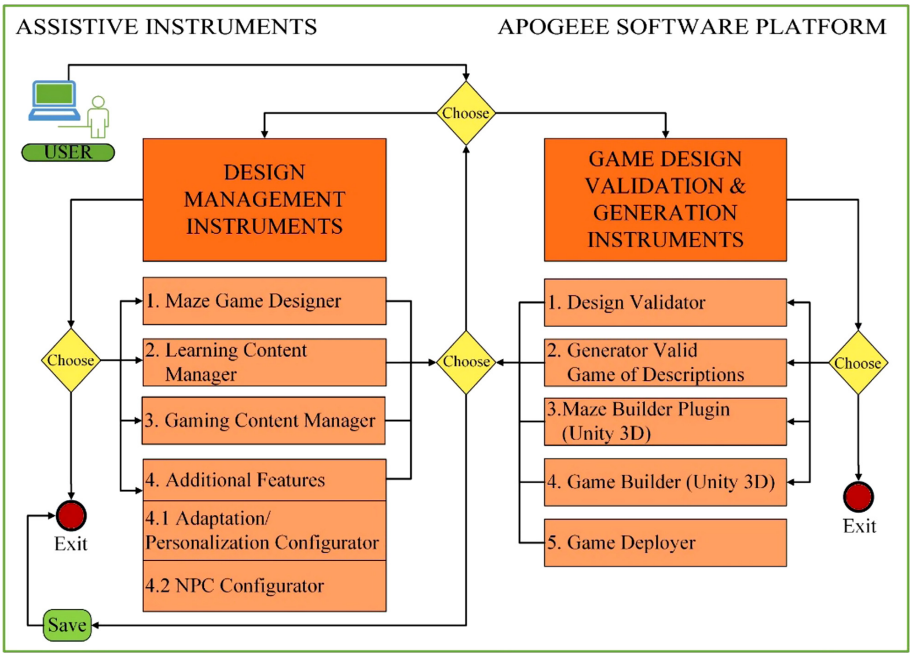

Fig. 3. Overview of the APOGEE software platform assistive instruments process.

Briefly, the process passes through several steps. The user intends to design and create an educational personalized video game. For this purpose, depending on his particular task, or the stage he has reached in designing a particular game, the user may

choose to use the set of two categories of Assistive Instruments - *Design Management Instruments* and *Game Design Validation and Generation Instruments*.

After making a choice, the user goes to the appropriate category. When the category Design Management Instruments is selected, the instruments available for use by the user are: 1) *Maze Game Designer*; 2) *Learning Content Manager*; 3*) Gaming Content Manager*; 4) Additional Features such as – *Adaptation/Personalisation Configurator* or *NPC Configurator*. After using these instruments and completing their work with them, the user returns to the starting position and can either go to the second category of tools and continue the process of creating and generating an educational personalized video game or to save its work and exit the platform.

When selecting the Game Design Validation and Generation Instruments category, the user similarly has the option to select the set of tools that are included in that category. These are: 1) *Design Validator*; 2) *Generator of Valid Game Descriptions*; 3) *Maze Builder Plugin (Unity 3D)*; 4*) Game Builder (Unity 3D)*; 5) *Game Deployer*. Once completed, the user can again save their changes and progress, exit the platform or return to the starting position and make changes to the design of their game using the Design Management Instruments.

4.3 Sample Customization of a Puzzle Game

The APOGEE platform allows teachers and educators to build video maze games enriched with puzzles of the four types described by the puzzle taxonomy in [22]. As explained in Sect. 3.2, these types of puzzles have both common settings and different customization features depending on the specific puzzle type and nature. The section presents an XML-based template for customization of both the personalization and adaptation of the APOGEE puzzle games. The template is going to be applied by the creators of educational mazes enriched with puzzles, through the APOGEE platform.

Each XML-based puzzle customization makes a part of the XML description of the whole puzzle game. The structure of the XML-based template for all the puzzle descriptions is presented by an XML Schema document, which is applied for both controlling an XSD-driven maze editor and for validation of XML description of each puzzle embedded into the maze. It follows a simplified version of an XML document for customization of one of a sample 2D puzzle, which is among the mini-games with relatively simpler customization.

```
<PuzzleGame>
  <Name>2D Puzzle</Name>
    <Settings>
    <General>
      <Audio>mysong.mp3</Audio>
      <AudioLoop>true</AudioLoop>
      <RelativeSize width="100" hight="100"></RelativeSize>
      <RelativePosition x="20" y="40" z="33"></RelativePosition>
    </General>
    <Level order="1">
      <Points>300</Points>
```

```
      <Time>120</Time>
      <NoOfItems>8</NoOfItems>
      <ShapeOfItems>rectangle</ShapeOfItems>
      <RotationOfItems>no</RotationOfItems>
    </Level>
    <Level order="2">
      <Points>700</Points>
      <Time>300</Time>
      <NoOfItems>24</NoOfItems>
      <ShapeOfItems>square</ShapeOfItems>
      <RotationOfItems>yes</RotationOfItems>
    </Level>
  </Settings>
  <Personalization schoolAge="primary, secondary"
           complexity="elementary"
           learningStyle="visual" playingStyle="dreamer">
      <GameElements>
        <GameElement level="1">
         <Text>What was the battle on this picture?</Text>
         <Image id="ID1">battle.jpg</Image>
        </GameElement>
        <GameElement level="2">
         <Text>
            Which was the Bulgarian capital in 12th century?
         </Text>
         <Image id="ID2">Tarnovo.png</Image>
        </GameElement>
    </GameElements>
    </Personalization>
    <Adaptation included="yes">
     <threshold about="pixels for matching two items"
level="1">5</threshold>
     <threshold about="pixels for matching two items"
level="2">3</threshold>
    </Adaptation>
  </PuzzleGame>
```

The XML description given over makes a part of the whole XML document used for the automatic generation of the maze. It contains a general settings section, followed by settings for each level including points to gain, expected playing time, a number of items to be arranged, and their shape and rotation. The personalization settings specify the learning content by levels and the characteristics of students the game is appropriate for, such as age, complexity level, and learning and playing styles. The customization of adaptation here includes only values of thresholds for the matching distance between pictures.

Figure 4 presents a screenshot of playing an APOGEE 2D puzzle game at the first level. To complete the level, the two items that are not yet arranged should be moved over the white squares at the proper places.



Fig. 4. Screenshot of the APOGEE 2D puzzle game.

5 Discussion

The design of educational video games is a complex and demanding activity, as both learning and game objectives have to be taken into consideration. Ensuring that learners achieve the desired educational objective while experiencing an immersive video game scenario. Taking into account adaptation and personalization strategies, the APOGEE platform allows the creation of educational video mazes enriched with puzzle mini-games, providing support for both the personalization and adaptation approaches. The personalization is achieved in two ways:

(1) For each maze hall – by selecting puzzle games appropriate for a specific group student profile including static properties like age, gender, and learning/playing styles (achieved at the beginning of the game). The game creator should select the learning goal of the game, which determines the choice of a specific learning scenario for the game making it an introductory, experiment-based, detailed-study, assessment, summarization, or intersectional one;
(2) For each puzzle mini-game – by adjusting the learning content and its presentation according to the same static student properties plus the initial knowledge for the domain (all these found by self-report prior to the playing session).

On the other hand, the adaptivity is realized by dynamic adjustments of the complexity of learning content and/or some playing features like task difficulty, sound volume, visual effects, and game dynamics. The adaptation is a dynamic process during a playing session which depends on observed outcomes (i.e. effectiveness), efficiency, and emotional state of the individual student.

Customization of both the personalization and adaptivity is achieved by XML settings that are to be specified for the maze and all the puzzle mini-games embedded into it. Besides the customization settings, the XML documents include descriptions of all the multimedia assets needed for the generation of the maze game. Though the platform provides templates for the XML descriptions, such customization appears rather difficult for teachers and educationalists. This is the reason to add to the current platform new software modules such as the maze game designer and the adaptation/personalization configurator, which are under development and will help game creators to tailor their games much more easily. For facilitation of seamless integration of game content, these modules will be integrated with the managers of learning and playing content.

Finally, game creators need instruments for assessing both the personalization and adaptivity customized for a specific learning scenario. The software instruments for learning and gaming analytics are designed for providing them with various student metrics collected via log files during the playing sessions. These metrics include learning outcomes, gained points, efficiency, playing time, and other results achieved for each level of each puzzle. As well, the analytics tools will provide correlations of logged metrics and both the static and dynamic student properties. Thus, they will help the game creators in assessing the appropriateness of the chosen customization of the game and, hence the validation of the eventual improvements of learnability and playability [26].

6 Conclusions

The paper presented approaches for personalization and adaptation of educational video games achieved by tailored inclusion of mini puzzle games into video mazes. Both the personalization and adaptation are realized in a specific learning scenario aiming at flexible support of tailored, student-oriented game-based learning.

The flexibility of the creation of personalized and adapted educational games is achieved by customization of playing and learning features of the maze game and any of the puzzles included in its halls. The customized game descriptions, together with all needed game assets, next are used for an automatic generation of the maze game. The instruments of the APOGEE platform presented here support the processes of designing, managing, creating, analysing, and evaluating educational video games applying a student-centric approach. These instruments are directly interconnected and enrich the APOGEE platform with a wide range of capabilities. Using these tools in the design processes of adaptive and personalized educational video games allows teachers and pedagogues to apply different strategies for learning personalization and adaptation.

Depending on the characteristics of the user and, subsequently, the user's behaviour during the game, the APOGEE platform will be able to provide its users with personalization of the content and adaptation of the gameplay. This enables teachers and educators to create within the APOGEE platform personalized and adaptable learning scenarios to suit the needs of the individual student or student group. By creating such learning scenarios, educators will be able to dynamically respond to the different

requirements of each of their students. Educational games with personalized and adaptive learning and gaming content can motivate usage, increasing user acceptance, and user identification within and outside of the game and the platform. Furthermore, educational video games provide a personalized experience, which is crucial to facilitate achieving the targeted positive outcomes, allowing users to make progress in a motivating and rewarding manner.

Future works on the APOGEE platform include finalization of all the assistive and analytics software instruments being under development, followed by their validation and assessment through controlled experiments. The experiments are going to involve practical usage of the platform for design, generation, and assessment of an education game through monitored game sessions. Two groups of students will play the same game – the first one will play it with personalization and adaptation of learning content and gameplay, and others (i.e., the control group) will play a game version without such customizations. After playing sessions, students will be asked to fill in questionnaires about the gaming experience, learning motivation, and game learnability [26]. By analysis of the self-reports and the playing and learning metrics measured during the game sessions with both the control and experimental groups, the effect of game personalization and adaptation will be estimated. Eventually, some machine learning methods will be applied for finding the most suitable adjustment of educational maze games with puzzles to both the static and dynamic properties of the student model.

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. Zagal, J.P.: Ludoliteracy: Defining Understanding and Supporting Games Education. ETC Press, Halifax (2010)
2. Göbel, S., Hardy, S., Wendel, V., Mehm, F., Steinmetz, R.: Serious games for health: personalized exergames. In: Proceedings of the 18th ACM International Conference on Multimedia, pp. 1663–1666. ACM (2010)
3. Jurado, F., Meza, R.E.: An exploratory study in the use of gamer profiles and learning styles to build educational videogames. Int. J. Eng. Educ. **33**(2), 1–10 (2017)
4. Miliband, D.: Personalised learning: building a new relationship with schools. In: Speech by the Minister of State for School Standards to the North of England Education Conference (2004)
5. Antonova, A., Bontchev, B.: Designing scenarios for personalized learning: enabling teachers to apply educational video games in class. Int. J. Educ. Learn. Syst. **4**, 20–26 (2019)
6. Paunova-Hubenova, E.: Are the school teachers ready to start using smart adaptive video games for education? In: Proceedings of the 13th International Technology, Education and Development Conference, Valencia, Spain, pp. 5191–5199 (2019). https://doi.org/10.21125/inted.2019.1294,
7. APOGEE Project. http://apogee.online/index-en.html. Accessed 26 May 2020

8. Bontchev, B.: Adaptation in affective video games: a literature review. Cybern. Inf. Technol. **16**(3), 3–34 (2016)
9. Terzieva, V.: Personalisation in educational games – a case study. In: Proceedings of 11th Annual International Conference on Education and New Learning Technologies, Palma de Mallorca, Spain, pp. 7036–7044 (2019). ISBN 978-84-09-12031-4
10. Moreno-Ger, P., Burgos, D., Martínez-Ortiz, I., Sierra, J.L., Fernández-Manjón, B.: Educational game design for online education. Comput. Hum. Behav. **24**(6), 2530–2540 (2008)
11. Streicher, A., Smeddinck, J.D.: Personalized and adaptive serious games. In: Dörner, R., Göbel, S., K-R, M., Masuch, M., Zweig, K. (eds.) Entertainment Computing and Serious Games. LNCS, vol. 9970, pp. 332–377. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-46152-6_14
12. Lopes, R., Bidarra, R.: A semantic generation framework for enabling adaptive game worlds. In: Proceedings of 8th International Conference on Advances in Computer Entertainment Technology, pp. 1–8 (2011)
13. Ney, M., Emin, V., Earp, J.: Paving the way to game based learning: a question matrix for teacher reflection. Procedia Comput. Sci. **15**, 17–24 (2012)
14. Oyesiku, D., Adewumi, A., Misra, S., Ahuja, R., Damasevicius, R., Maskeliunas, R.: An educational math game for high school students in Sub-Saharan Africa. In: Florez, H., Diaz, C., Chavarriaga, J. (eds.) ICAI 2018. CCIS, vol. 942, pp. 228–238. Springer, Cham (2018). https://doi.org/10.1007/978-3-030-01535-0_17
15. Huo, Y.: A pedagogy-based framework for optimizing learning efficiency across multiple disciplines in educational games. Int. J. Inf. Educ. Technol. **9**(10), 704–709 (2019). https://doi.org/10.18178/ijiet.2019.9.10.1290
16. Kolb, D.A.: Experiential Learning: Experience as the Source of Learning and Development. FT Press, Upper Saddle River (2014)
17. Petrovica, S.: Multi-level adaptation of an educational game to individual student's gameplay, knowledge and emotions. In: Proceedings of 9th International Conference on Education and New Learning Technologies, IATED, pp. 2220–2230 (2017). https://doi.org/10.21125/edulearn.2017.1462
18. Bontchev, B., Georgieva, O.: Playing style recognition through an adaptive video game. Comput. Hum. Behav. **82**, 136–147 (2018). https://doi.org/10.1016/j.chb.2017.12.040
19. Eseryel, D., Law, V., Ifenthaler, D., Ge, X., Miller, R.: An investigation of the interrelationships between motivation, engagement, and complex problem solving in game-based learning. Educ. Technol. Soc. **17**(1), 42–53 (2014)
20. Norris, J.M., Davis, M.J., Timple-Laughlin, V.: Second Language Educational Experiences for Adult Learners (1). Routledge, New York (2017)
21. Kiliçkaya, F.: Infusing action mazes into language assessment class using quandary. In: Asutay, H. (ed.) Balkan Educational Studies – 2017, pp. 223–231 (2017)
22. Antonova, A., Bontchev, B.: Exploring puzzle-based learning for building effective and motivational maze video games for education. In: Proceedings of 11th Annual International Conference on Education and New Learning Technologies, pp. 2425–2434 (2019). ISBN 978-84-09-12031-4
23. Antonova, A., Dankov, Y., and Bontchev, B., Smart services for managing the design of personalized educational video games. In: Proceedings of ACM International 9th Balkan Conference in Informatics (BCI 2019). ACM (2019). https://doi.org/10.1145/3351556.3351574
24. Dankov, Y., Bontchev, B.: Towards a taxonomy of instruments for facilitated design and evaluation of video games for education. In: Proceedings of ACM International Conference on Computer Systems and Technologies (CompSysTech 2020). ACM (2020)

25. Dankov, Y., Birov, D.: General architectural framework for business visual analytics. In: Shishkov, B. (ed.) BMSD 2018. LNBIP, vol. 319, pp. 280–288. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-94214-8_19
26. González Sánchez, J.L., Padilla Zea, N., Gutiérrez, F.L.: From usability to playability: introduction to player-centred video game development process. In: Kurosu, M. (ed.) HCD 2009. LNCS, vol. 5619, pp. 65–74. Springer, Heidelberg (2009). https://doi.org/10.1007/978-3-642-02806-9_9