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TECHNOLOGICAL APPROACHES FOR PERSONALIZED LEARNING USING EDUCATIONAL COMPUTER GAMES

ABSTRACT OF PhD THESIS

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Content of the Abstract of PhD Thesis

INTRODUCTION

Relevance of the problem

Technological advances have changed almost all spheres of modern society in recent decades. The changes cover the modes of work, training, and communication, such as information and communication technologies (ICT) and computers, significantly improving their quality and efficiency. Education, as a social field, is also strongly influenced, and these changes affect how knowledge is acquired on a global scale and at all levels of learning. Modern pedagogical approaches based on modern technologies – different types of technologically assisted or technologically based training – are emerging (Bell & Kozlowski, 2012). Educational video games that are part of the serious games are one of the successful forms of ICT application for learning purposes (Abt, 1970; de Freitas & Liarokapis, 2011; Chen & Hwang, 2014). Related pedagogical approaches are gamification, game-based learning (GBL), and its variation – training based on computer games. Particularly suitable are computer games, as adolescents perceive games as a pleasant and motivating activity.

Game-based learning is a science-applied field in which numerous academic studies are conducted on the characteristics of games that can serve different educational purposes and increase learning effectiveness (de Freitas, 2006). Training based on computer games is the intersection of electronic distance learning and game-based learning (GBL) – two areas developing rapidly recently (Sharples et al., 2013). Electronic distance learning is shaped by the massive uptake of computers and other digital devices in everyday life, accompanied by the widespread internet. GBL is rapidly growing due to the improvement and imposition of ICT in all spheres of contemporary society and because of the changed profile of today's learners (Prensky, 2003; Johnson et al., 2016). In this area, there is a need to develop methodologies for designing educational games and empirical evidence of the effectiveness of different types of games as a learning environment. Many researchers note the growing potential of educational computer games for all age groups of learners (Aguilera & Mendiz, 2003; Kapp, 2012, O'Donovan al., 2013). An additional prerequisite for this is the fact that the so-called "digital" generation receives a large part of the information and forms its knowledge electronically through various devices for access to the global network (Prensky, 2001). Computers, tablets, mobile phones, and video games are attractive to adolescents with their inherent imagery, color, and ability to access dynamic information. Educators recognize this trend and look for efficient ways to use digital technological gadgets in training.

Numerous scientific studies, convincingly showing that the integration into the educational context of elements of games (gamification), video games, or games with virtual, added, or mixed reality has a positive impact on the learning process (Bourgonjon et al., 2010; Connolly et al., 2011;

Hamari et al., 2015; Ebrahimzadeh & Alavi, 2017). Developing educational games suitable for application in school practice is key to their effective entry into the educational process. Therefore, one of the dissertation's goals is to study the influence that the various components of video games have on the motivation and support of students in the learning process.

Despite the abundance of evidence supporting the implementation of educational games, several main obstacles and difficulties have been identified in Bulgaria, which hinder the wider use of computer games in classroom learning (Tuparova et al., 2018). Among the main challenges mentioned are: a lack of technological means and time, a lack of suitable educational games, and insufficient knowledge of teachers to create or adapt available games for their purposes (Paunova-Hubenova & Terzieva, 2019). Therefore, a platform with tools that facilitates educational video game creation and allows for game customization is needed. Thus, educators will be able to participate in the process of design of engaging games for learners with integrated learning objectives.

Interdisciplinary nature of the study

The introduction of the concept of *educational technologies*, which are based on theories from different fields, the main of which are education, computer science, psychology, and communication, shows the interdisciplinary nature of the research conducted. Changes in the socio-economic sphere as a result of technological advances are also reflected in the field of education, and increasingly classical pedagogical methods of education are interpreted through ICT (Sharples et al., 2013; Serdyukov, 2017). Thus, different technological means are integrated globally, and the approaches of technologically assisted and technologically based training become part of pedagogical practice. With the development of the Internet and e-learning systems, pedagogical approaches are enriched and implemented in a new context. On the other hand, the concept of serious games and their application in training undergo significant evolution (Squire, 2002; Young et al., 2012). As a new emerging paradigm of online learning, educational games should be explored because of their potential to attract and motivate learners (de Freitas & Liarokapis, 2011; Morford et al., 2014). In this case, the psychological aspects of the problem should also be taken into account, as the attitudes and needs of both teachers and learners are crucial for the successful integration of educational video games into the learning process (Allisop et al., 2013; Gibson et al., 2014).

This research analyses approaches to developing personalized educational video games. In the theoretical aspect, it is influenced by the following areas – technology-based teaching, pedagogical approaches in training based on computer games, designing didactic mini-games, and creating a user model (for students) and models for customizing games and other related games. Research is targeted at the intersections of these areas, which form the theoretical foundations for developing and validating a personalized educational video game of maze type with built-in didactic mini-games.

The scientific formulation of the study

The object of this dissertation study is the technological approaches to game-based teaching through educational computer games.

The subject of the scientific research is the approaches to developing different kinds of educational video games, personalized to the characteristics and preferences of learners, taking into account the surveys of the opinions and preferences of teachers and students.

Goal and Tasks of the PhD Thesis

The goal set out in this PhD Thesis is to analyze existing approaches to designing educational games and to develop a model and methodology for creating personalized educational video games to be validated through practical experiments.

Main tasks of the research:

1) To analyze technological-based teaching approaches, part of which are educational games.
2) To make a quantitative assessment of the application of technological-based approaches and educational games in Bulgarian schools.
3) To analyze the opinions of teachers and students regarding suitable educational computer games for learning.
4) To analyze the constructive components of educational computer games and to develop an approach for their personalization.
5) To create models of educational video games and the user as a learner and player, as well as an approach to customizing educational video games.
6) To develop a methodology for creating a customizable educational video game of type enriched maze in the APOGEE platform and to develop sample customized learning resources for embedding in mini-games.
7) To develop a protocol for conducting experiments to validate and evaluate personalized educational video games and to analyze the results obtained

The hypothesis in this dissertation is: Educational video games are an efficient tool for helping teachers and learners in the learning process. In Bulgaria, there are conditions for their utilization in the educational environment. The personalization of educational video games, according to the preferences and characteristics of learners, is a factor in motivating and supporting learners in the process of knowledge acquisition.

Statements whose evidence supports the hypothesis:

1. In Bulgaria, there are conditions for the use of ICT in education - availability of technical means and motivation of teachers;

2. Among the pedagogues, there is an idea about the types of computer games that are most preferred for learning;

3. Personalized video games are more relevant and rated more highly by their intended learners than non-personalized ones.

Part of the scientific and applied results in this dissertation has been achieved and directly related to the work of the author within the following several national and international research projects. The author is part of the research team of the projects and works actively to fulfill the goals and objectives. Therefore, the author's research described in the proposed work independently achieved results as part of the project team's work. Most of the results of the projects are published in co-authorship, and another part – is single authorship. The results related to the dissertation are described in the author's reference.

Research Methodology

The methodology used to achieve the goal of the study is structured in the following research methods and approaches: research and critical analysis of the scientific field, a constructive scientific approach to modeling, empirical methods for the evaluation of quantitative and qualitative indicators (descriptive and statistical analysis), and practical experiments to validate the research hypothesis (testing and survey studies). The proposed methodology aims to prove the research hypothesis.

Structure and content of Ph.D. thesis

The proposed work consists of the following parts: introduction, five chapters, conclusion, references used, author's reference, and applications.

The topic, object, and subject of the dissertation work are indicated in the introduction. The problem relevance and the motivation for conducting the dissertation research are briefly described. The purpose of the research work and the tasks by which it will be achieved, the leading hypothesis, and the applied methodology in the conducted research are set.

In the first chapter, an overview and critical analysis of modern ICT-based approaches and technologies for training has been made. A theoretical review of the basic concepts, types, and characteristics of educational computer games and their use in a learning context is presented. Special attention is paid to personalized learning approaches that have been analyzed, and inferences have been drawn about their application at the GBL.

The second chapter examines the use of technological means and educational games in Bulgarian schools, analyzing the obstacles teachers face in creating and implementing educational games. The need to create digital learning resources such as educational video games to be effectively applied in the learning process is motivated. User requirements for the development and use of

educational video games are examined. Studies of teachers' preferences regarding the application of educational games and their customization are presented and analyzed. Learners' opinions about different types of educational games have been examined and evaluated.

Chapter three presents conceptual models for the design of educational video games. A combined learner model covering profiles such as user, learner, and player has been developed to serve the personalization of educational video games. Learning content requirements are defined, its different types are discussed, and a metamodel is shown for its representation from the point of view of its use in a personalized educational video game. A conceptual model for personalizing video learning games is presented, and a methodology for the personalization process is described.

The fourth chapter presents a conceptual model of an educational video game of the type enriched maze, which is the basis of the process of creating such games through the APOGEE platform. The developed methodology for customizing an enriched maze-type educational video game using embedded mini-games is presented. The developed universal and difficulty-level customized educational video games of the type enriched maze "Asenevtsi" were analyzed.

The fifth chapter presents the developed methodology for validating and evaluating personalized educational video games of the type enriched maze. A methodology for conducting the experiments, and evaluating qualitative and quantitative characteristics, is proposed. Two questionnaires for grading and comparing educational video games by students and college students are presented. It was organized validation of both versions of video games among two groups of learners, and results were analyzed. From experimental testing and the analysis of the data from the respondents' feedback, conclusions were drawn about the future development of these types of educational video games and their possible application.

The conclusion presents a summary of the results achieved and the main contributions of the Ph.D. thesis. Opportunities for future research and development are outlined. A list of scientific publications on the topic and the citations noticed are presented. The conclusion outlines the main results and outlines opportunities for future research. The Ph.D. thesis consists of 155 pages, 40 figures, 11 tables and 213 literary sources and 5 appendices.

The provided brief overview of the PhD thesis presents the essential issues that are addressed in the research process and the main results obtained.

CHAPTER 1. REVIEW AND ANALYSIS OF TECHNOLOGY-BASED TEACHING APPROACHES

Recently, research on the application of ICT in training has been increasing. It can be summarized that the integration of ICT in education is in three main aspects: the use of technological tools and resources for: 1) conducting communication and transmission of information; 2) the creation, preservation, and management of information resources; and 3) improving the organization and administration of the learning process.

Innovative technologies are also at the heart of the paradigm shift in learning (Desai et al., 2008; Reigeluth et al., 2016). At the center of the training process, the learners shall be placed taking into account their individual characteristics, learning objectives, and other indicators, and the aim is to provide them with a personalized learning approach, to improve their motivation and, accordingly, the learning results (OECD, 2006). ICT also favors the introduction of technologically based innovative forms and learning methods that significantly drive the development of new skills of learners required in the global digitalization process of society in the 21st century. Technological learning tools have a variety of applications through relevant approaches in addition to traditional training methods. In addition, technological means not only integrate into the traditional learning process but also influence pedagogical theories, and as a result, innovative and more effective approaches to training are emerging. Horizon reports (Johnson et al., 2014; Johnson et al., 2016) regularly identify the most critical technologies and trends that will significantly impact and change the educational area in the near future. Over the past decade, the following technologies have been identified: innovative online and hybrid learning, data-driven and evaluating, blending formal and non-formal learning, mobile learning, ICT integration, gamification, open educational resources, cloud technologies, use of social networks and mobile devices, personalized and adaptive learning, virtual and remote laboratories, augmented and virtual reality. Computer games are also seen as an essential technology that has the potential to impact substantially, so they are now entering education on a larger scale. They, along with digital simulations and virtual and augmented reality, are considered essential new educational tools, as they have significantly higher emotional impact and interactivity (Vogel et al., 2006). Although some of these technologies are still at an early stage of application in Bulgaria, they are spreading more and more and are likely to have a more significant role in the future.

1.1 Basic Concepts

Some of the most common technological-based learning approaches, such as e-learning, online, and distance learning, have different definitions. The reason is in the point of view that is used –

whether it is considered from the aspect of the technology that serves to implement it or according to other aspects.

From the point of view of modern technologies, distance learning is a kind of technology-based training or e-learning, given the environment used for communication, transmission, and storage of information and learning content, as well as for managing the learning process.

Due to the accessibility of technology and the Internet, the spread of non-formal and lifelong learning is growing, which provides opportunities for continuous learning and supports the development of skills in a different context. Teaching methods are enriched using different technologically-assisted approaches and integrating innovative tools such as educational games (Chen & Hwang, 2014). Training through games can be conducted both informal self-directed at a time chosen by the learner, as well as formal training in the classroom under the guidance of a tutor. Although informal and imperceptible, learning this way is a conscious activity for the learner, who acquires specific knowledge and develops skills. In this context, knowledge acquisition is considered more effective as it is on the learner's own initiative (Garris et al., 2002).

Among the theories that serve as the basis for most well-known teaching methods are behaviorism, cognitive constructivism (Ertmer & Newby, 2013), connectivism, collaboration, (Duke et al., 2013), multisensory learning theory, and the relatively new theory of multimedia learning (Mayer, 2002). In the technological age, these methods take on a new character by building on the integration of ICT funds (Peycheva-Forcite, 2022).

Innovation in the educational field covers a wide range of processes, but only the methods of teaching and learning that ICT influences will be discussed here. Innovations are being considered (Law et al., 2013; Serdyukov, 2017), to help education to adapt to a changing world and meet the growing demands of modern society and the digital generation (Prensky, 2001). A review of the technological means that transform pedagogical practice and have the potential to improve the learning process by adapting it to the characteristics and expectations of learners is provided (Edsys, 2018). Several forms of technology-supported training are considered to gain a comprehensive picture of their characteristics and applicability and to provide a theoretical basis for part of the studies on game-based training.

Educational technologies are defined as learning and ethical practices that facilitate learning and improve learning performance by developing, using, and managing appropriate technological resources and processes (Kozma, 2003). Modern educational technologies are a term that encompasses many types of technology-based learning practices. Educational technologies are based on theories from different fields, including education, computer science, psychology, and

communication (Selwyn, 2012). Modern forms of learning can be considered according to three aspects of innovation (Vieluf et al., 2012):

- Modernization and adaptation of the learning process – seen as a manner to improve the learning process to make it more attractive, more effective, and less stressful (technological means supporting classical teaching methods).
- Modification of the learning process – innovations that significantly change how the learning process is conducted, efficiency, or quality (e-learning, virtual reality).
- Transformation of the education system – innovations that completely transform the learning process (automated training systems based on artificial intelligence, self-study systems, mobile learning).

For the last decade, the following technologies and trends have been identified with a strong potential for impact on education: ICT integration; innovative online and hybrid learning; mixing formal and non-formal learning; integrating blockchain and big data technologies; training and evaluation, managed by data analysis, personalized and adaptive learning, mobile and mobile learning, social networks, open educational resources, software and educational computer games, cloud technologies, digital simulations, virtual and augmented reality (Johnson, 2014; Education Technology Trends, 2022). In Bulgaria, some of these technologies still need to be better involved in education, but their application is growing and is expected to become more widespread.

Educational games are seen as part of serious games. The term refers to desktop and digital games that have an explicitly stated and carefully considered educational purpose, and their primary purpose is not for entertainment (Abt, 1987). Educational games are explicitly created and designed to achieve educational goals or games that have additional educational value (de Freitas & Liarokapis, 2011). In an educational context, they can find applications of all kinds of games; their main goal is to support acquiring knowledge and skills in a given subject and facilitate their understanding of the game process. Defining factor in the prevalence of learning games is their ability to generate commitment and motivation (Salen et al., 2004). Research is also provoked by the emergence of new educational theories highlighting the importance of active training methods. As a result, a new type of digital game – the so-called serious games (SG), which have a primary pedagogical purpose – "the application of games or game technologies mainly for non-entertainment purposes" (Sawyer & Smith, 2008) is emerging. Numerous scientific studies confirm the educational potential of the games, highlighting their inherently strong motivating impact and, as a consequence – engaging and raising the interest of learners (Chapman & Rich, 2018).

Personalized education is defined differently depending on the context, relationship with pedagogy, and technology (OECD, 2006). In modern adaptive learning systems, personalization

refers to their adaptation to the characteristics of individual learners so that they get an improved learning process. Personalized learning environments enable students to develop on their path to improvement. According to Bray and McClaskey (2012), there are three different approaches to personalizing teaching: individualization, differentiation (grouping), and personalization. The essential characteristics of these approaches are as follows:

Individualized education usually is aimed at learners with special educational needs (SEN) or who need specific support. The concept of *differentiated (group) learning* is based on allocating learners into several groups based on their levels of knowledge and skills or interests about a subject or area of knowledge. *Personalized* teaching is learners-focused learning, and the learners lead in setting learning goals. Under this approach, the learning process corresponds most fully to the needs, level of knowledge, interests, and possible deficits, as well as the individual preferences of different learners.

1.2 Teaching through Technology Tools

The today's generation of digital learners (Prensky, 2001) is a challenge for educational institutions and teachers, so modern strategies are needed to keep their attention and commitment to the learning process. New ways of engaging learners should be relied upon, using the attractive power of innovative technologies, social media, and computer games to be integrated into lessons. Therefore, it is essential to offer up-to-date instructional strategies engaging learners more effectively in purposeful learning activities (Beetham & Sharpe, 2007).

Technology-based training (technology-based training) is a general term for learning content delivery through ICT, the Internet or other networks, audio and video channels, and the like (Bell & Kozlowski, 2012). E-learning is considered a generalizing term for various types of learning based on ICT and the Internet. In e-learning teaching is carried out using computers and communication technologies, and technological tools are involved in the whole process (Negash & Wilcox, 2008). The teacher is the leader; he selects, structures, and presents the learning content. Among the main advantages of e-learning is conducting without the need for simultaneous physical presence in a learning environment and the possibility of adapting the learning content, approaches, and speed of teaching to the learners.

1.3 Teaching through Educational Games

Gamification is a relatively new and rapidly developing field that is defined as the use of game elements in non-game contexts (Deterding et al., 2011; Dichev et al., 2014) or, more generally: "the use of game mechanics, aesthetics, and thinking, to engage users, motivate their actions, promote their learning and problem solving (Kapp, 2012). The gamification of learning requires selecting

appropriate game elements and relevant rules to achieve the goals set in the given domain, as well as the desired behavior of the learners.

Teaching through video games is considered appropriate for presenting complex topics or the intersection of subject areas of knowledge to promote learning through research and discovery, with learners advancing at their own speed. *Educational video games* can be considered a complex learning environment in which they are integrated into a realistic context of facts, knowledge, and situations through which the learner acquires a new cognitive experience (Aguilera & Mendiz, 2003; Annetta, 2008). GBL has proven advantages over classical teaching methods (Granic et al., 2014; Leaning, 2015): Students are more motivated and active in learning. Numerous scientific studies have argued that the educational potential of video games is due to the possibility of learning in an interactive environment by immersion in context. When building the game-based learning framework, the classical theories of learning must be considered. Often the GBL applies proven learning theories expanded for a game environment and the broader context of learning through educational games. Through an activity-based approach, the practices of GBL by computer games with relation to different educational theories, such as behaviorism, constructivism, situational and co-edition, and non-formal learning, are identified. The essential features and advantages of GBL are as follows (Garris et al., 2002; Boyle et al., 2016):

- Built-in interactivity in educational games provides learners immediate feedback that supports and stimulates their learning process.
- Motivates students (even in case of failure), raises their self-esteem, and they are more engaged and with a sense of responsibility.
- It enables students to exercise their knowledge and experiment.
- It enables both teaching and real-time evaluation.
- Allows to adapt the difficulty of playing tasks according to the performance of learners, which facilitates the learning process and engages their attention while reducing frustration.
- It is a prerequisite for absorbing soft skills such as collaboration, teamwork, and leadership.
- It contributes to more efficient use of time in class compared to lessons.

The effectiveness of learners in the GBL can be an indicator of their knowledge of the subject matter and computer or game skills. In order to focus learners on learning, learning tasks (challenges) should be consistent (or adapted) to the level of knowledge and goals of learners, as well as to provide almost instant feedback that is meaningful and stimulating, i.e., implementation of personalized learning. Compared to traditional learning approaches, educational games can easily be adapted to the learner's pace. Typically, video games simultaneously present information in different audio and

visual formats, which is suitable for different learning styles. Games can provide knowledge step by step, i.e., present the more complex tasks into small parts and gradually expand them.

Researchers have identified the main elements of games – mechanics, storyline, aesthetics, and technology, with each element having a specific role in shaping the game experience (Salen et al., 2004; Schell, 2008; Moreno-Ger, et al., 2008; Kiili et al., 2012). Since the components interact with each other during the design process, they need to be developed interrelatedly. The other components of educational games that also affect their educational value and the impact on learners are the game environment, design and interface, learning goals, educational content and pedagogy, virtual assistants and non-tactical characters, incentives, constant (inadvertently) feedback, unique experience, as their careful design makes learning a more effective and engaging.

1.4 Personalization of Education

The terms *personalized* and *individualized learning*, as well as a *personalized learning environment*, concern efforts to adapt the educational process to meet the different needs of learners (Murphy, 2016). Different institutions define personalized education differently, depending on the context, pedagogy, connection to technology, and other factors. The terms *personalized learning* and *adaptive learning* are used in similar contexts or as synonyms in numerous studies (Arroyo et al., 2006; Shemshack & Spector, 2020). Some of the best and proven methods of customizing learning are briefly described here.

Setting a goal – involves defining the learning outcomes that each student must achieve after completing a task, activity, learning unit, etc.

User model – an abstract representation of the available information about a specific user. An adaptive system uses it for customizing different aspects to the preferences and needs of each user (Tetzlaff et al., 2021).

Feedback – the information received by the students about their performance, which enables them to set reasonable goals, to track their realization so that they make adjustments in the course of their implementation in terms of efforts, learning, and other activities. Of great importance is the feedback to be specific, immediate, and with sufficient frequency.

Personalized curriculum – prepared based on the received feedback in the course of teaching and aims to personalize the learning process for individual learners.

Periodic formative assessment – a set of teacher actions that enable learners successfully to acquire, assimilate, and apply new knowledge during the lessons.

Compliance with the learning style – a method of personalization that has supporters and opponents. Usually, different learners have different learning styles and preferences for their way of study. It is good to combine with other ways of personalized learning.

Self-directed learning – an approach in which learners are given the opportunity to choose by themselves learning resources or to control their learning activities and thus to take responsibility for their training, which increases their motivation and commitment (Nicol & Macfarlane-Dick, 2006).

Modern ICTs enable the introduction of technology-assisted teaching methods that enable more engaging personalized training, corresponding to the expectations of the students. Among them are approaches to personalized learning using educational games, as the personalized game changes according to the learner's characteristics, needs, and individual preferences, i.e., it offers a personalized experience (Antonova et al., 2019). Personalized game content can trigger significantly greater engagement and more profound development of learners' cognitive abilities and skills (Hwang et al., 2012). The presented approaches to personalized learning can be realized through various technological means and can be used in educational games so that personalized game-based learning takes place:

- *Learning by doing* – educational game tasks requiring directed action by learners.
- *Learners actively and make decisions* in suitable practical tasks and scenarios.
- *Immediate feedback* – providing useful specific information when a problem, error, or difficulty occurs.
- *Stimulating learners* for every achieved success in order to motivate them.
- *Learning tasks and challenges focused on the skills* of learners.
- Provide an opportunity to *learn at students own speed.*
- *Dynamic adaptation of the learning tasks* to the current performance of the learner.

The detailed analysis leads to the conclusion that all these approaches can also be used in personalizing educational video games.

Conclusions from Chapter one

The areas of the object and the subject of the dissertation research were examined, presenting the main theoretical concepts and technological means for implementing technology-based approaches to learning, including through educational games. Basic concepts from the field of research object are introduced: technology-based and traditional teaching approaches, as well as adapted and personalized learning. Basic concepts related to technology-based teaching means and teaching through educational computer games are presented. An approach to classifying educational computer games is proposed, and their building components are examined. Methods for personalizing educational video games are analyzed.

CHAPTER 2. APPLICATION OF EDUCATIONAL VIDEO GAMES

Computer games are part of everyday life and favorite entertainment for today's children and young people and are also a convenient environment for providing knowledge and information. It is

a factor in their successful use as a teaching approach in the form of game augmentation and training based on games. This approach applies to knowledge acquisition imperceptibly and assessing learners, which is a significant advantage (Ketamo & Devlin, 2014). Essential considerations for using GBL are the built-in feedback in games, which in real-time provides information about progress and the availability of difficulty levels of game tasks, which is a motivating factor for learners and positively affects the learning process (Deterding et al., 2011; Cruz-Cunha, 2012).

The efficient application of GBL as technology-based teaching depends on several conditions, the most important being the availability of modern technological equipment in classrooms, teachers' digital competence, appropriate educational games, and support from institutions. As the GBL is part of a more general technology-based approach, these conditions are also necessary for its implementation. In this regard, an analysis of the application of technological means and educational games in Bulgarian schools has been made.

2.1 Analysis of the application of ICT tools in Bulgarian schools

More and more teachers are using technological resources in teaching, and the majority (82%) believe that they positively impact students. Most teachers understand the need to modernize pedagogical methods and assess the potential of technology-enhanced teaching for the cognitive development of learners (Fig. 2.2).

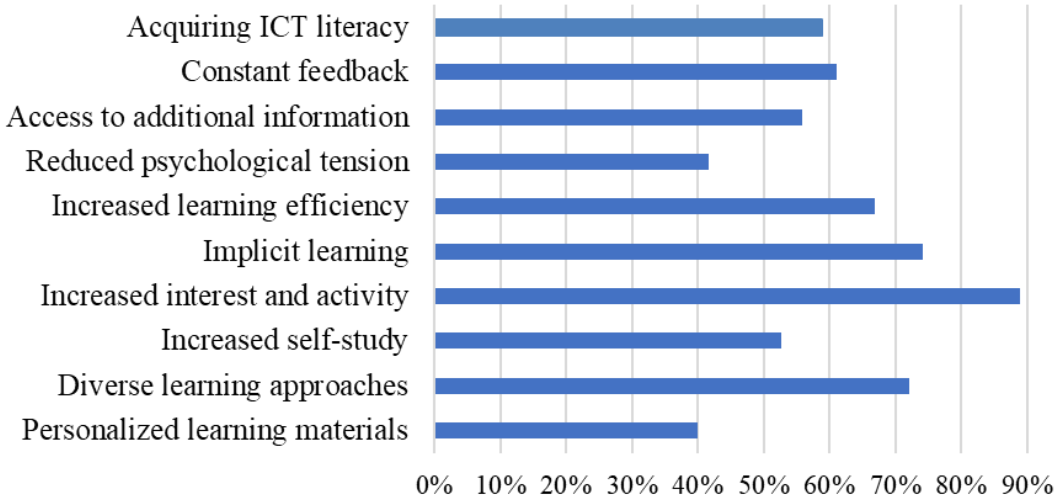

Fig. 2.2 The benefits for learners from technology-enhanced learning.

According to an online survey among innovative teachers, the side effect of learning with technological learning resources is that learners acquire and develop computer literacy. It facilitates access to additional information and stimulates independent learning (*Terzieva et al., 2016). The appropriate approach to integrating ICT resources in an educational context contributes to the motivation increase and assimilation of knowledge among learners, enables teachers to apply new forms and methods of teaching, helps to adapt and personalize learning resources, and to provide feedback. The results of the study show a generally positive effect of technology-enhanced learning.

Teachers use technological learning resources in different ways depending on the specifics of the subjects. Presentations are most preferred as they attract students' attention. Followed by videos, electronic text resources, educational games, and animations, virtual laboratories are the least used. The most used technical means are computers and projectors, and for technology-assisted learning, teachers rely on educational websites and electronic textbooks.

A survey covering over 1,600 teachers in Bulgaria investigates various indicators concerning available conditions for the application of ICT and educational games in school practice. The survey provides an objective view of the current state of the researched area, as the respondents are almost evenly distributed across the country, all subjects and all levels of school education. The analysis of the results indicates that most the Bulgarian schools already have conditions to apply technology-based teaching approaches and educational games (*Terzieva et al., 2018).

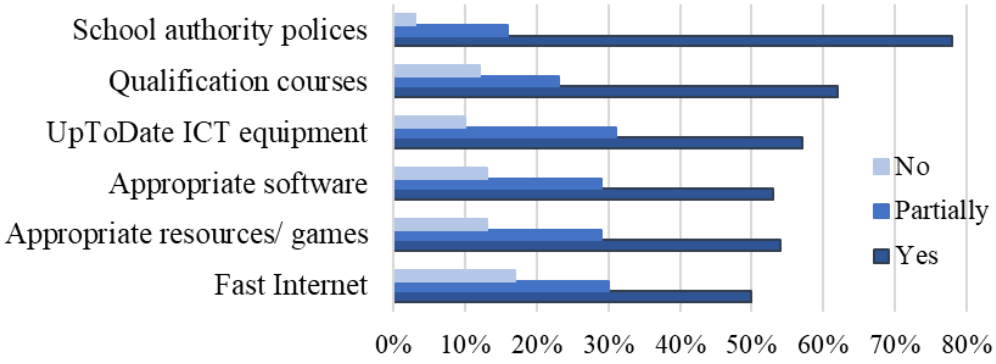

Fig. 2.4 Available conditions for using technological tools in schools.

2.2 Analysis of the use of Educational Computer Games in Bulgarian Schools

In the last decade, the teaching practice in our country has been increasingly engaged in game-based methods (Paunova-Hubenova et al., 2018; Spirova, 2018; Nikolova, 2019). Educational games with interactive and multimedia content are increasingly being used during traditional lessons in classes and not just in e-learning platforms. Many teachers are beginning to view educational games as an efficient approach, suitable for most age groups, complementary, and sometimes even basic training (usually for learners with special educational needs). For this reason, the need for modern quality educational games is growing, and even many teachers are already interested in developing such games on their own design. The integration of educational games into the teaching process is still relatively weak (Fig. 2.7).

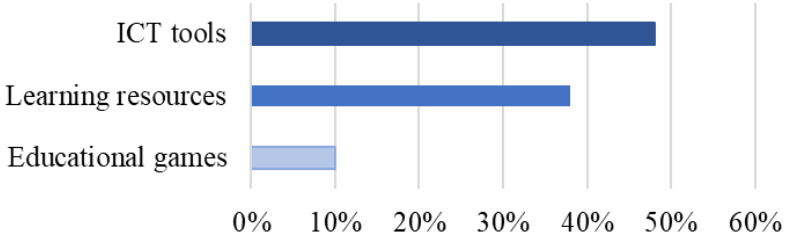

Fig. 2.7. Usage of technology resources for classroom teaching.

Most respondents use ICT technology only as an aid, and 38% rely on digital learning resources in teaching. The research shows that most Bulgarian teachers aren't familiar with the concept of GBL, citing the following main obstacles: lack of preparation and teachers' attitudes; need for a change in teaching style; lack of motivation; lack of appropriate products and technical means in the classrooms. The questionnaire survey shows that the majority of teachers (80%) state that they have difficulties in creating educational games, as well as that they lack time and sufficient experience to do so, so they usually use ready-made games (Fig. 2.8). A relatively small percentage of them have any technical skills to create or adapt these computer game learning resources.

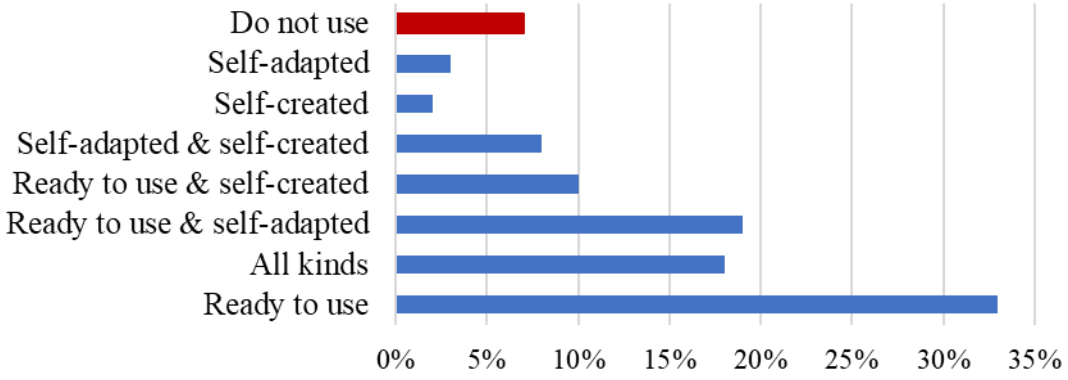

Fig. 2.8. Used educational computer games by origin

Since the subject of the practical implementation in the present study is an educational video game designed for teaching history, here is presented a sample of a survey concerning only the opinions of 57 teachers on this subject (Fig. 2.9).

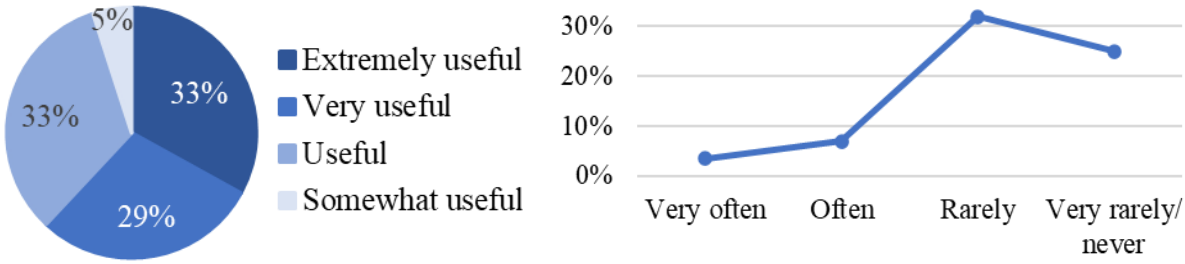

Fig. 2.9 Degree of usefulness and frequency of use of educational computer games.

More than half of them consider that educational games are extremely or very useful for the learning process, but regardless of this, they rarely or never use them. Again, the main reasons are lack of technical means, lack of teacher training and last but not least - lack of games that suit learning goals. The majority teachers do not have sufficient knowledge and experience and face difficulties in creating and using educational games.

2.3 Need for Educational Video Games

As part of research during the APOGEE project, a detailed study of the needs of teachers and learners from educational computer games was carried out. The survey designed for educators explores two aspects: A. Applicability of educational video games (14 questions) and B. Usability of

the APOGEE platform (7 questions). 206 teachers and 357 students responded - 177 girls and 180 boys, with an average age of 14.18 years. Teachers' attitudes about different types of mini-games presenting didactic tasks were studied (Table 2.1). The results show that teachers from all stages of school education share equally positive attitudes about the appropriateness of using different types of mini-games to achieve learning goals.

Table 2.1. Appropriateness of different types of mini-games for the maze video games.

Statistics / Type of mini-games	Primary School Teachers (N=52)			All Teachers (N=198)			Difference & Significance	
	M	SD	SE	M	SD	SE	ΔM	p
1. Answering a question to unlock the door to a maze room	3.7500	0.9471	0.1313	3.8939	0.9311	0.0662	-0.1439	0.3307
2. Passing a test to unlock the door	3.7692	0.8257	0.1145	3.7677	0.9906	0.0704	0.0015	0.5607
3. Solving an automatically generated 2D puzzle with learning image to unlock the door	3.7692	0.8311	0.1152	3.7071	0.9691	0.0689	0.0621	0.6445
4. Walking through the maze using an interactive map	3.7500	0.8135	0.1128	3.7980	0.9450	0.0672	-0.0480	0.7156
5. Rolling the balls marked with text/image to certain places or objects	3.5000	0.7796	0.1081	3.5152	0.9329	0.0663	-0.0152	0.9052
6. Detecting semi-transparent objects to earn points/ bonuses	3.5962	0.8227	0.1141	3.6111	0.9373	0.0666	-0.0149	0.9101
7. Finding invisible objects hidden in larger observable objects by moving them	3.5577	0.8947	0.1241	3.6010	0.9598	0.0682	-0.0433	0.7604
8. Collecting and grouping the found objects/ artefacts by a given criterion	3.9808	0.8282	0.1148	3.8889	0.9111	0.0647	0.0919	0.4878
9. Getting help from a virtual assistant player without asking explicitly	3.5385	0.9385	0.1301	3.4343	0.9991	0.0710	0.1042	0.4942
10. Asking questions a smart virtual player who draws knowledge of the game topics from Web-based sources	3.6731	0.8794	0.1219	3.7626	0.9501	0.0675	-0.0895	0.5223

Learners' motivations for playing educational video games have been explored (Fig. 2.18). For about half of the learners, the expectation is that through educational games, they will learn more effectively, increase their learning abilities and thus improve their performance in school.

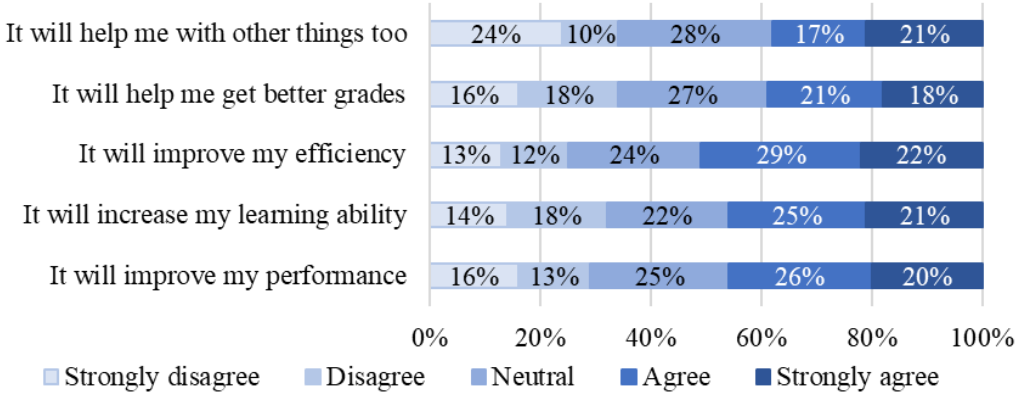

Fig. 2.18 Motivation of learners to play educational video games.

The study participated 502 respondents, of which 169 - school students and 333 - university students from various educational institutions, with 48% being girls and 52% being boys. More than half - 61% of students and 68% of students have never played educational games or computer games for fun, i.e., have no gaming experience. The results regarding whether to include different types of mini-games in the educational maze video game are presented in Table 2.4. Ratings are on a 5-point Likert scale from 1 - definitely no, to 5 - definitely yes.

Table 2.4 Learners preferences for types of mini-games in maze video games.

Mini- game / Statistics	Answering a question to unlock the door	Quiz	2D Puzzle	Word Games	Rolling Balls	Find Transparent	Find Hidden Objects	Sort Objects	Memory Game	Shooting Games
M K12 Students	3.5429	**3.2681**	3.2687	3.2847	2.8881	3.1111	3.0149	**3.2672**	3.5909	3.0963
M Uni St.	3.9845	**3.9469**	3.3312	3.5576	3.0159	3.1487	3.1044	**3.8476**	3.8522	3.1881
SD K12 Students	1.2313	1.2987	1.3274	1.2888	1.2783	1.2499	1.2802	1.1755	1.2658	1.4029
SD Uni Students	1.0199	0.9844	1.2461	1.2012	1.2089	1.1692	1.2190	1.0121	1.1075	1.3446
SE K12 Students	0.1041	0.1106	0.1147	0.1101	0.1104	0.1076	0.1106	0.1027	0.1102	0.1207
SE Uni Students	0.0567	0.0551	0.0701	0.0672	0.0683	0.0659	0.0687	0.0571	0.0622	0.0754

The T-test showed that statistically significant at (p-value < 0.05) are the differences between the quiz and object sorting mini-games (in bold). These mini-games are preferred by the students. These two types of mini-games require more solid knowledge and logic, so they are likely to be intellectually challenging for more mature learners – university students who have gained more knowledge and learning experience. Only two of the mini-games (door unlock question and memory game) are among the most approved for both age groups of learners, while two types of mini-games are the only ones most highly rated by the students (M > 3.5). For university students, quizzes, word games, and object sorting are among the most preferred mini-games – all games that apply knowledge and logic. All students do not value action-related mini-games that require more than knowledge and gaming skills.

Table 2.5 presents the survey results showing learner preferences for a feature of the learner model against which to customize learning materials in minigame-enriched maze video games. The most preferred criterion for personalizing learning materials is knowledge level, followed by interests and goals. A logical explanation for this result is the desire of learners to play games corresponding to their accumulated knowledge to perform well and acquire new knowledge. The respondents indicate the learning objectives as essential for personalizing the learning content. Preferred topics for learning materials presented in maze video games was explored. Learners arranged them in the following order – experiments, assessment/test, introduction, and summary.

Table 2.5 Student-preferred criterion for personalizing learning materials in educational video games.

Criterion / Statistics	Age of the learner	Knowledge level of the learner	Interests and goals of the learner	VARK learning styles
First place	19,88 %	39,34 %	21,33 %	16,77 %
Second place	18,43 %	31,68 %	28,99 %	15,32 %
Third place	13,87 %	17,81 %	30,64 %	31,26 %
Fourth place	42,44 %	6,83 %	13,87 %	29,61 %

Conclusions from Chapter two

An analysis of the use of ICT tools and educational games in Bulgarian schools was made. User preferences for using and customizing educational video games are explored. User opinions on different types educational games and mini-games and their suitability for learning are reviewed and evaluated.

CHAPTER 3. MODELING OF PERSONALIED EDUCATIONAL VIDEO GAMES

3.1 Design of Personalized Educational Video Games

When developing educational computer games, knowledge about their design, game themes, learning approaches, and defining educational game characteristics is needed (de Freitas, 2006; Ibrahim & Jaafar, 2009; Lameras et al., 2017). In addition, the developer has to be familiar with the target group of users. Initially, educational games are modeled at a conceptual level. Then during the design process, the created conceptual model is used as a framework that helps integrate teaching approaches into the game. In the beginning, the educational attributes of the game are identified, and it is explored how to incorporate them into the game components. Then the principles of learning through games are considered, which are a source of ideas and models for presenting learning resources, knowledge, and information in the design of an educational game. Subsequently, the processes and activities in their sequence for developing educational games are specified.

When creating educational computer games, the involvement of experienced educators is essential, as they can provide valuable guidance based on their experience, subject area knowledge, and acquaintance with learner characteristics, depending on their age. Teachers appropriately present the learning material to the students and know which concepts or lessons are hard to understand for the students and what should be emphasized. Experienced teachers use appropriate combinations of different formats (text, graphics, audio, etc.) and know how to require adequate feedback from students. For these reasons, teachers have a significant role in game design. Involving teachers in the process of creating educational game applications would have a positive impact on their attitudes toward incorporating educational games into teaching practice. The motivation for adapting and

customizing educational video games is based on the view that diversity in some user characteristics can affect the usability and effectiveness of the learning resources provided to them. It is believed that if a system performs its functions according to the preferences and characteristics of the users, then it will give them more benefits.

3.2 A Combined Model of Student-User of a Personalized Educational Computer Game

The model of students in an e-learning environment aims to model their acquired knowledge, cognitive skills, and interests. Based on this model, personalization of their interactions will be carried out. Here we present the developed learner model and the framework that is the basis for personalizing the learning process in the context of an educational maze game.

Student models present different information about them, such as acquired knowledge and skills, available competencies, achieved learning success rates (achievements), learning goals, individual preferences, cognitive skills, emotional characteristics, etc. (Kobsa, 2001; Chrysafiadi & Virvou, 2013). Models may also include components that support tracking of the time and manner of knowledge and skill acquisition by each learner, what is the outcome of applied pedagogical approaches, and even reflect cultural differences, individual interests, and specific learner preferences (Woolf, 2010). For adaptive learning, it is significant to know the main demographic characteristics of the learners (name, age, gender, class/course, etc.). This information provides the static parameters to consider when initializing the learning objectives and path.

The research describes several types of learner modeling techniques, and here are some of the most popular:

Stereotyped model – several fixed groups are created, and each learner is assigned to one of the possible categories, for example, beginner, advanced, or expert. Personalization takes place based on this categorization (Kobsa, 2001).

Overlay model – this approach models learner knowledge and skills as a subset of subject domain knowledge embedded in components, which are parts of declarative domain knowledge (e.g., topics, concepts, knowledge elements, and outcomes). Thus, learners' knowledge is modeled flexibly (Brusilovsky, 1994).

Combined model – combines the above two modeling approaches. Initially, the learners are categorized according to the stereotype to which they fall, and subsequently, the model is gradually modified and supplemented by overlaying information extracted during the learning process (Sosnovsky & Dicheva, 2010).

When creating the model of students, it is necessary to reflect on their characteristics related to the GBL process. It is a prerequisite for adapting the educational games to learners' profiles using their model. In this manner, the learning interactions between the user and the didactic tasks can be personalized.

When constructing the model of the learner-user of educational video games, a multi-spectrum flexible modeling system is used, covering three main aspects in the model: Characteristics as the user are general data identifying the user; learner–specific data that determine the personalization of educational content and learning tasks in the game to the attributes and preferences of the user; player–specific features are related to the adaptation and/or personalization of the parameters of an educational video game. Fig. 3.1 shows the designed conceptual combined model of the student as user, learner, and player.

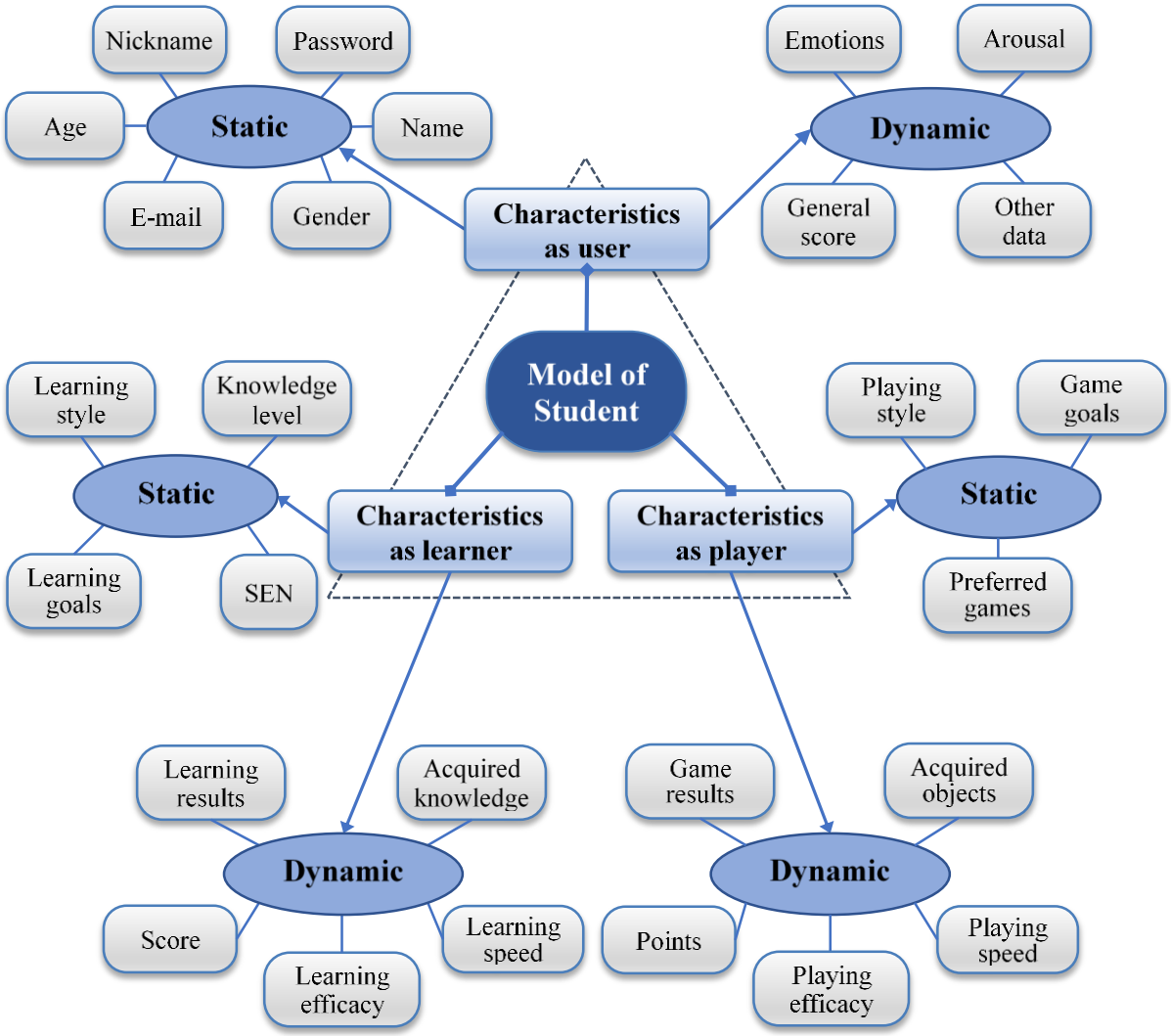

Fig. 3.1 A conceptual combined model of a student – user of an educational video game.

Each aspect of the student model contains two sets of attributes: static - reflect relatively constant characteristics of the learner over time (age, gender, interests and goals, preferences, level of knowledge, learning and playing style, etc.) and dynamic - related are with the various components

of results achieved in the game, as a result of the performance of the learning and game tasks (speed of solving, efficiency, points obtained, acquired knowledge/studied topics, etc.). Dynamic components are given value by techniques for retrieving their current readings in the game process and are used to update the learner model. It is necessary to design the structure of the data and the way of its extraction accordingly to achieve such an update. The essential user data that will be retrieved and stored must be identified in advance to provide the necessary information for dynamically updating the student model. For a smooth and trouble-free operation of the system, a reasonable trade-off between the amount of extracted data and the ability to account for the meaningful ongoing interactions and results in the game process, taking into account the learning and gaming aspects, is necessary. All the features described in the learner model are used when personalizing various components of an educational video game.

3.3 Methodology for the Presentation of Educational Content

Structuring learning content includes its description, granularity, and personalization. In e-learning systems, many different approaches to granulating the learning content are used, and each structural unit is defined according to its interrelationships with others. For example, a course consists of several semantically and logically distinct parts that make up several lessons, each of which may cover one or several topics. With the proliferation of e-learning systems, the need for standardization has arisen, and several standards have been developed for the interoperability of e-learning platforms and their content management systems. Therefore, the structuring of learning content is subject to the requirements of e-learning systems and the possibility of repeated use. Thus, learning resources based on these standards can be easily reused and combined in different ways to adapt and personalize to the learner (Dagger et al., 2002; Van Rosmalen et al., 2006). Modern standards for learning content (Learning Object Metadata, Sharable Content Object Reference Model, Dublin Core, etc.) allow a unified description of different types of learning resources so that they are easily portable and exchanged between diverse learning systems and applications (Arroyo et al., 2006).

The most significant factors on which the reuse of learning objects in e-learning systems depends are the following (Hodgins, 2006): learning objects must be stored online in databases and annotated corecrly with metadata that allows users to find and access (discover and share) them. Furthermore, they should be as independent as possible from the learning context in which they initially were developed. Thus, they will be suitable for different courses, groups of learners, and learning environments.

The user interface of the game is text, sound, and visual: The *text interface* determines the characteristics of the text through which the player receives messages - the font (type, size, and color), the background of the text, language (supports Bulgarian and English languages).

Audio interface – defines the characteristics of the sound through which the player receives audio messages. They are of three types – thematic music, sound signals indicating the success/failure of a didactic task (puzzle mini-game), and computer-generated speech (text-to-sound) for reading educational text resources.

Visual interface – defines the graphical characteristics of the screen through which the player interacts in the game (brightness, saturation, illumination).

Structuring learning content

The principle involved in designing the learning content structure in educational video games is aligned with the concept of reusing learning resources. This way, the object-oriented approach is applied, where digital components can be used repeatedly in different contexts and purposes. The technology for creating learning resources by "assembling/stitching" interoperable and reusable components (such as Lego blocks) is based on widespread specifications and standards for metadata and learning content creation. The structure of learning content in a maze-type educational video game consists of three levels of granularity (Fig. 3-2). At the highest level are learning objects dedicated to a general topic/lesson or a separate part of it, and they build the learning content in a particular room of the game - learning topic/lesson (TU). Each lesson/topic consists of a group of learning objects (LO), which are embedded in the didactic tasks of the mini-games. They should be customizable and reusable in different learning contexts (in different mini-games and different levels of learning content complexity). For this purpose, they consist of separate small information units - IE (information units), which can be used independently. The structure, size, and metadata of the learning content in a learning resource are essential to making it customizable for reuse.

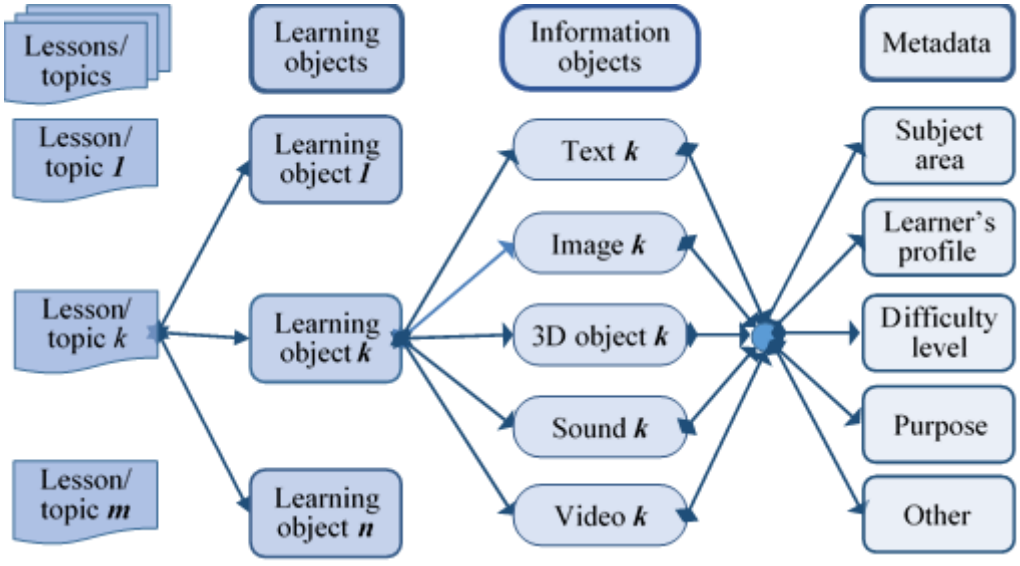

*Fig. 3.2 A general meta-model of learning content in an educational video game by *Terzieva (2019).*

The proposed concept suggests that mini-games and information boards in a maze learning game room will present learning content corresponding to one lesson or topic. The hierarchy of learning resources is defined as follows: each resource (lesson/topic) can contain many other resources (learning objects, learning units), i.e., each resource can have any number of building blocks and correspondingly different characteristics. There can be only one copy of each type of mini-game in the hall and up to 8 information boards - two on each of the four walls. Each information board presents educational material in a narrative form (facts, phenomena, events, pictures, etc.), and it can consist of multiple pages (with no volume limit), which can be flipped manually by pressing a button. Such learning objects are aimed at knowledge acquisition or knowledge expansion (cross-curricular connections), revision, or test preparation. All types of learning objects are described with metadata indicating their most important parameters. Thus, they are more easily identified, which is a contributing factor to easier customization and reuse. Some learning objects may allow hands-on implementation in several types of mini-games.

3.4 Customization of Educational Video Game

The following models were developed (Fig. 3.3) – *Model of the learning content of the game*, *Model of the game* (including methods and strategy of the game and the pedagogical approach embedded in the didactic models of the tasks), and *Model of the game user* (the learner-player). The user model defines how learning content is customized and how gameplay difficulty is adapted.

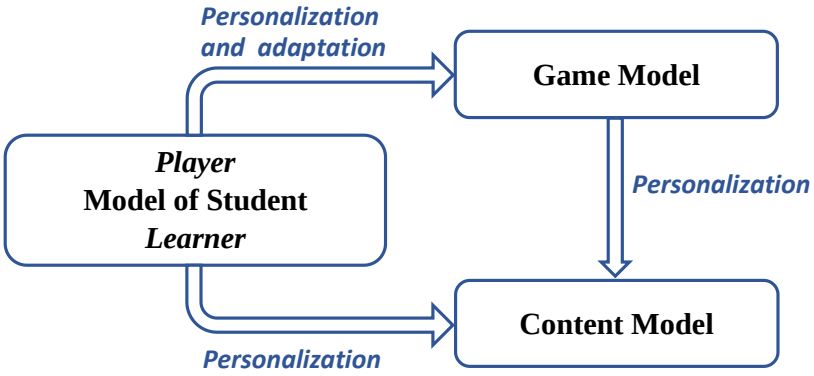

*Fig. 3.3 Dependencies between models in an educational video game (*Terzieva, 2019).*

Individual characteristics from the learner model play a primary role in appropriately personalizing learning interactions in the context of the educational maze game. The general conceptual framework for customizing an educational video game is as follows:

1. Registration of new users (students) and determination of their profiles through surveys;

2. Creating a model of the student, including static and dynamic characteristics;

3. Initial personalization according to the student's static characteristics of the three main groups of components of the educational video game: scenario, learning content, and didactic tasks embedded in the game context;

4. Starting a game session and collect data about the learner's performance;
5. Analysis of the achieved educational goals and game results;
6. Setting value/update dynamic features in the learner model;
7. Subsequent customization of educational video game components.

In the case of personalization, the number, type, and complexity of the didactic tasks, as well as the difficulty level and the volume of the educational content presented in them, are subject to selection. The dynamic characteristics of the user currently reflect the results achieved in different game sessions and serve for the subsequent personalization of learning resources and dynamic adaptation of the parameters of game tasks, such as execution time, number of attempts, speed, and other limitations. By analyzing the dynamic data about the way of playing and the achieved effectiveness of the learner as a player, precise changes can be made to the learning content embedded in the didactic tasks - volume, level of complexity, mode of presentation (text, images, sound, video) and other parameters. For text learning resources parameters such as font, size, background, color, etc., can be adjusted. Likewise, modifications can be made, and variations of game mechanics are generated – adapting the difficulty to motivate and hold the learner's attention as a player. It is accomplished by changing various parameters and constraints specific to the game mechanics of the particular learning task.

Individual learning style plays an essential role in the appropriate personalization of learning interactions in the context of an educational game. The playing style also has an important role - a characteristic that determines the way of playing. Individual playing style may vary across game types or over time, so it is a relative parameter that must be defined in the context of a particular game type (Bateman et al., 2011).

Conclusions from the Chapter three

The basic patterns needed in designing educational video games are presented. A combined student model encompassing profiles of the user, learner, and player is developed, which underlies the personalization of educational video games. The requirements for the learning content presentation are defined, the different types of learning content are discussed, and a metamodel presenting it, is shown from the point of view of its use in a personalized educational game. A conceptual model for the personalization of educational video games is developed, and a methodology for the personalization process is described.

CHAPTER 4. PERSONALIZED EDUCATIONAL VIDEO GAMES OF TYPE ENRICHED MAZE

4.1 Conceptual Model of an Educational Video Game of Type Enriched Maze

Mazes often are used in entertainment games; they are familiar to users, and therefore, they are very suitable for the interactive presentation of content. They are widely used in 3D role-playing and adventure games with context in various fields. In them, the player explores the content presented in the maze while moving towards their goal. Educational video games of type enriched maze are 3D video games representing interconnected separate maze halls with built-in didactic mini-games and multimedia materials (Bontchev, 2019). These learning games are a maze represented as a planar graph (Fig. 4.1). The requirements for the maze connectivity graph are the following: it must be planar; to have one launch hall; the connections at each graph node (i.e., the hall) of the maze are at most four; cycles are possible. From a pedagogical point of view, it is good that the graph allows different paths for traversing and/or reaching the final goal so that a personalized learning path can be chosen. The one shown in Fig. 4.1 structure of a maze-type educational video game allows setting four learning paths of different sequences and lengths.

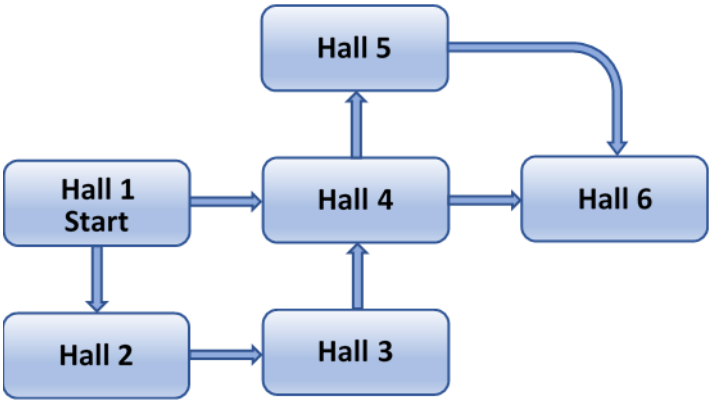

Fig. 4.1 Example of the structure of an educational video game of maze type.

Educational video game of type maze enriched with mini-games are suitable visual environments for presenting learning resources and information aimed at achieving learning goals (Antonova & Bontchev, 2019). They have the following characteristics, which determine their advantages and suitability for training (Bonchev, *Terzieva, Dankov, 2021):

- Allow easy structuring and description of learning content in an XML document;
- They are suitable for implementation in different educational contexts;
- They are suitable for personalization and adaptation - choosing different learning paths;
- Allow embedding of various didactic tasks - mini-games;
- Enable additional learning tasks tailored to the learner’s level.

Different combinations of puzzle mini-games within an enriched maze can build a variety of educational video games, helping to develop critical and logical thinking, thus making the learning process interactive and more engaging:

- Mini-games are different types of well-known puzzles that are not complicated and easily integrated into learning practice;
- The mini-games are interactive and are an appropriate tool for various learning scenarios in class, such as an exercise, a negotiation, a knowledge test, etc.;
- The mini-games are suitable for a wide range of subjects and areas of knowledge;
- Mini-games are combined and integrated into learning mazes on any subject.

Fig. 4.2 presents a graphical meta-model of an enriched maze-type educational video game. It shows the components of one hall of the maze. Each room has walls, ceiling, and floor overlaid with different textures and images according to the context of the game, and the aesthetic layout is complemented by an audio track (which may be different for each room) that plays when the player is in it. Halls may have one or more doors to other maze halls.

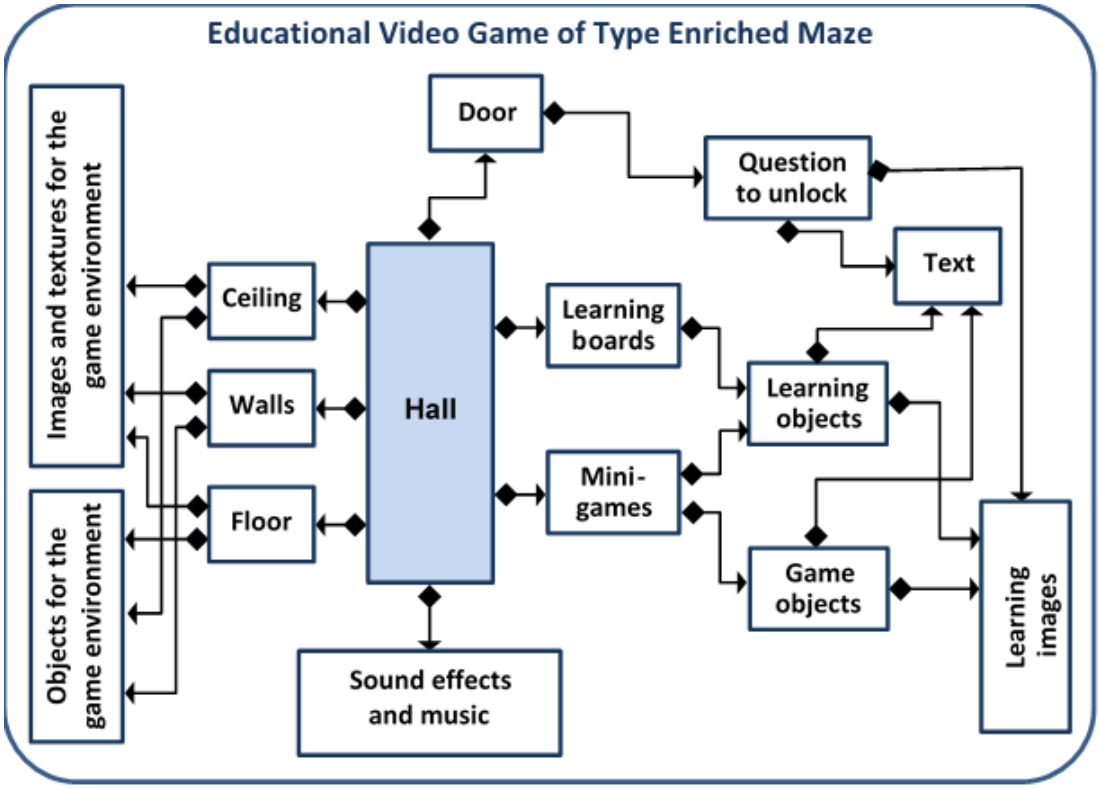

Fig. 4.2 Metamodel of an enriched maze educational video game

The door to another room is unlocked by correctly answering a question, which can be text or graphic. One or two learning boards can be placed on each wall (a maximum of eight in a room). Learning boards present learning objects that can contain text and/or graphics and the voluminous text is divided automatically into pages. Each learning board can have a different type of 2D mini-game embedded in it. Mini-games consist of game objects that can contain text and/or images. The

metamodel serves as the basis of an XML document describing a video game of maze type, and the XML document itself represents a model of the specific game. The XML document, in turn, reflects the connectivity graph of the game it describes. The game graph is subject to conditions (Bontchev & Panayotova, 2017), and the requirements for the maze halls are as follows: Each hall can have at most one map and one 3D mini-game on the floor; only one audio track (music resource) is played, and can have any number of hidden objects. Each hall wall can have only one door and a maximum of two learning boards. Each learning board can present text and/or graphical information, or a 2D mini-game (puzzle). Each mini-game can have different sound effects.

4.2 Creation of Educational Video Games of Type Enriched Maze through the APOGEE Platform

The design process of an educational 3D maze-type video game enriched with mini-games covers the following main stages (*Dankov, Antonova, Terzieva, Bontchev, 2021):

1. Setting learning goals and creating game scenarios that reflect them;

2. Collection and structuring of text and multimedia learning content;

3. Selection of appropriate types of didactic tasks and modeling of learning content in the relevant mini-games;

4. Designing an audiovisual layout of the halls of the labyrinth;

5. Creation of an XML document describing the halls of the maze, the presented learning resources, and the built-in mini-games;

6. Generate an online version of the game using the Unity 3D editor;

7. Testing and validating the initial version of the game with target users.

The APOGEE platform, which aims to automate the process of building and generating rich maze-type 3D educational video games, includes two main modules The maze editor, comprising a graphics editor and a game resource editor, is managed by metadata. The maze builder is fed with a manually or automatically created XML file with a structured declarative semantic game description and related multimedia content and automatically generates educational video games of type enriched maze using a Unity3D application (Bontchev et al., 2019).

The approach to personalizing educational maze video games is based on the learner model created (Fig. 3.1). The motivation for adaptation and customization is based on the understanding that changes in some of the characteristics of the learners can affect the usability of the games and the effectiveness of the learning process. For this reason, the user characteristics (described as static and dynamic quantities) involved in the learner model used in the APOGEE platform are considered. The student model can be continuously updated and modified, as well as models of new users to be created. The student model is at the heart of the personalization process of educational maze video

games. It is based on the assumption that if the functionality of some system is tailored to the user's characteristics, the users will derive more benefits from it.

Figure 4.4 presents a conceptual model for personalizing an educational video game of type maze enriched with embedded mini-games. The process of personalization of such type of game follows the steps described in Section 3.4 for the general case, as shown in the diagram, starting with registration and creation of the student model. The actual customization of the rich maze video game takes place in three main directions:

1) The structure of the maze is determined to match the learning content and further adapted to allow different learning paths;

2) The learning content on a given topic is selected and presented according to the characteristics of the learner's model, such as knowledge level, learning goals, learning style, etc.;

3) Appropriate puzzle mini-games are selected to represent the learning tasks, corresponding to the learning content and the attributes of the student model.

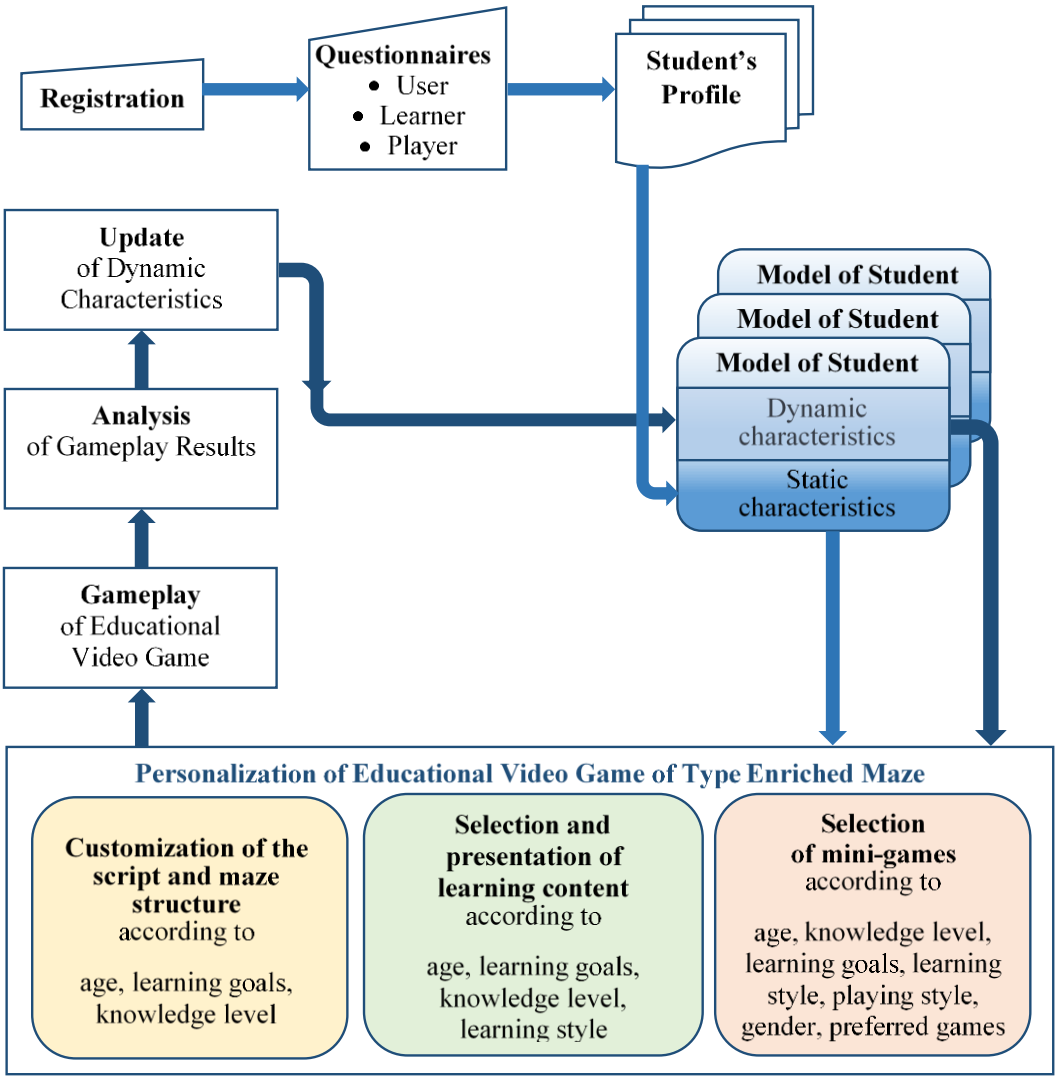

Fig. 4.4 Conceptual model for personalizing an educational video game of type maze enriched with embedded mini-games

Table 4.1 provides a summary of the personalization of the different types of mini-games built into an enriched maze educational game.

Table 4.1 Personalization of the different types of mini-games.

Types of mini-games	**Mini-games**	**Personalization according to learning style**	**Personalization according to difficulty level**
1. Question - answer	Door unlocking question	• closed, open question • text, picture question	• number of possible answers • difficulty level selection
	Multiple question quiz	• closed, open question • text, picture question	• number of possible answers • difficulty level selection • presence of a hints
2. Discovery games	Finding words in a table of letters	• kind of words • placement of words	• number of words • difficulty level selection • presence of a hints
	Finding tile pairs (Memory game)	• image to image • text to image • text to text	• number of tiles • difficulty level selection • image types • presence and type of hint
	Finding hidden objects	• size • species • location	• number of items • difficulty of placement • presence and type of hint
3. Sorting games	Sorting images according to a given criterion/ condition	• type of image • criterion/ condition • image size	• number of images • presence of a hints
	Classification of objects according to a given characteristic	• size of the object • type of objects • classification feature	• number of objects • availability of description • presence of a hints
	Arrangement of 2D picture puzzle	• type of image • image size	• number of puzzle pieces • presence of a hints
4. Action games	Rolling a ball marked with an image/text to a given position on a geographical map	• type of image • type of text • amount of text • type of map	• number of balls • number of positions • presence of a hints
	Roll a ball marked with an image/text to a corresponding ring	• type of image • type of text • amount of text	• number of balls • number of positions • presence of a hints
	Marking (hitting) moving balloons with attached target objects among other objects	• type of target objects • type and quantity of other objects • criterion/ condition	• number of objects • movement speed • presence of a hints

4.3 Personalization of Basic Educational Video Game of the Type Enriched Maze

The methodology for the development of an educational video game-maze focuses on identifying methods and tools for providing and acquiring knowledge during the game, tailored to the individual characteristics of students, taking into account their differences in the level of skills, goals, and interests, age, learning and playing styles, and other learning-related aspects. Constant reporting of progress and its visualization in the form of feedback is also an essential factor.

Personalization of in-game learning content

The personalization of the educational game of type enriched maze is carried out depending on the student model, considering his characteristics as a user, learner, and player. It has three aspects – the customization of learning content, game content, and feedback.

A. Personalization of learning content – depends on the students' characteristics, which are reflected in their model, such as age and level of knowledge, learning goals, current achievements in the game, etc. It refers to the informational content presented.

- *Level of complexity of the learning content* – it is related to the terminology used and the way of presenting the knowledge; three levels of complexity are defined: elementary (beginner), basic (advanced), and in-depth (expert).
- *Presentation of learning content* – is related to the means of expression used to present knowledge and depends on the learning style, preferences, and other characteristics of the student's model. Relevant information objects are used, including text, images, audio resources, and combinations thereof, and for the same educational content, there may be several information objects of different types to present the educational content. The various types of learning content elements are customized – variations are created by changing their constituent components, and they can be modified flexibly according to the pedagogical goals and the characteristics of the group of learners.

B. *Personalization of game-based learning content* – depends on attributes in the student model - age, gender, playing style, etc., as well as their current game performance. It is used for didactic tasks (mini-games) that require additional gaming skills.

- Setting an attribute indicating the mandatory performance of a given game task;
- Changing the game learning content - choosing a different type of didactic mini-games/tasks; changing parameters variations of placement in the halls of the labyrinth of didactic mini-games/tasks; changing the number of included game tasks.

C. *Personalization of feedback in educational puzzle mini-games*:

- Specific feedback – various types of hints for solving a learning task - leads to a reduction in the number of points that would be earned;
- Way of reflecting player progress – a different way of visualizing current results – in percentage, remaining tasks, points achieved, etc.;
- Feedback from a non-playing character (NPC) – also includes the ability to use different types of help for learning content or gameplay.

4.4 Realization of a Personalized Educational Video Game of Type Enriched Maze on the APOGEE Platform

This section shows screenshots from both versions of the educational video game of type maze enriched with embedded mini-games - Universal and Personalized. The universal version is shorter, easier, and oriented towards basic knowledge of the topics of Asenevtsi. The customized version of the game is longer and is designed to give a deep knowledge of the Asenevtsi dynasty and the medieval history of Bulgaria.

Figure 4.5 presents the graphic model of the maze for both versions of the educational video game "Assenevtsi". Its structure makes it possible to realize more than one game learning path, which is a prerequisite for customization according to learning goals.

Fig. 4.7 Graphical model of an educational video game "Assenevtsi" of the type of enriched maze

The mini-games are not limited in playing time, but the time it takes for the maze-type video game to be played to completion (i.e., solving all the required learning tasks) earns the player extra points. Both versions of the game (universal and customized by difficulty level) differ in the volume and complexity level of the presented educational content on the educational boards and in the educational resources embedded in the didactic tasks of the mini-games. The learning content presented in the universal game covers only the most essential knowledge of the subject, is less in volume, and uses a simple statement where possible. Correctly solving all mini-games - puzzles in the universal game can bring the learner a maximum of 320 points and in the customized game - 760 points. Some of the mini-games in both versions are mandatory while others are not, but they also bring points for the game's final score. In didactic tasks, the most significant difference is in the "Quiz" mini-game - the universal version has only one difficulty level with six questions, and the maximum number of points to be earned is 60. In the customized version, the quiz has 16 questions divided into three levels of complexity, and the maximum possible number of points earned is 320. In this mini-game, the points earned depend on the level of complexity of the questions and the

number of attempts to give a correct answer. In the other mini-games, there is a difference in the learning objects used - for example, in the memory development game, the images of historical figures have an explanatory caption, and in the customized version, the analogous learning object is of a higher level of complexity – without a caption.

Figure 4.8 presents screenshots of the same types of mini-games in the universal and personalized versions of the educational video game of type maze enriched with embedded mini-games "Asenevtsi". The personalized game consists of mini-games with increased difficulty and a larger volume of gaming learning tasks. From top to bottom and from left to right, various mini-games are shown, highlighting the differences between the two versions of the video game:

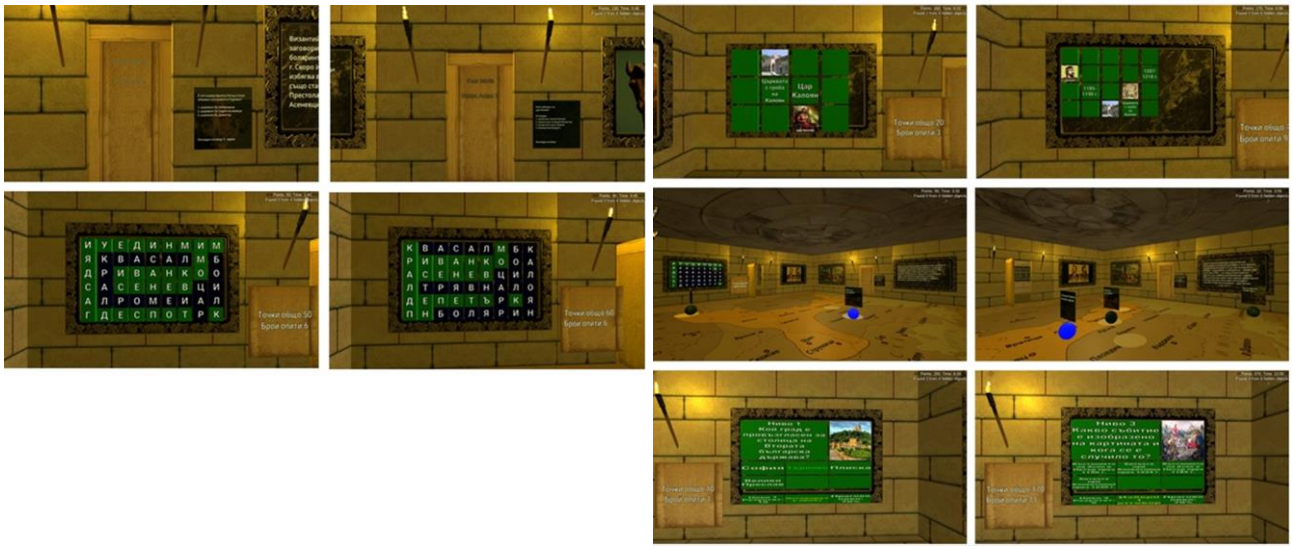

Fig. 4.8 Screenshots of the same type of mini-games in the universal version (left) and the customized version (right) of the educational video game "Asenevtsi".

- Game to answer a question about the door opening to another hall – the number of possible answers differs;
- Word search game in a table of letters – the type, number, and arrangement of the words differ;
- Game for finding pairs of matching tiles (Memory game) – the number of tiles and the type of correspondence differs;
- A game for rolling balls on a map on the floor to a corresponding place – the number of balls and the presence of misleading (redundant) positions differ;
- Game for answering a group of questions (quiz) – the number, type, and difficulty degree of questions differ.

Conclusions from Chapter Four

A conceptual model of an educational video game of type enriched maze is presented, which is the basis of the process of creation of such games through the APOGEE platform. Through a

constructive scientific approach, a methodology has been developed to customize an educational video game of type enriched maze by customizing the parameters of the embedded mini-games. The developed universal and personalized versions of the educational video maze games "Asenevtsi" have been analyzed and compared.

CHAPTER 5. VALIDATION AND EVALUATION OF A PERSONALIZED EDUCATIONAL VIDEO GAME OT TYPE ENRICHED MAZE

5.1 Methodology of Conducting the Experiments

Validation of educational video games usually is carried out by evaluating the two most essential indicators – the *game impact* (*game experience*) and *suitability for learning* (*learnability*). The term *game experience* is considered a complex indicator consisting of sensations, thoughts, feelings, actions, and meanings that arise in the player during a game session (Ermi & Mäyrä, 2005). *Learnability* refers to the characteristics of an interactive system that enable its users to understand quickly how to use it and how to achieve maximum performance (Dix et al., 2003). In this case, educational games are a kind of interactive system, so to be used for training; they must be easy to learn so that the user can quickly start playing. Specific direct and indirect measurable attributes are used to evaluate the usability of software products, such as educational video games (Sommerville, 2011).

The experimental research methodology consists of several stages: design of research surveys, targeted selection of respondents, processing, mathematical modeling, and analysis of the obtained results. The survey method used is web-based. The specialized applications Microsoft Forms and Google Forms were used as a tool for creating, distributing, and collecting data from online surveys.

Experimental setting

The educational video game of the type of enriched maze "Asenevtsi" is available online, so a prerequisite for its validation is access to a good Internet connection and a modern computer. The experimental study is conducted under the following protocol:

1) Selection of target groups of learners:

- Sixth-grade students – they are chosen because in the History subject curriculum during the second term, the subject of the Second Bulgarian Kingdom is studied, to which the educational video game "Asenevtsi" is dedicated;
- Sofia University students that are studying about the serious games during "Communication management" course.

2) Introducing the learners to the game through a presentation showing how to play, the types of mini-games, and the ultimate goal.

2.1) Sixth-grade students are divided into two approximately equal size groups. The main criterion for the division is the interest in the history of Bulgaria. An additional criterion for dividing students into groups may also be applied, e.g., the History grade mark from the previous term.

- Group A: learners with a deep interest in the topic and a desire to gain additional knowledge – they play the personalized game, allowing consolidating and upgrading knowledge.
- Group B: learners without a deep interest in the topic and a desire for additional knowledge – they play the universal (basic) game, providing only the opportunity to consolidate basic knowledge.

2.2) Students are invited to play both versions of the game, indicating their interest in the history of Bulgaria.

3) Game process – each learner plays independently on a computer online the corresponding version of the educational video game "Asenevtsi".

4) After playing the game, learners complete an online survey. It covers several sections on profiling questions, including their interest in Bulgarian history and game results (time played, objects collected, quiz score obtained, and total points). In addition, games are rated on the components of two metrics – gaming experience and learnability. In addition, students compare the two game versions according to several criteria.

5) Processing and analysis of questionnaire surveys.

Experimental testing with sixth-grade students was conducted face-to-face while with university students - online as part of the training course.

Qualitative and quantitative evaluation characteristics

Learnability is one of the essential attributes of the usability of educational video games, so the Asenevtsi maze game is evaluated based on the following indicators: Ease of Learning; Familiarity; Consistency; Predictability; Informative Feedback; Error Handling (Reaction to errors).

The *game experience* of a computer video game is a multidimensional measure of impact during a gaming session. The educational game "Asenevtsi" is evaluated according to the following indicators (Poels et al., 2007): Flow (Game Flow), Challenge, Competence, Positive Affect, Negative Affect, Immersion, Tension.

5.2 Experimental Testing of Educational Video Game of the Type Enriched Maze

The educational video game of the type enriched maze delivers learners a visually rich learning environment that traditional teaching methods cannot provide. The universal video game is without customization to the characteristics and preferences of a specific type of user, whereas the personalized version of the game is aimed at users with a higher level of knowledge, with a

pronounced interest in the subject matter and learning goals aimed at acquiring new knowledge. The online survey was conducted after the experimental testing by playing the universal and personalized versions of the game "Asenevtsi".

Profile of the participants: 40 students from two classes in the sixth grade of a secondary school in Sofia city and 30 fourth-year students of the University of Sofia participate in the experiment. Surveys show that most students have little gaming experience, having played little or no educational games. Some students had difficulty playing on the computer due to insufficient computer skills.

5.3 Processing and Analysis of Experimental Results

Fig. 5.3 presents a comparison of the opinions of sixth-grade students and university students about replaying an educational video game. Definitely, school students are significantly more inclined to acquire knowledge and improve their game performance than university students. Only 30% of students would try to improve their scores, and about 40% would upgrade their knowledge by playing a game at the next difficulty level. These results have a logical explanation in the profile of the students, a considerable number of whom do not play games, and 90% have never played educational games before the "Asenevtsi" game.

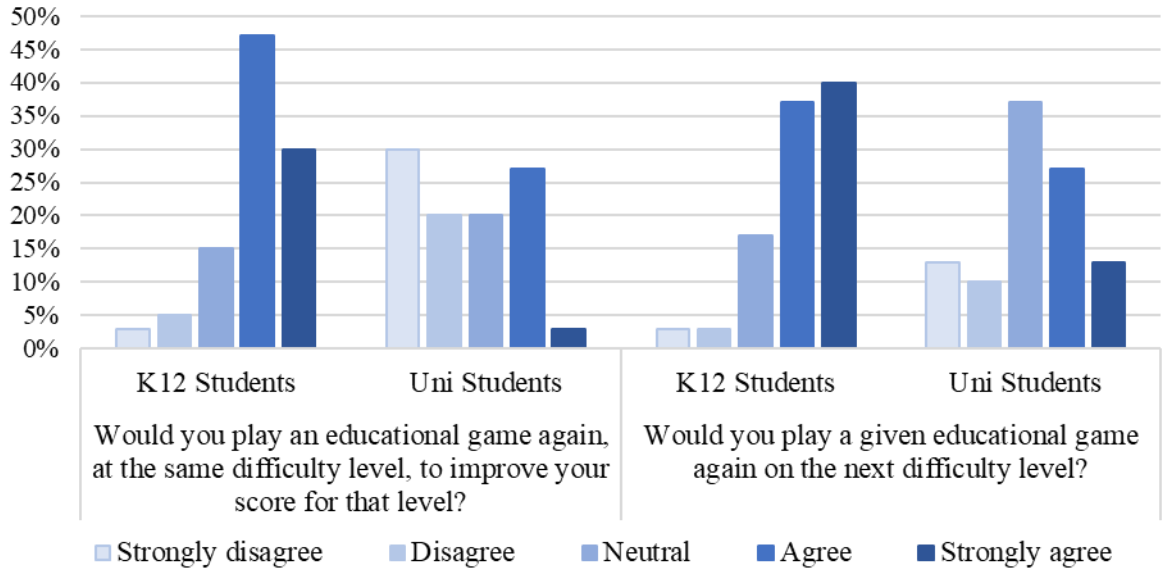

Fig. 5.3 K12 students and university students' opinions about replaying an educational game.

The comparison of two versions of the educational video game "Asenevtsi" is made based on the average values of the given ratings on a five-point Likert scale with a minimum of 1 and a maximum of 5 points. The following indicators are evaluated: Learnability (Suitability for learning), Game experience, and Overall educational value of educational video games. Also, the comparison is made concerning the opinions of the different groups of participants in the experiment.

Learnability: The results show that students rate the personalized game higher on this metric (Fig. 5.4). Statistically significant (for *p-value* < *0.05*) were the differences in the evaluation of the

components of help received (informative feedback) and the evaluation of the visualization of the results of the interaction with the mini-games (reaction to errors). Probable reasons - students who played the personalized game are more interested in the subject matter and need to get helpful information about the correct answer, which will help them complete the task. However, the universal game also receives relatively high marks, which leads to the conclusion that when an educational game matches the level of knowledge and interests of students, it is well received and evaluated.

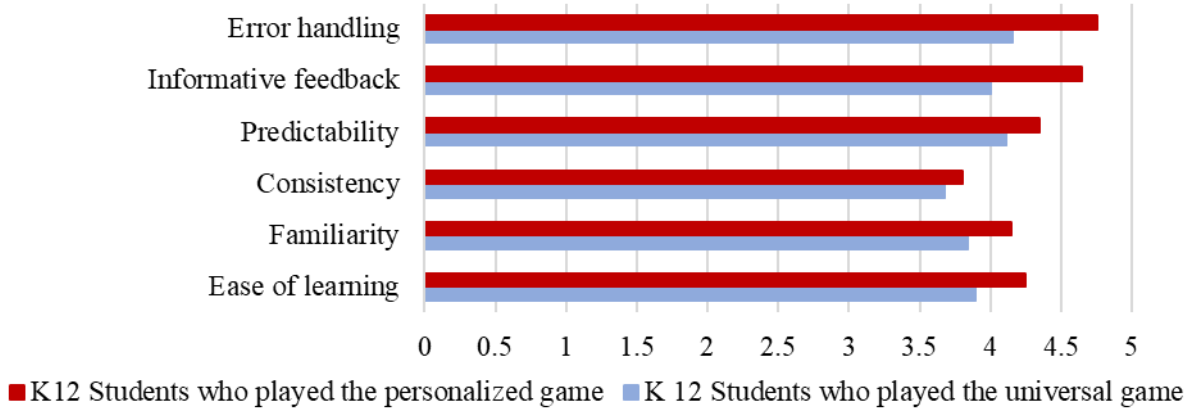

Fig. 5.4 Suitability for learning the educational game "Assenevtsi" - assessment of the K12 students.

Students rate the educational game "Assenevtsi" slightly lower in terms of the indicator of learnability compared to school students (Table 5.3).

Table 5.3 Evaluations of the learnability of the educational video game "Assenevtsi" – comparison by groups of learners.

Criterion / User	Ease of Learning	Familiarity	Consistency	Predictability	Informative Feedback	Error Handling
School students – universal game	3.89	3.84	3.68	4.11	4.00	4.16
School students – personalized game	4.25	4.15	3.80	4.35	4.65	4.75
University students – universal game	3.07	3.40	3.33	3.6	4.03	3.77
University students – personalized game		3.33	3.5			

The logical explanation of the K12 students' higher appreciation of learnability components of both versions of the game is as follows: the video game is purposefully created as a theme and knowledge level for sixth-grade students, with the embedded learning content and didactic tasks in the mini-games corresponding to their level. However, scores for all components of learnability are above the mean level on a 5-point Likert scale, indicating that this educational game "Asenevsti" creates a motivating learning environment and is efficient for learning purposes for both groups of learners.

Game experience: Student ratings of the fun and positive impact of the personalized game were slightly higher than those of the universal game (Fig. 5.5). Students with a strong interest in history who played the personalized version of the game did not find it difficult, challenging, or stressful. On the other hand, the universal game, which covers the basic knowledge of the subject matter, corresponds to the knowledge level and competence of the students who played it. They have felt entirely absorbed in the process of playing, it seems to them quite fascinating and also has a positive influence on them, but at the same time, it creates some tension. These results show that the presented game tasks correspond to the level of knowledge of the respective groups of students, and they play the game "Asenevtsi" with pleasure and interest. However, some K12 students don't have enough gaming skills and competence to achieve the game objectives quickly. That is why they feel some negative impact.

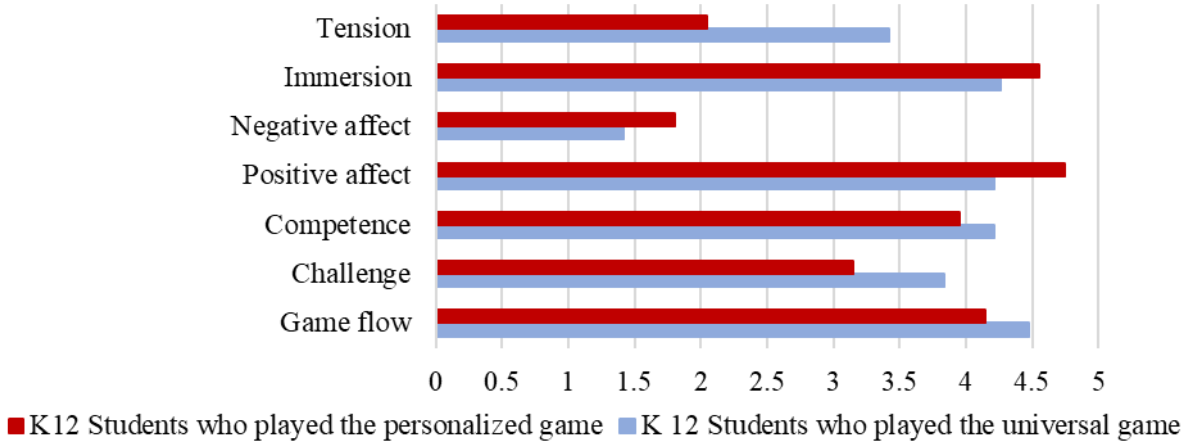

Fig. 5.5 Game experience of the educational game "Asenevtsi" - assessment of K12 students.

Overall evaluation of educational value for the two versions of the video game "Assenevtsi": Mean values on a five-point Likert scale for various indicators related to the learning process for the personalized and universal games were calculated (Fig. 5.6 and Fig. 5.7). University students with no interest in history strongly rated the learning opportunities of the personalized game higher as an effect, the differences being significant at p-value < 0.05. The students interested in history are not so decisive – they rate the learning opportunities and motivation of the personalized version of the game higher as an effect at most indicators, but the differences with universal version are insignificant (Fig. 5.7).

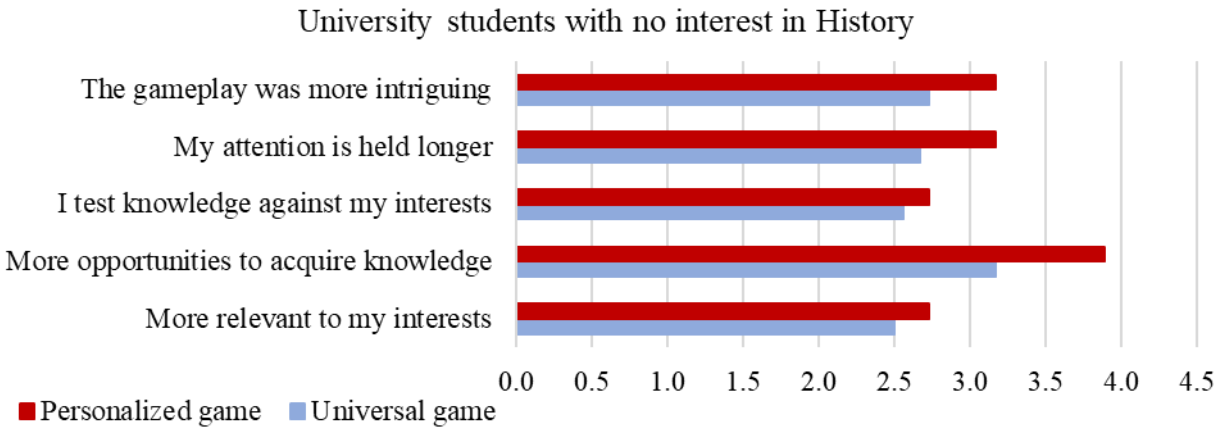

Fig. 5.6 Evaluation of the educational value of the video game "Assenevtsi" – university students with no interest in History.

The most significant difference concerns the statement "More opportunities to acquire knowledge", which is logical, since the game personalization is made according to the knowledge level and is intended for users who self-assess as advanced in the subject matter. The personalized version of "Asenevtsi" covers a broader field of knowledge on the subject, and it is also reflected in the didactic tasks of the mini-games, which have a more of game objects and learning objects and a higher degree of difficulty.

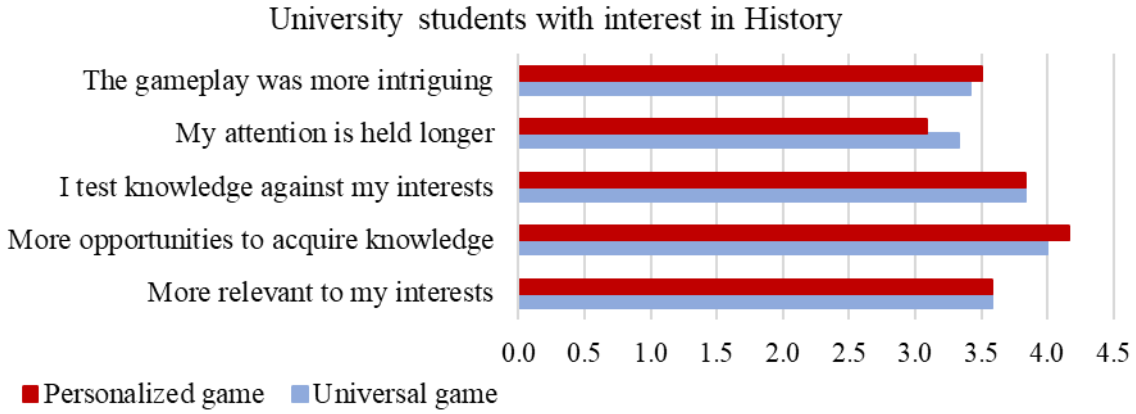

Fig. 5.7 Evaluation of the educational value of the video game "Assenevtsi" – university students with an interest in History.

Generally, both groups of learners – university students and sixth-grade school students who participated in the experimental study, rated the personalized version of the educational video game "Asenevtsi" more highly than the universal version. However, there are some indicators on which the evaluations, especially of the university students, are not definite. One of the possible reasons is the lack of or little gaming experience of the participants in the experimental testing. Almost all of them have never played educational games before. More testing with more participants and with a more diverse profile is needed.

Conclusions from Chapter Five

The results of the questionnaire surveys after the game testing show that the personalized video game "Asenevtsi" created in the process of scientific research, is an efficient learning tool and is rated highly in terms of suitability for learning. Both schoolchildren and students give such an assessment, regardless of their interest in the game theme. The opportunities and motivation for learning that the personalized game gives compared to the universal one are significant, according to the students' evaluations.

CONCLUSION

This PhD thesis considers and explores many aspects of technology-based learning with the particular focus on personalized games as an efficient learning tool that can meet the preferences and demands of modern learners and motivate and support them in their learning and knowledge acquisition. The experimental study shows that the personalized version of the educational video game "Asenevtsi" is more appreciated highly than the universal version concerning its indicators learnability, game experience and educational value. During the research process, ideas for additional research and development developments appeared.

Opportunities for future development

Scientific-applied developments and conclusions from the dissertation will further help to develop and improve the platform for creating educational video games APOGEE and to upgrade its functionalities. A further in-depth study of the results of all survey studies and the use of the findings as a basis for developing a research project proposal is planned. A perspective direction is also the research of the possibilities concerning educational video game personalization, implemented for mobile devices and intended for microlearning.

List of the Author' Scientific Publications

1. Dankov, Y., Antonova, A., **Terzieva, V**., Bontchev, B. (2021). Applying User-Centered Design for a Climate Resilience Video Game. International Journal of Differential Equations and Applications, 20(2) pp. 147-156. Academic Publications, Ltd., 1314-6084, **SJR 0.1, Q4, Scopus - 1 цитиране**
2. **Terzieva, V**. (2019). Personalization in Educational Games – A Case Study. Proceedings of the International Conference on Education and New Learning Technologies, pp. 7080-7090, ISSN:2340-1117 https://doi.org/10.21125/edulearn.2019.1694 **WoS - 4 цитирания**
3. **Terzieva, V**. (2018). The Potential of Educational Maze Games for Teaching in Primary Schools. Proceedings of the International Conference of Education, Research and Innovation ICERI2018, pp. 2480-2489, ISSN:2340-1095 https://doi.org/10.21125/iceri.2018.1542 **WoS - 5 цитирания**
4. **Terzieva, V.,** Paunova-Hubenova, E., Dimitrov, S., Dobrinkova, N. (2018). ICT in Bulgarian Schools – Changes in the Last Decade. Proceedings of the International Conference on Education and New Learning Technologies EDULEARN18, pp. 6801-6810, IATED, ISSN:2340-1117, https://doi.org/10.21125/edulearn.2018.1612 , **WoS**
5. Bonchev, B., **Terzieva, V**., Dankov, Y. (2021). Educational video games-mazes. Magazine Nauka, XXXI, 1, Union of Scientists in Bulgaria, ISSN:0861 3362 (print), 2603-3623 (electronic), pp. 25-33, (in Bulgarian), available at: http://spisanie-nauka.bg/arhiv/ 1-2021.pdf

6. **Terzieva, V.** (2018). Video games for learning in school. Proceedings of the National Conference "Education and Research in the Information Society", ARIO and IMI-BAN, 2018, ISSN:1314-0752, pp. 84-93, (in Bulgarian) available at: http://sci-gems.math.bas.bg:8080/jspui/bitstream/10525/2950/1/ERIS2018-book-p09.pdf - **4 citations**
7. Todorova, K., **Terzieva, V.**, Kademova-Katzarova, P. (2018). Educational games in school - research and analysis. Reports of the National Conference "Education and Research in the Information Society", pp. 116-125, ARIO and IMI-BAN, ISSN:1314-0752: (in Bulgarian) http://sci-gems.math.bas.bg:8080/jspui/bitstream/10525/2954/1/ERIS2018-book-p13.pdf - **4 citations**
8. **Terzieva, V.**, Todorova, K., Kademova-Katsarova, P. (2016). Teaching through technology - the shared experience of Bulgarian teachers. Reports of the National Conference "Education and Research in the Information Society", pp. 185-194, ARIO and IMI-BAN (in Bulgarian), http://sci-gems.math.bas.bg:8080/jspui/bitstream/10525/2756/1 /ERIS2016-book-p19.pdf - **15 citations**

Approbation of the results

Part of the presented results in the present dissertation study was achieved and tested with the participation of the author in the activities of several scientific projects:

1. Project "Analysis of the data for the integration of ICT resources in Bulgarian schools", financed by FNI, No. DM02/1/2016. The project was successfully completed in 2019.

2. Project APOGEE - "Innovative platform for intelligent adaptive video games for education", financed by the Scientific Research Institute under No. DN12/7/2017. The project was successfully completed in 2022.

3. Project HERITAGE'BG - with the head of the task Prof. Boyan Bonchev. Procedure BG05M2OP001-1.001-0001 Construction and development of a Center of Excellence, 2020-2021.

4. Project e-Creha - "education for Climate Resilient European Architectural Heritage" 2020-2023, with the head of the Bulgarian team Prof. Boyan Bonchev, financed under the Erasmus + program, number 2020-1-NL01-KA203-064610.

Main Results of Ph.D. Thesis

The following results have been achieved in this dissertation, which are also contributions. They are related to the research conducted and its successful implementation to create a personalized educational video game of the type of enriched maze with built-in mini-games.

1) A conceptual combined student model aimed at the personalization of educational computer games, was created.

2) A classification of the types of educational computer games is proposed.

3) A qualitative and quantitative assessment of the usage of ICT and educational computer games in Bulgarian schools is presented.

4) A methodology for personalizing educational video games, based on a combined model of the learner, was created.

5) A methodology for personalization of an educational video game of type maze, enriched with built-in didactic mini-games, was created.

6) A methodology for investigating, validating, and evaluating the learnability, game experience, and effectiveness of a personalized educational video game of type enriched maze, was developed.

7) A universal and personalized educational video game of type maze, enriched with built-in didactic mini-games dedicated to Bulgarian medieval history, has been created and successfully validated against the above methodology.

Bibliography

Abt, C. (1970). Serious games. New York: Viking Press.

Aguilera, M.D., & Mendiz, A. (2003). Video games and education: Education in the face of a "parallel school". *Computers in Entertainment*, 1(1), 10, ACM.

Allisop Y., Yildirim, E., Scepanti, M. (2013). Teachers' beliefs about game-based learning: a comparative study of pedagogy, curriculum and practice in Italy, Turkey and the UK. In: *Proceedings of ECGBL* 2013, pp. 1-10.

Annetta, L.A. (2008). Video games in education: Why they should be used and how they are being used. *Theory into practice*, *47*(3), 229-239.

Antonova, A., Bontchev, B. (2019). Exploring puzzle-based learning for building effective and motivational maze video games for education. In: *Proceedings of 11th International Conference EDULEARN 19*, pp. 2425-2434, Palma de Mallorca, Spain.

Antonova, A., Dankov, Y., & Bontchev, B. (2019). Smart services for managing the design of personalized educational video games. In *Proceedings of the 9th Balkan Conference on Informatics* (pp. 1-8).

Aroyo, L., Dolog, P., Houben, G-J., Kravcik, M., Naeve, A., Nilsson, M., Wild, F. (2006). Interoperability in personalized adaptive learning. *Educational Technology & Society*, 9(2), 4-18.

Bateman, C., Lowenhaupt, R., & Nacke, L.E. (2011). Player typology in theory and practice. *Proceedings of Think Design Play: The 5th International Conference of DIGRA.*

Beetham, H., Sharpe, R. (Eds.) (2007). Rethinking pedagogy for a digital age: Designing and delivering e-learning, Routledge, New York

Bell, B.S., & Kozlowski, S.W. (2012). Advances in technology-based training. In *Managing human resources in North America* (pp. 27-43). Routledge.

Bontchev, B. (2019). Rich educational video mazes as a visual environment for game-based learning. In *CBU International Conference Proceedings*, Vol. 7. 380-386.

Bontchev, B., Panayotova, R. (2017). Generation of educational 3D maze games for carpet handicraft in Bulgaria. *In Digital Presentation and Preservation of Cultural and Scientific Heritage*, VII, pp. 41-52.

Bontchev, B., Vassileva, D., Dankov, Y. (2019). The APOGEE Software Platform for Construction of Rich Maze Video Games for Education. In *Proceedings of the 14th International Conference on Software Technologies (ICSOFT 2019*), pp. 491-498, SciTePress. https://doi.org/10.5220/0007930404910498

Bourgonjon J., Valcke M., Soetaert R., Schellens T. (2010). Students' perceptions about the use of video games in the classroom. *Computers & Education*, 54, 1145–1156.

Boyle, E.A., Hainey, T., Connolly, T.M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C. & Pereira, J. (2016). An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. *Computers & Education*, *94*, 178-192.

Bray, B. & McClaskey, K. (2012). Personalization vs differentiation vs individualization. Report (v2). Available at: https://Education.Alberta.Ca/Media/3069745/ Personalizationvsdifferentiationvsindividualization.Pdf

Brusilovsky, P. (1994). The construction and application of student models in intelligent tutoring systems. *Journal of Computer and Systems Sciences International*, 32 (1), 70-89.

Brusilovsky, P. (1998). Adaptive educational systems on the world-wide-web: A review of available technologies. In *Proceedings of Workshop" WWW-Based Tutoring" at 4th International Conference on Intelligent Tutoring Systems (ITS'98),* San Antonio, TX.

Chapman, J. R., & Rich, P. J. (2018). Does educational gamification improve students' motivation? If so, which game elements work best? *Journal of Education for Business*, *93*(7), 315-322.

Chen, N.S., Hwang, G.J. (2014). Transforming the classrooms: innovative digital game-based learning designs and applications. *Educational Technology Research and Development* 62(2), 125–128

Chrysafiadi, K., & Virvou, M. (2013). Student modeling approaches: A literature review for the last decade. *Expert Systems with Applications*, *40*(11), 4715-4729.

Connolly, T., Stansfied, M., Hainey, T. (2011). An alternate reality game for language learning: ARGuing for multilingual motivation. *Computers & Education*, 57(1), pp. 1389-1415.

Cruz-Cunha, M. M. (Eds.) (2012) Handbook of Research on Serious Games as Educational, Business and Research Tool, IGI Global.

Dagger, D., Wade, V. & Conlan, O. (2002). Towards a Standards-based Approach to e-Learning Personalization using Reusable Learning Objects. *Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education*, 2002 pp. 210–217.

de Freitas, S. & Liarokapis, F. (2011). Serious games: A new paradigm for education? (pp. 9-23). M. Ma, et al. (Eds) *Serious Games and Edutainment Applications*. Springer: UK.

de Freitas, S. (2006). Using games and simulations for supporting learning. *Learning, Media and Technology*, 31 (4), 343-358.

Desai, M.S., Hart, J., & Richards, T.C. (2008). E-learning: Paradigm shift in education. *Education*, *129*(2).

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: defining "gamification". In *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments* (pp. 9-15). https://doi.org/10.1145/2181037.2181040.

Dichev, C., Dicheva, D., Angelova, G., & Agre, G. (2014). From gamification to gameful design and gameful experience in learning. *Cybernetics and information technologies*, 14(4), 80-100.

Dix, A., Finlay, J., Abowd, G.D., Beale, R. (2003). *Human-Computer Interaction*; Pearson Education: New York, NY, USA.

Duke, B., Harper, G., & Johnston, M. (2013). Connectivism as a digital age learning theory. *The International HETL Review, 2013*(Special Issue), 4-13.

Ebrahimzadeh, M., Alavi, S. (2017). The effect of digital video games on EFL students' language learning motivation. *Teaching English with Technology*, 17(2), 87-112.

Edsys, (2018). 50 Innovative teaching methods in science, достъпно на: https://www.edsys.in/innovative-science-teaching-methods/

Education technology trends (2022). достъпно на: https://powergistics.com/education-technology-trends/

Ermi, L., & Mäyrä, F. (2005). Fundamental components of the gameplay experience: Analysing immersion. In *DiGRA International Conference: Changing Views: Worlds in Play*.

Ertmer, P.A. & Newby, T.J. (2013). Behaviorism, Cognitivism, Constructivism: Comparing Critical Features from an Instructional Design perspective. *Performance Improvement Quarterly*, 26 (2), pp. 43-71, DOI: 10.1002/piq.21143

Garris, R., Ahlers, R., Driskell, J. (2002). Games, motivation and learning: A research and practice model. *Simulation and Gaming*, 33(4), 441–467.

Gibson, D.C., Knezek, G., Redmond, P., Bradley, E. (Eds.) (2014). *Handbook of Games and Simulations in Teacher Education*. Chesapeake, VA: Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/147471

Granic, I., Lobel, A. & Engels, R. C. (2014). The benefits of playing video games. *American psychologist*, 69(1), 66.

Hamari J., Shernoff, D., Rowe, E., Coller, B., Asbell-Clarke, J., Edwards, T. (2015). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior*, 54(2016), 170-179.

Hodgins, H. W. (2006). The future of learning objects. *Educational Technology*, Vol.46 (1), pp. 49-54. Available at: http://www.jstor.org/stable/44429269

Hwang, G. J., Sung, H. Y., Hung, C. M., Huang, I., & Tsai, C. C. (2012). Development of a personalized educational computer game based on students' learning styles. *Educational Technology Research and Development*, *60*, 623-638.

Ibrahim, R., & Jaafar, A. (2009). Educational games (EG) design framework: Combination of game design, pedagogy and content modeling. In 2009 International Conference on Electrical Engineering and Informatics, Vol. 1, pp. 293-298. IEEE.

Johnson, L., Adams Becker, S., Cummins, M., Estrada, V., Freeman, A., Hall, C. (2016). NMC Horizon Report: 2016 Higher Education Edition. Austin, Texas: The New Media Consortium.

Johnson, L., Adams Becker, S., Estrada, V., Freeman, A., Kampylis, P., Vuorikari R., Punie, Y. (2014). Horizon Report Europe - 2014 Schools Edition. Luxembourg: Publications Office of the European Union, & Austin, Texas: The New Media Consortium

Kapp, K. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education*. San Fransisco, CA: John Wiley & Sons.

Ketamo H., Devlin K. (2014). Replacing PISA with global game-based assessment. In: C. *Busch, (ed.) ECGBL 2014*, pp. 258-264, Berlin, Germany.

Kiili, K., de Freitas, S., Arnab, S., Lainemac, T. (2012). The design principles for flow experience in educational games. *Proceedings of the 4th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES'12)*. 15, pp. 78–91. Elsevier.

Kobsa, A. (2001) Generic User Modeling Systems. In *User Modeling and User-Adapted Interaction*; Kluwer Academic Publishers: Norwell, MA, USA, Volume 11, pp. 49–63.

Kozma, R. (2003). Technology, innovation, and educational change: A global perspective.

Lameras, P., Arnab, S., Dunwell, I., Stewart, C., Clarke, S., & Petridis, P. (2017). Essential features of serious games design in higher education: Linking learning attributes to game mechanics. *British journal of educational technology*, *48*(4), 972-994.

Law N, Miyake N, Kampylis P, Bocconi S, Han S, Punie Y, et al. (2013). ICT-enabled innovation for learning in Europe and Asia: Exploring conditions for sustainability, scalability and impact at system level. *Publications Office of the European Union,* gamedoi/10.2791/25303

Leaning, M. (2015). A study of the use of games and gamification to enhance student engagement, experience and achievement on a theory-based course of an undergraduate media degree. *Journal of Media Practice*, 16(2), 155-170.

Mayer, R. E. (2002). Cognitive theory and the design of multimedia instruction: an example of the two-way street between cognition and instruction. *New directions for teaching and learning*, *2002* (89), 55-71.

Moreno-Ger, P., Burgos, D., Martínez-Ortiz, I., Sierra, J. L., & Fernández-Manjón, B. (2008). Educational game design for online education. *Computers in Human Behavior*, *24*(6), 2530-2540. doi:10.1016/j.chb.2008.03.012

Morford, Z.H., Witts, B.N., Killingsworth, K.J., & Alavosius, M.P. (2014). Gamification: The intersection between behavior analysis and game design technologies. *The Behavior Analyst/MABA*, 37(1), 25–40. https://doi.org/10.1007/s40614-014-0006-1.

Murphy, M., Redding, S., Twyman, J.S. (Eds.) (2016). Handbook on Personalized Learning for States, Districts, and Schools. Center for Innovations in Learning, Philadelphia, PA.

Negash, S., & Wilcox, M.V. (2008). E-learning classifications: Differences and similarities. *In Handbook of distance learning for real-time and asynchronous information technology education* (pp. 1-23). IGI Global.

Nicol, D.J., Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education* 31(2), 199–218.

O'Donovan, S., Gain, J., Marais, P. (2013). A case study in the gamification of a university-level games development course. *SAICSIT '13-Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference*, 242-251.

OECD (2006). Schooling for Tomorrow. Personalising education. OECD Publishing, Paris https://doi.org/10.1787/19900716.

Paunova-Hubenova, E., Terzieva V. (2019). Information Technologies in Bulgarian School Education. In *Proceedings of International Conference (INTED2019*), IATED, pp. 5226-5235,

Poels, K., de Kort, Y.A., IJsselsteijn, W.A. (2007). D3. 3: Game Experience Questionnaire: Development of a Self-Report Measures to Assess the Psychological Impact of Digital Games. The FUGA Project; Technische Universiteit Eindhoven: Eindhoven, The Netherlands.

Prensky, M. (2001). Digital Natives, Digital Immigrants Part 1. On the Horizon, 9(5), pp. 1-6.

Prensky, M. (2003). Digital Game-Based Learning. McGraw-Hill.

Reigeluth, C.M., Myers, R.D., & Lee, D. (2016). The learner-centered paradigm of education. In *Instructional-Design Theories and Models, Volume IV* (pp. 5-32). Routledge.

Salen, K., Tekinbaş, K. S., & Zimmerman, E. (2004). Rules of play: Game design fundamentals. MIT press. Cambridge.

Sawyer, B., & Smith, P. (2008). Serious games taxonomy. In *Slides from the Serious Games Summit at the Game developers conference* (Vol. 5).

Schell, J. (2008). *The Art of Game Design: A book of lenses*. CRC press.

Selwyn, N. (2012). Ten suggestions for improving academic research in education and technology. *Learning, Media and Technology, 37*(3), 213-219.

Serdyukov, P. (2017). Innovation in Education: What Works, What Doesn't, and What to do about it?, Journal of Research in Innovative Teaching & Learning, 10(1), pp. 4-33, https://doi.org/10.1108/JRIT-10-2016-0007

Sharples, M., McAndrew, P., Weller, M., Ferguson, R., FitzGerald, E., Hirst, T., Gaved, M. (2013). *Innovating Pedagogy 2013: Open University Innovation Report 2*. Milton Keynes: The Open University.

Shemshack, A., Spector, J.M. (2020). A systematic literature review of personalized learning terms. *Smart Learning Environment* **7**, 33 https://doi.org/10.1186/s40561-020-00140-9

Sitzmann, T. (2011). A meta-analytic examination of the instructional effectiveness of computer-based simulation games. *Personnel psychology*, *64*(2), 489-528.

Sommerville, I. (2011). Software-Engineering-9th-Edition. ISBN-10: 0-13-703515-2, Addison-Wesley

Sosnovsky, S., & Dicheva, D. (2010). Ontological technologies for user modelling. *International Journal of Metadata, Semantics and Ontologies*, *5*(1), 32-71.

Squire, K. (2002). Rethinking the role of games in education. *Game Studies*, 2(1).

Tetzlaff, L., Schmiedek, F., & Brod, G. (2021). Developing personalized education: A dynamic framework. *Educational Psychology Review*, *33*, 863-882.

Tuparova, D., Tuparov, G., Veleva, V., Nikolova, E. (2018) Educational computer games and gamification in informatics and information technology education — Teachers' points of view, *41st International Convention MIPRO*, pp. 0766-0771, doi: 10.23919/MIPRO.2018.8400142.

Van Rosmalen, P., Vogten, H., Van Es, R., Passier, H., Poelmans, P., & Koper, R. (2006). Authoring a full life cycle model in standards-based, adaptive e-learning. *Journal of Educational Technology & Society*, *9*(1), 72-83.

Vieluf S., Kaplan, D., Klieme E., Bayer, S. (2012). Teaching Practices and Pedagogical Innovation: Evidence from TALIS, OECD Publishing. http://dx.doi.org/10.1787/9789264123540-en

Vogel, J.J., Vogel, D.S., Cannon-Bowers, J., Bowers, C.A., Muse, K., Wright, M. (2006). Computer Gaming and Interactive Simulations for Learning: A Meta-Analysis. *Journal of Educational Computing Research*, 34(3), 229–243.

Woolf, B. P. (2010). Student modeling. In *Advances in Intelligent Tutoring Systems* (pp. 267-279). Berlin, Heidelberg: Springer Berlin Heidelberg.

Young, M., Slota, S., Cutter, A., Jalette, G., Mullin, G., Lai, B., Simeoni, Z., Tran, M., Yukhymenko, M. (2012). Our princess is in another castle: A review of trends in serious gaming for education. *Review of Educational Research* 82(1), 61-89.

Nikolova, E. (2019), Educational games supporting informatics learning in the 8th grade when studying the topic "Numbers and their representations", XII National Conference "Education and Research in the Information Society", pp. 117-125. (in Bulgarian)

Paunova-Hubenova, E., Terzieva, V., Boneva, J., & Dimitrov, S. (2018). Trends in the application of educational games in Bulgaria in the last five years. Proceedings of the 11th National Conference "Education and Research in the Information Society" (in Bulgarian)

Peycheva-Forsyth, R. (2022). Paradigms of learning as a theoretical basis for the implementation of diverse models of e-learning, available at (June 2023) https://www.vedamo.com/bg/knowledge/paradigmi-na-ucheneto/ (in Bulgarian)

Spirova M. (2018). The place of play-based learning in school. XI National Conference "Education and Research in the Information Society", pp. 41-46. (in Bulgarian)