Designing Smart Services to Support Teachers to Create Personalized and Adaptable Video Games for Learning

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Abstract

Smart services are increasingly adopted in many industry sectors, providing data-enabled, automated, user-centered and context-oriented digital solutions. However, the role of smart services in education is still not well researched, especially in the field of learning personalization and adaptation. Therefore, the present research aims to explore a smart service design model and its first pilot implementation for supporting teachers to build educational video games. Stepping on the platform APOGEE, enabling construction of adaptable and personalized educational maze video games, the pilot experiment aims to facilitate teachers to create a complex learning environment focusing on improving learners' experience. The first part of the paper investigates the main features and reasons for applying smart services in education. Next, there are outlined the roles of smart services to support teachers in designing complex personalized learning experiences. The last part explores the pilot implementation of a smart service model, allowing teachers to better conceptualize educational maze video games features to provide personalized and adaptable learning experiences.

Keywords

Smart services, educational video games, learning personalization, serious games

1 Introduction

The emergence of new digital tools for education significantly accelerated during the last few years. However, enriching learning processes with digital technologies is not an automatic process. Different studies prove that learning depersonalization, lack of personal contact and missing teacher involvement result in low learning effectiveness, low retention of knowledge and low student satisfaction [1]. The considerable drop-out level of massive open online courses (MOOCs) confirms this trend, showing that less than 7% of all enrolled learners finish the courses [2]. Many studies demonstrate that teacher' personality, attitude and emotions influence the outcomes of the learning process. In micro perspective, the research of [3, 4] explores that social skills and teacher' enthusiasm lead to better learners' engagement, self-confidence, learning satisfaction and learning success. In macro perspective, empowering and investing in teachers is considered as the key success factor of the advanced Finish educational system [5].

All this come to show that education is social, interactive and interpersonal activity, and teachers play a crucial role in further student success. In this context, educational technologies should assist and encourage teachers to further excel in their functions of role model, mentor, tutor, coach, and facilitator. Furthermore, in the new realms of fast changing labor market requirements, intensive work place automation and new competencies demand, learners should be prepared to adapt for to "jobs of the future". Therefore, digital technologies have to encourage teachers to better prepare, design, and deliver fulfilling student-oriented learning experiences, boosting students' talents, creativity and motivation to

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learn. However, this is rarely considered in practice. For example, the main reason for the low adoption of educational video games in class is the low involvement of teachers in video game design and the lack of adaptation strategies to fit in the class learning scenario [6].

In this context, smart services can provide appropriate tools and approaches to support teachers and to facilitate their work by delivering data-enabled, user-centered and context-aware recommendations and automatic configurations [7]. Furthermore, smart services combine data analytics and users' profiling to improve end-user experiences. Though widely explored in many sectors and industrial applications, smart services are still not well researched in the context of education and classroom digital transformation [8].

Considering this, the present research aims to propose an educational smart services design model and to discuss its pilot implementation. More specifically, the smart services model investigates different approaches to support teachers and non-IT professionals to build 3D educational maze video games on the APOGEE platform [9]. The research is based on the APOGEE platform (http://www.apogee.online/), as it is dedicated to support teachers in developing and evaluating educational 3D video maze games enriched with mini-games [9].

The current research further aims to investigate how smart service system can facilitate teachers to understand and adopt innovative teaching as: (1) promoting active learning approaches and scenario-development models to improve student learning experience design, (2) design and implementation of educational games and game-based learning to align with educational goals; (3) identify models and strategies for learning personalization and learning adaptation, supported by the APOGEE platform.

The first part of the paper makes an overview of the main concepts of smart services and their key features. Then, there are outlined the role of the smart service in education, supporting teachers in designing complex and personalized learning experiences. The third part identifies the key elements of the smart service design and key recommendations for smart services pilot implementation. Finally, several screen visualizations and examples demonstrate the implemented smart service model, supporting teachers to create, modify multiple times and generate educational 3D maze video games in the APOGEE platform.

2 Smart Services in Education

The role of smart services in education is still not well-researched [8]. Considering the complexity of the educational system and educational process, smart services can be researched from different levels of investigation (e.g. educational level, school level, class level, teacher level, and student level). Admitting that smart services can be part of many interconnected and complex digital systems in education, this paper focuses on teachers as key designers and implementers of learning experiences.

In general, smart services emerged in the context of manufacturing and industry automation, closely referring to the concepts of smart factories, Industry 4.0, digital twins, smart product-service systems, and cyber-physical systems [10, 11]. Smart services can also refer to "smart products" and "smart product-service systems", covering robots, wearables, and autonomous physical systems, among others [12, 13]. Alternative terms for smart services are data-driven services, smart web services, intelligent services, intelligent or smart products, smart product-service systems, and others.

The fast-accumulating research in the field of smart services provides numerous definitions and characteristics. For example, the review of [14] explores smart services as real-time, user-oriented, adaptable and context-oriented services, delivered within networked systems and platforms. Among the first to specify smart service functioning, [15] explore the four-level model, consisting of the physical layer (physical infrastructure), application layer (digital services and access to computational capacity), and data layer (contextualized and personalized data). These four main layers of a smart service system or 4C (i.e., connection, collection, computation, and communications) can transfer to the basic smart service model. As described in [14], when considering smart services in education, they have to cover all these main 4C – connectivity "improving access to people, devices, and educational environments", collection "of (study-related) data", computation of "key factors, influencing learning and student satisfaction"; and communication "within or through technology-equipped education device and environment for increasing value co-creation between students, teachers, and other stakeholders".

More specifically, in a non-industrial context, smart services can be defined as digital services, adapted and delivered based on specific user profiles and requirements, data analytics, and contextual data [11]. The main elements of smart services include service structure, service delivery process, service outcome, and service business model [16]. Marquardt [17] explains that smart services have three main perspectives – technology perspective (technology infrastructure), end-user perspective (context of service delivery and value co-creation), and business perspective (value offering, based on the integration of data, technology, and inter-organizational networking capacity).

The smart service system is often described as a service system capable of learning, dynamic adaptation, and decision-making based upon data received, transmitted, and/or processed and leading to improved response to a future situation [14]. The perceived values of smart service systems may come from service personalization, recognizing the user or the contexts, improving decision-making, resource savings (saving time, cost, etc.), outcomes optimization (reducing undesired and increasing desired outcomes), and monitoring or tracking ability [14]. Some other characteristics of smart services include [18]:

- communication capabilities (interacting with their environments);
- embedded knowledge (integrated knowledge capacity such as machine learning capacity or knowledge-based systems);
- learning capability (capacity to extend the existing knowledge in the system);
- reasoning capability (capacity to make decisions);
- perception capability (capturing data from the environment);
- control capability (when reacting to the environment);
- self-organization (capability to independently adapt to the environment);
- context-awareness (to be able to interpret the environment).

2.1 Smart Services Supporting Teachers

As already discussed above, the educational system is complex, centralized and supports many applications and sub-systems. Thus, smart services can be applied in different contexts. For example, smart service systems can support the establishment of “smart education”, “smart school” system, “smart classroom”, and even smart whiteboard, textbooks, and many others. However, teachers are the most important factors for learning success and student satisfaction, and they are the main designers of the learning experiences in class. A short summary of the role of smart services for teachers, as discussed in [8] is provided in Table 1 below.

Table 1. Smart services supporting teachers, based on [8]

Main process	Smart service perspective
Personalized learning goals	Smart services can support teachers to specify and personalize learning goals, based on individual learning profiles (static), students’ interests and goals (related to specific subjects), and class goals (summing up individual goals within differentiation strategies). This way, teachers can determine general class learning goals and objectives, figuring strategies for personalization, differentiation, and individualization.
Lesson plans and learning scenarios	Considering students’ preferences and learning goals, smart services can support teachers to structure appropriate lesson plans and active learning scenarios.
Curriculum adaptation	Curriculum adaptation can result from lesson plans and learning scenarios. Starting with the standard curriculum, teachers can explore different strategies to provide more engaging experiences for learners in different contexts.
Personalized Learning activities	Smart services can recommend individual and group learning activities, based on learners’ profiles and personalization strategies. Based on data, observations and recommendations, teachers can recognize the most appropriate learning activities and content to design effective engagement strategies for their students.

Learning materials	Smart services can assist teachers with a dynamic recommendation system, either exploring available learning materials or providing advice about content adaptation and personalization. Learning content can be structured in multiple ways, such as document, presentation, video, experiment, tutorial, template, questionnaire, scenario, script, games and mini-games, learning boards, and many others.
Assessment strategies	Considering that learners are motivated by positive and timely feedback on every learning activity, smart services can provide specific strategies for monitoring and evaluation. Thus, assessment strategies can consider fast and relevant feedback; based on quantitative and qualitative evaluation models, aligning strategies for summative and formative assessment;
Monitoring, reflection, and evaluation	Smart services can assist teachers in monitoring the level of completing the learning goals, the individual and class progress, and the necessary adjustments. Smart services can highlight learning paths to overcome risks and difficulties, or set up more ambitious learning targets, better corresponding to learners' dynamic interests and motivation.

In general, as outlined in Table 1, smart services allow teachers to better recognize different advantages of learning strategies, learning personalization and dynamic adaptation. Data analytics can provide a better understanding of the learning efficiency of every activity, compared to students' expectations, progress, and outcomes. Students can be encouraged to take part in instruction co-design activities, suggesting models for learning scenarios improvement and adaptation.

3 Smart Services Design Elements

Designing smart services for teachers requires a good understanding of data collection and data analysis strategies, models of service adaptation, and personalization and digital infrastructure or learning environment. Especially considering educational video game design and implementation, smart services should support teachers to select an appealing visual design and game flow and engaging learning strategies, fulfilling specific learning goals.

3.1 Data Collection Strategies

Data collection strategies are among the most important features of smart service design. On one hand, smart services can combine several data sources, on the other hand, the data collection strategies should specify requirements for data sources, data flow (static and dynamic), quantitative and qualitative data, and others.

- **Profile data** – recognizes the end-user profiles. Thus, data collection strategies should cover qualitative data, covering surveys, feedback questionnaires, student satisfaction forms, and others. Some data sources can be unstructured (multimedia, texts, videos, podcasts), such as video interviews, social media posts, comments, and others. Profile data can be obtained directly or indirectly from other educational stakeholders, students, teachers, and parents.
- **Context-specific data** – recognizes the context of service delivery and use. The context can be set with a pattern recognition module, integrating historical data, log systems data, service delivery patterns, and others. The context-specific data is derived mainly from quantitative data sources, such as system logs, test data, structured system outputs, formal evaluations, and system analytics.

3.2 Models for Service Personalization and Adaptation

The smart service systems support three main personalization and adaptation scenarios [7, 15]:

1. Interactive configurations: customized smart services, adapted both to the customer profile (explicit data and implicit preferences) and to the service delivery context.

2. Recommendation systems: customized service models, supporting decision-making and choosing options, based on personal preferences, past data, and environmental/contextual information.

3. Personalized interactive processes: application of different models of service interactions, so that the services are tailored to the individual preferences and context/environment data.

3.3 Smart Service Infrastructure

The digital infrastructure defines how data collection strategies and models for service personalization and adaptation are implemented in the context of smart service platform. Smart service technologies should support data analysis and data visualization, best practices for evaluation and recommendation systems, digital tools for collecting structured and unstructured data, and others.

4 Designing Smart Services to Support Teachers to Create Adaptable and Personalized Educational Video Games

The pilot experiment for a smart service implementation is defined as a platform, allowing teachers to create educational video games in the APOGEE platform. The APOGEE platform for construction and generation of rich educational video maze games is presented in details in [9]. A rich educational maze is defined as a maze 3D video game with multimedia learning content presented within the maze halls not only on learning boards but as well within personalized and adaptive puzzle mini-games of various types, embedded into each hall. The mini-games have to be tailored to the end user profile, which combines both a player and a learner preference model. The learning content can be personalized upon the player/learner model attributes such as demographic characteristics, demonstrated outcomes, learning/playing style, and emotional status.

4.1 APOGEE Video Maze Game Design

To generate an XML document formally representing an educational maze video game for the platform APOGEE, the game designers should describe all game elements, combining text, images, and audio files, together with the mini-games placed in the maze halls. In these settings, teachers have to describe and upload all the features of the educational video game – such as the number of halls, the structure of the maze, the learning panels, and the mini-games. The process is highly iterative, requiring many versions and modifications, before completing the final version for a game generation.

To facilitate and support teachers in this process, we considered using a Google Drive platform, designing a Google website (https://sites.google.com/view/smart-services-for-apogee/home) and integrating it with Google forms, Google spreadsheets and Google charts. The website is on Bulgarian and contains four main sections (“Game-based learning”, “APOGEE game generation”, “Smart services” and “About”). The first section introduces active learning theories and how to improve setting goals for games for learning (Fig. 1).

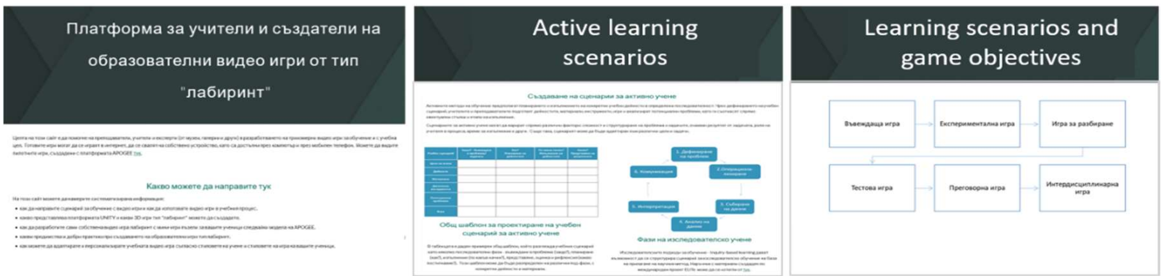

Figure 1: Smart Service platform overview – design of active learning scenarios and learning scenarios with games

The second section of the platform is dedicated to APOGEE maze video game development. The process is divided into three main parts. The first part introduces the general parameters of the video game, the second is dedicated to game halls design and the third part allows teachers to make a request for game generation. A special page explains types of the mini-games supported in the model, highlighting how they can be adapted and used to personalize student experience.

Following this process, teachers first have to fill out a Google form, making an easy step-by-step approach, selecting answers, and uploading game elements. When the file is submitted, users receive by mail a link to their data in the form, allowing them to make multiple revisions and modifications. Every hall in the maze is separately generated, including all elements such as educational panels and mini-games.

Among the key reasons to decide to use Google forms to support game generation, there are:

- The data can be downloaded in a standard CSV file. This allows the process to be later on automated.
- The forms can be modified and revised many times by the teachers.
- Teachers got used to Google forms and easily understand how they work.
- Teachers can easily share, collaborate with colleagues and ask for additional support and assistance.
- The process is transparent for the involved teachers and teachers have ownership of their work.

Figure 2: Interactive process of Maze-Game design, starting with 1. Maze Design, 2. Defining Maze Halls, 3. Selecting Mini Games.

4.2 Apogee Smart Services Design

The third section of the platform is dedicated to smart services. The smart services supported in the platform are defined in previous research [8] (Table 2), but several modifications were imposed to services (A5 and A6). In the pilot implementation, smart services are presented in Fig. 3, and A5 and A6 address learning personalization and learning adaptation.

Table 2: Smart Services in APOGEE, as defined in [9]

Smart service	Description
A1: design maze connectivity	Recommend best structure based on the learning scenario and student demographics.
A2: recommend mini-games	Recommend how to select and construct educational mini-games for each maze hall.
A3: recommend maze content	Recommend game content for the maze and the embedded mini-games – extracting learning objects and game assets (e.g., textures, 3D patterns, animated pictures, and sound) from the database and recommend them to the creator of the game.
A4: recommend learning content	Recommend how to personalize the didactic content (text, images, and audio) in the halls, incl. that on the learning boards and mini-games, and depending on the learner's demographics.
A5: adaptation setup service	Provides the appropriate threshold values for the dynamic adaptation of the game's difficulty depending on the player model.

A6: a virtual player setup service	Automatic set up of parameters to the NPC (non-player character).

The main benefit of smart services in the logic of educational video game development is to provide data-supported evidence, best cases recommendations, references from peers and automatic adaptations. This section is integrated with dynamic google spreadsheets and charts, which will allow further video games experimentation, adaptation and personalization. After collecting enough qualitative and quantitative data from teachers, every page will provide dynamic data analysis, visualization and best-practices recommendation, based on teachers' experiences.

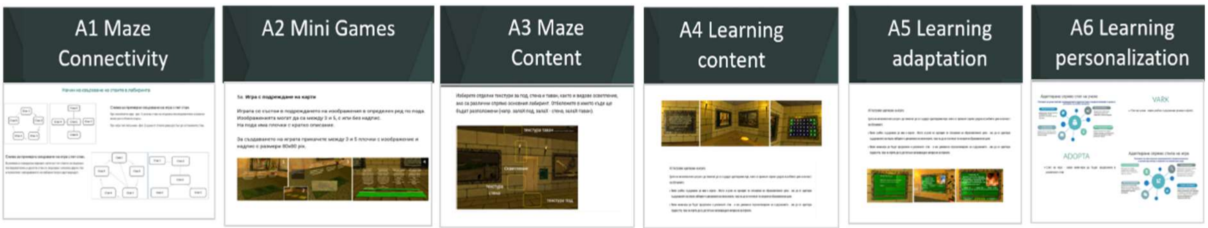

Figure 3: Example of recommendation panels – A1-A6, covering Smart services visualizations

The Google Drive environment provides multiple features, allowing first pilot implementation. Taking account that its interactive, fast, cheap and easy to build, this experience allow many modifications and improvements. Later on, we can reconsider maze game automation and adaptation with other software solutions.

4 Conclusions and Future Work

The present research demonstrated a design of smart service platform to support teachers and non-IT professionals, such as educational experts, parents and students to design educational video games. Via recommendations, statistics and dynamic data collections, and best practices identification, teachers can not only learn how to design adaptable and personalized maze video games but improve their skills, gain experience from others. The next step of the platform implementation is to organize a detailed validation process with teachers and end-users, observing their experiences and interest to create and implement educational video games in class.

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