Didactic and Psychological Principles of Successful Design of Serious Games

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Abstract: In this paper, a systematic, evidence-based overview of didactic and psychological design principles is provided, which have a significant impact on the learning success of Serious Games. Design criteria are described that relate to the structure of games, the principle of learning through play, interaction regarding usability and playability, as well as motivation with the necessary game incentives. Furthermore, perspectives on the future development of Serious Games are outlined, focusing particularly on the implementation of concepts of adaptive e-learning and AI-supported learning.

Keywords: Serios Games, Game Design, Principles of Learning Through Play, Learning Success

1. Introduction

Today, adept handling of digital technologies and technical assistance systems in everyday work is becoming increasingly important. New job profiles emerge, demanding corresponding competencies (Lehmann et al., 2021; Zinke, 2019). The imparting of so-called Future Skills, such as the ability to work in digital networks or proficiency in handling digital data (data literacy), is gaining significance (Spiegel et al., 2021; Ehlers, 2020). Digitalization not only alters the work environment but also impacts the education sector (Bohlinger et al., 2022; Schumann et al., 2022). Educational approaches and methods are continuously becoming more digital. Innovative learning concepts, such as Serious Games, are gaining increasing importance.

Serious Games are digital learning games designed to support individual learning processes, having an entertainment purpose but also serving to convey learning content and develop and train competencies, skills, and abilities (Becker and Metz, 2022; Dörner et al., 2018; Strahinger and Leyh, 2017). They aim to make learning more engaging and effective. Knowledge and skills are imparted in an entertaining manner, creating a high diversity of perspectives. Learning content can simultaneously encompass various subject areas such as competency building, health management, communication, or teamwork.

The unique aspect of the learning concept of Serious Games lies in integrating learning content and tasks into a gaming environment. They enable individualized learning with numerous opportunities for reflection and facilitate the internalization of knowledge and the retrieval of learning content, which can then be transferred not only into the virtual world but also into Real-life-situations. To achieve this, it is important to consider didactic and psychological design principles in the development of Serious Games. Didactic criteria pertain to the learning objectives pursued with Serious Games, the structure of the game, the game design, and the method of conveying learning content. Psychological design criteria focus on the motivation of the player, emotional, and behavioral aspects. A successful Serious Game should motivate players to engage, experience positive emotions, and change their behavior. By considering these criteria, the design of Serious Games can be made more effective and engaging.

This paper describes design criteria related to game structure, the principle of learning through play, interaction regarding usability and playability, as well as motivation with the necessary game incentives. Prior to that, it delves into pedagogical foundations that delineate the conceptual framework of Serious Games.

2. Pedagogical Framework of Serious Games

Serious Games are based on the potentials of playing and self-directed learning (Jeske, 2022; Wouters and Oostendorp 2017; Breuer, 2010). In contrast to purely entertainment games, Serious Games pursue specific learning objectives to promote skills or behaviors, as well as to continuously motivate and activate players in the learning process. This includes adapting to the individual needs and abilities of players and integrating feedback mechanisms. It is important for Serious Games to be flexible enough to address the diversity of players and their needs, enabling a personalized learning experience.

From a pedagogical perspective, the game structure in Serious Games should allow players to take on the role of active agents. Players must make decisions, solve problems, and complete tasks to progress in the game

(Brauner and Ziefle, 2022; Schutz and Schutz, 2022). The underlying game design should not be immediately apparent, and the challenges should be engaging and solvable to enable and promote immersion. Immersion is the process or state in which a person fully engages in an experience and loses themselves in it, forgetting the environment around them. In an immersive gaming world with authentic scenarios and lifelike characters, whose identity learners actively assume, learning should be perceived as natural rather than strenuous and tedious. Through additional media, players can be further integrated into the setting. For example, players can be multimedia integrated into the game world beyond the learning environment through emails in a regular account or via SMS on their mobile phones.

Playing is a voluntary and intrinsically motivated activity pursued for its own sake and not specifically aimed at achieving certain teaching-learning goals (Huizinga, 2006; Oerter, 1999). Learning occurs conceptually on different levels. Serious Games support the analysis of decision-making processes and appropriate behavior with the concept of situational learning. Furthermore, players' own competencies become experientially accessible and can thus unfold. This enables competency activation and growth. The offered learning paths, depending on the game setting, can contribute not only to the promotion of professional and methodological competence but also to an increase in learners' self and social competence. Competencies for successfully navigating Serious Games can be incidentally acquired – that is, without direct learning intention (Kerres, 2013, 2001). Since Serious Games can be used very flexibly and tailored to players, they are granted a high degree of learning autonomy, which is further reinforced by the self-control contained within the game. This fosters specific action competencies such as self-directed learning. Other content can be acquired in explicit learning mode, for example, when specific tasks or missions need to be solved, such as strategic thinking and problem-solving skills, strategic, analytical, and combinatorial abilities, concentration, persistence, or frustration tolerance.

Social complexity, problem control and resolution, and self-regulation are also important factors in the pedagogical concept of Serious Games. Different learning aids can be incorporated to support the learning process (Bopp, 2005), such as tutorials explaining the basics of game mechanics as didactic learning aids, and forums where hints for coping with certain game situations can be found or other players can be asked for help.

Klimmt (2005) distinguishes between exploratory and problem-solving actions in the game. Exploratory action is used when additional information or objects are needed to solve specific problems (missions, etc.). The state of problem-solving, on the other hand, involves immersion in the game world. As long as the person subjectively moves through the game world, implicit or incidental learning takes place in the game cycle. Only when the person gets stuck, they are more likely to switch to explicit learning, and only for as long as necessary to immerse themselves back into the game world and apply the new knowledge to solve problems. A game world should offer both phases alternately, with explicit learning phases being rather short. Learning processes in Serious Games can be situated on four levels (Hofinger, 2003):

- Level of content-related problem constellations: Understanding problems, taking action, bringing about solutions.
- Level of individual thinking processes: Thinking strategies, aspects of motivation (including motivation balance, motivation goal), emotions (e.g., dealing with frustration), biographical characteristics (e.g., age).
- Level of problem-solving process control: Goal setting, decision-making process, implementing action plans (action organizations), and work organization (observing the further situation, controlling the effects of the measures taken, and critical reflection as well as background control, e.g., hazard cognition).
- Level of social processes: Dealing with social complexity, balancing teamwork, assessing the respective consequences of actions, analyzing the effects of decisions on the environment and in detail, etc.

In complex game worlds, it is not only about applying previously named rules, i.e., transferring declarative knowledge into procedural knowledge. It is also about generating procedural knowledge in interaction with the game system. Learning the game can be promoted through a didactic-immersive game design. Case-based and action-oriented learning creates a learning experience that motivates learners to understand the underlying theories and concepts. This means that play comes first, experiences are gathered, and then knowledge and theories are conveyed. This contributes to a relaxed learning atmosphere with a positive and motivated context for change.

3. Consideration of Didactic and Psychological Aspects in the Design of Serious Games

Embedded within the outlined pedagogical framework, the success and effectiveness of a Serious Game depend on the extent to which it manages to align the game structure, gameplay, and progression with didactic and psychological principles (Becker and Metz, 2022; Breiner and Kolibius, 2019; Gee, 2007). Didactic design principles refer to learning-promoting elements integrated into game development to create an effective learning environment. These include aspects such as clear definition of learning objectives, feedback mechanisms, opportunities for adaptation to player characteristics, and integration of real problem-solving situations. These principles are intended to ensure that Serious Games are not only entertaining but also achieve a sustainable learning effect.

Psychological design principles of Serious Games involve the integration of insights from psychology into game development to influence players' behavior, motivation, and learning. This includes aspects such as the application of motivational reinforcement mechanisms, consideration of players' cognitive abilities, and the creation of emotionally appealing and stimulating game worlds. These principles are aimed at ensuring that Serious Games are not only effective learning tools but also promote the well-being and engagement of players.

From didactic and psychological perspectives, Serious Games should simulate situations and challenges in a gameplay that learners may encounter in their professional or personal lives. Game mechanics and interactions should therefore be designed to allow players to acquire the desired knowledge and required skills or competencies. Serious Games should cater to individual learning needs in addition to content. Skills or competencies can thus be trained in the safe environment of Serious Games and assessed within a space for reflection. Players thereby have the opportunity to learn from their actions, decisions, and mistakes.

In Serious Games, patterns of action, thought, and communication are observable. The underlying experiences and mental models, values and goals, or behavioral rules can be made consciously, discussable, and understandable in an evaluation and reflection phase, thereby also being subject to change. For the transfer from the gaming situation to the learning and work context, it is less about factual knowledge than about one's own learning competencies, approach to knowledge acquisition, and assistance in retrieving knowledge. Therefore, debriefing is very important, whether as a discussion afterwards or as reflection with other learners or with a coach or teacher (Peters and Vissers, 2004). The role of the teacher is to guide through the stimulating learning environment and deliberately encourage reflection. Learning is thus sustainably accompanied by a coaching-based process of reflection, and learning effects can be reinforced through this didactic structuring of self-observation and self-reflection (Helm and Theis, 2009). Furthermore, in a simulation, behavior can be tried out and adjusted multiple times, as often as necessary. In particular, new behavioral patterns emerge by consciously developing and practicing action strategies. Serious Games thus enable the tracking of learning progress.

The context of the game and its appropriate use are further influencing factors on the effectiveness of Serious Games. Contextual factors consider the place of use, technical support, and the learning environment (Ravyse et al, 2017). For the success of Serious Games, it is crucial that quality and functionality are ensured and an appealing design is present. Speed and immediate recognition are also important. The game content must be engaging and have a trial-and-error character, meaning that tasks must be assigned and goals set, points awarded for actions, and players should be able to compare themselves.

In conjunction with the described didactic and psychological design criteria, the usability of Serious Games in terms of usability, user-friendliness, or playability also plays an important role (Becker, 2022; Shneiderman and Plaisant, 2018). The game setting should relate to a captivating theme, an exciting plot, and an entertaining environment and have a playability to maintain the player's interest or level of attention. It should be ensured that the functionalities of a digital learning game and their usability are designed as accurately as possible with the specific requirements of the target groups or user base. Serious Games can unfold the intended learning effects when the game design is user-oriented and the interaction between the virtual learning medium and the players – the user interface – is characterized by high usability (Jeske, 2022; Marcus, 2011). If players can cope with the game structure and gameplay, they often experience a sense of control, which promotes the acceptance of Serious Games. With increasing usability, the learning success of digital learning games increases.

For successful Serious Games design, playful motivational mechanisms such as feedback, reward, fun, etc., are important. Through the playful character and the integration of reward systems, learners are motivated, their engagement is promoted, and they are involved in the learning process. An immersive gameplay ensures a sense of success and enhances motivation. It should not be too easy, but also not too difficult, should never bore, but

also not permanently overwhelm. The challenges and difficulty level of the game should be adjustable according to performance and progress to maintain learning motivation and flow continuously and promote the player's learning progress. The flow state describes a mental state of complete immersion and concentration in an activity and unity with the task (Csíkszentmihályi, 1975). It represents an optimal balance between the demands of an activity and the individual's abilities. In a flow state, people feel particularly motivated, engaged, creative, and fulfilled. The difficulty level should be gradually increased, and progress should be continuously experienced. Level design sets certain stages of increasing difficulty that must be completed before reaching the next, more difficult level. In this regard, the motivational psychological "principle of fit" (Heckhausen, 1989), "Mastery-Learning" (Bloom, 1971), or "Scaffolding" (Vygotsky, 1978) come into play. Learners are gently guided into increasingly challenging situations, thereby developing more competencies. Serious Games should therefore be able to adapt to the level of the players to lead to experiences of success. From a learning psychological perspective, repetitions, referred to as the Game Loop, are characteristic. Through repetitions, acquired knowledge can be practiced, reinforced, and internalized. Depending on the competency-related goals associated with Serious Games, the requirements should be increased in the course of the game or from level to level (spiral didactic principle). Coping with the increasing demands on the players also has a positive effect on motivation and the experience of flow. From a cognitive psychology perspective, attention lapses, comprehension difficulties, or feeling overwhelmed should be avoided and addressed through different learning paths.

Another important design element of Serious Games that also provides enjoyment is the ability to experiment. In the game setting, activities and processes should be embedded according to an experimental or problem-based educational approach (Boud and Feletti, 1991). The player does not need to know everything in the digital gaming world; they can try out certain moves and receive feedback from the system. Through repeated rounds, the player acquires knowledge. Repetitive patterns are implicitly learned, leading to improvement, increased speed, and task accomplishment. The knowledge acquired by the player in such game worlds is a collection of scripts or patterns (Schank and Abelson, 1977). In a script, knowledge is stored on how to handle a specific type of situation, what to consider, and the typical sequence of actions. This knowledge becomes routinized through repeated application and automatically activates when a situation is assigned to a specific script. Expertise is characterized by learners having a set of elaborated scripts available and highly routinized. This increasing game competence triggers a feeling of joy and efficacy. The uplifting feeling of increasing competence is another significant source of motivation (Behr et al, 2008).

Learning in a safe, manageable, and realistic environment is an important framework factor for the sustainability of this form of learning and thus a crucial advantage of Serious Games. The learned material is integrated sustainably through the realistic game situation – the experience – and reflective engagement, which can then unfold not only in the virtual world but also be applied in real situations. Teachers or trainers can observe the progress of learners and provide situational feedback to enhance the learning experience. Players, on the other hand, have the opportunity to directly experience their decisions and actions in the game and learn from the consequences of their actions – even in retrospect. This leads to a deeper understanding of oneself. Players are also motivated to question and optimize their own actions.

4. Future Perspectives of Serious Games

Against the backdrop of increasing demand for digital teaching and learning formats as a result of rapid technological progress and societal transformations, it can be expected that the need for Serious Games will continue to grow in the future. This is facilitated by the increasing dissolution of the perceived separation between entertainment and learning elements, thereby increasing the acceptance of formats of game-based learning. Also, digital selection tests (recruitment) and opportunities for personal development give digital learning games more significance for the identification and development of professional competencies and skills (Jansen et al., 2023; Gensicke et al., 2021).

The assessment that the importance of Serious Games will increase in the future can also be supported by figures on the previous use of Serious Games in vocational education. In the Weiterbildungsmonitor 2021, questions were asked about the use of digital formats and media in teaching/learning processes. The proportion of further education institutions that reported using Game-Based Learning or Serious Games in Germany increased by 2 % from 2019 (11 %) to 2021 (14 %) (Koscheck et al., 2022: 24). Although this percentage refers to the circle of providers of further education measures, it can serve as a guideline for the dissemination of digitized learning games in the entire field of vocational education. Accordingly, there are significant potentials for expansion in the use and deployment of Serious Games.

It is important that existing media pedagogical and media didactic game concepts are adapted and further developed to the structural changes of the necessary professional competencies in the workplace. The intention should be to increase the willingness to learn among users of digital learning games and to achieve sustainable learning success. What distinguishes Serious Games, namely learning by doing, is a particularly effective form of adaptation and internalization of learning content. Simulations mimic real situations to practice without risk and acquire skills that are important and useful for professional life. The combination of physical action and mental concentration stimulates complex cognitive processes. Especially in recognizing, understanding, and comprehending in a digital learning environment, attention, spatial vision, cognitive, and social development are promoted.

In the future, the increased use of Serious Games will play a special role because learning environments are created that enable creativity, cooperation, and agility, especially to promote qualifications for solving new tasks and problems. In such learning formats, Future Skills can be learned and trained in decentralized and digital structures in a special way (Stifterverband für die Deutsche Wissenschaft, 2020; Rapp et al., 2019). Essentially, it is about the task-related combination of digital competencies (digital literacy, agile working, etc.) and classical skills such as problem-solving ability, creativity, adaptability, etc.

The potentials of Serious Games should be used more strongly than before because digital games are an important everyday medium for younger generations. Learning content can be prepared in a target group-specific manner and be made motivating for learners who do not have access to it in everyday life. Therefore, in the future, it is particularly important to involve the respective (even heterogeneous) user group participatively in the development and further development of digital learning games and to enable learning and thus qualification in the sense of participation.

5. Discussion

The previous discussions aimed to provide a systematic and literature-based overview of didactic and psychological principles for the successful design of Serious Games. The relevant design principles pertain to the game structure, the concept of learning through play, interaction regarding usability and playability, and motivation with the necessary game incentives.

The benefit of this systematic compilation lies in offering a framework for the development and practical application of digital educational games. Considering didactic and psychological principles increases the likelihood that the intended learning objectives of a Serious Game can be comprehensively achieved. However, it should be noted that knowledge or skills learned within a game are not automatically transferred to real-life situations. This transfer of learning to practice should be part of the didactic concept and included in the reflection framework.

The use of Serious Games should not occur in isolation but should be embedded in appropriately designed learning architectures depending on the user group, learning objectives, and content, incorporating analog learning forms. This underscores the special significance of educators as learning coaches and mentors. As previously stated, educators should guide learners through the playfully designed learning environment and support the learning process through coaching-based reflection processes. Through didactically structured self-observation and self-reflection, learning effects can be enhanced, and individual learner development can be effectively supported and promoted. It is essential that educators have access to appropriate guidelines and instructions. These materials serve to facilitate the entry into digital learning games and motivate practical use of Serious Games.

A particular aspect of learning with Serious Games is their adaptability to the individual needs of learners, allowing learning in various locations and times. By offering personalized learning experiences tailored to the individual learning style and needs, Serious Games provide an effective way to actively engage learners in the learning process. Additionally, Serious Games can confront learners with complex situations and challenges in a practical manner. By creating simulated environments where learners can make decisions and experience their consequences directly, critical thinking and problem-solving skills are developed and strengthened in a realistic way. Another aspect is the social component of digital learning games, which promotes collaboration and collective learning, developing skills for effective teamwork in a digital environment.

Considering the described didactic and psychological principles allows the potential of Serious Games to be fully exploited, especially in connection with Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI). However, this should not overshadow the limitations of Serious Games. The acceptance, access, and use of

digital learning games, and thus their success, depend heavily on intervening variables such as age, gender, educational level, competence level, social class, etc., of the players. This must be considered when developing and using appropriate Serious Games.

The described didactic and psychological principles can also serve as criteria for assessing the quality of digital games in a broader application context. A systematic and methodologically sound evaluation by independent experts in a peer-review process, focusing on game design and associated player experiences such as attractiveness, motivation, flow experience, involvement, and usability, as well as learning success in terms of effectiveness and efficiency, offers the possibility of certifying Serious Games (Bruder et al, 2012; Caeserman et al, 2020; Certifications, such as the RAL quality seal awarded in Germany, can sustainably ensure the quality of Serious Games and promote it through "Best Practices" (Gütergemeinschaft Serious Games, 2024; SG-IV, 2023).

6. Summary

Serious Games integrate learning content and tasks into a gaming environment that is meaningful for achieving goals and fits the user context and other learning measures. Digital learning games promote active learning. Various scenarios can be played out, and the learner can experiment with alternative problem-solving approaches. The game structure of Serious Games should be designed so that players take on the role of active agents. The underlying game design should not be immediately recognizable, and the challenges should be engaging and solvable to unfold important didactic and psychological principles such as motivation, enjoyment of playing, sense of achievement, flow, and immersion optimally. Additionally, there should be sufficient space for review, reflection, and introspection.

It is expected that the use of Serious Games will continue to increase in the future. An important development path lies in the development of AI-supported learning programs, which enable Serious Games to be flexibly adapted to players with different learning prerequisites. Significant impulses for the further development and optimization of digital learning games can also be expected from an intensification of scientific accompanying research. The spectrum ranges from questions of the acceptance of game-based learning depending on the professional competence field, the expectations, and experiences of players differentiated by age, gender, competence level, to the changing roles of educators in learning support. On the other hand, investigations are needed on the influence of usability on the sustainable learning effects of Serious Games and on the change in learning culture through smart tools and learning algorithms. Helpful here are research and development concepts characterized by interdisciplinary collaboration between game developers, educators, psychologists, and the recipients or users of Serious Games.

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