

# USING HEURISTICS TO EVALUATE USER EXPERIENCE IN EDUCATIONAL VIDEO GAMES

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## Abstract

Educational video games have gained popularity in recent years as a means of enhancing student learning outcomes. In video games, the scene of a concrete context is designed in which certain problems are solved and it gives the player, in our case the student, the opportunity to make decisions, research, create and be interactive. One promising approach is the use of heuristics, which are cognitive strategies that individuals use to solve problems and make decisions. This paper aims to investigate the impact of heuristics on learning outcomes in educational video games. This paper reviews the literature on heuristics in education and video games, exploring the different types of heuristics that can be used and their effectiveness. Additionally, the potential drawbacks of using heuristics in educational video games are discussed, and suggestions for further research are made. The study employs a mixed-methods approach to gather data and assess the effectiveness of heuristics in educational video games. The findings of this research will contribute to the understanding of how heuristics can be used to improve student learning outcomes in educational video games

*Keywords:* Video games, heuristics, education.

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## 1. Introduction

In recent years, educational video games have gained significant attention as a promising approach to engage learners and enhance their educational experience. These games provide a distinct blend of amusement and instructive content, offering an engaging and participatory setting for learners to acquire knowledge and cultivate crucial abilities. Nonetheless, assessing the user experience (UX) in educational video games poses a notable obstacle given the intricate nature of gameplay, educational objectives, and diverse user inclinations. To tackle this challenge, scholars have embraced heuristics as a valuable tool for evaluating UX in educational video games. Heuristics represent sets of principles or guidelines that enable assessors to methodically gauge the usability and user-centered design facets of a system. Originally formulated within the field of human-computer interaction, heuristics have been widely adopted as an efficacious approach for UX assessment across diverse domains, including video games. The utilization of heuristics in appraising educational video games holds substantial potential. By employing established heuristics frameworks or crafting context-specific ones, researchers can evaluate the efficacy, efficiency, and overall satisfaction of learners within these digital learning environments. The systematic evaluation of UX via heuristics allows for a comprehensive grasp of the strengths and weaknesses of educational games, furnishing invaluable insights to guide design choices and facilitate iterative enhancements in their development.

This study seeks to investigate the effectiveness of utilizing heuristics in the evaluation of user experience in educational video games. By harnessing established heuristics frameworks and customizing them to the unique context of educational games, researchers can evaluate the efficacy, efficiency, and overall user satisfaction within these digital learning environments. Through a systematic assessment of UX, valuable insights can be obtained, enabling informed design choices and iterative enhancements in the development of educational games.

Numerous applications today entertain, but only a few deliver truly innovative user experiences. Nintendo's Wii1 controller serves as an excellent example of a novel interface that enables intuitive and natural interactions, leading to completely fresh user experiences. This innovation also motivates older players to engage in video games. However, traditional board games like Risk and Monopoly continue to be popular due to their emphasis on social interaction. Unlike solitary screen-based experiences or online play with friends, traditional board games offer face-to-face interactions, fostering a sense of camaraderie (Amaya & Davis, 2008) Multiplayer dynamics and the lively atmosphere of laughter, cheering, discussions, and even friendly arguments make classic board games captivating, outweighing the limitations of interactivity and complexity found in video games.

On one hand, contemporary game consoles and video games lack various non-verbal communication elements that are vital for in-person interactions. Conversely, traditional board games are constrained by static game media, limiting the implementation of intricate scenarios and fully interactive environments. Therefore, it is logical to combine the strengths of video games and traditional board games to create a novel gaming experience.

Playability in video games encompasses effectiveness, efficiency, flexibility, safety, and enjoyment within the context of play (González Sánchez, 2011). Educational video games (EVGs) are most effective and educational when they offer elements of fantasy, immersion, learning, and captivating challenges to engage players. These aspects can be incorporated in diverse ways to establish a playable and educational environment. Researchers have long been exploring augmented EVGs that bridge the gap between video games and e-learning systems. This hybrid genre opens up a wide range of possibilities for entertaining and educational systems. Recently, significant efforts have been made to extend playability concepts to investigate player experience (PX) and enhance game design. Consequently, there is a growing need to evaluate the playability and PX of designed EVGs. Assessing this experience poses a major challenge due to the complex structure of EVGs. Playability attributes offer a convenient and effective tool for analyzing and measuring the experience received by players during gameplay. While several heuristics have been developed in related studies,

## **2. User-centered design in games**

User-centered design is a design philosophy that embodies a prototype-driven approach to software development, where the user's involvement is integrated throughout the design and development process. This iterative design process comprises several stages, including requirements analysis, user analysis, prototyping, and evaluation.

The principles of user-centered design are outlined in EN ISO 9241-210 - Human-centered design processes for interactive systems (ISO 9241-210, 2010). This approach has also been applied in game design, as demonstrated by (Fullerton, Swain, & Hoffman, 2004) who proposed a three-stage development process: conceptualization, prototyping, and game testing. During the first phase, thorough planning takes place, involving the identification of goals, challenges, rules, controls, mechanics, skill levels, rewards, narratives,

and other relevant factors. Game designers document these specifications in the game design documents (Pagulayan, Keeker, Wixon, & Romero, 2003).

The second phase, prototyping, focuses on the rapid generation of playable content. This version of the game is not the final product, but it serves as an effective means for playtesting. Players have the opportunity to engage with the game, test its mechanics, and provide feedback on their experience (Fullerton, Swain, & Hoffman, 2004). Measurable attributes such as overall quality (commonly referred to as "fun"), ease of use, and the balance of challenge and pace can be evaluated during this phase (Pagulayan, Keeker, Wixon, & Romero, 2003). During playtesting, a range of usability methods can be employed to gather data on these variables. Pagulayan et al. (2003) suggest two viable methods: structured usability tests and rapid iterative testing and evaluation. Additionally, other evaluation methods such as prototyping, empirical guidance documents, and heuristics can be utilized.

Heuristics, in particular, offer a swift and reliable evaluation method for assessing user experience in games. They provide a cost-effective approach to evaluating the usability and user-centered design aspects of a game, allowing for quick identification of potential issues and areas for improvement. By employing established heuristics frameworks or creating context-specific ones, researchers can effectively evaluate the user experience and make informed design decisions to enhance the overall quality of the game.

### **3. Heuristics Evaluation**

Heuristic evaluation is an expert-based usability inspection method that offers an efficient and cost-effective approach to evaluating usability throughout the development process (Nielsen & Mack, 1994). It involves a group of three to five experts, knowledgeable in application and usability, inspecting a system based on established heuristics (Nielsen & Mack, 1994). Heuristics can be viewed as practical rules that describe user behavior and possibilities within a given system, providing more universal guidance compared to specific usability guidelines (Koeffel C. , 2007). The formulation of heuristics should provide evaluators with sufficient information to identify potential problems within a system (Sarodnick & Brau, 2006).

Heuristic evaluation enables the evaluation of systems at an early stage, even with paper prototypes or early design models (Nielsen & Mack, 1994). While numerous heuristics exist for evaluating video games, there is a lack of specific research on how to assess user experience using heuristics. However, heuristics can still provide valuable insights into the overall user experience of video games, allowing for the identification of potential issues and areas for improvement.

The idea of using heuristics for game evaluation was first introduced by Malone, primarily focusing on educational games and not fully considering the graphical, acoustic, and computational possibilities found in modern video games (Malon, Heuristics for designing enjoyable user interfaces: Lessons from computer games., 1982)& (Malon, What makes things fun to learn? heuristics for designing instructional computer games, 1980). Malone categorized his heuristics into challenge, fantasy, and curiosity dimensions. While Malone introduced these heuristics in 1980, it wasn't until Jakob Nielsen introduced his ten heuristics in 1994 that they gained wider recognition and adoption (Nielsen, 1994). Nielsen's ten heuristics have become the most commonly referenced set of heuristics and are frequently applied to various types of applications:

- Visibility of system status: The system should always keep users informed about what is happening, providing feedback and appropriate status updates.
- Match between the system and the real world: The system's language, concepts, and actions should be based on familiar and understandable terms for users.
- User control and freedom: Users should have the ability to undo actions, exit undesirable states, and navigate freely within the system.
- Consistency and standards: The system should follow established conventions and standards to ensure consistency across different parts of the interface.
- Error prevention: The system should be designed to prevent errors whenever possible, through careful design and user guidance.
- Recognition rather than recall: The system should minimize the need for users to remember information by presenting relevant options and information when needed.
- Flexibility and efficiency of use: The system should cater to both novice and expert users, providing shortcuts, accelerators, and customizable features to enhance efficiency.
- Aesthetic and minimalist design: The interface should present information and elements in a clear and concise manner, avoiding unnecessary clutter or complexity.
- Help users recognize, diagnose, and recover from errors: When errors occur, the system should provide clear and informative error messages that guide users toward recovery.
- Help and documentation: The system should offer easily accessible help and documentation to assist users in understanding and navigating the interface. (Nielsen, 1994)

The user experience of games is influenced by integral factors such as the state of flow and immersion, which determine the level of enjoyment and entertainment. Flow is considered an optimal experience in gaming and is often measured using various methods (Sweetser & Wyeth, 2005). Hassenzahl relates flow closely to the concept of user experience, describing it as a positive experience resulting from a well-balanced interaction between challenges and skills in a goal-oriented environment (Hassenzahl, 2008). Immersion is another important concept closely associated with the user experience. In a study conducted by Brown, three stages of immersion were identified: engagement, involvement, and total immersion. Engagement is the initial stage, where players must have an interest in the game to achieve this state. As the player continues playing beyond the engagement stage, they reach a state of enthusiasm. In the involvement stage, the player's emotions become directly influenced by the game. The highest level of immersion is total immersion, where the player is fully engaged and experiences a sense of absolute presence, with the game and the emotions it evokes being the primary focus.

In a subsequent study, Cheng and Cairns further explored the different stages of immersion (Cheng & Cairns, P., 2005). They conducted an experiment involving 14 participants who played a game with changing graphics and behavior. The results revealed that when users are deeply immersed in a game, they tend to overlook usability issues and may not even notice changes in the game's behavior. This finding highlights the powerful effect of immersion on the user's attention and perception during gameplay.

#### **4. Heuristics in educational video games**

To ensure a high-quality game experience, a thorough evaluation is crucial. The process typically begins with a comprehensive scanning of the game to identify and address any obvious and critical issues. Once this step is completed, the game should undergo user testing to uncover any additional issues that may have been missed during the initial evaluation.

Heuristics serve as valuable guidelines for expert evaluators to quickly identify common design issues in games. Jacob Nielsen introduced the heuristic methodology as an inexpensive and intuitive approach that can be used early in the development process without prior planning. Game heuristics originated from Malone's work, which focused on educational play and categorized heuristics into challenge, fantasy, and curiosity, aiming to create an enjoyable interface.

Currently, there are numerous heuristics specifically developed for analyzing video games. Livingston categorized these heuristics into three groups: usability, playability, and a combination of both. Playability heuristics address elements related to the dramatic and formal aspects of games, such as game narrative and player engagement. These heuristics are based on current literature and have been reviewed by playability experts and game designers.

Evaluating educational video games (EVGs) adds additional complexity as it involves considering the game's evaluation both as a video game and as a teaching tool. The evaluation of EVGs encompasses aspects such as the balance between educational and entertainment content, which greatly impacts the player's experience, as well as the effectiveness of the implemented learning process in improving players' skills and knowledge. This dual evaluation makes assessing EVGs more challenging compared to traditional video games. (Koeffel C. H., 2009)

#### **5. Balanced educational video games heuristics**

Achieving a balance between fun and educational content is a critical challenge in the development of educational video games (EVGs). The success of EVG hinges on effectively blending learning and entertainment. However, many EVGs struggle to strike the right equilibrium between engaging gameplay and educational activities, as well as challenges and skill development. Additionally, the absence of robust learning models grounded in pedagogical standards and effective teaching methods is a prevalent weakness in EVGs, leading to a disconnect between learning and play experiences. To address these concerns, researchers have identified key attributes for characterizing educational gaming, including supportability, educability, enjoyment, learnability, effectiveness, immersion, motivation, emotion, and socialization. These facets enable the analysis and management of educational content within the game structure, encompassing various elements such as aesthetics, interactivity, and social aspects. By considering these attributes, EVG designers can enhance the educational value and overall experience of their games.

In the evaluation of the learning process in educational video games (EVGs), several factors can be considered to assess the effectiveness of learning and the overall experience of players. These factors include:

- **Result:** EVGs aim to improve and reconstruct players' skills, knowledge, and information. Evaluating the results involves measuring the level of satisfaction and interaction among players during the learning process. Positive results indicate a higher level of engagement and motivation.
- **Performance:** The learning process in EVGs focuses on improving players' performance by teaching them new skills and knowledge and requiring them to apply these in the game's educational challenges. Measuring performance often involves educators and observers who closely monitor players' progress during gameplay.
- **Learning strategy:** The success of the learning process in EVGs is closely tied to the enhancement of knowledge, skill development, and attitude change among players. Evaluating the learning strategy involves assessing the alignment of the implemented learning content with the desired learning objectives and measuring the acquisition and application of knowledge and skills.
- **Motivation:** Motivation plays a crucial role in evaluating the learning process. It influences players' engagement in learning activities and determines their willingness to acquire new knowledge and skills. High motivation levels lead to the utilization of higher cognitive processes, resulting in more effective learning. Motivation can be fostered through various means within the EVG, such as intrinsic interest, rewards, and challenges.

By considering these factors and conducting evaluations based on them, the learning process in EVGs can be critically examined, leading to insights for improving learning outcomes, player engagement, and overall educational effectiveness. (Ibrahim, 2012)

## **6. Case Study: Minecraft Education heuristic evaluation**

Minecraft Education is a game-based platform that inspires creative, inclusive learning through play. Some heuristics that Minecraft Education claims to have are:

- **Appropriateness Heuristic** - The game should provide content and challenges suitable for different age groups and skill levels of learners.
- **Control and Flexibility Heuristic** - The game should offer opportunities for exploration, creation, building, and free development of ideas and projects by students.
- **Help and Guidance Heuristic** - The game should provide clear instructions and assistance to help students understand the objectives, rules, and gameplay mechanics.
- **Enjoyment and Motivation Heuristic** - The game should be enjoyable, stimulating, and motivating for students, creating a sense of success and progress.
- **Level of Adaptability Heuristic** - The game should offer different levels of difficulty to accommodate students' abilities and progression.
- **Interaction and Collaboration Heuristic** - The game should encourage interaction and collaboration among students, offering team-based gameplay and shared projects.
- **Familiarity and Skill Adaptation Heuristic** - The game should utilize students' existing knowledge and skills, connecting them to the game's context and educational objectives.

These heuristics have been used to create an educational experience in Minecraft Education, focusing on the adaptability, motivation, and engagement of students, as well as providing necessary help and guidance to support their learning and skill development.

We selected a group of high school students in Kosovo with limited or no prior exposure to educational video games. They engaged with the Minecraft Education game for a few days and subsequently filled out a questionnaire that was specifically designed to assess their user experience in the game.

According to our research, only 42.9% of the students responded affirmatively when asked if they had previously played educational video games. Some of the games they mentioned playing include Portal, Europa Universalis, and Age of Empires, while 57.1% stated that they had never played educational video games before. When asked about their opinion regarding the integration of technology and educational video games in the learning process, 71.4% believed that it strengthens and enhances learning, while 28.6% held a neutral stance, stating that the use of technology and educational video games had no significant impact.

In terms of the Minecraft Education interface, when students were asked to rate its ease of use and understandability on a scale of 1 to 5 (with 1 being not at all understandable and 5 being very understandable), 14.3% chose 3 (neutral), 57.1% chose 4 (stating that it is understandable), and 28.6% indicated that the interface was highly understandable and easy to use. Similarly, when asked about the difficulty in finding and using various functionalities within Minecraft Education, 57.1% selected 3 (neutral), suggesting that some effort was required to locate desired features, while 42.9% chose 4, indicating that it was easy to find and use different functionalities.

Regarding their experience, students expressed that the instructions and guidelines provided by Minecraft Education were clear and easy to follow, attributing this clarity to the tutorials offered by the game. However, as beginners, they mentioned that it took some time to become accustomed to the game.

When asked about the information or aids that helped them the most in understanding the rules and objectives of Minecraft Education, they mentioned the assistance provided by their ICT professor as well as the in-game tutorials and interactions with the Minecraft Education research center.

In terms of feedback during gameplay, students agreed that Minecraft Education provides sufficient and appropriate feedback to understand the purpose of specific tasks and offers hints when they encounter difficulties.

The elements in Minecraft Education that motivated and engaged the students in learning and exploring the materials included the presence of different challenges and objectives, which sparked their curiosity and kept them engaged. They did not encounter any difficulties or confusion while playing the game.

All of the students agreed that the control and interaction system in Minecraft Education is intuitive and easy to use, thanks to the step-by-step instruction sheet explaining the game.

When asked if they believed that Minecraft Education had improved their skills in specific areas of knowledge such as math, science, and languages, the students affirmed that it had enhanced their abilities in creativity, critical thinking, science, math, and coding.

Based on the user heuristics, the students provided suggestions and comments to enhance the user experience in Minecraft Education. They recommended shortening the informative texts, as they found them to be a bit lengthy. Additionally, they suggested improving the enjoyment and motivation heuristic, as they felt the game could become somewhat monotonous.

When asked if they believed educational video games were more enjoyable than traditional teaching methods, the students agreed that educational video games can be more enjoyable due to their novelty and rarity in schools in Kosovo. They expressed that these games offer a new space for collaborative learning and appear

to be easier and more engaging than what they were accustomed to. However, they emphasized the importance of using educational games sparingly and under continuous supervision from their teachers or parents.

In conclusion, the student's experience with Minecraft Education was highly positive. The game facilitated creativity, collaboration, critical thinking, and the application of subject knowledge. Its adaptability, immersive environment, and engaging gameplay contributed to a meaningful and enjoyable educational experience for students across various subjects and grade levels.

## 7. Conclusion

In conclusion, the use of heuristics to evaluate user experience in educational video games, such as Minecraft Education, has proven to be a valuable approach to understanding and enhancing students' learning experiences. By applying heuristics, researchers can assess the effectiveness, engagement, and overall impact of these games on student learning outcomes. The heuristics employed in evaluating user experience provide a framework for assessing different aspects of the game, including appropriateness for educational goals, control and flexibility, help and guidance, enjoyment and motivation, adaptability, interaction and collaboration, and the incorporation of prior knowledge and skills. These heuristics enable researchers to comprehensively analyze the educational value and effectiveness of games like Minecraft Education. The research conducted on Minecraft Education has demonstrated that students' experiences while playing the game are overwhelmingly positive. The game's adaptability and versatility allowed us as educators to integrate various subjects and tailor learning experiences to students' needs. The open-ended nature of the game promotes creativity, critical thinking, and problem-solving skills among students, while collaboration and teamwork are encouraged through shared projects and challenges. Students are actively involved in constructing virtual worlds, applying knowledge in real-world contexts, and experiencing a sense of achievement as they progress and accomplish tasks.

In conclusion, the utilization of heuristics to evaluate user experience in educational video games, exemplified by Minecraft Education, sheds light on the positive impact of such games on student learning. By leveraging the strengths of these games and addressing areas of improvement identified through heuristic evaluation, educators can harness the full potential of educational video games to create engaging, effective, and meaningful learning experiences for students.

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