

Designing inclusive educational games: accessibility rubric

*O design de jogos educativos inclusivos:
rubrica de acessibilidade*

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Accessibility is an essential component of inclusive design. Through accessibility affordances, developers and design teams can allow players with various needs (vision, hearing, motor, and cognitive) to use any given educational game to its fullest purpose while enjoying the experience, and educators can ensure all students engage in digital activities. Despite the recent increase in accessibility efforts, it can still be challenging for design teams to evaluate accessibility quality in digital educational games. Educational games have an extra layer that aims to promote learning of specific content, meaning its accessibility features have to allow learners to receive and process the content of information. This study proposes an applied and research-based rubric to discuss accessibility quality in educational games. The rubric is designed to support the design process with reflective guiding questions to address educational accessibility challenges.

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A acessibilidade é um componente essencial do design inclusivo. Por meio de affordances de acessibilidade, desenvolvedores e equipes de design podem permitir que jogadores com vários tipos de necessidades (visuais, auditivas, motoras e cognitivas) usem qualquer jogo educativo ao máximo de seu propósito enquanto aproveitam a experiência, e educadores podem garantir que todos os estudantes se envolvam em atividades digitais. Apesar do crescimento recente nos esforços de acessibilidade, ainda pode ser desafiador para equipes de design avaliar a qualidade da acessibilidade em jogos educativos. Estes têm uma camada extra direcionada a promover o aprendizado de conteúdos específicos, de modo que seus recursos de acessibilidade permitam aos alunos receber e processar o conteúdo da informação. O presente estudo propõe uma rubrica aplicada e fundamentada em pesquisa para discutir a qualidade da acessibilidade em jogos educativos. A rubrica foi projetada para sustentar o processo de design com questões orientadoras reflexivas para enfrentar os desafios da acessibilidade educacional.

1 Introduction

The economic and cultural impact of digital games in our society is not a surprise nor new. It is also no longer a novelty, but rather to be expected that educational games impact education. Interactive game experiences offer players multiple learning paths and conceptual reinforcement, providing opportunities for cognitive enhancement. Empirical research shows the effectiveness of educational games to teach various content and change learners (e.g., Plass et al., 2020; Engledowl, 2023).

As society evolves and reflects a greater understanding of the importance of diversity, equity and inclusion, developers, design teams, and educators have been moving towards inclusive design (Lupton et al., 2021). Accessibility is an essential part of this inclusive approach, ensuring that users with various needs (vision, hearing, motor, and cognitive) can use any given material or product to its fullest purpose while having a good experience.

Game studios and developers are increasing their accessibility efforts, making accessibility a core design value (GDC, 2023), it is worth mentioning the contributions of Microsoft,¹ Able Gamers Charity,² Game Accessibility Guidelines,³ and Unity.⁴ Despite the progress, data from the industry shows that a significant part of developers and studios do not add accessibility features into their games (GDC, 2023). It can still be challenging for design teams to prioritize accessibility for several reasons, such as budget limitations, lack of shared vocabulary to describe accessibility features, and the need for more knowledge to address accessibility challenges. These challenges become even more prominent for developers when designing educational digital games. In addition to accessibility issues related to navigation, controllers, game status communication, and user interface, educational games have an extra layer because they aim to promote the learning of specific content. In this sense, accessibility features have to allow learners to receive and process the learning content.

Understanding that there is no default learner and recognizing learners' variability, design teams and developers can design accessible educational games, fostering an equal opportunity for learners to learn considering their needs through gameplay and design activities (Meyer et al., 2014). These professionals and teams would benefit from a structure that facilitates accessible design through guided reflection during the design process, vocabulary building to talk among peers, and ways to review accessibility in educational games.

This study proposes a practical rubric to support developers and design teams to review educational games' accessibility. The rubric was created using practical game development and theoretical knowledge. The *Learning Games Lab at New Mexico State University* has been developing educational games for 20 years as a university-based development studio specialized in translating research-based content into educational tools for various audiences. Through action research (Muratovski, 2016; Kemmis & McTaggart, 2005), the lab engages in accessibility discussions, creating

- 1 Microsoft gaming accessibility fundamental: <https://learn.microsoft.com/en-us/training/paths/gaming-accessibility-fundamentals/>
- 2 Able Gamers Charity: <https://ablegamers.org>
- 3 Game Accessibility Guidelines: <https://gameaccessibilityguidelines.com>
- 4 Unity Practical Game Accessibility: <https://learn.unity.com/course/practical-game-accessibility>

intentional actions and design processes to make their educational media more inclusive (Cezarotto et al., 2022). Through a narrative literature review, we articulated and identified educational and instructional theories, including the Universal Design for Learning (UDL; Meyer et al., 2014) and an accessibility framework for game design (Cezarotto & Chamberlin, 2021). This rubric is based on practical knowledge from developing games in the Learning Games Lab and the Lab's application of educational and instructional theories.

2 Educational games: complex systems of information

Games are complex systems of many elements intentionally interconnected and organized to provide unique experiences through interaction (Meadows, 2022, p. 66; Zimmerman, 2022, p. 69). This study understands educational games as complex systems of information that aim to provide an effective and meaningful learning experience while changing the player's knowledge, skill, behavior, emotion, or physiology (Chamberlin & Schell, 2018). For example, a food safety educational game can engage youth in fun gameplay and change their knowledge and attitudes around food safety practices, such as cooking meat at the proper temperature and handwashing before handling food (Quick et al., 2013).

Meaningful learning experiences happen when instruction activities engage and support **active learning** – learners are mentally involved with the task, **constructive thinking** – learners constantly build interpretations of the content, **intentional activities** – learners have clear goals that lead to fulfillment, **authentic experiences** – learners' experience relates to the content problems, and **collaboration** – learners have opportunities to discuss or collaborate with others (Jonassen & Strobel, 2006).

Information is the core element of the learning game system (and any given game). Information tells what players need to know to start and keep playing the game (rule-based), represents what the game system collects and presents to the player as the game status (responsive system), guides players through activities to learn the content (learning goals), and affects the player's action during the entire gameplay experience (design elements) (Plass et al., 2019; Järvinen, 2008).

Unlike purely entertainment-focused games (which can also foster learning), educational games have specific learning goals and instructional design components guiding their development. To achieve these learning goals, the gameplay experience provides activities designed to foster a change in players. Thus, the design of educational games needs not only to consider elements of usability and play experience, but also to articulate activities and instructional strategies to support and foster learning.

Based on human evolution, cognitive science established four essential components to support learners in the learning process (Dehaene, 2020):

- **Attention:** Supports learners' focus on the learning information, allowing them to receive, select, and process the information.

- **Active engagement:** Supports learners' curiosity to explore things, test ideas, confront thoughts, and test hypotheses;
- **Error feedback:** Supports learners to compare their predictions with reality, allowing them to correct their mental models of the world;
- **Consolidation:** Supports learners to solidify what was learned, by allowing learners to repeatedly practice what they learned to improve and build a level of expertise.

Instruction methods that support these components are more likely to be successful in promoting meaningful learning. When thinking about the learning process in a digital environment, in this study focusing on educational games, there are proven instructional benefits such as **supporting learners' attention**, helping them focus on specific parts of the content, **reducing the cognitive load** by introducing content and examples gradually, and **supporting motivation** by explaining complex concepts visually and interactively, **fostering** safe learning spaces where students can make mistakes and experience things in a safe and scaffolded environment (Clark & Lyons, 2011). However, to fully provide students with these digital technological benefits, accessibility needs to be an intrinsic part of the design and development of the game, addressing each user's needs and abilities. Accessibility design throughout the process will help the game support learners' needs to receive the information, make sense of the information, explore possibilities, understand mistakes, act in the game interface, master the skill, and enjoy the game experience.

3 Supporting the design of accessible educational games

The quality of educational software, including educational games, relies on its capacity to address users' learning needs and requirements (Gomes & Padovani, 2005). If the educational game is designed without considering accessibility, players' needs may not be fully considered, causing learning barriers. This means that to measure the quality of an educational game, accessibility cannot be disassociated from it.

In the literature, researchers and developers have been fostering important research towards accessibility in games, discussing the state of the art when designing for inclusion (Brown & Anderson, 2021) and the value of accessibility in digital games to enable players (Cairns et al., 2019). Studies also foster tools to review the accessibility of games (Larreina-Morales, 2023). Despite their contributions, these studies focus on games intended purely for entertainment; thus, the accessibility of educational games is not part of the discussion.

Little research has been done to support the design of accessible educational games; for example, Salvador-Ullauri et al. (2020) reviewed the accessibility of 82 serious games using a method based on the Web Content Accessibility Guidelines (WCAG). Hersh and Leporini (2013) drew up principles for the accessibility, playability, pedagogical merit, and general usability of educational computer-based games.

The literature and the educational game community would benefit from practical tools to allow developers, design teams, or game design professors to review the accessibility of educational games, a flexible structure that allows educational and instructional reflection on accessibility decisions.

3.1 Reviewing games

In the game community, reviewing games' quality is a common practice and has different purposes. For example, yearly game competitions bring together authorities in the field to review games and find winners in terms of educational value and innovation. When teaching game design, instructors and professors ask design students to review several games to build critical thinking on this media. Also, when designing new games, developers play and review many games to gain ideas and insights and to better understand mechanics and gameplay possibilities (Presser et al., 2013).

Reviewing games as part of the design process potentially can increase the quality of games because, as developers, we get better by playing and reviewing games. This design practice can be beneficial specifically to improving accessibility efforts, giving the team a safe space to normalize and foster a vocabulary about accessibility and identify accessibility barriers and features (Cezarotto et al., 2022).

Developers and design researchers have developed playability and usability heuristics to evaluate games and digital media in development and post-production. These methods include Malone's (1982) *Heuristics for designing enjoyable user interfaces: Lessons from computer games*, which focus on player-centered categories – challenge, fantasy, and curiosity – and Korhonen and Koivisto's (2006) *Playability heuristics for mobile games*, which use three modules: game usability, mobility, and gameplay. In addition to games, developers and researchers have created frameworks for evaluating educational media (Lee & Cherner, 2015; Papakadis et al., 2018). Within these frameworks, education or instruction are just as essential as player enjoyment and usability.

In some cases, these evaluation tools include components related to accessibility. For instance, within the Gameflow model, Sweetser and Wyeth (2005) include the element of "concentration," which is the balance of games having a high workload for players while considering players' perceptual, cognitive, and memory limitations. In the *PLAY framework*, heuristics include "error prevention," which states players of all levels "are able to play and get involved quickly and easily with tutorials, and/or progressive or adjustable difficulty levels" (Desurvire & Wiberg, 2009, p. 564). In the *Comprehensive Evaluation Rubric of Instructional Apps*, one of the dimensions in the domain of "instruction" includes accommodation of individual differences, in which apps can be customized to address players' needs and support diverse learners (Lee & Cherner, 2015). While these frameworks are useful, having more evaluation tools that focus specifically on accessibility, like the *POUR principles*, remains an ongoing need.

3.2 Accessibility principles – POUR

The U.S Legislation, section 508 of the Rehabilitation Act, defines accessibility rules for information and Communications Technology (ICT). This section regulates that digital media must be accessible, supportive for users with various needs, and ensure that individuals are not excluded from using media technology. The World Wide Web Consortium (w3c) is one of the main authorities informing and supporting developers, with guidance and resources on how to be in compliance with section 508. The consortium mainly focuses on accessibility for Web.

The w3c is well known for their Web Content Accessibility Guidelines (WCAG). Their material is grounded on four main principles necessary for anyone to access and use Web content. The principals are POUR – Perceivable, Operable, Understandable, and Robust.

- **Perceivable:** Information must be presented to user in ways they can perceive.
- **Operable:** Interface components, including navigation, must be operable.
- **Understandable:** Information and operation must be understandable.
- **Robust:** Information must be robust enough, and support a wide variety of assistive technology.

3.3 Universal Design for Learning & Accessibility

POUR principles are often incorporated in teaching and learning frameworks that center learner variability and accessibility, like Universal Design for Learning. Universal Design for Learning (UDL) is a teaching and learning framework based on the understanding that “all learners can access and participate in meaningful, challenging learning opportunities” (CAST, 2018). By understanding that all students have the capacity and desire to learn, UDL centers on creating learning environments and experiences that incorporate multiple means for 1) engaging in learning, 2) representing information, and 3) acting within a learning and expressing knowledge. These three principles – engagement, representation, and action and expression – are based on learning networks within the brain – affective, recognition, and strategic – the interconnection of these networks, and the variability of brain networks among learners (Grant & Perez, 2018).

Accessibility is often referenced within UDL practices both in terms of being able to access the content as a means to minimize barriers to learning (Grant & Perez, 2018). Centering accessibility within UDL practices nurtures learning environments that are equitable for all learners at the same time (Edyburn, 2005). In order to support educators in selecting and designers in creating educational materials that are accessible, the POUR principles were used by the National Center on Accessible Educational Materials (2022) to frame vetting and

designing digital materials. Components of these guidelines incorporate UDL principles in their reflective questions. Combining POUR and UDL principles was helpful in creating guidelines that supported developers in evaluating their products during and post-production as well as educators in vetting digital materials to use with their learners.

3.4 Accessibility framework for games

Accessibility is about users' needs, understanding that all users need a degree of accessibility to use any given product, media, or game. In educational games, it represents a set of characteristics that developers design into the game to support these needs, which provides access and ways that players can use the game to its fullest purpose to learn content (Cezarotto & Chamberlin, 2021).

From the social model of disability, accessibility lives in the product and not in the user (Oliver, 2013). In this model, the disability is a mismatch between the design and the person's needs, instead of a personal health condition. Through this lens, a good game design should match players' needs, enabling players. On the other hand, a bad game design that does not match players' needs disables players.

It can be challenging for design teams to identify user needs. One approach is to use categories. In the literature, four main categories of players' needs are used for framing accessibility – visual, hearing, motor, and cognitive (Cezarotto et al., 2022). These categories allow the identification of possible barriers players may face in games:

- **Visual needs:** when conveying visual information in the educational game interface, does the design support players with some degree of vision loss (e.g., low vision, legal blindness, complete blindness, color blindness)?
- **Hearing:** when conveying auditory information in the educational game, does the design support players with some degree of loss in the ability to hear, either from one or both ears (e.g., hearing loss, hard of hearing, deafness)?
- **Motor:** when motor interactions are used to play and control the educational game, does the design support players with some mobility limitations (e.g., cerebral palsy, lack of steadiness, lack of mobility, age-related issues, neurological disorders, paralysis)?
- **Cognitive:** when the educational game presents information and content, does the design support players with mental or psychological disorders? Cognitive needs are broad, and players may have a deficit in the ability to learn, process or remember information, communicate, make social interaction, and make social decisions. Examples include neurodivergent learners and those with learning disabilities (e.g., dyslexia and dyscalculia) or intellectual disability.

4 Rubric for accessibility in educational games

Our goal for this rubric is to provide a simple and practical tool for developers and design teams (Table 1). The rubric was built using the categories from POUR (perceivable, operable, understandable and robust; W3C, 2023; CAST, 2023), Universal Design for Learning practices (Grant & Perez, 2018), and the concepts from our accessibility for games framework (Cezarotto & Chamberlin, 2021). In addition to the four POUR principles, a fifth principle, *fun*, was added, because this rubric focuses specifically on educational games. Providing players with disabilities an enjoyable experience is more than just enabling access to the game or performing a task. The rubric also gives them an opportunity to choose the experience they want to have in terms of fun and aesthetically pleasing interactive systems (Cairns et al., 2019). Thus, the rubric structure is organized in four main categories:

- **Perceivable – Enables players to receive information.** For players to make sense of the information, they first need to be able to receive the information. There are three main communication channels for this: auditory, visual, and tactile. A game needs to convey information using a combination of these channels – or at least one of the channels that the player can receive information from.
- **Operable & Robust – Enables players to take action in the game interface:** For players to take action in the game, they need to be able to interact with the interface (physical and virtual). Thus, their motor needs should be considered, and customization options and assistive technology need to be supported in the controls. Here, accessibility overlaps with usability, in the sense of how easy it is for players to use the interface and learn how to navigate the system. An educational game with good usability will enable the player to achieve productivity and efficiency in game goals and task completion while interacting with the interface.
- **Understandable – Enable players to make sense of the information.** For players to process the game information/content, their cognitive needs and variability must be considered. Cognitive needs are essential for effective learning and can vary depending on the content. However, the main factors to be supported are proper time for processing information, activity feedback, and instructions for new game mechanics, actions and content.
- **Fun – Enable players to enjoy the game experience:** To enable players to enjoy the game experience, developers need to consider elements of user experience. Attention to providing an enjoyable user experience for players in the spectrum of need is an important element that overlaps with accessibility; however, it is usually not considered.

Table 1 Rubric for accessibility in educational game.

Perceivable: Does the game enable players to receive information?	Yes	Somewhat	No	NA
P1. Does the game provide ways for players with vision and hearing needs to receive the information? (e.g., audio transcripts, alternative text for images, and video captions)?				
P2. Does the game allow players to customize the interface (e.g., text size, level of contrast, remove sound effects)?				
Operable & Robust: Does the game enable players to take action in the game interface?	Yes	Somewhat	No	NA
O1. Does the game provide flexible options for navigation (e.g., remapping keys, shortcuts, screen gestures, voice control)?				
O2. Does the game support the use of assistive technologies (e.g. screen magnification software, input devices, voice recognition)?				
Understandable: Does the game enable players to make sense of the information?	Yes	Somewhat	No	NA
U1. Does the game offer a gameplay version considering players who need more time to process information (e.g., version without time pressure, different levels of difficulty)?				
U2. Does the game provide feedback in multiple ways (e.g., not only in audio or text)?				
U3. Are the game content and structure consistent (e.g., actions in the game, content presentation, progression in content)?				
U4. Does the game provide instructions for gameplay (e.g., tutorial for new mechanics, or when new elements are introduced to the gameplay)?				
U5. Does the game provide essential information for content understanding (e.g., explain new concepts or key terms, reinforce important information)?				
U6. Does the game provide supportive or alternative materials (e.g., allow players to engage in the activity in different ways, support the game activities)?				
Fun: Does the game enable players to enjoy the game experience?	Yes	Somewhat	No	NA
F1. Does the game offer ways that various players and skills can thrive?				
F2. Does the game offer engaging gameplay for various players and skills?				

5 Conclusion

Design for inclusion has been gaining attention among developers, studios, and institutions. Providing players with various needs, skills, and background opportunities to use a product is an intrinsic core element of this design approach. Despite the progress, it is still a challenge for design teams to approach accessibility and support players' variability in educational games. Many players still face interaction and learning barriers when playing non-accessible games.

One way to support design teams and developers in this challenge is to offer a common vocabulary to discuss accessibility and provide tools to identify accessibility barriers and features. In this study, we proposed a rubric to review the accessibility quality of educational games that translates theories and research regarding accessibility into actionable applications for game production. The rubric is short to avoid overwhelming teams with too much academic language and extensive and complex accessibility lists and addresses core accessibility areas when

designing accessible educational games. The rubric has the potential to support design teams to review existing games, teach game accessibility, and guide discussions during the design process of educational games.

Despite the potential of the rubric, future studies still need to evaluate and validate the tool. We plan to evaluate the rubric with developers and design teams, review the language, and identify possible missing components based on responses from a broad range of developers. Additionally, we will evaluate the rubric's potential to teach accessibility in game design in a case study within our Learning Games Lab educational programs.

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