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From feature to function. Rethinking videogame accessibility as distributed learning

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Abstract: Videogame accessibility is conventionally framed as accommodation, treating design interventions as compensatory mechanisms. This paper proposes an alternative conceptualization grounded in extended and distributed cognition, arguing that accessibility features function as pedagogical operators that redistribute cognitive labour across the player-game interface rather than merely compensating for deficits. The analysis applies the Game Accessibility Guidelines framework to Minecraft Education through heuristic evaluation, systematically assessing compliance across motor, cognitive, visual, hearing, speech, and general accessibility domains. Results indicate substantial alignment with basic and intermediate guidelines addressing common accessibility needs, including control remapping, interface scaling, text-to-speech, and tutorial support, while advanced guidelines targeting less prevalent conditions remain partially or wholly unimplemented. Interpreting these findings through extended cognition theory reveals that implemented features most effectively redistribute perceptual, motor, and memorial demands across common dimensions of embodied variation, whereas persistent gaps involve more complex redistributions or less standardised technical solutions. The reconceptualization of accessibility features as pedagogical operators offers a theoretically grounded framework for understanding how inclusive design shapes learning in game-based educational contexts.

Keywords: videogame accessibility; extended cognition; distributed cognition; Minecraft Education; game-based learning.

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1. Introduction

Videogame accessibility is conventionally understood through accommodation. Features such as configurable controls, subtitles, colorblind modes, and adjustable difficulty are characterized as provisions enabling players with disabilities to engage with otherwise excluding games (Brown & Anderson, 2020; Di Leo, 2025; Hassan, 2023). This understanding carries implicit theoretical commitments: it locates disability in the individual body, conceptualizes accessibility interventions as compensatory mechanisms, and treats gameplay as a stable structure to which players must adapt. Such assumptions, prevalent in industry discourse and academic literature alike (Anderson & Schrier, 2021; Brown & Anderson, 2020), warrant critical examination. An alternative perspective emerges from a different question: what if accessibility

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features actively reconstitute the cognitive processes involved in play, functioning as extensions of the player's own mind?

This paper pursues that question by bringing videogame accessibility into dialogue with extended and distributed cognition. Clark and Chalmers (1998) proposed that cognitive processes can extend beyond the brain when external resources are appropriately integrated into an agent's reasoning. Hutchins (1995), working in distributed cognition, demonstrated how achievements like navigation are accomplished by systems that include people, artifacts, and representational media. These frameworks invite reconceptualization of accessibility features as elements within a cognitive ecology that determines what processing occurs and where.

The analysis centers on Minecraft. The game ranks among the most widely played in history, with over two hundred million copies sold (Murphy, 2023), and has established credibility as an educational tool (Di Leo & Traetta, 2025). Minecraft: Education Edition, released in 2016, formalized what educators had recognized: the sandbox mechanics offer affordances for teaching diverse subjects, from architecture to computer programming (García-Álvarez & Acevedo-Borrega, 2025; Kersánszki et al., 2024; Nebel et al., 2016). The game has also developed comprehensive accessibility options addressing motor, visual, auditory, and cognitive dimensions of play. This conjunction of educational significance and accessibility infrastructure makes Minecraft an apt site for investigation.

The argument proceeds in three movements. The first reconstructs the prevailing model of videogame accessibility, demonstrating how it individualizes disability and conceptualizes play as information transfer from fixed game structure to receiving player. The second proposes an alternative reading through extended cognition, treating accessibility options as pedagogical operators that redistribute cognitive labor across the player-game interface. The third develops co-evolutionary accessibility, attending to the temporal dynamics by which design practices and player habits mutually transform one another across development cycles and play sessions.

2. Theoretical framework

2.1. Extended and distributed cognition

The philosophical and cognitive-scientific landscape shifted considerably in the late twentieth century with the emergence of externalist accounts of mental processes. Among the most influential is the extended mind thesis, articulated by Andy Clark and David Chalmers (1998). Their argument challenges the assumption that cognition occurs exclusively within the skull, proposing an "active externalism" wherein external artifacts and environmental structures can become genuine constituents of cognitive processes when agent and artifact are linked through ongoing two-way interaction.

The thesis develops through cases of environmental scaffolding before arriving at a belief-based comparison between Inga, who relies on biological memory to locate a museum, and Otto, who has Alzheimer's disease and consults a constantly-carried notebook. Clark and Chalmers contend that the notebook plays the same functional role for Otto that biological memory plays for Inga; if Inga's belief existed before conscious retrieval, Otto's belief was already present in his notebook. The boundaries of mind are thus determined by functional integration into cognitive activity rather than by skin and skull. The thesis applies to external objects meeting specific criteria:

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reliable availability, direct accessibility, automatic endorsement, and prior conscious endorsement of the information. Technology and material culture, under the right circumstances, become woven into the fabric of thought.

Edwin Hutchins developed a complementary perspective emphasising distribution across individuals and technological systems. His ethnographic study of naval navigation, *Cognition in the Wild* (1995), showed that determining a ship's position cannot be located in any single brain. Cognitive labour is parcelled out across navigators performing specialised sub-tasks and an array of instruments, charts, and notation systems; the position emerges from coordinated activity within this socio-technical system. Charts and plotting sheets actively participate in the cognitive work, allowing navigators to perceive relationships in ways difficult to achieve through internal representations alone. Competence, in this framework, is distributed across brain, body, artifact, and social structure.

David Kirsh contributes a third strand through his investigations into the intelligent use of space. With Paul Maglio, he introduced a foundational distinction between pragmatic and epistemic actions (Kirsh & Maglio, 1994). Pragmatic actions achieve physical goals; epistemic actions alter the agent's cognitive state by modifying the external environment. Skilled Tetris players, the study observed, rotate pieces more often than placement requires, perceiving shapes from different angles without mental simulation and thereby reducing cognitive load.

These frameworks together provide a theoretical foundation for reconceiving videogame accessibility. If cognition routinely extends into notebooks, navigation equipment, and the spatial arrangement of Tetris pieces, control remapping, adjustable game speed, and high-contrast visual modes can be understood as instances of cognitive extension available to all players rather than as compensations for deficient individuals. The accessible videogame becomes an explicit site of distributed cognition, where redistribution of perceptual, motor, and memorial labour across player and interface is a matter of deliberate design.

2.2. The pedagogical operator concept. Environmental design and the redistribution of cognitive labour

If extended and distributed cognition frameworks establish that artifacts participate in thought, the subsequent task is to examine how designed features shape learning. The concept of the "pedagogical operator" captures this dynamic. A pedagogical operator is an element of environmental or technological design that redistributes cognitive labor, altering what a learner can perceive, attend to, remember, or do (Skulmowski, 2023). It is pedagogical because it changes developmental trajectories; it is an operator because it performs transformative work between organism and environment.

This concept's lineage traces through scaffolding, the support a knowledgeable other provides to enable learners to accomplish otherwise unreachable tasks (Wood et al., 1976). Originally interpersonal, scaffolding has since been extended to technological supports (Pea, 2018), though its logic remains oriented toward temporary assistance and autonomous mastery.

The pedagogical operator shares scaffolding's attention to enabling structures but departs in two respects. It does not presuppose eventual independence: in contexts involving disability and technology, external resources often remain permanent cognitive constituents. A player using control remapping for limited hand mobility may never transition to standard controls, nor should such transition be normatively ex-

pected. Additionally, following Norman's (2013) analysis of affordances and constraints, the concept foregrounds how design configures cognition. Design carries implicit pedagogy; a well-designed door handle teaches its use without instruction.

Videogame accessibility features exemplify this logic. Slowing game speed restructures the temporal distribution of cognitive labor, providing additional time for perception and motor planning. Control remapping reconfigures the sensorimotor loop between player and game. High-contrast modes reduce visual processing load; navigation aids externalize information otherwise held in working memory. Each feature reshapes what players can learn and how. This framing aligns with Pea's (2018) observation that technologies for learning actively participate in shaping learning itself. Games are environments saturated with pedagogical operators; accessibility design simply renders these operators explicit, adjustable, and responsive to diverse embodiments.

2.3. Player-reported accessibility experiences

These theoretical claims find empirical support in a mixed-methods analysis of 448 accessibility reviews from Can I Play That?[1] (2019-2024), which developed a three-dimensional framework encompassing physical, cognitive, and socio-emotional dimensions (Di Leo, 2025). The study identified six thematic categories: Controls, User Interface and Navigation, Audio/Speech/Sound, Difficulty Settings, Visual Accessibility, and Subtitles. Longitudinal data reveal increasing attention to accessibility from 2019 to 2021, followed by slower growth, a pattern suggesting that the discourse is maturing and that once-optional features are becoming baseline expectations. Players experience these features as conditions for meaningful engagement rather than mere accommodations for individual deficits. By redistributing perceptual, motor, and cognitive demands across the player-game system, such features instantiate extended and distributed cognition in designed form, grounding the theoretical construct of the pedagogical operator in empirical evidence.

3. Methodology

3.1. The Game Accessibility Guidelines as analytical lens

The systematic evaluation of Minecraft Education's accessibility provisions required an analytical instrument capable of addressing the diverse modalities through which players interact with digital games. The Game Accessibility Guidelines (GAG)[2] served this purpose. Developed collaboratively by accessibility specialists, game designers, and disabled gamers, the GAG framework organises accessibility considerations into six domains: motor, cognitive, vision, hearing, speech, and general. Each domain is further stratified into basic, intermediate, and advanced tiers, reflecting both the prevalence of particular needs and the implementation complexity of corresponding features. Basic guidelines address the most common requirements and typically involve straightforward design choices; advanced guidelines target less prevalent conditions or demand more sophisticated technical solutions.

[1] https://caniplaythat.com

[2] https://gameaccessibilityguidelines.com

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The selection of this framework reflects its established status within accessibility evaluation practice and its comprehensive scope. Unlike accessibility checklists developed for web content or productivity software, the GAG addresses the distinctive characteristics of interactive entertainment: real-time responsiveness, spatial navigation, challenge calibration, and the integration of auditory, visual, and haptic feedback. These characteristics align closely with the cognitive dimensions of gameplay discussed in the theoretical framework above. The guidelines thus provide a systematic inventory of the interfaces through which cognitive labour is distributed between player and game.

3.2. Case selection and evaluation procedure

Minecraft Education was selected as a single embedded case because it is widely promoted for classroom use with diverse learners and has been discussed as supporting creativity, collaboration, and problem solving in formal education (Checa-Romero, 2016; Nebel et al., 2016; Kersánszki et al., 2024; Di Leo & Traetta, 2025; García-Álvarez & Acevedo-Borrega, 2025). Its sandbox mechanics, its substantial accessibility options, and its dedicated classroom management tools distinguish it as a site where questions of inclusive design intersect directly with pedagogical practice. The evaluation focused on the latest release as of November 2025 and considered both individual play and typical classroom configurations, including the companion Classroom Mode application that enables educators to monitor and manage student activity.

To situate Minecraft Education within the broader Minecraft ecosystem, the analysis also compared it with two other versions of the game: Bedrock Edition and Java Edition. These comparisons served to identify features unique to the educational release as well as those inherited from the underlying codebase. Where relevant, discrepancies between versions were noted, particularly concerning features such as sound subtitles, which are available in Java Edition but not yet implemented in Bedrock or Education.

The evaluation procedure followed established practices of heuristic evaluation, in which evaluators inspect an interactive system against a structured set of principles and record problems relative to each one (Nielsen & Molich, 1990). Using the full set of GAG items applicable to the game's genre and platform, the evaluator systematically examined configuration menus, in-game interfaces, and classroom management tools. Play sessions engaged with core activities such as building, navigation, interaction with non-player characters, and the use of world templates provided for educational purposes. Alongside active play, the analysis traversed online documentation published by Mojang Studios and Microsoft to locate accessibility-relevant options and behaviours that might not be immediately apparent through interface inspection alone.

For each guideline, the evaluation recorded whether the feature was implemented in a manner that plausibly supports disabled players and students (coded as satisfactory), absent or clearly problematic (coded as not met), or not applicable to the game's mechanics or context. Partial implementations received intermediate coding with accompanying notes specifying the nature and extent of compliance. This tripartite coding scheme permitted nuanced judgements in cases where a feature was present but fell short of full implementation.

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The recorded judgements were then collated by accessibility domain to produce structured tables indicating the status of basic, intermediate, and advanced items within each category. Field notes documented how particular implementations interacted with the pacing, assessment demands, and social organisation of classroom play. These observations drew on prior empirical and theoretical work concerning game-based learning with Minecraft (Checa-Romero, 2016; Nebel et al., 2016; Kersánszki et al., 2024; Di Leo & Traetta, 2025; García-Álvarez & Acevedo-Borrega, 2025) and provided context for interpreting the practical significance of design choices that might appear minor when considered in isolation.

The resulting tables and notes constitute the empirical foundation for the domain-by-domain analysis presented in subsequent sections. By grounding the evaluation in both direct interaction with the game and systematic application of the GAG framework, the methodology seeks to balance experiential insight with evaluative rigour. The procedure does not claim exhaustive coverage of every possible interaction scenario; rather, it aims to capture the accessibility landscape of Minecraft Education as it presents itself to a player navigating the core loops of educational gameplay.

4. Results and discussion

4.1. Overview of findings

The systematic application of the Game Accessibility Guidelines to Minecraft Education yields a complex picture. The game demonstrates substantial alignment with accessibility principles in several domains while exhibiting persistent gaps in others. Compliance is strongest among basic and intermediate guidelines, which address the most common accessibility requirements and typically involve established design solutions. Advanced guidelines, which target less prevalent conditions or demand more sophisticated technical implementations, remain partially or wholly unimplemented across most domains. This pattern suggests that Minecraft Education has achieved a baseline of accessibility that addresses widespread needs but has not yet extended its provisions to the full range of disabled players and learners.

The evaluation also reveals considerable variation across accessibility domains. Figure 1 outlines the results.

Figure 1. Minecraft Education GAG compliance dashboard.



4.1.1. Motor accessibility

The motor domain encompasses guidelines related to control, mobility, and physical interaction with the game. Minecraft Education performs well on foundational items in this category. The game supports extensive control remapping across keyboard, mouse, controller, and touch input methods, allowing players to configure controls to suit their individual needs[3]. This capacity for reconfiguration aligns with the principle that control schemes should function as malleable interfaces rather than fixed constraints. The game also supports multiple input devices and permits adjustment of camera and cursor sensitivity across all supported input modes.

Touch interfaces on mobile devices expose on-screen controls that players can resize and reposition through a dedicated customisation mode. This feature addresses the GAG guideline concerning the size and spacing of interactive elements on small or touch screens. The customisation system prevents buttons from overlapping and

[3] https://edusupport.minecraft.net/hc/en-us/articles/360061503031-Accessibility-Features

provides per-button sliders for position, scale, and opacity, offering meaningful control over the touch interface layout.

4.1.2. Cognitive accessibility

Cognitive guidelines address thought, memory, information processing, and the management of complexity. Minecraft Education satisfies many items in this domain through features that reduce navigational friction and provide in-context support. The game can be launched without extensive menu traversal; a single Play button leads directly to the world selection screen, and existing worlds can be entered with minimal additional interaction. Tutorial worlds guide new players through core mechanics such as navigation, crafting, and block placement. In-world practice spaces can be configured to remove most failure conditions through classroom settings that disable mob spawning, player damage, and inventory loss upon death.

Contextual help is available through multiple channels. The Show Input Hints option displays device-specific control information during gameplay. Non-player characters can be programmed to provide instructions and guidance, and chalkboard objects permit educators to embed learning goals and explicit directions within the game world. The Immersive Reader integration provides reading support for text surfaces including books, signs, NPC dialogue, and Code Builder tutorials, with features such as reading aloud and word highlighting that aid comprehension.

Several narrative-oriented cognitive guidelines are partially outside the scope of a sandbox title. Minecraft lacks a fixed overarching story, so guidelines concerning narrative summaries or progress recaps do not apply directly. Educational lesson worlds typically present short, focused activity sequences with defined learning objectives, but there is no built-in system for presenting story-so-far summaries across multiple sessions. The game partially meets the guideline concerning replay of narrative and instructions; persistent objects such as signs, boards, and NPC dialogue can be revisited at any time, though transient notifications cannot be recalled.

4.1.3. Visual accessibility

Vision guidelines concern the presentation of visual information and the accommodation of diverse visual capabilities. Minecraft Education provides a field-of-view slider in video settings, with a moderate default appropriate for typical viewing distances. Additional options allow players to adjust the strength of FOV effects triggered by movement and status effects, world brightness, and the intensity of distortion effects such as those caused by the nausea status. These controls permit players to calibrate the visual experience to their comfort and perception.

Interface scaling is available through multiple mechanisms. A global GUI scale setting controls the size of menus and heads-up display elements, with an Auto mode that selects the largest comfortable scale for the current display resolution. Chat text has its own size control, and text background opacity can be adjusted to improve contrast between text and the underlying game world. On some platforms, a high-contrast resource pack is available that enhances the visibility of user interface elements. Touch controls can be enlarged and repositioned as described above.

The game employs shape and iconography as well as colour to represent key status values. Health, hunger, armour, and experience are indicated through distinct icons and bar lengths, not through colour alone. This design choice aligns with the

GAG guideline to avoid conveying essential information exclusively through colour. Ore textures were redesigned to feature unique patterns recognisable by shape, a change explicitly motivated by accessibility concerns for colourblind players.

4.1.4. Hearing accessibility

Hearing guidelines address the presentation of auditory information and the accommodation of deaf and hard-of-hearing players. Minecraft Education provides separate volume controls for multiple sound categories, including music, sound effects, ambient sounds, weather, and text-to-speech. This separation permits players to balance audio channels according to their preferences and to mute categories that are distracting or inaccessible.

Text chat is robustly supported. Players can communicate through typed messages, and text-to-speech for chat is available on supported platforms. Chat history can be reviewed, and chat text appearance can be customised with respect to font size, colour, and background opacity. These features provide a visual communication channel that does not depend on hearing.

4.1.5. Speech accessibility

Speech guidelines concern the use of voice input and the accommodation of players who cannot or do not wish to speak. Minecraft Education addresses these guidelines primarily through the absence of speech-dependent mechanics. The game does not require speech input in any context; all actions, navigation, and communication can be accomplished through keyboard, mouse, controller, or touch input without voice. Players who cannot produce speech or who prefer not to use voice are not excluded at the interaction level.

Advanced speech recognition guidelines, such as those concerning vocabulary size or volume-threshold activation, are not implemented because the game includes no speech recognition system. This absence means that players who might benefit from voice control as an alternative input method do not have access to it within the base game, though external tools and modifications exist for some platforms.

4.1.6. General accessibility

General guidelines address documentation, difficulty options, settings persistence, and solicitation of feedback. Minecraft Education includes an in-game accessibility menu displayed by default when opening settings, which provides centralised access to accessibility-relevant options. Online documentation published by Microsoft and Mojang Studios describes accessibility features for Minecraft Education in detail, satisfying the guideline concerning disclosure of accessibility provisions on websites[3].

Difficulty and world behaviour can be tuned through classroom settings, which include toggles for mob spawning, player damage, inventory retention, day-night cycle, weather, and destructive items. These settings enable educators to configure the learning environment according to the needs of their students, removing hazards and distractions as appropriate. The companion Classroom Mode application extends this control, permitting teachers to pause the world for all players, monitor student locations, and send chat messages to the entire class.

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Manual saving is available through the Save and Exit function, and worlds are automatically backed up to cloud storage upon closing. These provisions address guidelines concerning save features.

Certain advanced general guidelines remain unmet. There is no in-client mechanism for saving multiple named profiles of accessibility settings; players who share a device or who wish to switch between different configurations must manually adjust options each time. There is no way to express preferences about the use of accessibility features in multiplayer matchmaking, though this guideline may be of limited relevance in educational contexts where multiplayer sessions are typically organised by teachers rather than through public matchmaking systems.

5. Conclusions and future perspectives

Several patterns emerge from the domain-by-domain analysis. Minecraft Education aligns well with basic and intermediate GAG guidelines that address common accessibility needs: control remapping, multiple input support, text-to-speech for chat, tutorials, separate audio channels, and interface scaling. These features correspond to the provisions most frequently discussed in accessibility reviews and most commonly implemented across the game industry. The game falls short or remains partially compliant on advanced guidelines, including those concerning macros, input cool-downs, fine-grained control of motion and flash effects, VR embodiment, and symbol-based communication.

This distribution of compliance reflects broader patterns in game accessibility development. Basic guidelines address the largest populations of disabled players and involve design decisions that have become relatively standardised. Advanced guidelines target smaller populations or require more complex technical solutions, and their implementation may be deprioritised in development schedules. The result is an accessibility landscape that opens the game to many disabled players while leaving others without the provisions they require.

The theoretical framework developed in earlier sections offers a lens for interpreting these findings. Accessibility features can be understood as pedagogical operators that redistribute cognitive labour across the player-game interface. Control remapping redistributes motor demands, allowing players to couple their bodies with the game in configurations suited to their embodiments. Interface scaling and high-contrast modes redistribute perceptual demands, reducing the visual processing required to extract gameplay-relevant information. Tutorials and in-world guidance redistribute memorial demands, externalising information that would otherwise need to be held in working memory. The features that Minecraft Education implements well are those that most directly support this redistribution across common dimensions of variation.

The gaps that remain tend to involve less common dimensions of redistribution or more complex couplings. Step-turn camera control would redistribute motor and perceptual demands for players who cannot use continuous analogue input, but implementing it requires rethinking the fundamental camera mechanics. Comprehensive sound subtitles would redistribute auditory information into the visual channel for Bedrock-based editions as they already do for Java, but the technical infrastructure has not yet been extended. Symbol-based chat would redistribute communicative demands away from textual literacy, but no dedicated pictogram interface exists.

These observations suggest directions for future development. Implementing a step-turn or digital camera mode would serve players who require discrete inputs. A user-friendly game speed control accessible to students, not only to teachers with cheats enabled, would support learners who benefit from slowed pacing without requiring teacher intervention.

The evaluation also carries implications for educational practice. Teachers using Minecraft Education with diverse learners should be aware of both the accessibility provisions available and the gaps that remain. Classroom settings can remove many failure conditions and environmental hazards, supporting students who might otherwise be excluded by difficulty. Text-to-speech and Immersive Reader integration support students with reading difficulties. Control remapping and touch customisation support students with motor impairments. At the same time, students who rely on sound subtitles, who require speech input as an alternative modality, or who benefit from advanced visual accommodations may find that Minecraft Education does not yet meet their needs.

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