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COGNITIVE ACCESSIBILITY OF DIGITAL LEARNING RESOURCES A CRITICAL COMPARISON OF COGNITIVE, PEDAGOGICAL AND TECHNICAL APPROACHES

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ABSTRACT

The accessibility of a digital learning resource extends beyond its availability and technical compliance. It also involves the conditions under which learners can locate, understand and use information. This conceptual article compares approaches to digital accessibility, cognitive load, multimedia learning and Universal Design for Learning (UDL). It draws on a targeted narrative synthesis of scientific publications and institutional guidelines, analysed in terms of their focus, level of intervention and the nature of their supporting arguments. The analysis distinguishes four interdependent dimensions: access and orientation, management of extraneous cognitive load, meaning construction and self-regulation. It also identifies three design tensions: diversifying formats without increasing processing demands, providing guidance without restricting autonomy, and preserving learning objectives across adaptations. The discussion examines the approaches' convergences, differences and conditions for complementarity. A synthesis framework translates this comparison into guidance for design and evaluation. The contribution lies in moving beyond the juxtaposition of guidelines by linking each adaptation to a barrier, a hypothesised mechanism and an observable indicator. The proposed framework requires empirical testing; its transferability depends, in particular, on learner needs, instructional mediation and the material conditions of use.

Keywords: Cognitive Accessibility; Digital Learning Resources; Cognitive Load; Multimedia Learning; Universal Design for Learning.

1 INTRODUCTION

Digital learning resources play a central role in mediating knowledge. Online courses, short educational videos, e-books, simulations, learning platforms and interactive activities offer opportunities for flexibility, personalisation and the diversification of learning materials. However, multiplying formats does not, in itself, guarantee better understanding. A resource may be technically accessible yet remain difficult to navigate, interpret or remember.

This distinction suggests that cognitive accessibility should be considered a specific dimension of educational quality. It refers to the conditions that enable learners with diverse profiles, prior knowledge and self-regulatory capacities to understand how a resource is organised, identify relevant information and use it. It should not be confused with a form of simplification that impoverishes content. Rather, it involves making relationships between information explicit and reducing barriers unrelated to the object of learning itself.

Web accessibility provides essential criteria for making content perceivable and usable. Since the early recommendations disseminated by Chisholm et al. (2001), this approach has helped formalise shared design requirements. In a learning environment, however, access to content does not guarantee that students can grasp its conceptual relationships, understand instructions or transfer their knowledge to a new situation. Educational objectives therefore require us to examine what happens after a document is opened or a video is started.

This concern aligns with the holistic approach of Kelly et al. (2004), which connects accessibility in education with pedagogical purposes, usability, available resources and learner needs. It encourages examination of the resource within a learning experience. A learning material may be readable and operable yet remain difficult to use meaningfully; conversely, an intellectually relevant activity may become inaccessible because of how it is presented.

The literature draws on several frameworks to address this issue. Cognitive load theory examines the limits of working memory and distinguishes content complexity from the demands imposed by its presentation. The cognitive theory of multimedia learning analyses the conditions under which words and images can support the construction of a coherent mental representation. Universal Design for Learning encourages the provision of multiple means of engagement, representation, and action and expression. The Web Content Accessibility Guidelines help make interfaces perceivable, operable and understandable, without fully addressing educational effectiveness.

The scholarly challenge lies in integrating these frameworks. They do not describe the same object or produce the same type of evidence. A technical recommendation enables certain content characteristics to be checked; a cognitive theory explains mechanisms; a pedagogical framework organises instructional possibilities. Simply placing them alongside one another does not establish what should be changed when a learner encounters a specific barrier.

The guiding question is therefore as follows: what convergences, differences and limitations characterise cognitive, pedagogical and technical approaches to the accessibility of digital resources, and under what conditions can their contributions be integrated? The article pursues three objectives: to clarify the concept of cognitive accessibility in an educational setting, examine complementarities and tensions among the selected frameworks, and develop a framework linking design decisions to their rationale and evaluation.

The central argument is that cognitive accessibility is a relational property of the learning situation. It results from the alignment of a resource, a task, a learner and the conditions of use. This position makes it possible to consider accessibility without reducing difficulties to individual characteristics or equating inclusion with lower disciplinary expectations. The contribution takes the form of a critical comparison and a synthesis framework whose implications are intended to be tested.

2 APPROACH TO COMPARING THE FRAMEWORKS

This article is a conceptual study supported by a targeted narrative synthesis. This approach is consistent with its objective: to connect frameworks addressing different dimensions of the same design problem. Jaakkola (2020) emphasises that a conceptual contribution should make explicit the role of the theories employed and the logic of their integration. This methodological requirement is adopted here without transferring the specific objects of her original discipline to education.

References were searched for and checked using titles, authors, DOIs and terms associated with cognitive accessibility, cognitive load, multimedia learning and Universal Design for Learning. Publisher records, scientific abstracts and accessible full texts were consulted, alongside official W3C and CAST documents. Purposive selection aimed to compare the foundations, prescriptions and empirical support of the selected approaches. It does not constitute an exhaustive review of the literature.

Three criteria guided source selection: a direct connection with the problem studied, an identifiable contribution to explanation or design, and verifiable bibliographic information. Earlier studies were retained when they established a concept; more recent reviews and studies were used to discuss its scope. Institutional texts were treated as design guidelines rather than experimental findings. Where a full text was unavailable, use of the publication was restricted to information explicitly stated in its abstract or bibliographic record, without detailed interpretation of its analyses.

The analysis compares sources through four questions: what barrier is addressed, what mechanism or principle is invoked, what design decision follows, and what indicator could be used to assess its value? The comparison reveals convergences but also tensions among representation options, processing demands and control over the learning pathway. The dimensions of the framework and the implications discussed below were developed by the author from this comparison; they are not attributed to a pre-existing framework.

This approach supports discussion of the complementarities and limitations of the approaches. It does not, however, allow estimation of the frequency of practices or the average effectiveness of adaptations. Published findings are reported within their stated scope. Resource examples clarify the proposed decisions and represent neither field observations nor experiments conducted for this article.

3 CONCEPTUAL FOUNDATIONS

3.1 Defining Cognitive Accessibility

In education, cognitive accessibility introduces a question of purpose: accessible information must be understandable and usable in a learning activity. A clear interface does not guarantee that learners will understand a causal relationship presented in an animation. Conversely, an educationally relevant activity may become inaccessible if its instructions are scattered or its navigation requires unnecessary searching.

Cognitive accessibility is therefore considered here as a relational property. It depends on the interaction among resource characteristics, the assigned task, prior knowledge and self-regulation needs. This definition avoids automatically associating difficulty with an individual characteristic: the barrier may lie in the design of the resource or the absence of instructional mediation.

This relational definition should not obscure the specific needs of people with cognitive or learning disabilities. The W3C COGA note (2021) explicitly addresses these users and emphasises their participation in design and testing. It complements WCAG criteria with usability objectives and recommendations; it does not constitute an additional conformance requirement. Cognitive accessibility is thus rooted in the field of disability, even though some improvements may benefit other learners.

Within education, we distinguish three levels. Access refers to the ability to perceive information and interact with the learning material. Understanding involves constructing a coherent representation of the content and task. Appropriation refers to the ability to use this understanding in an activity. These levels are not equivalent: a student may navigate effortlessly yet develop an incorrect interpretation, or understand a concept while encountering a barrier to submitting an assignment.

This distinction helps locate difficulties without medicalising them. Instructions scattered across several files may impose avoidable memorisation; a new concept may require legitimate disciplinary effort. In the first case, the change concerns the organisation of the activity. In the second, it may take the form of an example, an explanation or scaffolding. Design benefits from identifying the nature of the difficulty before selecting a tool or format.

3.2 Cognitive Load and Prior Knowledge

Information processing requires learners to select relevant elements, organise them into a coherent representation and connect them with prior knowledge. Because working memory is limited, irrelevant elements, duplication, repeated shifts between screen areas and ambiguous instructions may consume resources that are then unavailable for understanding the concept being studied.

The review by Sweller et al. (2019) places the relationships among working memory, long-term knowledge and task characteristics at the centre of design. Intrinsic load depends, in particular, on the elements that must be processed jointly and the knowledge available. Extraneous load refers to processing demands generated by inappropriate presentation or organisation. In contemporary developments of the theory, resources devoted to productive processing are not simply a third independent load to be added to the other two.

The educational implication is not to eliminate all difficulty. It is to preserve the effort required for learning while reducing operations that do not serve the objective. This distinction invites scrutiny of the function of switching between screens, an animation or instructions that must be remembered. It also requires consideration of prior knowledge: explanatory information may be necessary for one learner but already available to another.

In a digital environment devoted to organic chemistry, Russell and Hannon (2012) investigate relationships among content complexity, presentation and performance. Their experimental design crosses levels of intrinsic and extraneous load. The reported results support reducing unnecessary presentation demands when the elements to be processed are highly interdependent. This study provides context-specific support; it does not demonstrate that any reduction in content improves learning or that an identical effect occurs for every learner population.

In our analysis, cognitive load therefore provides an explanatory mechanism, but not a general measure of inclusion. An interface that is easier to navigate may still contain a sensory barrier. Similarly, lower perceived effort may reflect better guidance or reduced engagement. Interpretation requires considering effort alongside task completion and the quality of the knowledge developed.

3.3 Multimedia Learning and the Organisation of Meaning

Multimedia can support learning when different modes of representation complement one another and each provides useful information. It can, however, cause overload when a screen simultaneously presents redundant text, narration, decorative animation and controls that are difficult to locate. The issue is therefore not to choose between text, images and sound, but to determine their function in meaning construction.

Mayer and Moreno (2003) connect several overload situations with design decisions: segmenting, preparing prerequisite knowledge, coordinating representations and avoiding irrelevant processing. Their contribution lies in linking presentation to cognitive functioning rather than attributing automatic effectiveness to the use of multimedia. From this perspective, combining text and an image is appropriate only if learners can establish the relationships required for understanding.

The meta-analysis by Rey et al. (2019), covering 56 investigations and 88 comparisons, reports favourable effects of segmentation on retention and transfer. It also identifies a reduction in overall cognitive load and an increase in learning time. This latter finding matters for accessibility: a resource that supports better learning does not necessarily lead to faster completion. Available time is part of the conditions under which learning materials are used.

The appropriate unit of segmentation is therefore a line of reasoning or an intelligible step, rather than an arbitrary duration imposed on all videos. For a procedure, separating successive decisions may be appropriate. For a demonstration, excessive fragmentation may obscure connections between arguments. We infer that a segment should be identifiable locally while remaining connected to the overall structure of the resource. Segmentation is thus a pedagogical choice that requires justification.

Meaning construction also requires distinguishing essential elements from supporting material. A diagram does not become educational merely by being present. Its function may be to compare, explain a process or represent a relationship. Evaluation should address that function: can the student explain the intended connection, or merely recognise a familiar shape? This question shifts attention from the appearance of the material to the intellectual activity it enables.

3.4 Universal Design and Self-Regulation

Universal Design for Learning proposes anticipating learner variability rather than adding adaptations retrospectively. It promotes multiple means of engagement, representation, and action and expression. In digital environments, this orientation may translate into format choice, pacing controls, options to display or hide support, and varied modes of producing work.

Version 3.0 of the CAST guidelines (2024) organises possibilities around engagement, representation, and action and expression, emphasising learner agency. In online education, Rogers-Shaw et al. (2018) discuss using this framework to improve a course for adults. These sources direct design towards anticipating variability; they do not remove the need to examine the specific barriers encountered in a given task.

The options provided must also be understandable and usable. Panadero (2017) compares several models of self-regulated learning and demonstrates the breadth of this field, which encompasses cognitive, metacognitive, motivational and affective dimensions. Self-regulation therefore extends beyond controls for slowing down or restarting. It involves setting a goal, monitoring one's activity and interpreting the feedback received.

From this perspective, we distinguish between user-controlled adaptability and automated adaptation. The former allows users to select or adjust options; the latter relies on decisions made by a system using available information. This distinction is analytical: a single environment may combine both. It prompts questions about who decides, on what basis and with what opportunity for revision.

An adaptation is pedagogically defensible when it supports achievement of the objective without permanently assigning the student to an impoverished learning pathway. A choice of support should remain reversible; a choice of format should preserve access to useful elements. Personalisation alone therefore does not resolve the question of accessibility. It requires a usable baseline design and explicit criteria for organising adjustments.

4 CRITICAL ANALYSIS OF COMPLEMENTARITIES AND TENSIONS

4.1 Complementary Frameworks Operating at Different Levels

The identified frameworks can be considered complementary. Web content accessibility provides a foundation for access and interaction; cognitive load theory helps analyse presentation demands; multimedia learning clarifies the combined use of semiotic modes; universal design extends consideration to learner variability; and adaptation allows support to be adjusted once needs have been identified.

WCAG 2.1 defines testable criteria organised around the principles of perceivability, operability, understandability and robustness (W3C, 2018). WCAG 2.2 extends these guidelines; the version used must be identified in any evaluation (W3C, 2024). These documents are not intended to measure disciplinary learning outcomes. Using them as evidence of educational effectiveness would therefore constitute an unjustified shift in the level of analysis.

Conversely, a favourable learning outcome does not demonstrate a resource's conformance. A performance comparison involving students who can all use a mouse does not establish the keyboard accessibility of the activity. Integrating the frameworks must preserve this distinction: access determines the possibility of participation, while cognitive and pedagogical analysis examines the conditions and effects of that participation.

We therefore propose a functional integration. Technical guidelines are used to verify opportunities for access and action; cognitive approaches help explain certain difficulties; UDL broadens instructional options; and self-regulation clarifies how learners use them. Integration becomes useful when it enables a specific decision to be formulated. Adding several frameworks to a bibliography does not, in itself, establish this coherence.

4.2 Diversifying Formats without Requiring Simultaneous Presentation

Diversification may address perceptual or usability barriers, but it may also increase the number of elements that must be selected and coordinated. Tension arises when the availability of several versions is equated with their permanent display. Text, narration and animation do not necessarily fulfil three different functions. The issue is to determine what should remain available and what should be presented at the same time.

Captioning illustrates this tension. A principle of redundancy reduction does not justify removing an access route required by deaf or hard-of-hearing people. In an inclusive approach, access to the message is a condition of participation. The arrangement may be adjusted, but a useful alternative should not disappear on the grounds that it would be superfluous for other users. We thus distinguish presentation redundancy from the availability of multiple access routes.

One design solution is to organise versions around the same identifiable content: a captioned video, a structured transcript and an explanation of relevant visual information. Options must remain easy to locate and their functions explicit. This proposal does not mean that every resource requires every possible format. It requires alternatives to be justified in relation to the objective and learner needs, followed by examination of their pedagogical equivalence.

Walker et al. (2017) present augmented reality as a possible means of implementing UDL and illustrate educational uses. Their contribution demonstrates opportunities for representation and support; it does not provide general evidence that augmented reality is superior. Within the framework proposed here, an enhanced technology remains subject to the same questions: what information does it add, what barrier does it resolve and what new demands does it introduce?

4.3 Providing Guidance without Creating Dependence on It

Guidance makes an activity manageable by making explicit its steps, criteria and the relationships to be constructed. It may nevertheless take over part of the reasoning that learners must gradually learn to perform. The opposition between

autonomy and support is therefore misleading: the issue concerns the type of support, its availability and the conditions for its withdrawal.

We propose distinguishing access support, which makes participation possible, from learning support, which assists the development of a competence. The former should not be withdrawn simply because a student progresses; the latter can be adjusted as knowledge becomes established. A transcript required for access to a course does not play the same role as a fully worked example used to learn a method.

This distinction suggests organising support at several levels. Students may first receive a hint about the approach, followed by a more detailed explanation if needed. The designer maintains a shared objective while allowing different scaffolding pathways. The expected effect concerns the ability to continue the task and understand its progression, rather than merely reducing the number of errors during a highly guided activity.

A difficulty remains: asking learners to choose appropriate support presupposes that they can recognise their needs. Design must therefore make the choice intelligible and provide feedback enabling it to be adjusted. In our framework, autonomy is assessed through increasingly well-founded decisions. It cannot be inferred either from the absence of teacher intervention or from the number of options displayed.

4.4 Distinguishing Educational Promise from Evidence of Effectiveness

Research on UDL does not provide a homogeneous body of evidence. Al-Azawei et al. (2016) analyse twelve studies published between 2012 and 2015; nine report positive findings, but only one examines a fully online setting, and most originate in the United States. This scope precludes using the review as universal evidence of UDL effectiveness across all digital contexts.

Capp (2017) presents a meta-analysis of empirical studies published between 2013 and 2016. More recently, King-Sears et al. (2023) examine twenty studies comparing instructional conditions, from early childhood to adulthood. Their synthesis reports a moderate positive pooled effect on achievement, with Hedges' g of 0.43. This effect concerns the interventions analysed; it is not a guaranteed gain for every resource labelled UDL.

This distinction has two implications. First, UDL should not be presented as a mere principle without empirical support. Second, overall findings do not allow the benefit to be attributed to an isolated component, such as the availability of a format choice. Interventions may simultaneously change materials, tasks, interactions and assessment methods. Accessibility analysis must therefore describe the changes actually implemented.

Seymour's study (2024) provides a complementary perspective on the redesign of an online research methods module. Students interviewed emphasise access to resources, course structure, peer exchanges and teacher communication, among other aspects. These data inform perceived experience; they should not be equated with measurement of the causal effect of each change. Comparison with experimental syntheses enriches the analysis precisely because the questions and indicators differ.

5 COMPARATIVE SYNTHESIS AND IMPLICATIONS FOR DESIGN

The comparison reveals distinct contributions to the same learning situation. WCAG and the COGA note examine conditions of access and use; cognitive load theory explains processing demands; multimedia learning specifies the organisation of representations; and UDL broadens opportunities for participation. Self-regulation provides a cross-cutting perspective on the use of choices and support. These approaches are compared in terms of their focus, mechanisms, prescriptions, supporting evidence and limitations.

Table 1 translates the findings of this comparison into design questions. It does not present a new validated model. The four selected dimensions serve to examine a resource associated with a specific task. Access and orientation concern available information and actions; extraneous load concerns unnecessary operations; meaning construction concerns relationships to be understood; and self-regulation concerns opportunities to adjust one's activity.

This combined reading avoids treating any single criterion as a general measure of accessibility. Clear navigation does not compensate for missing information; satisfaction does not demonstrate learning; and an average improvement in performance does not establish access for all users. Several indicators should therefore be retained and their possible divergences examined, without reducing them to an overall score.

A video explaining a graph illustrates these differences. The technical approach examines controls, captions and access to visual information. The cognitive approach examines unclear references and information that must be remembered while viewing. Multimedia learning calls for coordinating the explanation with the graph. UDL encourages the provision

of means of representation and expression suited to the objective. Self-regulation prompts examination of whether students understand replay options, know when to use them and can assess their understanding. This example is hypothetical and does not constitute an experimental finding.

Table 1: Design Guidance Derived from the Comparison

Dimension	Design decision	Indicators to examine
Access and orientation	Identify the objective, group instructions together and make controls accessible.	Task identification; pathway followed; access barriers.
Extraneous cognitive load	Place relevant information close together and remove operations with no instructional function.	Avoidable back-and-forth navigation; perceived effort; presentation-related errors.
Meaning construction	Make relationships explicit and preserve essential information in alternatives.	Explanation in the learner's own words; justification; application to a new task.
Self-regulation	Make support understandable, available and open to revision.	Reasons for choices; use of support; adjustments following feedback.

Source: the author's interpretive synthesis of the approaches compared. The indicators provide guidance for observation and do not constitute a validated scale.

Evaluation must respect these distinctions. An audit provides information about access, observation about use, and a justified response about understanding. Leppink et al. (2013) propose a ten-item instrument to distinguish types of cognitive load; its use in another context requires checking the language, population and measurement model. Comparing the approaches thus leads to defining indicators according to the question being asked, rather than assuming that a single measure can distinguish among them.

6 DISCUSSION

6.1 Complementarity Requires Distinguishing the Focus of Each Approach

Examining the approaches reveals a fundamental difficulty: accessibility, understanding and learning are often associated even though they do not refer to the same outcome. WCAG enables verification of access and interaction characteristics. Cognitive load theory explains processing demands in relation to the task and prior knowledge. Multimedia learning specifies the organisation of verbal and visual representations. Universal Design for Learning broadens opportunities for participation by anticipating learner variability (W3C, 2018, 2024; Sweller et al., 2019; Mayer and Moreno, 2003; CAST, 2024). These differences in focus determine the scope of their prescriptions.

A resource may therefore be keyboard-accessible and include text alternatives while leaving relationships essential to understanding implicit. Conversely, a presentation that supports learning in a given group may remain unusable for someone who cannot perceive the selected channel. Technical conformance and educational performance thus provide distinct information. Treating them as equivalent measures would risk neglecting either the conditions of participation or the quality of the intellectual activity proposed.

This distinction clarifies the value of the holistic approach of Kelly et al. (2004). It encourages examination of a resource within an educational setting, together with its objectives, users and available means. Complementarity does not, however, consist in adding recommendations together. It requires linking an observed difficulty to the framework capable of explaining it. An inaccessible control first requires an interaction correction; an explanation that is difficult to follow calls for analysis of its organisation; an unused format option prompts questions about its relevance and comprehensibility. This reasoning preserves the distinctive contribution of each approach.

6.2 The Proximity of Cognitive Approaches Does Not Eliminate Their Differences

Cognitive load theory and multimedia learning share an emphasis on information-processing limitations. Bringing them together is particularly fruitful for analysing digital resources, but their contributions do not overlap completely. Sweller et al. (2019) place relationships among working memory, prior knowledge and task complexity at the centre of explanation. Mayer and Moreno (2003) examine several overload situations associated with multimedia presentation and propose principles for organising processing. The first framework helps explain why a task becomes demanding; the second specifies how certain presentation methods may increase or limit that demand.

This difference has a design implication: modifying the learning material does not replace the knowledge required to perform the task. Segmenting a demonstration allows a step to be revisited, but does not guarantee that the student possesses the concepts involved. Similarly, removing decorative elements may reduce unnecessary demands without making an insufficiently explained conceptual relationship understandable. Before simplifying a document, it is therefore necessary to determine whether the difficulty arises from its presentation, available knowledge or the relationships learners must construct.

The findings of Rey et al. (2019) provide empirical support for this distinction between ease of use and learning. Their meta-analysis associates segmentation with benefits for retention and transfer, but also with longer learning time. Speed alone therefore cannot assess the quality of an adaptation. A resource may require more time while supporting deeper understanding. The educational challenge is to reduce processing that does not serve the task while maintaining the effort necessary for knowledge acquisition.

6.3 Diversifying Opportunities without Multiplying Barriers

UDL and cognitive approaches reveal a tension between the diversity of available pathways and the demands of using them. Diversification may address needs relating to access, participation or expression; it may also impose difficult choices, additional navigation or information that must be coordinated. This tension extends beyond the simultaneous display of formats. It also concerns how options are named, presented and linked to the task. An available alternative that is difficult to find remains of limited use.

Captioning clarifies this trade-off. For a deaf person, captions may be a condition of access to the message. Removing them in the name of a general reduction in redundancy would eliminate that opportunity for participation. For other users, their usefulness may depend on content, language or listening conditions. It is therefore necessary to examine the function of the text in the situation concerned, then improve its readability and coordination with visual elements. The availability of a necessary access route cannot be judged solely according to the preferences of the majority group.

The CAST guidelines (2024) direct design towards varied possibilities; cognitive approaches invite examination of their processing demands. Integrating them encourages identifiable alternatives that are consistent with the objective and accompanied by guidance on their use. The W3C note (2021) reinforces this attention to interface comprehensibility and user participation. The educational value of a resource then depends less on the number of formats offered than on their ability to remove specific barriers without creating new ones.

6.4 Guidance Should Be Assessed According to the Function of Support

The relationship between guidance and autonomy constitutes another apparent divergence. Cognitive approaches justify making steps explicit when unnecessary operations consume learners' resources. UDL gives prominence to choice and agency. These orientations can support one another, provided that autonomy is not equated with an unsupported learning pathway. Through a review of self-regulated learning models, Panadero (2017) recalls that monitoring activity involves cognitive, metacognitive, motivational and affective dimensions. The presence of a control option therefore does not, by itself, indicate the ability to use it.

Distinguishing access support from learning support helps clarify decisions. A transcript may remain indispensable throughout a course. A worked example, by contrast, may be adjusted as students progressively master a procedure. Applying a withdrawal logic indiscriminately to both forms of support would confuse a condition of participation with instructional scaffolding. Progress should be assessed in relation to the intended competence, with the means of access necessary to demonstrate it.

The choice of support also raises a question of interpretation. An infrequently used option is not necessarily useless: users may fail to notice it, misunderstand it or perceive it as stigmatising. These possible explanations must be investigated rather than inferred solely from usage logs. Observing practices and discussing them with learners can clarify what quantitative indicators leave unresolved. Self-regulation thus makes a cross-cutting contribution to the comparison: it shifts attention from the features offered to the decisions students can actually make and revise.

6.5 The Nature of the Evidence Limits Conclusions about Effectiveness

A rigorous comparison must account for the status of the documents used. WCAG comprises recommendations containing conformance criteria; the COGA note provides complementary guidance addressing cognitive and learning needs. Empirical studies examine effects or experiences in defined situations. Reviews bring together studies whose participants, interventions and indicators may vary. These sources therefore cannot be used interchangeably to answer questions about an approach's effectiveness.

Research on UDL illustrates this difficulty. Al-Azawei et al. (2016) describe a still limited body of research, particularly for fully online settings. King-Sears et al. (2023) report a positive pooled effect on achievement in the comparative studies they include. This finding supports the value of the interventions examined. It does not, however, allow their benefit to be attributed to a specific option or establish the superiority of UDL over other frameworks. An intervention may combine format diversification, segmentation, support and assessment redesign. The theoretical label used is insufficient to describe what was changed.

The findings of Seymour (2024) offer a different perspective by highlighting the role of course structure, resource access and interactions in the student experience. They complement examination of learning outcomes without constituting an equivalent measure. To compare design solutions, research should describe the changes implemented, maintain comparable objectives and jointly examine access, understanding and user experience. Conclusions would then concern identifiable educational configurations. Given the current body of literature, an overall ranking of approaches would exceed what the evidence supports.

6.6 Integration Must Be Tested under Local Educational Conditions

The comparison takes on particular significance when related to educational conditions. A solution that is appropriate in principle may become difficult to use if it requires unavailable equipment, a continuous connection or inadequately organised support. Dalton et al. (2019), in their discussion of inclusion in higher education, recall that professional practices and the institutional environment contribute to accessibility. The quality of the learning material must therefore be examined alongside the conditions of its distribution, updating and use.

At UNCHK and FASTEF, the approaches studied can guide a diagnostic assessment, but they do not permit assumptions about the barriers encountered. Technical examination, content analysis and discussions with users would address complementary questions. A lightweight version constitutes an improvement only if it preserves essential information; an alternative format is relevant only if it enables the intended activity to be completed. Working languages, assistive technologies and tutoring arrangements must also be documented. Contextualisation requires observations of these conditions rather than immediate transfer of findings obtained elsewhere.

The scope of this study remains that of a targeted narrative synthesis. Document selection and unequal access to full texts limit its coverage of the field. The proposed framework formalises the insights derived from the comparison; its practical relevance has not been tested. Its contribution is to make explicit the reasons for a design choice and the criteria through which it can be discussed. Future research could examine whether this integrated reading helps teams identify the barriers actually encountered, weigh sometimes competing prescriptions and improve resources together with the learners concerned.

7 CONCLUSION

The comparison shows that the cognitive accessibility of digital learning resources cannot be assessed through a single framework. Accessibility guidelines specify conditions of access and use; cognitive load theory explains processing demands; multimedia learning clarifies the organisation of representations; UDL opens opportunities for participation; and self-regulation informs their uptake. These contributions address distinct questions within the same learning situation.

The principal tensions concern format diversification, the risk of overload, the degree of guidance and autonomy. Resolving them requires identifying the barrier, preserving the objective and considering user needs. The analysis does not support an overall ranking of approaches according to effectiveness. Instead, it calls for their use to be justified according to the difficulty encountered and the type of evidence sought.

The synthesis framework translates this comparison into guidance for design and evaluation. It constitutes a discussion tool to be tested in different contexts, particularly digital higher education in Senegal. The resulting perspective is one of a reasoned integration of approaches whose relevance should be assessed jointly through effective access, understanding and learner experience.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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