

Enhancing Visual Studies Education through Hypertext-Based Interactive Video: Insights from Developing Regions

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ABSTRACT

In the context of resource-limited and culturally complex environments, such as Yemen, this study examines the use of interactive hypertext video, a type of digital learning tool that allows learners to navigate, pause, and interact with visual content, as a pedagogical approach for Art and Design education. The research aims to explore how this technology, supported by an AI-assisted video compression system developed by the researcher, can overcome bandwidth limitations and enhance visual learning. An interpretive qualitative methodology was employed, collecting data through semi-structured interviews, focus groups, and classroom observations involving 35 participants, including instructors, students, cultural leaders, and government officials from 18 universities. Thematic analysis identified three key dimensions: aesthetic mediation fostering visual reasoning, pedagogical adaptation enabling cooperative and scaffolded learning, and creative resilience transforming infrastructural constraints into opportunities for innovation. Results indicate that interactive hypertext video encourages learners to actively navigate, pause, reflect, and co-create meaning behaviors critical for artistic cognition but often neglected in high-speed digital environments. The study proposes a context-sensitive framework for integrating interactive hypertext videos in higher education, offering a practical, equitable, and sustainable approach to creative learning in developing nations.

Contribution/Originality: This study contributes to the existing literature by re-conceptualizing hypertext-interactive video as an aesthetic and cognitive medium within Art and Design education. This study is one of the very few qualitative investigations conducted in a low-bandwidth context. The paper's primary contribution is the HyperLearnX framework, which integrates visual aesthetics, creative interaction, and pedagogical scaffolding to support artistic learning under

infrastructural constraints.

1. Introduction

In contemporary Art and Design education, digital media increasingly shapes how students engage with visual knowledge and creative practice. Yet, in resource-limited contexts such as Yemen, the adoption of advanced digital tools remains constrained, and pedagogical approaches for interactive visual learning are underdeveloped. Hypertext-based interactive videos offer a unique solution, enabling nonlinear exploration of content, scaffolded learning, and engagement with layered visual information that aligns with the demands of design-oriented disciplines (Bulle, 2021).

Despite its potential, the specific role, structure, and effectiveness of hypertext interactive videos in Art and Design remain poorly defined. Existing applications often rely on linear or quiz-based formats, failing to fully exploit the medium's capacity for adaptive, exploratory, and contextually relevant learning (Magsalin, 2022; Zhang et al., 2022). Moreover, in settings affected by technological limitations, socio-cultural constraints, and inconsistent institutional support, such as Yemeni universities, the lack of structured frameworks for development and implementation further hinders effective use (Alshoibi, 2019; Sauli et al., 2018).

This study addresses these gaps by examining how hypertext interactive videos can support visual reasoning, aesthetic understanding, and creative engagement in Art and Design education. By focusing on undergraduate students and instructors, it explores the intersection of pedagogical principles, technological affordances, and artistic requirements, providing insights for the design of effective, context-sensitive digital learning tools.

To address these challenges, this study introduces HyperLearnX, an AI-assisted, low-cost hypertext interactive video platform. HyperLearnX enables high-quality, nonlinear, and visually rich learning experiences even in low-bandwidth settings, making it particularly suitable for Art and Design education in resource-constrained environments such as Yemen (Alshabi et al., 2025).

1.1. Research Objectives

This study investigates the use of hypertext-based interactive videos to enhance Art and Design education in Yemen. Using Color Theory as a case study, it examines how interactive videos can enrich aesthetic understanding, support creative reasoning, and improve learning outcomes. Additionally, the study proposes a practical framework for designing accessible, engaging, and pedagogically effective digital learning tools tailored to resource-limited and culturally diverse contexts.

2. Literature Review

2.1. Evolution of Interactive and Hypertext Video as an Artistic Medium

Interactive video is conceptualized as a transformative artistic medium that shifts learning from passive observation to multimodal visual exploration. Instead of merely delivering information, hypertext video structures create aesthetic experiences where

meaning is shaped through non-linear paths, layered content, and interpretive choice. This aligns with [Sauli et al. \(2018\)](#), who highlight how embedded hyperlinks, contextual cues, and dynamic navigation support deeper meaning-making. Hypertext video thus emerges not only as a pedagogical tool but also as a form of digital visual storytelling that encourages active interpretation ([Bai et al., 2024](#)). Yet, despite its expressive potential, the literature reveals a lack of cohesive design models guiding how interactive aesthetics should be constructed for artistic or creative education ([Palaigeorgiou et al., 2019](#); [Poquet et al., 2018](#)).

2.2. Artistic Engagement, Visual Cognition, and the Gaps in Current Scholarship

Existing studies point to several gaps between artistic intention and technical implementation in interactive video. While researchers acknowledge the rich possibilities of branching narratives, overlays, and visual cues, few studies examine how these aesthetic components shape creative thinking or visual cognition ([Palaigeorgiou et al., 2019](#)). Moreover, scholars like [Zhang et al. \(2022\)](#) and [Wei et al. \(2022\)](#) emphasize that most systems prioritize teacher-driven annotations rather than empowering learners to interact creatively with the visual interface. This indicates a missed opportunity to harness hypertext structures as creative spaces where viewers interpret, manipulate, and co-construct artistic content, an area essential for digital art education but still underdeveloped in the literature.

2.3 Contextual Constraints and the Aesthetics of Access in Developing Regions

Infrastructural limitations pose critical artistic questions regarding their impact on the aesthetics of digital learning. In contexts like Yemen, low bandwidth, unstable connectivity, and limited access to digital tools shape not only what can be taught but also how visual experiences are produced and received ([Kelly & Rossotto, 2012](#); [Tuparov et al., 2015](#)). These constraints influence file size, compression quality, color fidelity, and visual smoothness, key elements in any aesthetic experience ([Chiang et al., 2019](#); [Tekalp, 2015](#)). Studies by [Muthanna and Karaman \(2011\)](#) and [Webb \(2018\)](#) further reveal that socio-cultural factors, including gendered access to university environments, frame the digital encounter itself. Thus, hypertext video becomes a potential bridge not only technologically but artistically, allowing flexible, home-accessible, visually rich learning experiences that respond to local artistic and cultural realities.

2.4. Hypertext Video Within Digital Art and Design Practices

A growing body of scholarship underscores the value of hypertext video for enhancing artistic perception, multimodal interpretation, and creative participation. Researchers such as [Yadav and Williamson \(2024\)](#) and [Jie et al. \(2024\)](#) argue that interactive visual environments can stimulate artistic thinking, especially in communities affected by crisis or limited educational access. Similarly, studies by [Kolyvas et al. \(2024\)](#), [Rushton and Callow \(2018\)](#) highlight how digital tools expand the visual vocabulary and interpretive capacity of art learners. The study strategically selects color theory as a test case precisely because its visual nature aligns with the strengths of hypertext video, enabling learners to manipulate hue, contrast, and spatial relationships interactively a claim supported by [Cattaneo et al. \(2019\)](#) and [Zhang et al. \(2022\)](#) that through this lens, hypertext video becomes not just a tool for instruction but a medium for aesthetic exploration.

2.5. Vygotskian Mediation and the Visual-Social Construction of Meaning

According to Vygotsky's Sociocultural Theory (Vygotsky, 1978), based on participants' responses and design analysis, Hypertext video is reframed as an artistic artifact that integrates pedagogical function with aesthetic experience that mediates meaning through socially influenced visual engagement (Daniels, 2008; Tappan, 1997). Features such as hotspots, layered visuals, and non-linear sequences act as mediational tools that guide learners through a visually scaffolded Zone of Proximal Development (Pulido et al., 2021). Le Blanc and Singer's (1976) mediation models further support this interpretation by emphasizing how tools shape perception, interpretation, and creative behavior. In this sense, hypertext video functions not merely as an educational material but as a cultural and artistic interface that constructs knowledge visually, interactively, and socially. Based on participants' responses and data analysis, developing a structured framework tailored to Yemen's context is essential for harnessing these aesthetic and cognitive potentials

3. Research Methods

3.1. Research design and participants

This study adopts a qualitative research design grounded in an interpretive paradigm to explore the pedagogical, aesthetic, and technological dimensions of hypertext-based interactive video in Art and Design education. A qualitative approach is appropriate as the study seeks to generate an in-depth understanding of participants' experiences, perceptions, and contextual challenges rather than to measure predefined variables. This design allows for the exploration of multiple perspectives and socially constructed meanings, which are essential when investigating creative learning practices and digital media use within complex, resource-constrained educational environments (Braun & Clarke, 2006)

3.2. Research Location

The study was conducted across public and private universities in Yemen offering undergraduate programs in Art and Design, with a particular focus on Graphic Design education. Yemen was selected as the research location due to its prolonged infrastructural constraints, limited access to high-bandwidth digital technologies, and the pressing need for alternative, low-cost digital learning solutions. This context provides a critical setting for examining the feasibility and relevance of hypertext interactive video in visually intensive disciplines under real-world limitations.

3.3. Study Population

The study population consisted of key stakeholders involved in the design, implementation, regulation, and use of interactive video-based learning in higher education. These included academic staff, undergraduate students, interactive video developers and technical experts, and government officials responsible for higher education and digital learning policies. The inclusion of multiple stakeholder groups enabled a holistic understanding of hypertext interactive video from pedagogical, technical, institutional, and policy perspectives.

3.4. Sample Size

A total of 35 participants took part in the study. The sample comprised 5 government officials, 4 university lecturers, 8 interactive video developers and technical experts, and 18 undergraduate and postgraduate students enrolled in Art and Design programs.

3.5. Sample Size Justification

The sample size was determined based on the principle of data saturation, whereby data collection continued until no new themes or substantive insights emerged across participant groups. In qualitative research, adequacy of sample size is evaluated through informational richness rather than statistical representation. The inclusion of diverse stakeholder categories ensured sufficient depth, variation, and analytical rigor to address the research aims.

3.6. Sampling Method

A purposive sampling technique was employed to select participants with direct experience or expertise in interactive video design, digital education implementation, or Art and Design instruction. This method was appropriate as the study required participants who could provide informed, context-specific insights into hypertext interactive video use within Yemeni higher education. Inclusion criteria focused on active involvement in digital learning initiatives, instructional design, policy development, or undergraduate learning experiences.

3.7. Data Collection Procedures

Data were collected through semi-structured individual interviews, focus group discussions, and direct observations. Interviews and focus groups were conducted either virtually or remotely using platforms such as Google Meet, Zoom, WhatsApp, or phone calls, depending on participant preference and accessibility. Each interview session typically lasted 45–60 minutes, while focus group discussions ranged from 60–90 minutes.

All sessions were audio-recorded with participants' informed consent to ensure accuracy and reliability. These methods enabled the collection of rich qualitative data concerning participants' experiences, design considerations, technical challenges, and perceptions of hypertext interactive video in Art and Design education.

3.8 Data Analysis

Data were analysed using [Braun and Clarke's \(2006\)](#) six-phase thematic analysis, supported by NVivo software. The analysis process involved:

- i. Familiarisation with the data through repeated reading of transcripts;
- ii. Initial coding of meaningful data segments;
- iii. Searching for potential themes across codes;
- iv. Reviewing and refining themes for coherence and relevance;
- v. Defining and naming final themes;
- vi. Producing an interpretive account supported by representative excerpts.

Triangulation across stakeholder groups, iterative comparison of themes, and systematic documentation within NVivo enhanced analytical transparency and trustworthiness. The analysis aimed to inform the development of a practical, context-sensitive design framework, rather than to generate a grounded theory.

3.9. Ethical Considerations

Ethical approval for the study was obtained from the UiTM Research Ethics Committee (Ref. No: REC/08/2025 (PG/MR/474)). All participants were fully informed about the study's purpose, procedures, and their rights prior to participation. Written or recorded informed consent was obtained, and participants agreed to the use of their real names where applicable.

Confidentiality, data security, and professional autonomy were strictly maintained throughout the research process. In addition, the study's creative artefact, *HyperLearnX: Adaptive Hypertext Interactive Video for Low-Bandwidth Education*, was formally registered under the Malaysian Copyright Act 1987 (Notification No. CRLY2025W07508), ensuring ethical compliance with respect to intellectual ownership and creative practice.

Table 1 presents the participants who are directly quoted in this paper. Each participant is assigned a unique code, which is used in the Results section to link quotes to their respective background and expertise. All participants have given explicit consent for their names, roles, and affiliations to be published.

Table 1: Participant Profile Table – Quoted Participants and Their Backgrounds

Participant Code	Name	Role / Position	Experience / Notes
E1	Prof. Sharaf Abdulhak Alhomdy	Professor of Art and Design / Higher Education Expert, IT Dept., FCIT, Sana'a University	+15 years
E2	Rola Alhajj	Graphic Designer & Lecturer, Jordanian-Yemeni University, Graphics Dept.	5+ years
S1	Student Focus Group	Undergraduate Students	Focus group participants
E3	Elyas Almajedi	Master's in AI, Al-Razi University	Student
E4	Dr. Fekri M. Abduljalil	PhD in Computer Science, Senior Academic Expert	+15 years
E5	Fua'ad Hasan	Executive Director, Higher Education IT Center	10+ years
E6	Dr. Mohammed Alshargabi	International Accreditation Expert, PhD in Computer Science, Education Quality Expert	10+ years
E7	Prof. Mossa Ghurab	Lecturer, Sana'a University	10+ years
E8	Dr. Mohammed Al-Riyashi	Chamber of Commerce, PhD in IT, President of Yemeni Union	10+ years
E9	Dr. Abdulrahman Alsabri	Dean, Faculty of Computer Science, Sana'a University	15+ years
S2	Eman Alaqueel	Art and Design Student	Undergraduate

4. Results

4.1. Aesthetic mediation: Visual, sensory, and meaning-making processes in hypertext-interactive video

Related to Objective 1: Understanding the aesthetic and technological mediation in hypertext-interactive video-based learning. This section examines how HyperLearnX mediates aesthetic meaning-making in Colour Theory instruction. HyperLearnX functions as a visual pedagogical medium where colour, motion, hyperlinks, and interface cues guide learners' perception and understanding. From a Vygotskian perspective, these aesthetic elements act as tools guiding attention, supporting interpretation, and shaping emotional and conceptual responses.

4.2.1. HyperLearnX Features and Visual Expression

Participants interacted with a demonstrative simulation of the core features of HyperLearnX. The responses indicated that the video was perceived as a visually expressive learning environment characterized by clarity, harmony, and guided interaction. Colour harmony, visual pacing, interface minimalism, and hyperlink transitions were identified as central elements supporting engagement. Participants noted that these design features enhanced readability, facilitated understanding, and reduced the time required to process information. These perceptions are reflected in participants' own descriptions of the visual interface and its clarity:

"The interface is neat, with colors that made the questions and answers clear and easy to read." (E1)

"The video is simple and does not require extra guidance." (E2)

"Short, attractive, and easier to understand." (S1).

Table 2 presents the key aesthetic elements identified by participants and their perceived effects on learning.

Table 2: Key aesthetic elements in HyperLearnX and perceived impact.

Reported Impact	Participant Type	Aesthetic Element
Enhanced focus, clarity	Lecturers, Designers	Colour harmony
Maintains attention, reduces cognitive overload.	Students	Visual pacing
Reduces distraction, guides learning.	All	Interface minimalism
Supports conceptual navigation, active engagement	Students	Hyperlink transitions

4.2.2. Voices from the Field: Aesthetic Perception as Learning Narrative

Participants articulated aesthetic mediation as a lived learning experience, highlighting emotional, sensory, and artistic dimensions in their responses. Participants described interactivity as a key factor that transformed viewing into active cognitive engagement:

"The interactivity forces you to think, not just watch." (S1)

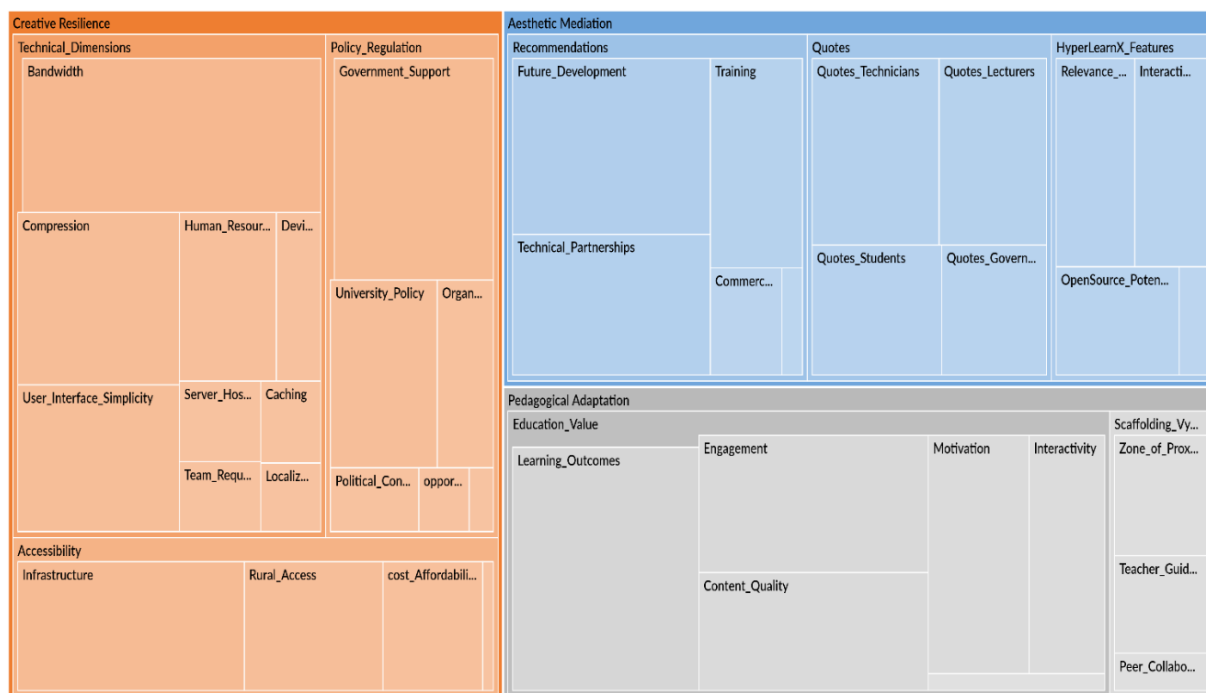
"Interaction prevents distraction; you have to respond." (S1)

"Answering a question and getting instant responses enhances understanding and saves time." (E3)

"The video guides me step by step." (S1)

The feedback emphasized that the learning environment was engaging and capable of integrating practical and theoretical perspectives simultaneously, while its interactive nature prompted active cognitive involvement rather than passive viewing. Additionally, participants noted that HyperLearnX contributed to learning efficiency, allowing users to spend less time interacting with the content while gaining a greater amount of information. Figure 1, which presents a bar chart of the most frequently occurring codes related to aesthetic cues generated using NVivo, may be inserted at this point.

Figure 1: Most frequent aesthetic cues identified in HyperLearnX



4.2.3. Recommendations for Enhancing Aesthetic Mediation

- Based on participants' feedback:
- Strengthen colour harmony and visual coherence.
- Maintain interface minimalism.
- Enhance sensory engagement via micro-animations or highlight transitions.
- Provide orientation notes for hyperlinks and interactive pauses.
- Offer adjustable resolution for different internet speeds.
- Include multiple expert viewpoints to enrich the visual narrative.

4.3. Creative Resilience: Navigating Constraints through Design Innovation

In relation to Objective 2, which seeks to explore the challenges and opportunities associated with developing digital art learning in Yemen, participants highlighted that, despite the presence of promising aesthetic qualities, the teaching and learning process remains shaped by significant infrastructural, economic, and institutional constraints. Rather than acting solely as limiting factors, these conditions were described as catalysts for creative resilience, prompting educators and learners to adopt adaptive strategies and design-driven innovations. Within this context, constraints fostered flexible pedagogical approaches and context-sensitive design solutions, enabling digital art learning to evolve through innovation, resourcefulness, and responsive adaptation to local realities.

4.3.1. Accessibility and Digital Inclusion

Participants reported that their engagement with the video was shaped by limited internet connectivity, device quality, and the cost of online access. These conditions influenced not only when and how learners interacted with the content, but also how visual, interactive, and structural design choices needed to be adapted to constrained technological environments. Participants emphasized that offline usability and low-bandwidth functionality were not merely technical requirements, but essential design considerations for achieving inclusive and accessible digital learning experiences.

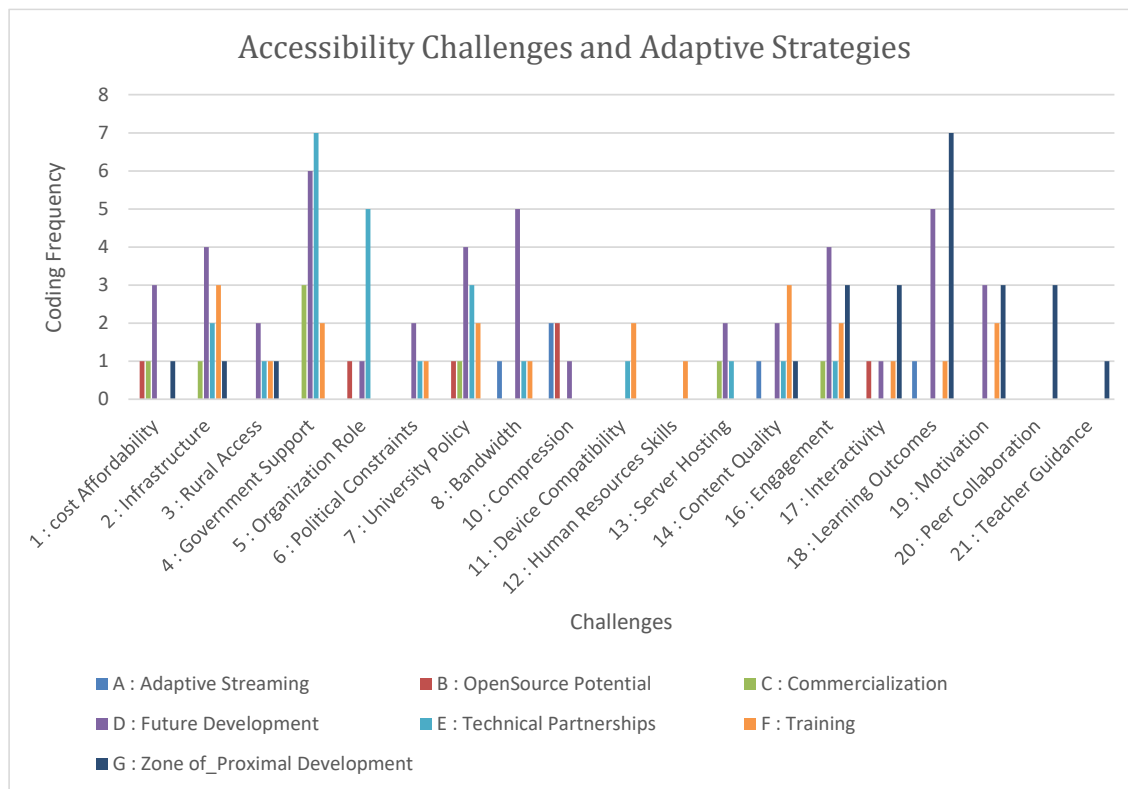
These concerns were strongly articulated by academic and professional participants working within low-resource environments:

“As long as the video is compressed and its size reduced, it is suitable for the Yemeni environment.” (E1)

“A two-hour lecture can be compressed into fifteen minutes with questions inside, and it works even with weak internet.”(E4)

As illustrated in [Figure 2](#), the horizontal axis represents key accessibility and infrastructural challenges, while the vertical axis reflects the frequency with which these challenges were associated with different adaptive design strategies. The figure shows that design responses such as adaptive streaming and compression functioned as enabling design mechanisms, allowing visual and interactive elements to remain effective under bandwidth limitations. In contrast, future-oriented development strategies were more closely linked to learning outcomes, reflecting the role of thoughtful design adaptation in sustaining engagement and meaning within digital art learning contexts.

Figure 2: Matrix Coding of Accessibility Challenges and Adaptive Design Strategies



4.3.2 Policy and Institutional Dimensions

Institutional factors played a significant role in shaping design decisions, including interface simplicity, Arabic localization, and predictable navigation.

Government officials, including participants from the Ministry of Higher Education, affirmed that interactive video could support students in remote areas, female learners with mobility limitations, and those displaced by conflict or economic hardship. E5 described HyperLearnX as “*a major societal achievement*” precisely because it responds to such real constraints.

At the policy and accreditation level, E6 emphasized that “*the future of education is inevitably digital*” and stressed that Yemen requires structured standards aligned with global accreditation criteria.

Similarly, higher education officials such as E7 reported the absence of a clear national plan and highlighted that the Ministry of Higher Education has not yet fully operationalized its regulations on e-learning.

Participants emphasized that the absence of clear policies and strategic frameworks in higher education institutions constrained effective implementation. As E1 noted: “*Higher education suffers from the absence of clear strategies... need official recognition, coordination, and support.*” (E1)

These insights highlight the critical importance of coherent institutional policies and official support mechanisms to guide the development and adoption of digital learning solutions.

Political fragmentation was also identified as a structural barrier to systematic adoption. According to E8, Yemeni higher education institutions operate under “*different*

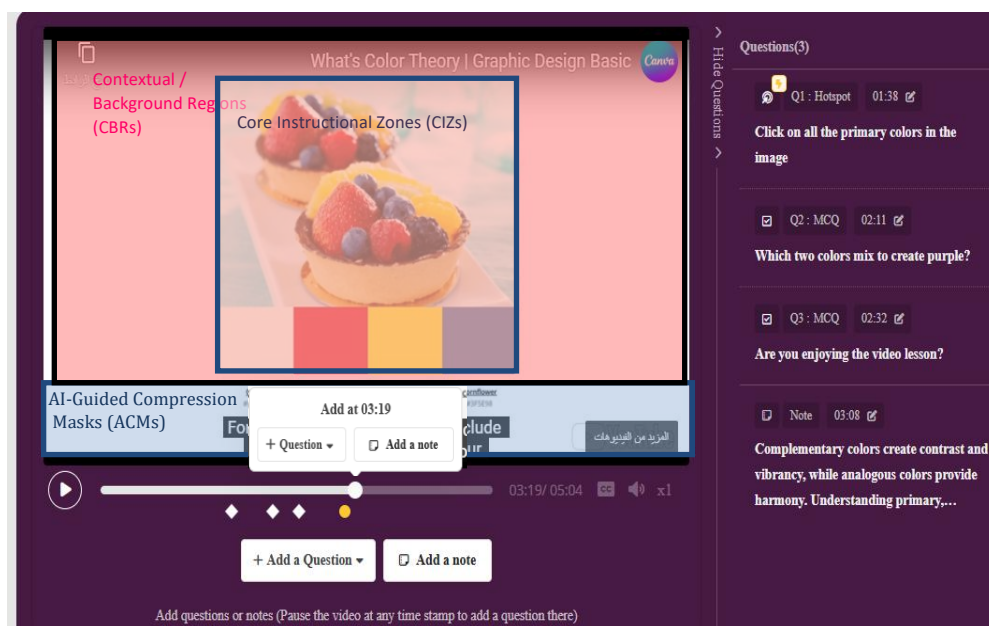
authorities with competing priorities" which complicates national coordination and unified policy implementation.

These perspectives collectively highlight the need for a unified national roadmap that transcends regional divisions and enables coherent adoption of digital learning tools across the higher education sector.

4.3.3. Technical Dimensions and Creative Adaptation

Technical constraints, including content compression, caching efficiency, server hosting limitations, and device compatibility, significantly influenced design and delivery decisions. These challenges were addressed through creative technical adaptations embedded within the HyperLearnX framework, notably SmartZone Compression and adaptive streaming, to ensure effective performance across low-bandwidth and multi-device contexts. SmartZone Compression employs AI-based semantic segmentation to identify Zones of Interest (ZOIs) within instructional video frames, enabling selective compression that preserves primary educational content while minimizing unnecessary data transmission. Adaptive streaming further optimizes delivery by dynamically adjusting content quality in response to real-time network conditions and device capabilities. Together, these mechanisms enhance accessibility, reduce latency, and support consistent user experiences in technologically constrained environments, as illustrated in Figure 3.

Figure 3: HyperLearnX Adaptive Technical Model



4.3.4. Vygotskian Scaffolding and Cognitive Mediation

Drawing on Vygotskian principles of scaffolding and cognitive mediation, HyperLearnX integrates layered pedagogical supports across aesthetic, cognitive, and social dimensions. Aesthetic scaffolding is implemented through color cues and visual hierarchy to direct learner attention, while cognitive scaffolding is realized via content segmentation, summarization, and interactive prompts that encourage active engagement. Social scaffolding is supported through teacher guidance and feedback loops embedded within the learning process. Participants highlighted the value of these

supports for self-paced and reflective learning. Expert participants further emphasized the role of interactive video in supporting revisitation and practical understanding:

“Interactive video allows students to rewatch unclear sections and supports practical understanding.” (E9).

The ability to revisit ambiguous content enhances understanding and autonomy, while students emphasized that the step-by-step guidance promotes active thinking rather than passive viewing.

4.3.5. Educational Value and Artistic Learning Outcomes

The findings indicate that HyperLearnX enhances visual comprehension, cognitive engagement, and creative learning in Art and Design education. Participants described the system as a *“mini-library inside the video,”* emphasizing the value of hypertextual links in supporting exploratory and self-directed learning.

“It feels like a mini-library inside the video.” (S1)

“This technology makes learning much easier and more accessible. For someone like me, it is not just useful, it is necessary.” (S2).

These features align with outcome-based learning principles by enabling learners to access layered information and revisit content according to their developmental needs, consistent with Vygotskian concepts of the Zone of Proximal Development (ZPD). As summarized in Table 3, pedagogical and aesthetic learning outcomes varied across participant groups but consistently highlighted improvements in engagement, understanding, and creative expression.

Table 3: Summary of Pedagogical and Aesthetic Learning Outcomes by Participant Type

Dimension	Sub-theme (NVivo Code)	Key Learning Outcome	Participant Group	Evidence Source
Pedagogical Adaptation	Learning_Outcomes	Improved conceptual understanding	Students	Focus group quotes
Pedagogical Adaptation	Scaffolding_Vygotsky	Stepwise learning support	Lecturers	Interview data
Aesthetic Mediation	Content_Quality	Enhanced visual comprehension	Students	NVivo coding
Aesthetic Mediation	Engagement	Increased cognitive engagement	Students	Positive nodes
Creative Resilience	Accessibility	Learning continuity under constraints	Technicians	Technical interviews

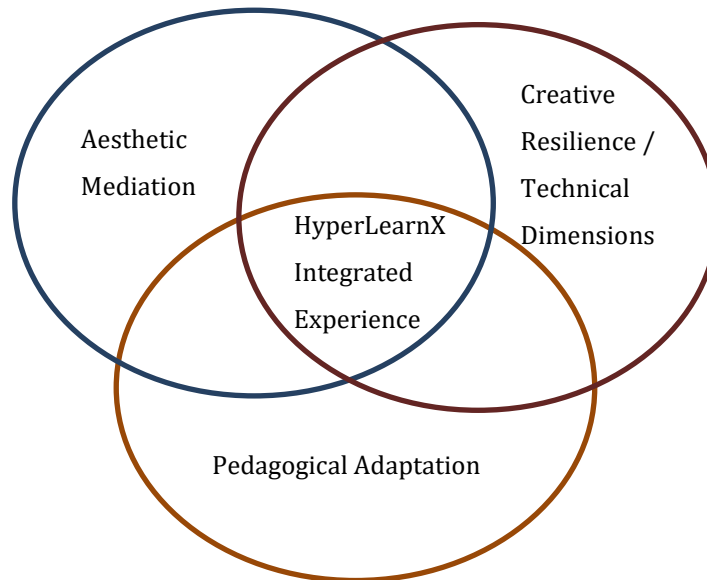
4.5. Toward an Integrated Framework for Art and Design Education

4.5.1. Synthesizing the Three Dimensions

Analysis across themes demonstrates that HyperLearnX operates through the interaction of three interrelated dimensions: Aesthetic Mediation, Creative Resilience, and Pedagogical Adaptation. Aesthetic clarity and intuitive navigation support conceptual understanding; technical constraints prompt creative and adaptive design

responses; and pedagogical scaffolding enables guided, stepwise learning. Together, these dimensions form a holistic learning environment that responds to both contextual limitations and educational objectives. Figure 4 presents a conceptual framework illustrating the integration of these three dimensions within the HyperLearnX model.

Figure 4: Integrated Aesthetic–Pedagogical–Technical Framework for HyperLearnX



The findings demonstrate that HyperLearnX functions as an integrated socio-cultural–aesthetic ecosystem, supporting scaffolded, creative, and visually guided learning within low-bandwidth contexts. By combining aesthetic mediation, adaptive technical strategies, and pedagogical scaffolding, the system addresses infrastructural constraints while enhancing learning outcomes in Art and Design education. These findings provide the foundation for the following section, which introduces a structured framework for implementing hypertext-interactive video in similar educational contexts.

5. Conclusion

This study examined the potential of hypertext-based interactive video, particularly through the HyperLearnX prototype, to enhance Art and Design education in low-resource and culturally complex environments such as Yemen. Using an interpretive qualitative methodology involving students, lecturers, developers, and policymakers, the study identified three interconnected dimensions that shape learning through hypertext-interactive video: aesthetic mediation, pedagogical adaptation, and creative resilience. Together, these dimensions demonstrate how interactive hypertext video can support visual reasoning, scaffold conceptual learning, and transform technological constraints into opportunities for innovation.

5.1. Summary of Key Findings

The results show that HyperLearnX fosters active engagement by enabling learners to navigate, pause, and interpret content at their own pace. Participants highlighted the clarity of visual cues, the usefulness of interactive links, and the system's ability to integrate theoretical and practical components of Colour Theory. Despite infrastructural limitations such as bandwidth instability and limited device capabilities, users were able to maintain consistent learning experiences through adaptive compression and interface

minimalism. Institutional gaps, particularly the absence of strategic digital education frameworks, further shaped the need for context-sensitive design and pedagogical alignment.

5.2. Theoretical Contribution

The study contributes to sociocultural learning theory by demonstrating how hypertext-interactive video functions as a mediational tool within Vygotsky's Zone of Proximal Development (Vygotsky, 1978). The findings expand the role of digital scaffolding beyond text and dialogue to include visual layering, non-linear navigation, and dynamic aesthetic cues. This positions hypertext video not only as a technological artifact but as a cultural and cognitive interface through which learners construct meaning, interpret artistic concepts, and engage in reflective visual reasoning. The study also extends existing hypervideo literature by linking aesthetic design components with cognitive and social dimensions of learning in resource-constrained settings.

5.3. Practical Contribution

Practically, the study offers a framework for designing and implementing hypertext-based interactive learning systems that accommodate low-bandwidth realities. The integration of SmartZone Compression, interface minimalism, and adaptive streaming provides a feasible model for universities seeking cost-effective digital learning solutions. HyperLearnX demonstrates how interactive video can serve as both an instructional tool and a digital "*mini-library*," offering layered content that supports self-paced learning, accessibility for marginalized learners, and flexibility for instructors. The proposed framework is directly applicable to Art and Design education and can be adapted for broader disciplines requiring visual and interactive learning.

5.4. Limitations

Although the study involved a diverse group of stakeholders, it is limited by its qualitative scope and its focus on Colour Theory within a single cultural and educational context. The HyperLearnX prototype was presented through a demonstrative simulation rather than full-scale deployment, which may influence users' perceptions of its long-term functionality. Additionally, infrastructural challenges in Yemen restricted opportunities for large-scale classroom trials, and the findings may not fully represent learners in other regions with different technological or cultural conditions.

5.5. Recommendations for Future Research

Future studies should explore the implementation of hypertext-interactive video in real classroom settings using extended longitudinal designs to measure learning outcomes over time. Comparative studies between hypertext video and other forms of interactive media, such as VR, AR, or dynamic learning platforms, could deepen understanding of how different technologies support visual cognition and creative learning. Further technical research is recommended to enhance SmartZone Compression, evaluate system performance across devices, and integrate AI-driven personalization features. Finally, expanding the framework to disciplines beyond Art and Design would help establish its broader relevance and scalability in low-resource educational environments.

Ethics Approval and Consent to Participate

Formal ethical approval for this study was obtained from the Universiti Teknologi MARA (UiTM) Research Ethics Committee (Ref. No: REC/08/2025 (PG/MR/474)). All procedures involving human participants were conducted in accordance with UiTM ethical guidelines and the Declaration of Helsinki. All participants received full information about the study and provided informed consent, including explicit consent for the use of their real names in academic publication.

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Conflict of Interest

The author declares that there is no conflict of interest regarding the authorship or publication of this article.

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