Design and Effectiveness of Text-, Visual-, and Audio-Oriented Multimedia Based on E-Learning for User Experience in Museums

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Abstract

Museum management can no longer rely on traditional archiving methods due to the dynamic development of media. A new approach is needed through digital archiving presented via interactive multimedia devices, enabling information to be delivered quickly, easily, and engagingly. The main challenge lies in ensuring the effectiveness of information delivery so that content is thoroughly understood by visitors. This study was conducted at Bale Panyawangan Diorama Purwakarta (BPDP) and Bale Panyawangan Diorama Nusantara (BPDN), employing an e-learning approach to assess the effectiveness of information delivery and a user experience (UX) framework to evaluate the quality of user interaction. The research process was carried out under conditions where the museums were deliberately arranged to be free from other visitors, in collaboration with the museum management, allowing the trials to run more focused and controlled. The findings indicate that visual multimedia formats were the most effective in delivering information, while text-based formats scored the lowest. These results highlight the significant role of pragmatic UX quality in enhancing information reception. Building on these findings, the study also proposes a follow-up design in the form of a wall projection (hyperwall) as an alternative to touchscreen devices to strengthen interactivity. The outcomes of this research and design provide a foundation for future multimedia development in museums.

Keywords:E-learning Multimedia MuseumUser experience Information effectiveness

INTRODUCTION

Interactive products have become one of the key means of delivering information and education in museums. Their presence serves not only as entertainment but also as an educational medium expected to convey information effectively to visitors. An effective interactive product should evoke positive emotions while simultaneously providing informative experiences, enabling visitors to gain enjoyment without experiencing frustration. However, if an interactive product is designed with demands for knowledge or skills beyond the users' capabilities, it may instead increase feelings of frustration. Consequently, the main challenge lies in designing interactive devices in museums that can provide both enjoyable experiences and effective information delivery (Keyson, 2008).

To address this issue, two relevant approaches can be considered: user experience (UX) and e-learning principles. UX emphasizes not only the efficiency of devices in delivering information but also how these devices affect users' feelings and experiences, as an encounter between the system and active or passive users (Wechsung & De Moor, 2014). Furthermore, Hassenzahl (in Hassenzahl & Tractinsky, 2006: 91–97) highlights two main constructs in UX: non-instrumental quality and emotional quality. The non-instrumental dimension relates to the overall quality of a product, whereas the emotional dimension concerns how the device influences the users' psychological state.

Previous studies have shown the importance of UX in interactive devices, including touchscreen-based multimedia. The operation of such multimedia is also influenced by functional aspects and the layout of menus, often referred to as usability factors. Nielsen (2010: 3) asserts that a system is considered useful if it can be employed to achieve user goals, while usability represents the extent to which users can operate the system's functions. Usability may further be described as ergonomic or pragmatic quality, referring to the effectiveness and efficiency of a device (Hassenzahl et al., 2015). Pragmatic quality may also encompass effectiveness, efficiency,

productivity, ease of use, and learnability (Hartson & Pyla, 2012). In addition to pragmatic quality, however, hedonic quality plays a crucial role in fostering positive experiences. Hassenzahl & Tractinsky (2006: 91–97) emphasize that "pleasure" is a dominant aspect of hedonic quality, representing a non-functional dimension related to motivation and a sense of novelty that affects users' emotions. Ultimately, both qualities—pragmatic and hedonic—serve as the foundation for evaluating the attractiveness of interactive products, which determines user acceptance or rejection.

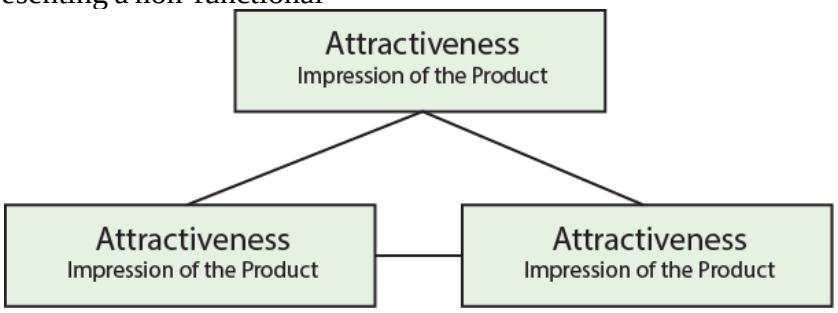

Figure 1. The Relationship between Attractiveness, Pragmatic Quality, and Hedonic Quality

Furthermore, the effectiveness of information delivery can also be understood through the framework of e-learning principles, which emphasize reducing cognitive load in the learning process. The use of multimedia is considered superior to conventional methods because it enables users to better retain information that often cannot be fully understood through a single exposure. Although the integration of text and images may increase memory load, such a combination in fact strengthens information retention. The presence of animation or illustrations accompanied by narration has been shown to stimulate memory more effectively compared to the use of text or narration alone (Nielsen, 2010).

Three fundamental principles of e-learning—multimedia, modality, and contiguity—highlight the strengths of this approach. The multimedia principle emphasizes the importance of combining words and graphics rather than relying on text alone. The modality principle demonstrates that information presented in both audio and visual formats can be processed more effectively through two distinct cognitive channels. Meanwhile, the contiguity principle stresses the placement of text and graphics in close proximity to facilitate easier comprehension (Clark & Mayer, 2008). Unlike print media, multimedia offers greater flexibility, allowing adjustments tailored to user needs.

Previous studies also confirm the effectiveness of multimedia in museum contexts. Hornecker and Ciolfi (2019) showed that interactive devices enhance visitor experience by integrating educational and entertainment aspects. Informal learning environments such as museums are particularly well-suited to fostering interest through visitor-led exploration and engaging exhibitions. Museums also provide a unique space for experimenting with novel interface designs, as exhibitions are often expected to evoke a sense of awe or wonder. These findings are consistent with Roussou and Katifori (2020), who reported that in terms of usability, simple and enjoyable interfaces are generally perceived as easier to use, even by visitors with little prior experience with touch-screen devices.

Building on these insights, this study investigates the effectiveness of touch-screen multimedia devices in museums, categorized into three types of kiosks: text-based, text-visual, and audio-visual. The research was conducted at Bale Panyawangan Diorama Purwakarta (BPDP) and Bale Panyawangan Diorama Nusantara (BPDN). The novelty of this

study lies not only in evaluating the effectiveness of information delivery based on e-learning principles but also in analyzing the quality of user experience (UX) from pragmatic, hedonic, and attractiveness dimensions. The central question concerns how these three types of devices can deliver information effectively while simultaneously providing a positive visitor experience.

The outcomes of this study are expected to serve as a conceptual foundation for designing multimedia walls (hyperwalls) that incorporate text, graphics, illustrations, sound effects, music, and narration. Although the design object differs, the researcher's focus remains on evaluating the relative influence of audio-visual components compared to text. Ultimately, the goal is to identify the most beneficial design of interactive devices that can also be used as a reference for museum development elsewhere. Thus, museums are no longer regarded merely as repositories of archives but are redefined as interactive, effective, and socially relevant public learning spaces**.**

METHOD

First, this study involved 90 respondents, consisting of visitors from the Bale Panyawangan Diorama Purwakarta (BPDP) and the Bale Panyawangan Diorama Nusantara (BPDN). Participants were asked to complete two different questionnaires as part of the data collection process. The first instrument was the User Experience Questionnaire (UEQ), which assessed three core dimensions within the pragmatic–hedonic quality framework: attractiveness, pragmatic quality, and hedonic quality. The second instrument was perceived usefulness**,** designed to evaluate the effectiveness of three approaches to delivering information through multimedia devices. The sampling technique employed was convenient sampling**,** with participants ranging in age from 18 to 35 years. This research represents an extension of a previous study conducted in 2017, enriched with updated references and new conclusions presented in a more accessible manner.

A quantitative research method was applied by dividing participants into three groups, with each device tested by 30 respondents who alternately interacted with the three multimedia formats—text-based, text–visual-based, and audio–visual-based. One device was placed at BPDP (text-based multimedia), while the other two were located at BPDN. The tested devices consisted of a text-based touchscreen, a text–visual touchscreen, and an audio–visual touchscreen.

Prior to the trial session, participants were briefed about the characteristics of the devices and the objectives of the study. Each respondent was then given approximately 5 to 10 minutes to interact with the devices in a museum environment intentionally arranged to be quiet in order to minimize distractions. After the trial, participants were instructed to complete the two questionnaires. Overall, each individual required between 15 and 20 minutes to complete all stages of testing across the three multimedia devices.

Second, the findings of this study will serve as the foundation for developing a new multimedia device to be implemented at the others museum. This preliminary investigation is considered crucial for examining the extent to which the interplay of text, visuals, and audio contributes to effective message delivery. It also provides a conceptual basis for designing the composition of text, graphics, sound effects, and narration as an integrated educational medium. Furthermore, the outcomes validate that the combination of graphics and illustrations with narration can reinforce message clarity, while highlighting the potential of the narrator's voice (audio) as a powerful element for enhancing information delivery.

Figure 2. Touchscreen multimedia devices tested

RESULT AND DISCUSSION

The comparative analysis of the three categories of multimedia reveals that text-based devices are relatively less effective in generating positive user experiences. The lower scores obtained across the dimensions of attractiveness, pragmatic quality, and hedonic quality emphasize that text-only information delivery fails to adequately meet user expectations in terms of effectiveness, efficiency, and emotional satisfaction. This finding aligns with prior studies indicating that text-based presentation often increases cognitive load and limits user engagement (Kim & Gilman, 2008).

In contrast, visual-based devices achieved higher scores across all UX dimensions, suggesting that the incorporation of graphics and illustrations enhances comprehension while simultaneously stimulating user interest. The multimedia principle in e-learning underscores that combining text with images strengthens information retention and reduces working memory load.

Meanwhile, audio-visual devices yielded the highest scores, particularly in pragmatic and hedonic qualities. The integration of audio with text and images is considered more comprehensive, as it engages two distinct cognitive processing channels—auditory and visual—thereby improving both learning effectiveness and the user's emotional experience (Moreno & Mayer, 2007). This further affirms that museum multimedia interfaces incorporating audio-visual elements are more accessible, even for users with limited experience in touchscreen technologies, without diminishing the quality of interaction.

In conclusion, differences in multimedia design approaches significantly affect user experience. Text-based multimedia tends to be suboptimal, text-visual multimedia proves more effective in capturing attention and enhancing comprehension, while audio-visual multimedia stands out as the most effective in delivering

information efficiently while providing a richer and more enjoyable museum experience. A detailed comparison is presented in the following table:

Table 1. Test result

variable	score			compare	mean diff	t-value	p-value
	text	Text-visual	Audio-visual				
attractiveness	674	961	1035	text – text-vis	-9,56	-8,40	0.000*
				Text-vis – aud-visual	-2.46	-11.39	0.090
				Audio-visual – text	-12.03	-1.72	0,000*
pragmatic quality	1360	1823	1969	text – text-vis	-15.40	-7.60	0,000*
				Text-vis – aud-visual	-4.86	-2.02	0,047*
				Aud-visual – text	-20.30	-10.80	0,000*
hedonic quality	873	1105	1146	text – text-vis	-7.73	-4.78	0,000*
				Text-vis – aud-visual	-1.36	-0.76	0,448
				Aud-visual – text	-9.10	-7.64	0,000*

The differences in scores among text-based, text-visual, and audio-visual multimedia were further examined using an independent samples t-test to determine whether significant differences existed among the three approaches. For the variable of *attractiveness*, the results indicated no significant difference between text-visual multimedia and audio-visual multimedia, with a p-value ≥ 0.05 ($p = 0.090$). Similarly, for the variable of hedonic quality, the results showed no significant difference between text-visual and audio-visual multimedia, with a p-value ≥ 0.05 ($p = 0.448$). Detailed test results for both variants are presented in the following table.

The t-test results demonstrate that the differences between text-visual multimedia and audio-visual multimedia are not statistically significant for either attractiveness or hedonic quality. This suggests that both approaches to information delivery exhibit comparable levels of effectiveness in creating positive user experiences. In other words, the addition of audio elements to visual-based multimedia does not necessarily yield a significant improvement in attractiveness or emotional experience, even though, in general, the scores for audio-visual multimedia are slightly higher. However, in terms of pragmatic quality—which relates to device operation and usability—audio-visual multimedia was found to be more favorable. For

greater clarity, the results are summarized in the following table.

Table 2. Conclusion from the Visitor Assessment

Variabel	Attractiveness	Pragmatic Quality / Usability	Hedonic Quality / Playfulness
Device presenting data predominantly in text	Low level of interest	Low level of interest	Low level of interest
Device presenting data/content with a combination of visuals (graphics and appealing elements)	Significant effect	Low interest	Significant effect
Device relying on audio-visuals (animations/videos)	Significant effect	Significant effect	Significant effect

These findings can be interpreted through User Experience (UX) theory, which highlights that hedonic quality is primarily shaped by the match between user expectations and the experience itself, rather than the addition of extra features (Hassenzahl & Tractinsky, 2006). When visual elements already fulfill users' needs for enjoyment and engagement, audio does not necessarily produce significant improvements. From the perspective of e-learning, this aligns with the modality principle, which argues that combining text, visuals, and audio reduces cognitive load by distributing information across auditory and visual channels (Clark & Mayer, 2014). However, if the cognitive load has already reached an optimal level through visuals, the addition of audio may not further enhance emotional aspects such as attractiveness or hedonic quality.

Despite this, audio-visual multimedia still offers a richer experience overall. Interestingly, in the museum context, visitor appreciation for "text-visual" and "audio-visual" approaches does not differ significantly, reflecting the museum's role as a non-formal learning space where enjoyable engagement often outweighs formal instructional structures. Therefore, the effectiveness of museum multimedia depends not only on e-learning principles but also on emotional involvement and interactivity.

In conclusion, audio-visual multimedia was rated most highly by visitors, reinforcing its value as the most effective medium for information delivery in museums.

Design of the Hyperwall for the Horticulture Museum in Purwakarta

Based on this study, the author developed a design derived from the survey conducted previously in 2017 using the same dataset. These findings suggest that information related to e-learning can be optimally received by users when both text–visual and audio–visual aspects are incorporated into the design of the hyperwall at the Horticulture Museum, Purwakarta.

The hyperwall designed in this research is conceived as a large-scale interactive medium intended to present educational content in public spaces, particularly museums and thematic exhibition halls. The displayed content encompasses various topics, including the Horticulture Village, seedling activities, Indonesian vegetable horticulture, plant pests and diseases, as well as fish processing and marketing. The selection of these themes is grounded in the need to deliver information that is engaging, easily comprehensible, and relevant to agricultural and food security issues in Indonesia.

Drawing on previous studies, audio–visual aspects have been shown to significantly

influence users' levels of engagement and enjoyment when interacting with digital media (Hassenzahl & Tractinsky, 2006; Nielsen, 2010). Accordingly, the hyperwall is designed on a larger scale to generate a stronger visual impact while simultaneously facilitating a more immersive learning experience.

From a technical standpoint, the hyperwall operates using capacitive sensor technology embedded behind the images. When users touch a specific area of the projected or printed surface, the system responds by transforming static visuals into animations that provide more detailed information. This interaction is managed by a microcontroller—Arduino in this case—programmed with a dedicated language to control media transitions. Through the integration of both hardware and software components, the hyperwall is capable of delivering an interactive experience that simultaneously combines visual, auditory, and kinesthetic dimensions.

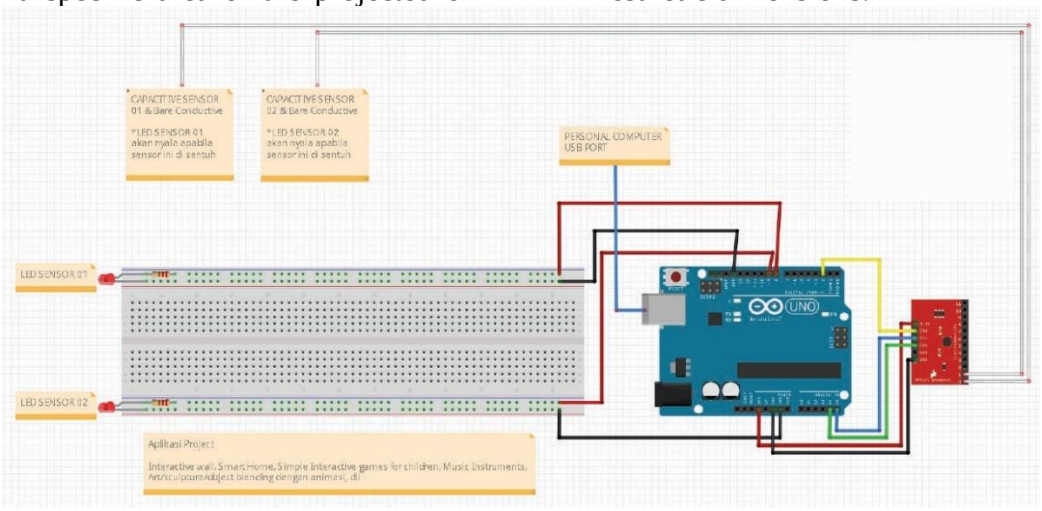

Figure 3. Cencor sheme to arduino.

From a user experience (UX) perspective, the hyperwall design fulfills three essential aspects: attractiveness, pragmatic quality, and hedonic quality. The presence of interactive animations enables visitors not only to receive information passively but also to engage actively in exploring the content. Meanwhile, from the perspective of e-learning, the use of such interactive media reinforces the modality principle, namely the simultaneous processing of information through both auditory and visual channels, thereby enhancing learning effectiveness (Mayer, 2003).

Thus, the hyperwall functions not merely as an information delivery tool but also as an innovative learning medium that combines education and entertainment (edutainment). This aligns with the notion that informal learning spaces such as museums can serve as ideal environments to experiment with new interface designs that inspire and provide extraordinary experiences for visitors.

Figure 4. Interface design (top) before interaction; (bottom) after touch input, displaying an interactive animation.

The development process of the hyperwall was carried out through several stages. First, the content design stage, which involved collecting visual, textual, and audio data related to horticulture and fisheries materials. The collected content was then processed into digital illustrations and interactive animations using graphic design software and vector-based animation applications. Second, the interaction system design stage, in which capacitive sensors were installed behind the image panels. These sensors functioned to detect user touch and transmit signals to the microcontroller. Third, the microcontroller programming stage, in this case using Arduino, which was coded to regulate the visual transition from static images into animations according to the designated touch points.

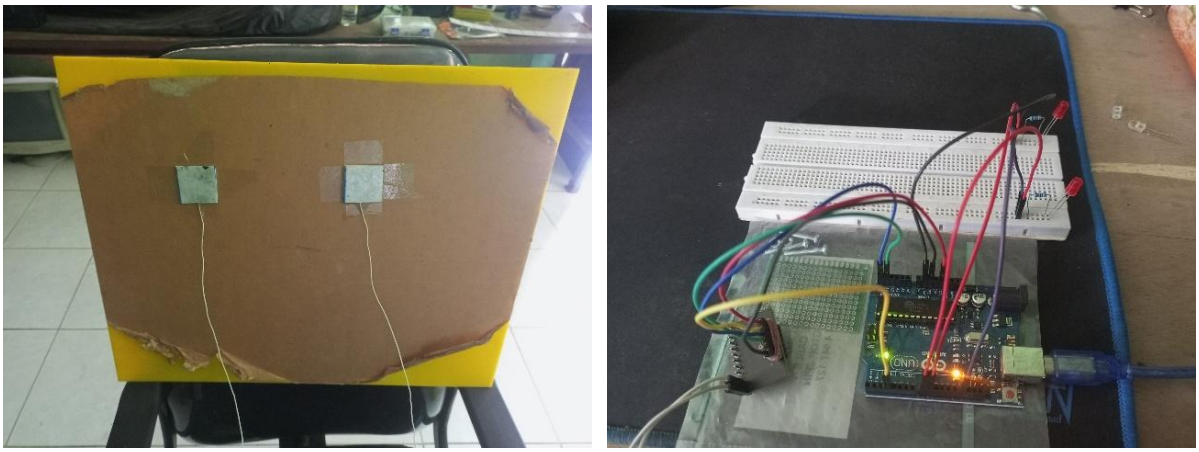

Figure 5. Placement of Sensors Behind the Panel Medium Connected to Arduino

Figure 6. Hyperwall result

The developed hyperwall prototype was successfully operated in accordance with the initial design specifications. All capacitive sensors embedded behind the image panels responded accurately to user touch and reliably transmitted signals to the Arduino microcontroller. The transition from static images to interactive animations occurred smoothly without noticeable delays, thereby ensuring a more natural user interaction experience. Trial results also demonstrated that the integrated audio-visual system enhanced the delivery of information in a more engaging manner while simultaneously increasing visitor involvement in exploring the content. This entire process was grounded in prior research, which highlighted the effectiveness of audio-visual elements in improving visitor experience. The successful operation of the prototype confirms that the design is not only technically feasible but also effective in supporting educational objectives through interactive multimedia in museum settings.

Research Implications

The findings of this study provide significant implications for the future design of

interactive museum technologies. First, the integration of capacitive sensors with audio-visual content can be considered a reliable alternative to touchscreen-based systems, particularly in large-scale installations such as hyperwalls. Second, the smooth transition between static and animated content demonstrates the potential of interactive media to reduce cognitive load while enhancing engagement, in line with e-learning principles. Finally, this research highlights the importance of balancing pragmatic and hedonic qualities in user experience design, suggesting that interactive hyperwalls can simultaneously serve as tools for education and entertainment (edutainment). These insights may guide museum curators, designers, and educators in developing more immersive and impactful learning environments.

CONCLUSION

The findings of this study indicate that audio-visual–based multimedia received the highest level of appreciation from visitors as the most effective medium for conveying information in archival museums. This conclusion is drawn from research conducted at the Bale Panyawangan Purwakarta Museum (BPDP) and the Bale Panyawangan Nusantara Museum (BPDN), both of which feature diverse touchscreen multimedia kiosks under controlled conditions. Interactive and engaging visuals were found to not only enhance the effectiveness of information comprehension but also to create enjoyable user experiences. However, regression analysis revealed that only in the case of audio-visual–based multimedia did the attractiveness variable demonstrate a significant influence on perceived usefulness. In contrast, no direct relationship between UX dimensions and perceived usefulness was identified in text-based or text–visual multimedia. These findings suggest that the perceived usefulness of multimedia devices is shaped not only by the effectiveness of information delivery but also by the degree of emotional engagement and aesthetic appeal offered by the system.

When interpreted through the lens of Clark and Mayer's (2014) modality principle, these results remain consistent. The principle highlights that presenting information simultaneously through audio and visual channels reduces cognitive load during learning. In this study, while text–audio multimedia showed some contribution in terms of attractiveness, audio-visual multimedia emerged as the most dominant in fostering a comprehensive and informative experience. Thus, audio-visual elements can be regarded as central to visitor engagement, although in the context of museums as informal learning spaces, emotional involvement and visitors' visual preferences further reinforce the educational effectiveness of multimedia.

This aligns with Hassenzahl and Tractinsky's (2006) perspective, which emphasizes the role of hedonic qualities in generating positive experiences, and with Keyson's (2008) view that interactive systems must avoid frustration and align with user expectations to be considered useful. Accordingly, the results underscore that multimedia design in museums should account for both pragmatic and hedonic qualities in order to achieve effectiveness.

Beyond the specific museum context, these findings provide an empirical foundation for the design of multimedia systems in general and the hyperwall in particular. By confirming the critical role of audio-visual integration in enhancing both perceived usefulness and user experience, this study establishes a rationale for prioritizing dynamic visual content, animation, and narration in large-scale interactive systems. In the case of the Purwakarta Horticulture Museum, the hyperwall design builds upon these insights to deliver immersive, engaging, and educational experiences that merge text, graphics, and audio into a coherent interactive learning environment.

ACKNOWLEDGMENT

The author gratefully acknowledges the invaluable guidance, constructive

suggestions, and active participation provided by all parties who contributed to the completion of this article. Their support, both academically and practically, has been essential in ensuring the quality and completion of this research.

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