



**HAL**  
open science

# Usability Evaluation of Integrated and Separated Interfaces in an Immersive Authoring Tool based on Panoramic Videos

Daniel Xuan Hien Mai, Guillaume Loup, Jean-Yves Didier

## ► To cite this version:

Daniel Xuan Hien Mai, Guillaume Loup, Jean-Yves Didier. Usability Evaluation of Integrated and Separated Interfaces in an Immersive Authoring Tool based on Panoramic Videos. *IEEE Transactions on Visualization and Computer Graphics*, 2025, 31 (5), pp.2475–2483. <10.1109/TVCG.2025.3549127>. <hal-04983859>

**HAL Id: hal-04983859**

**<https://hal.science/hal-04983859v1>**

Submitted on 11 Apr 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

# Usability Evaluation of Integrated and Separated Interfaces in an Immersive Authoring Tool based on Panoramic Videos

Category: Application papers

## ABSTRACT

Immersive authoring tools have emerged as key enablers for trainers-designers to create Virtual Reality Learning Systems (VRLS) without requiring extensive programming skills. However, the design of such tools presents significant challenges in terms of interaction, usability, and interface complexity. These challenges underscore the need to validate an appropriate design interface to ensure these tools can be effectively utilized by non-technical users. This study evaluates the usability of an immersive authoring tool for VRLS using interactive panoramic videos. Two types of interfaces were compared: one that integrates storyboarding and rendering visualization, and one that separates these functionalities. Quantitative and qualitative data were collected from 24 participants divided into two groups. The results indicated that the separated interface was more effective, efficient, and satisfactory, particularly for more complex scenarios. Moreover, the integrated interface led to more pronounced symptoms of cybersickness while motivation levels did not differ significantly between the two groups. These findings highlight that integrating all functionalities into a single interface may not always be the best approach, especially for complex tasks, as it can lead to decreased usability and increased physical discomfort.

**Index Terms:** immersive authoring tool, virtual reality learning systems, usability, panoramic videos, user experience, storyboarding, rendering visualization.

## 1 INTRODUCTION

The advent of Virtual Reality Learning Systems (VRLS) has significantly transformed the landscape of educational technology. These systems utilize the immersive capabilities of virtual reality to create engaging and interactive learning environments [24]. To facilitate the creation of these systems, authoring tools have been developed [9, 27], enabling trainers-designers to build VRLS without requiring extensive programming knowledge. These tools are essential for allowing non-technical users to design, develop, and personalize various types of digital content.

Among these authoring tools, a notable distinction can be made between traditional Windows, Icons, Menus, Pointer (WIMP) interface tools and immersive authoring tools. While traditional WIMP tools rely on conventional desktop interfaces, immersive authoring tools allow trainers-designers to create interactive content within the virtual reality environment itself [32]. This capability provides a unique advantage, as it enables trainers-designers to instantly visualize the results of their work from a perspective identical to that of the learner, thereby facilitating a more effective and engaging content creation process [7].

VRLS use interactive panoramic videos to build virtual environments that create a stronger sense of presence for learners [5]. This approach not only enhances the immersive experience but also reduces the technical skill requirements associated with 3D environment modeling for trainers-designers [18]. Therefore, it is necessary that immersive authoring tools provide an integrated and intuitive authoring environment that covers designing, managing scenarios, configuring interactions, and testing results [6]. Proper user interface and interaction design are essential to achieving this goal.

Therefore, ensuring the usability of these tools is an important aspect that warrants careful consideration. A thorough assessment

is needed to understand their impact on effectiveness, efficiency, and user satisfaction. By identifying design solutions that reduce obstacles and complexities in creating and interacting with virtual environments, we can mitigate cognitive overload in certain scenarios. Notably, few studies have focused on evaluating how different interface designs affect cognitive load and cybersickness, particularly in complex virtual reality environments. This gap highlights the need for research comparing various interface designs to provide a more comprehensive understanding of their impact on usability in immersive systems.

This study presents experiments that develop VRLS with scenarios of varying complexity, using two different types of interfaces: one that integrates storyboarding and rendering visualization, and one that separates these functionalities. Through the collection and analysis of quantitative and qualitative data, this study evaluates user effectiveness, efficiency, satisfaction, cybersickness, and motivation.

In Section 2, we review the current state of immersive authoring tools, beginning with a discussion on authoring tools for VRLS, highlighting usability challenges and technical complexities. We then shift focus to immersive authoring tools that use interactive panoramic videos, exploring how these tools facilitate scenario creation while maintaining user engagement and immersion. Section 3 introduces our research hypotheses, comparing the usability of integrated and separated interfaces on an immersive authoring tool that has been customized to meet the specific objectives of the experiment. Section 4 outlines the experimental design, detailing participant selection, the tasks performed, and the evaluation methods for measuring usability, cybersickness, and motivation. Section 5 presents the experimental results, including quantitative and qualitative data, with a focus on task completion, execution time, satisfaction, motivation, and cybersickness symptoms. Section 6 provides a detailed discussion of these findings, comparing them to prior studies and offering observations on the usability of different interface types. Finally, Section 7 concludes the paper by summarizing the key results and proposing directions for future research to further enhance the usability of immersive authoring tools in educational contexts.

## 2 BACKGROUND AND RELATED WORK

### 2.1 Authoring tools for virtual reality learning systems

An authoring tool is defined as a software system that allows non-programming users to design, develop, and personalize various types of digital content. In the context of digital education, it provides an intuitive user interface and automation features to support the creation of educational content, define learning activities and assessments, and manage interaction and collaboration between learners and educational content [10, 21, 23].

To provide a comprehensive classification of tools used for creating VR/AR environments, Nebeling & Speicher [22] categorized existing platforms into five classes based on two criteria: (1) the skills and resources required, and (2) the level of fidelity in AR/VR. Their review evaluated a total of 18 tools, covering a wide range from basic authoring platforms to complex development environments. While some of these tools, such as Unity3D and Unreal Engine, require advanced programming skills, others, such as HoloBuilder and Proto.io, are more accessible to non-technical de-

signers. This distinction is essential for selecting the appropriate tools based on user needs and technical capabilities.

Several studies offer solutions to simplify and make the design of interactive scenarios in virtual reality more accessible, focusing on trainers-designers with limited programming skills. The SAVE (SAfety Virtual Environment) authoring tool allows trainers to collaboratively create and test virtual environments, both on traditional interfaces for scripting and in VR for rendering visualization [15]. This dual approach significantly reduces development and adaptation time but also presents communication challenges during collaboration, which can lead to cognitive overload for the trainer using the VR interface, especially when the complete structure of complex scenarios cannot be fully memorized.

Another study on collaborative design introduced the Spacetime authoring tool to control interactive empowerment while facilitating flexible collaboration among multiple users [30]. The results showed that trainers-designers tend to regularly review previously completed design work. The choice between simultaneously displaying complete or partial scenario information and interaction information can influence the trainer's perception and decisions regarding the actions required to build the scenario.

A solution to reduce the technical complexity of the scenario creation process is to break down tasks into specific requirements [31]. This can make it easier for non-technical users to develop interactive VR scenes, making usability assessments more objective. While the web-based authoring tool VREUD [31] is built on top of the A-Frame library, the immersive authoring tool FlowMatic [32] employs Functional Reactive Programming (FRP) diagrams to facilitate behavior creation. Research has demonstrated significant usability advantages compared to traditional interface tools, thanks to a more intuitive interface and a reduced learning curve for novice developers.

For FlowMatic, although immediate feedback is considered an advantage, it can also pose difficulties when trainers-designers accidentally trigger interactions while adjusting prototypes. This necessitates a distinct mechanism to switch between editing mode and execution mode.

In summary, while various authoring tools for VR/AR environments have been developed, they often present challenges for non-technical users, particularly in terms of usability and the need for technical skills. Understanding these limitations and the strengths of existing tools is crucial. This analysis provides a foundation to identify gaps and opportunities for improvement in the design of immersive authoring tools. By examining the usability and user experience issues highlighted in previous studies, this research aims to develop an interface that simplifies the creation of interactive scenarios and reduces cognitive overload, thereby enhancing the effectiveness of immersive authoring tools.

## 2.2 Authoring tools using interactive panoramic videos

Specific studies on panoramic videos also offer interesting perspectives. Adão et al. [1] explored design methods for integrating interactions into panoramic videos, emphasizing the importance of immediate user feedback to maintain engagement and immersion. Their work showed that real-time visualization of modifications in a virtual environment significantly improves the accuracy and efficiency of educational scenarios.

Coelho et al. [8] presented a collaborative immersive tool enabling real-time creation of VR experiences, highlighting the importance of real-time collaboration to improve the efficiency of creative processes. Another study evaluated three different interfaces (desktop, immersive, and tangible) for creating 360-degree multi-sensory videos [7], they demonstrated that immersive and tangible interfaces offer better user satisfaction and presence compared to traditional desktop interfaces, which allow for faster task completion due to users' familiarity with keyboards and mice. In 2022,

they conducted a systematic review of authoring tools for virtual reality experiences, analyzing 29 studies, identifying the strengths and weaknesses of different approaches, and emphasizing the need to develop more intuitive and integrated tools to improve the user experience [9].

As a result, it is necessary to examine and evaluate different user interface designs to determine the most appropriate design approach to improve the usability of authoring tools when creating 3D interactive scenarios. This study focuses on the seamless integration of storyboarding and rendering visualization in an immersive authoring tool using panoramic videos, which is expected to enable effective creation and adjustment of scenarios.

## 3 RESEARCH HYPOTHESIS

In the context of this research, the design of the immersive authoring tool for VRLS using panoramic videos includes two primary functionalities: (1) The Storyboarding function allows trainers-designers to create and organize different elements of the scenario, such as scenes and transitions between them, through simple drag-and-drop operations. These transitions define the flow of the scenario, enabling users to build complex, branching narratives. (2) The Rendering Visualization function enables trainers-designers to add and customize additional objects within the panoramic videos. Users can adjust properties such as size, color, and behavior, providing flexibility in creating interactive and dynamic VR environments.

We consider two interface approaches for these functionalities: integrated and separated. The integrated interface combines storyboarding and rendering visualization into a single workflow, while the separated interface divides these tasks into distinct modules, allowing users to focus on one task at a time. Both approaches are implemented entirely within the VR environment. Understanding these differences is crucial for evaluating their impact on usability. Our experiment explores how these interface approaches affect user performance, satisfaction, and overall experience.

Our first hypothesis (H1) suggests that differences in the interaction interface, whether integrated or separated for storyboarding and rendering visualization, will lead to differences in usability between them. Previous research on multi-layer interface design indicates that integrated interfaces can enhance efficiency by reducing the effort required to switch between tasks, providing a more seamless user experience [26]. However, this benefit could be limited by the potential for cognitive overload when handling more complex tasks. On the other hand, separated interfaces allow users to concentrate on individual tasks, which can improve task effectiveness [20]. Based on these findings, we expect to observe differences in usability, with integrated interfaces favoring efficiency and separated interfaces favoring effectiveness.

Our second hypothesis (H2) suggests that there will be no significant difference in cybersickness symptoms between the two interface conditions, both of which involve using a VR headset. Cybersickness is primarily caused by factors such as sensory mismatch, frame rate, latency, and field of view [25]. Both the integrated and separated interfaces in this study operate within the same VR environment, using identical hardware and display settings. The key difference between the interfaces lies in the amount of data or objects displayed at any given time, rather than in the visual or sensory signals. Since these factors are the primary contributors to cybersickness, we do not expect a significant difference in symptoms between the two interface conditions.

Our third hypothesis (H3) assumes that participants using the integrated interface will be more motivated than those using the separated interface in this experiment. Seamless interaction within virtual environments can enhance user engagement and motivation by minimizing task-switching and providing a more fluid experience [28]. Integrated interfaces may help maintain focus by reduc-

ing workflow interruptions. In contrast, separated interfaces could require more task-switching, which might affect user motivation.

## 4 METHOD

### 4.1 Participants

The participants in the experiment, ranging in age from 21 to 56 with an average age of 34, were divided into two groups corresponding to two types of VR interfaces, with each group consisting of 12 participants. The age distribution was balanced between the two groups. All participants were proficient in French, ensuring adequate understanding of the information presented in the language and the ability to engage in conversations throughout the experiment.

In terms of prior experience with virtual reality (VR), 12.5% reported using VR headsets daily, 12.5% weekly, 16.67% monthly, and 58.33% had used them less frequently. Regarding VR applications, participants were allowed to select multiple categories. The most common uses included training and simulation (55%) and video games (45%), followed by cultural discovery (cinema, museums, etc.) at 20%.

The experiment was approved by the Research Ethics Committee of *Anonymous* University. All participants provided informed consent before participating in the study, including details on confidentiality rights, potential benefits, and risks. They were informed about their right to withdraw from the study at any time without any consequences, and all data were anonymized to ensure confidentiality.

### 4.2 Immersive authoring tool Wixar

Wixar [29] is a multi-platform authoring tool, offering a range of options for creating scripted content for interactive panoramic videos. We used version 2.0-beta.1 of Wixar, released in November 2023. The application design process by the trainers-designers includes three phases: 1) Adding media resources, such as panoramic videos, audios, and 360 images, 2) Integrating and configuring the interaction objects and scenario, and 3) Releasing applications.

In this experiment, different panoramic video scenes were provided, and an overview of the scenario to be played was presented to the participants beforehand.

The devices used in this experiment included: two Meta Quest 2 headsets equipped with the Wixar 2.0-beta.1 VR authoring tool with minor display adjustments between the two versions.

### 4.3 VR interfaces

Wixar VR interfaces are designed with a focus on ease of use and consistency. This ensures that both groups of participants (those using the integrated and separated interfaces) can interact with the system seamlessly. The VR interfaces allow trainers-designers to manage 360-degree videos and interactive scenes directly within the virtual environment. The toolbar provides options for accessing scenario management tools and configuring the environment (as shown in Fig. 1). Regardless of the interface type, the interaction processes, such as selecting resources, editing scenarios, and testing, remain uniform across both groups.

Trainers-designers are presented with a 360-degree view of the environment, which can be explored simply by rotating their head or body. Additional objects have the same customizable interface across both types of interfaces (Fig. 2), ensuring that all interactions follow the same consistent steps.

Key difference in content display: despite the consistency in the toolbar and interaction processes, a key difference between the integrated and separated interfaces lies in the way the scenario information is displayed.

For participants using the integrated interface, the scenario information is shown on a transparent panel that overlays the 360-degree environment. This transparent design allows trainers-designers to

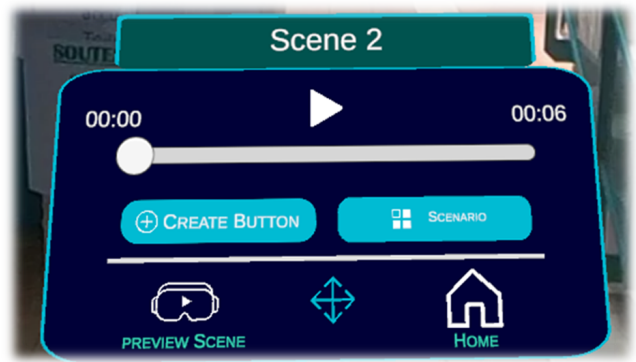


Figure 1: Toolbar of Wixar VR interface



Figure 2: Color picker of additional object (button)

access and review the scenario information without obstructing their view of the panoramic video and other additional objects within the virtual environment. This helps maintain a continuous sense of immersion, as trainers-designers can still interact with the environment while accessing scenario details (Fig. 3).

In contrast, participants using the separated interface experience a different approach to scenario information display. When the scenario information panel is opened, a full overlay is activated (Fig. 7 a), which temporarily blocks out the 360-degree environment, including the panoramic video and any additional objects (Fig. 7 b). This requires trainers-designers to focus solely on the scenario details without any distractions. They can switch between the environment and the scenario panel through the scenario option on the toolbar (Fig. 1).

The preview mode allows trainers-designers to review their scenarios in real-time within the VR environment, ensuring that changes made to the interactive elements can be visualized immediately. Additionally, the use of simple drag-and-drop operations when creating or editing scenes (Fig. 4), combined with clear navigation options, allows for a consistent user experience. These features were designed to ensure that both groups of participants experience a cohesive and intuitive workflow, despite the differences in the way content is displayed.

### 4.4 Scenario and procedure

A technical presentation of the equipment and software was conducted using an explanatory video. The participants were equipped



Figure 3: Transparent panel displaying scenario information in the integrated interface

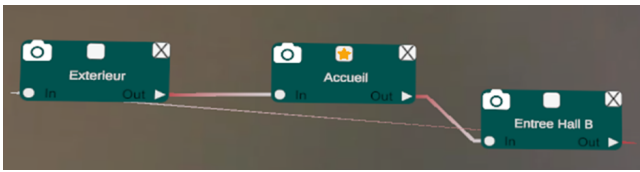


Figure 4: scene creation and editing using drag-and-drop operations

with an Oculus Quest 2 headset, and the Wixar 2.0-beta.1 application was launched.

To begin, a tutorial invited the participants to perform a demonstration mission to familiarize themselves with the interface, features, and basic requirements of the experiment.

The mission context is to create a VR application allowing new students to visit a university building using pre-recorded panoramic images and videos. These images and videos need to be linked together by adding additional objects to each scene (rendering visualization) and configuring the scenario (storyboarding). Fig. 5 is a simple diagram of the building and the scenario pathway.

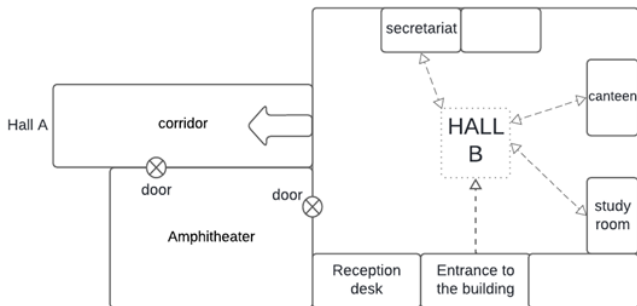


Figure 5: Simple map of the building

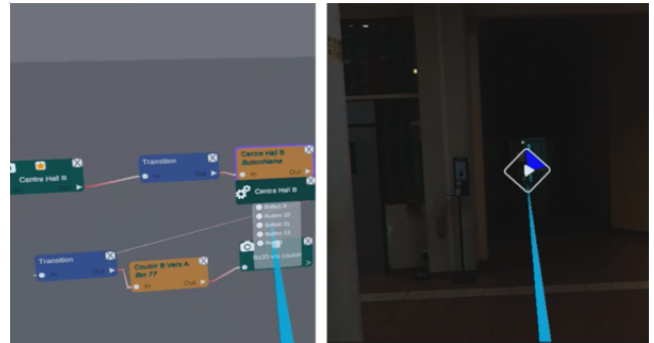
The scenario is divided into three missions: (1) The first mission involves creating a simple linear scenario where the path starts from the entrance, goes through the central corridor, and reaches the building’s hall. This scenario requires minimal decision-making and straightforward navigation. (2) The second mission introduces a branching scenario where, from the hall, additional objects (Fig. 7b) allow access to different areas such as the secretariat office, the canteen, and the study room, then return to the hall. This scenario requires more interaction and decision-making as partici-

pants must create different branches. (3) The final mission involves a looping scenario where participants start from the hall, go through a long corridor to reach another area, and encounter a door that allows access to the amphitheater before returning to the hall through another door. This scenario is the most complex, requiring participants to manage cyclic navigation and multiple decision points.

Each participant group performed tasks on each different type of interface. The first group (G1) used an integrated interface: storyboarding is accessible simultaneously with rendering visualization (Fig. 6). Participants could add, modify, and delete additional objects while editing the scenario. On the other hand, for the other group (G2) using the separated interface (Fig. 7), these tasks had to be performed separately.



Figure 6: Interface of G1 integrating storyboarding and rendering visualization



a. Storyboarding interface of G2 b. Rendering visualization interface of G2

Figure 7: Interface of G2 separating storyboarding from rendering visualization

At the end of the three sequences, participants were asked to complete feedback questionnaires.

#### 4.5 Data collection and measures

Before the start of the activity, a demographic questionnaire was administered to the participants to gather information about their personal characteristics, such as age, gender, education level, and prior experience with virtual reality and authoring tools. An algorithm was developed and integrated into Wixar 2.0-beta.1 to collect quantitative data on user behavior during task execution. These data included operations related to the creation, deletion, and movement of objects. The data were then analyzed to compare the effectiveness and efficiency between the two types of interfaces.

After the activity, we used the NASA-TLX scale [14], translated into French by Ganier et al. [11], to assess the workload involved. Cybersickness (SSQ) was evaluated using the French questionnaire proposed by Kennedy et al. [17]. The F-SUS scale is the

French version of the System Usability Scale (SUS) [4] proposed by Gronier & Baudet [12]. The participants' motivation was assessed using the Situational Motivation Scale (SIMS) [13], French version proposed by Mener [19].

The obtained data was then analyzed to evaluate the usability of the two different types of interfaces during participant interactions. According to ISO 9241-11 [16], usability encompasses three key criteria: (1) Effectiveness, (2) Efficiency and (3) Satisfaction.

Usability, therefore, is measured by how well users can perform tasks accurately and completely (effectiveness), how resource-efficiently they can achieve these tasks (efficiency), and how satisfied they are with the process and outcome (satisfaction). Specifically, in this experiment, effectiveness was related to the number of errors made during the participant's scenario execution, with fewer errors indicating higher effectiveness. Efficiency was measured by the time required to complete the tasks in relation to the quality of the work achieved, with less time and higher quality indicating higher efficiency. Satisfaction was assessed using the F-SUS questionnaires, with an adjective rating scale [2] was used to interpret the SUS scores.

### 5 RESULTS

The quantitative and qualitative data collected were standardized to select the appropriate parameters, then analyzed using SPSS (version 25, IBM Corp). A Shapiro-Wilk test was first performed to check for normality of the data distribution. If the p-value was greater than 0.05 for both groups, the data were normally distributed, and a Student's T-test was performed for the bivariate correlation test. If at least one of the groups had a p-value less than 0.05, indicating a non-normal distribution, a non-parametric Mann-Whitney test was used instead. The data were collected from two experimental groups, each consisting of 12 participants, corresponding to the two types of VR interfaces.

#### 5.1 Effect of the Interactive Interface on Effectiveness

In both groups, no errors were recorded on the first two scenarios. However, the final scenario (S3) indicated that some participants were unable to complete the entire task list. The Mann-Whitney test on the number of errors committed on S3 for the two groups showed that the integrated interface G1 (M=0.83, SD=0.937) made more errors compared to the separated interface G2 (M=0.17, SD=0.389), indicating a significant difference (p=0.031). This demonstrates that the separated interface G2 was more effective, as fewer errors were made, reflecting higher accuracy and completeness in achieving the specified goals.

#### 5.2 Effect of the Interactive Interface on Efficiency

In terms of execution time, the separated interface G2 completed the tasks faster than the integrated interface G1 in scenarios S1 and S3 (see Fig. 8).

The Levene's test for S1 (p=0.009) indicated a statistically significant difference in variances between the two groups. Following this, the Student's T-test (p=0.016) showed a statistically significant difference in the means of the two groups. The Mann-Whitney test (see Tab. 1) indicated a significant difference between the integrated interface G1 and the separated interface G2 in terms of execution time for S3 (p=0.004), but no significant difference for S2 (p=0.686).

To further analyze efficiency, we examined the relationship between the time required to complete the tasks and the quality of work achieved, represented by the number of errors. In scenario S2, there was no significant difference in time, and the quality of work (errors) was also similar. However, in scenarios S1 and S3, where the separated interface G2 completed the tasks faster, they also made fewer errors (S3), indicating higher effectiveness. This

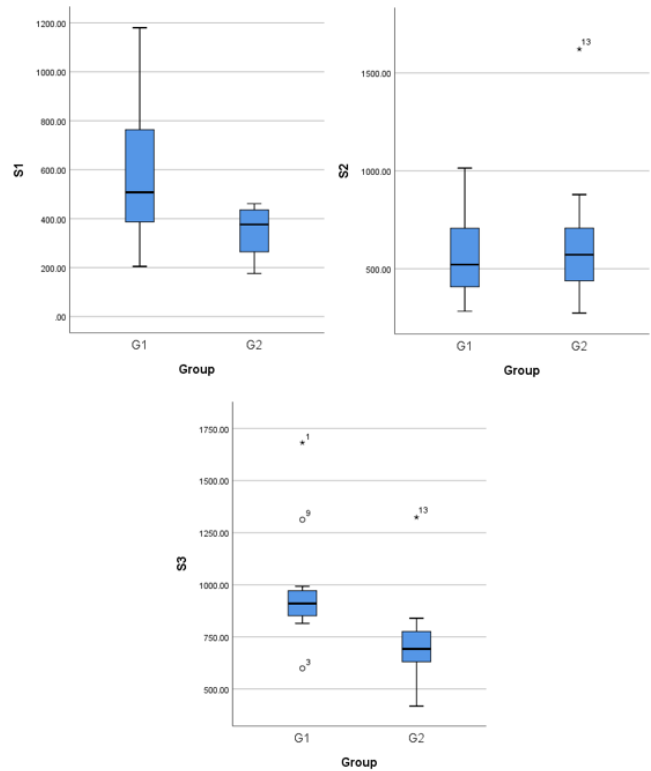


Figure 8: Distribution of execution time (seconds) differences for the integrated interface G1 and the separated interface G2 by sequence

Table 1: Statistical significance tests between the integrated interface G1 and the separated interface G2 for execution time differences across 3 missions

	Group	p (SW)	p (MWU)	p (Levene)	p (T-Test)
S1	G1	.389	–	.009	.016
	G2	.281	–		
S2	G1	.477	.686	–	–
	G2	.006			
S3	G1	.008	.004	–	–
	G2	.013			

correlation suggests that the separated interface G2 was able to achieve better results in less time, demonstrating higher efficiency.

#### 5.3 Satisfaction

The results of the F-SUS questionnaire showed no significant difference between the integrated interface G1 (M=66.54, SD=19.97) and the separated interface G2 (M=75.21, SD=16.6). Despite the wide diversity of opinions indicated by the significant standard deviation values, the SUS Means suggested that the G2 system offers a higher level of user satisfaction. This conclusion is based on the comparison of F-SUS scores between the two groups. According to the adjective rating scale described by Bangor et al. [2], a SUS score from 71.4 to below 85.5 is considered "Good" usability, while a score from 50.9 to below 71.4 is considered "OK". Therefore, the higher mean SUS score for the separated interface G2 indicates a better perceived usability compared to the integrated interface G1.

#### 5.4 Cybersickness

The SSQ developed by Kennedy et al. [17] is widely used to measure symptoms associated with cybersickness, including nausea,

oculomotor disturbances, and disorientation. In 2011, Bouchard et al. [3] revisited the factor structure of the SSQ and proposed a two-factor model, consolidating symptoms into two categories: nausea and oculomotor disturbances. Their analysis showed that several items from the original questionnaire overlapped across multiple factors, indicating that the boundaries between symptom categories were less distinct than initially thought. They argued that this simplified model is better suited for civilian applications, especially in virtual reality systems, which are increasingly used in professional training, immersive video games, and educational environments.

In this study, the results of the SSQ, which measured symptoms of nausea and oculomotor disturbances, showed that the symptoms appeared slightly more pronounced in the integrated interface G1 (Fig. 9).

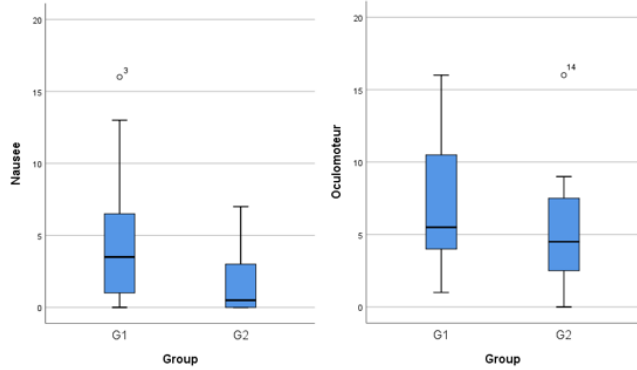


Figure 9: Distribution of differences in indices measuring symptoms of nausea and oculomotor disturbances between the integrated interface G1 and the separated interface G2

Indeed, the Shapiro-Wilk normality test led to a Mann-Whitney evaluation on nausea symptoms, revealing that participants in the integrated interface G1 experienced significant symptoms ( $p=0.037$ ). However, there were no significant differences in oculomotor disturbances, as the results of the Levene’s test ( $p=0.615$ ) and the T-Test ( $p=0.35$ ) showed no statistically significant differences in variances or means between the two groups (Tab. 2).

Table 2: Evaluation of cybersickness symptoms

	SSQ	Group	p (SW)	p (MWU)	p (Lev)	p (T-Test)
Nausea		G1	.029	.037	-	-
		G2	.007			
Oculomotor		G1	.254	-	.615	.35
		G2	.205			

### 5.5 Motivation

The results of the SIMS questionnaire helped identify the type of user motivation through the Situational Motivation Scale (Fig. 10). Regarding intrinsic motivation, identified regulation, external regulation, and amotivation, there was no significant difference between the integrated interface G1 and the separated interface G2 (Tab. 3).

### 6 DISCUSSION

The results of our study supported our first hypothesis (H1), showing significant differences in usability between the two types of interfaces. Specifically for effectiveness, participants using the separated interface made fewer errors, particularly in complex scenarios (S3). In terms of efficiency, the separated interface allowed for faster task completion in scenarios S1 and S3, indicating better performance. Satisfaction levels were also higher for the separated

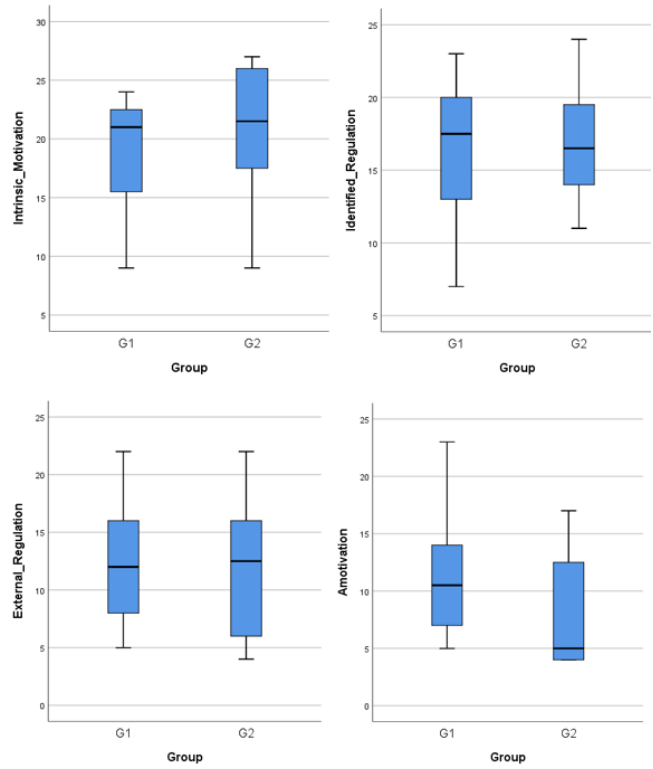


Figure 10: Distribution of differences in Situational Motivation Scale indices between the integrated interface G1 and the separated interface G2

Table 3: Evaluation of motivation types between the integrated interface G1 and the separated interface G2

	Group	SW	MWU	Levene	T-Test
Intrinsic motivation	G1	.079	-	.574	.373
	G2	.222			
Identified regulation	G1	.591	-	.361	.736
	G2	.997			
External regulation	G1	.327	-	.821	.806
	G2	.425			
Amotivation	G1	.353	.076	-	-
	G2	.004			

interface, as reflected by higher SUS scores based on the adjective rating scale [2]. These findings underscore that the separated interface offers substantial advantages in effectiveness, efficiency, and user satisfaction, particularly for complex tasks where cognitive overload with the integrated interface can lead to increased errors.

Our findings align with the work of Nebeling & Speicher [22], who highlighted the difficulties non-technical designers face in using integrated tools for prototyping VR experiences. The cognitive overload observed in the integrated interface group can be attributed to the simultaneous management of storyboarding and rendering visualization, which is consistent with the challenges discussed by Yigitbas et al. [31] regarding the complexity of immersive authoring tools.

In terms of cybersickness (H2), contrary to our hypothesis, the results showed that the integrated interface led to more pronounced symptoms of nausea compared to the separated interface. A possible explanation is the longer usage time in the integrated interface group. As highlighted in the efficiency analysis, participants using

the integrated interface spent more time interacting with the system. Rebenitsch & Owen [25] suggest that extended use of VR systems correlates with higher incidences of cybersickness. In this case, the cognitive load from managing multiple tasks simultaneously, combined with the longer usage time, likely contributed to the more pronounced symptoms observed.

Regarding motivation (H3), contrary to our hypothesis, the situational motivation scale revealed no significant difference between the two groups. This indicates that interface design alone may not have a measurable impact on user motivation. Wang & Lindeman [28] found that Hybrid Virtual Environments (HVEs) can improve task performance through smoother transitions and task synchronization, but these improvements do not necessarily lead to changes in motivation. Similarly, in our study, while the interface design likely influenced usability, it did not appear to affect intrinsic motivation. This outcome suggests that other factors beyond interface design may play a more critical role in shaping user motivation in immersive environments.

Despite these promising results, our study has some limitations. The study focused solely on scenario design for panoramic videos, which may not reflect the usability of the interfaces in other VR contexts. For future research, it would be relevant to explore the effects of these interfaces in different VR contexts and to include a greater variety of tasks and scenarios. Moreover, the study could be extended to examine how the integration of additional features, such as collaborative elements or artificial intelligence tools, could further improve the effectiveness and efficiency of immersive authoring tools. A longitudinal analysis could also provide valuable insights into the evolution of user satisfaction and performance over an extended period.

While the results of this study are focused on the immersive authoring tool used in the design of VRLS based on panoramic videos, they suggest potential benefits for other immersive application domains. The spatiotemporal storyboarding and rendering visualization approaches evaluated in this research could offer valuable insights for the design of interfaces in fields such as architectural and urban planning, where designers must manage complex spatial relationships and interactions. Additionally, immersive therapy applications, which require precise control over interactive environments, could benefit from similar interface designs to enhance user experience and effectiveness. Cultural heritage preservation is another promising area, where immersive tools can be used to create interactive and educational experiences for users, utilizing spatiotemporal visualization to represent historical and cultural contexts. Although further research is required to generalize these findings to other immersive tools, the interface approaches evaluated here hold potential for broader application in various immersive design fields.

## 7 CONCLUSION

The primary objective of our study was to evaluate and compare the usability of two types of VR interfaces for an immersive authoring tool based on panoramic videos: one that separates storyboarding and rendering visualization, and the other that integrates these functionalities. By performing the same tasks to design interactive scenarios, quantitative and qualitative data were collected to assess the usability, cybersickness and motivation for each interface.

The results of the experiment indicate that the separated interface facilitated better performance in executing more complex scenarios compared to the integrated interface. The satisfaction level in the group using the separated interface was higher than that in the group using the integrated interface. These results are particularly significant for more complex scenarios, where cognitive overload appears to be reduced due to the separation of the storyboard and visualization tasks.

In conclusion, this research highlights the importance of inter-

face design in improving the usability of immersive authoring tools. Separated interfaces seem to offer significant advantages in terms of performance and user satisfaction, especially for complex tasks, making it a promising direction for the future development of immersive authoring tools.

## REFERENCES

- [1] T. Adão, L. Pádua, M. Fonseca, L. Agrellos, J. J. Sousa, L. Magalhães, and E. Peres. A rapid prototyping tool to produce 360° video-based immersive experiences enhanced with virtual/multimedia elements. *Procedia Computer Science*, 138:441–453, 2018. doi: 10.1016/j.procs.2018.10.062 2
- [2] A. Bangor. Determining what individual sus scores mean: Adding an adjective rating scale. *Journal of usability studies*, 4(3):114–123, 2009. 5, 6
- [3] S. Boucard, G. Robillard, and P. Renaud. Revising the factor structure of the simulator sickness questionnaire. *Annual review of cybertherapy and telemedicine*, 5:128–137, 2017. 6
- [4] J. Brooke. *SUS: A 'Quick and Dirty' Usability Scale*, vol. 189. CRC Press, 1996. Publication title: Usability Evaluation In Industry. doi: 10.1201/9781498710411 5
- [5] T. Chambel, M. N. Chhaganlal, and L. A. R. Neng. Towards immersive interactive video through 360° hypervideo. In *Proceedings of the 8th International Conference on Advances in Computer Entertainment Technology*, ACE '11, pp. 1–2. Association for Computing Machinery, 2011. doi: 10.1145/2071423.2071518 1
- [6] I. L. Chamusca, C. V. Ferreira, T. B. Murari, A. L. Apolinario, and I. Winkler. Towards sustainable virtual reality: Gathering design guidelines for intuitive authoring tools. *Sustainability*, 15(4):2924, 2023. doi: 10.3390/su15042924 1
- [7] H. Coelho, M. Melo, L. Barbosa, J. Martins, M. S. Teixeira, and M. Bessa. Authoring tools for creating 360 multisensory videos—evaluation of different interfaces. *Expert Systems*, 38(5):e12418, 2021. doi: 10.1111/exsy.12418 1, 2
- [8] H. Coelho, M. Melo, J. Martins, and M. Bessa. Collaborative immersive authoring tool for real-time creation of multisensory VR experiences. *Multimedia Tools and Applications*, 78(14):19473–19493, 2019. doi: 10.1007/s11042-019-7309-x 2
- [9] H. Coelho, P. Monteiro, G. Gonçalves, M. Melo, and M. Bessa. Authoring tools for virtual reality experiences: a systematic review. *Multimedia Tools and Applications*, 81(19):28037–28060, 2022. doi: 10.1007/s11042-022-12829-9 1, 2
- [10] D. Dermeval, R. Paiva, I. I. Bittencourt, J. Vassileva, and D. Borges. Authoring tools for designing intelligent tutoring systems: a systematic review of the literature. *International Journal of Artificial Intelligence in Education*, 28(3):336–384, 2018. doi: 10.1007/s40593-017-0157-9 1
- [11] F. Ganier, C. Hoareau, and F. Devillers. Évaluation des performances et de la charge de travail induits par l'apprentissage de procédures de maintenance en environnement virtuel. *Le travail humain*, 76(4):335–363, 2013. doi: 10.3917/th.764.0335 4
- [12] G. Gronier and A. Baudet. Psychometric evaluation of the F-SUS: Creation and validation of the french version of the system usability scale. *International Journal of Human-Computer Interaction*, 37(16):1571–1582, 2021. doi: 10.1080/10447318.2021.1898828 5
- [13] F. Guay, R. J. Vallerand, and C. Blanchard. On the assessment of situational intrinsic and extrinsic motivation: The situational motivation scale (SIMS). *Motivation and Emotion*, 24(3):175–213, 2000. doi: 10.1023/A:1005614228250 5
- [14] S. G. Hart and L. E. Staveland. Development of NASA-TLX (task load index): Results of empirical and theoretical research. In P. A. Hancock and N. Meshkati, eds., *Advances in Psychology*, vol. 52 of *Human Mental Workload*, pp. 139–183. North-Holland, 1988. doi: 10.1016/S0166-4115(08)62386-9 4
- [15] R. Holm, E. Stauder, R. Wagner, M. Priglinger, and J. Volkert. A combined immersive and desktop authoring tool for virtual environments. In *Proceedings IEEE Virtual Reality 2002*, pp. 93–100, 2002. doi: 10.1109/VR.2002.996511 2

- [16] I. ISO. 9241-11: 2018 ergonomics of human-system interaction—part 11: Usability: Definitions and concepts. *International Organization for Standardization*. [https://www.iso.org/obp/ui/#iso:std:iso:9241\(11\),2018](https://www.iso.org/obp/ui/#iso:std:iso:9241(11),2018). 5
- [17] R. S. Kennedy, N. E. Lane, K. S. Berbaum, and M. G. Lilienthal. Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. *The International Journal of Aviation Psychology*, 3(3):203–220, 1993. doi: 10.1207/s15327108ijap0303\_3 4, 5
- [18] D. X. H. Mai, G. Loup, and J.-Y. Didier. Usability of an immersive authoring tool: An experimental study for the scenarization of interactive panoramic videos. In *16th International Conference on Advances in Computer-Human Interaction (ACHI 2023)*, pp. 174–180. IARIA, 4 2023. 1
- [19] M. L. Mener. *The academic performance of university students in their first-year : influence of cognitive abilities and motivation*. PhD thesis, University of Burgundy, 2012. 5
- [20] M. H. Miraz, M. Ali, and P. S. Excell. Adaptive user interfaces and universal usability through plasticity of user interface design. *Computer Science Review*, 40:100363, May 2021. doi: 10.1016/j.cosrev.2021.100363 2
- [21] S. S. A. Naser. ITSB: An intelligent tutoring system authoring tool. *Journal of Scientific and Engineering Research*, 3(5):63–71, 2016. 1
- [22] M. Nebeling and M. Speicher. The trouble with augmented reality/virtual reality authoring tools. In *2018 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*, pp. 333–337, 10 2018. doi: 10.1109/ISMAR-Adjunct.2018.00098 1, 6
- [23] J. K. Olsen, D. M. Belenky, V. Alevan, N. Rummel, J. Sewall, and M. Ringenberg. Authoring tools for collaborative intelligent tutoring system environments. In S. Trausan-Matu, K. E. Boyer, M. Crosby, and K. Panourgia, eds., *Intelligent Tutoring Systems*, pp. 523–528. Springer International Publishing, 2014. doi: 10.1007/978-3-319-07221-0\_66 1
- [24] C. G. Pang, S. Devi, D. Wong, Y. Cai, and R. Ba. The use of immersive virtual reality technology to deepen learning in singapore schools. In Y. Cai, W. van Joolingen, and K. Veermans, eds., *Virtual and Augmented Reality, Simulation and Serious Games for Education*, pp. 45–59. Springer, 2021. doi: 10.1007/978-981-16-1361-6\_5 1
- [25] L. Rebenitsch and C. Owen. Review on cybersickness in applications and visual displays. *Virtual Reality*, 20(2):101–125, June 2016. doi: 10.1007/s10055-016-0285-9 2, 7
- [26] B. Shneiderman. Promoting universal usability with multi-layer interface design. *SIGCAPH Comput. Phys. Handicap.*, (73-74):1–8, 2002. doi: 10.1145/960201.957206 2
- [27] D. Ververidis, P. Migkotzidis, E. Nikolaidis, E. Anastasovitis, A. Papazoglou Chalikias, S. Nikolopoulos, and I. Kompatsiaris. An authoring tool for democratizing the creation of high-quality VR experiences. *Virtual Reality*, 26(1):105–124, 2022. doi: 10.1007/s10055-021-00541-2 1
- [28] J. Wang and R. Lindeman. Coordinated hybrid virtual environments: Seamless interaction contexts for effective virtual reality. *Computers & Graphics*, 48:71–83, May 2015. doi: 10.1016/j.cag.2015.02.007 2, 7
- [29] WideWebVR. *Wixar - Your Human Resources Metaverse*, september 2024. 3
- [30] H. Xia, S. Herscher, K. Perlin, and D. Wigdor. Spacetime: Enabling fluid individual and collaborative editing in virtual reality. In *Proceedings of the 31st Annual ACM Symposium on User Interface Software and Technology*, UIST '18, pp. 853–866. Association for Computing Machinery, 2018. doi: 10.1145/3242587.3242597 2
- [31] E. Yigitbas, J. Klauke, S. Gottschalk, and G. Engels. VREUD - an end-user development tool to simplify the creation of interactive VR scenes. In *2021 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC)*, pp. 1–10, 2021. doi: 10.1109/VL/HCC51201.2021.9576372 2, 6
- [32] L. Zhang and S. Oney. FlowMatic: An immersive authoring tool for creating interactive scenes in virtual reality. In *Proceedings of the 33rd Annual ACM Symposium on User Interface Software and Technology*, UIST '20, pp. 342–353. Association for Computing Machinery, 2020. doi: 10.1145/3379337.3415824 1, 2