STRATEGIC DESIGN RESEARCH JOURNAL

A Questionnaire for Assessing Immersive Websites

Sabrina Scuri [a b *] | Nuno J. Nunes [b c] | Valentina Nisi [b c]

[a] Politecnico di Milano, Department of Design, Milan, Italy
[b] ITI/LARSyS, Funchal, Portugal
[c] Instituto Superior Técnico - U. Lisbon, Departamento de Engenharia Informática, Lisbon, Portugal
* Corresponding author: sabrina.scuri@polimi.it

ABSTRACT

Web-immersion – i.e., a deep sense of cognitive and perceptual absorption engendered by the content and interactive features of a website - plays an important role in our modern, digital world. Yet, this topic has received little attention from Design and HCI scholars. The lack of tools to assess and measure immersion in the Web may severely limit our ability to understand the nature of such experience, thereby constraining future research in the area. To address this issue, we designed a questionnaire for assessing immersive websites and conducted a preliminary evaluation of it. In this article, we outline the questionnaire design and report on findings from a preliminary study conducted to analyze its reliability and validity. Moreover, we present results from Factor Analysis performed to investigate the dimensionality of the instrument. Finally, we conclude by discussing the implications of our findings, along with limitations of the study and future work.

Keywords: Web Design, Web-Immersion, User Experience, Interaction Design, Immersive Websites, Questionnaire.

INTRODUCTION

Three years after the start of the COVID-19 pandemic, a substantial part of our everyday life still takes place online. The Web has become the primary interface; the main entrance into such a new, digital 'reality'. As we live in a world where dichotomies such as 'close/distant' or 'virtual/real' have lost most of their meaning, our online interactions should be carefully (re-)designed. It has been long recognized that the focus of web design needs to shift from pure usability to a more experiential perspective (Thielsch et al., 2014). The quality of a website is indeed no longer determined by its utilitarian/functional attributes alone. On the contrary, users base their judgment of websites on experiential/hedonic values too (Huang, 2003). For example, attributes such as sensual novelty and aesthetic satisfaction proved to be strong drivers for first impression formation in website use (Kim, 2019). Moreover, it is observed that "experiential design" is an increasingly popular trend in web design (Susanto, 2020); suggesting that, now more than ever, an effective web experience should contemporarily affect users' sensations, emotions, and cognition (Susanto, 2020), and ultimately deliver an illusion of reality by transporting users into the digital 'space' (Gao & Li, 2019). In other words, we argue that in the current scenario surfing a website should generate a sense of immersion. In this context, immersion is described as a deep sense of cognitive and perceptual absorption in the content and/or in interacting with a website (Scuri, 2017). Thus, an immersive website

is much more than a ‘digital document’; it’s "a space to be explored, something to be experienced" (Emanuel et al., 2015).

Despite the extensive body of literature on immersion in Virtual Reality and game environments, the nature of such experience on the Web has received scant attention, with very few studies to date (Jennings, 2000; Coyle & Thorson, 2001; Emanuel et al., 2015; Scuri, 2017). Due to the growing ubiquity of web-based applications, web-immersion is emerging as a primary topic of interest for design research. Yet, the lack of tools to assess and measure immersion in the web may limit future research in this area. To address this issue, we designed and conducted a preliminary evaluation of a questionnaire for assessing immersive websites, which focuses on how multimedia cues and interactive features affect the experience of immersion. In this regard, it’s worth mentioning that the present research focuses on desktop-based web browsing only. Such a decision was motivated by the fact that mobile user experience and desktop user experience are inherently different (Mendoza, 2013). Specifically, it was decided to exclude the mobile web environment for two main reasons:

- Characteristics of the device – "mobile devices are smaller than laptops with limited screen sizes, display resolution, storage capacity, and processing capabilities" (Wrede, 2018). For this reason, mobile-based interaction is less engaging compared to its desktop counterpart (Mendoza, 2013).
- Modes of interaction and mindset of users when browsing via mobile – desktop users are more focused on the screen and generally spend more time interacting with the website. On the contrary, mobile users normally have a ‘bite-sized’ experience (Mendoza, 2013), as most of the time the interaction takes place while the user is on the go. For this reason, immersion via mobile is not only harder to achieve but might also be undesired and, in some cases, even dangerous as it could divert their attention from the ‘outside world’.

The contribution of this study is two-fold. First, the development of the scale in itself could shed light and expand our understanding of web-immersion, thus providing guidance for further research in the field. Second, developing a reliable scale, designed ad-hoc for the web, allows for a more accurate assessment of the qualities of an immersive website and their contribution to the overall experience.

The present article is structured as follows: section 1 provides an overview of relevant literature on immersion in general and in the areas of Human-Computer Interaction (HCI) and Web Design in particular. In section 2 we describe the methodology adopted to design and evaluate the questionnaire. Results for reliability, validity and factor analysis are presented in section 3. Main findings are summarized and discussed in section 4. We conclude by describing the implication of this study, along with limitations and future work.

1. BACKGROUND

The feeling of 'being surrounded' by a mediated reality, here defined as immersion, has been studied across several disciplines. The academic literature provides a wide array of conceptualizations and frameworks for its analysis. However, due to the diversity of viewpoints dealing with this experience, immersion is still a nebulous concept, even named differently depending on the field of study. In this section, we attempt to map out the main approaches to the study of such an experience. It’s important to point out that our review isn’t

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

meant to be exhaustive. Rather, it's intended to provide an overview of how the subject matter is dealt with in different disciplines and serves as a background for our study.

1.1. Immersion in Communication, VR, and Game Research

The concept of immersion has received considerable attention from media and communication scholars since the early '90s, resulting in a rich body of literature. Among the many frameworks available for analyzing such an experience, the one most worth mentioning (as it represents the theoretical basis of many others) is probably the one developed by Steuer (1992). According to this model, the sense of 'being there' in a mediated environment - what Steuer refers to as 'telepresence' - is determined by the vividness and interactivity of the media; defined respectively as "the representational richness of a mediated environment[…], that is, the way in which an environment presents information to the senses", and "the extent to which a user can participate in modifying the form and content of a mediated environment in real-time". As pointed out by Steuer himself, the main advantage of this bidimensional model is that it can be used to classify a variety of media. Several are indeed the empirical studies that found evidence of a strong relationship between the experience of immersion and these two factors - see Schuemie et al., (2001) for an extensive list of these studies.

Vividness and interactivity are also included in the framework elaborated by Lombard & Ditton (1997). In their article, the authors provide an in-depth analysis of the concept of 'presence' - i.e., the illusion that a mediated experience isn't mediated - with the goal of paving the way for more systematic research on the topic. By analyzing how the concept is addressed within different academic fields, they identify a list of variables that engender the experience of presence in media users. These variables are classified into three main categories:

- Media form, which refers to the formal characteristics of the media - in terms of 'sensory richness' and 'vividness' –, and includes aspects such as number and consistency of sensory outputs, visual display characteristics (e.g., image quality), and interactivity (e.g., consistency between inputs and response).
- Media content: the quality of the content itself, regardless of its presentation (e.g., the extent to which content is perceived as realistic, authentic, or credible).
- Characteristics of the users: e.g., willingness to suspend disbelief or prior experience with the medium.

While Lombard & Ditton consider both interactivity and vividness as relevant components of an immersive experience, Tham (2018) postulates the central role of interactivity in designing immersive media. With the goal of setting out a 'blueprint' for future research and shedding light on challenges and opportunities of immersive media, the author conceptualizes seven dimensions of interactivity:

- Reciprocity/Ease of response: the ability to facilitate real-time, reciprocal communication;
- Synchronicity/Context awareness, which is "represented by just-in-time information presented to the user;"
- Connectedness/Ubiquity/Pervasiveness: the use of ubiquitous or pervasive computing that allows users to "access multiple platforms with a continuous experience;"

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

- User control/Personalization: the degree of control the user has over the interactive experience;
- Navigability/Accessibility: the ability to access content and perform a task;
- Entertainment/Sensibility: the ability of the media to "communicate or react to users with human-like style and personality;"
- Sensory stimulations/Multimodality: "the degree to which an interface involves human senses".

Undoubtedly, the concept of 'immersion' is most commonly associated with Virtual Reality (VR). In this context, however, the term only refers to "what the technology delivers from an objective point of view" (Slater, 2003) – i.e., the extent to which a technology engages the user's senses. On the contrary, the subjective experience of 'being there' is called 'presence' and understood as "a human reaction to immersion" (Slater, 2003). Countless are the frameworks investigating presence in VR environments - a review of the main ones can be found in Schuemie et al., (2001). Despite the obvious differences between them, most frameworks present a common characteristic: they identify the objective features of the technology (i.e., immersion) as determinants of presence. An example of this is the model put forward by Sheridan (1996), which outlines three main determinants of presence: (i) fidelity of the multimodal displays (visual, acoustic, or tactile); (ii) ability to modify sensor position (e.g., change viewpoint); and (iii) ability to change the configuration of the environment (e.g., move objects).

Sheridan's framework has been further elaborated and extended by Slater & Wilbur (1997). In their article, the authors speculate on the role of presence in virtual environments and ultimately outline five characteristics of immersive virtual environments that are supposed to increase presence. These are:

- Inclusiveness: the extent to which physical reality is shut out;
- Vividness: resolution, fidelity, and variety of the sensory stimuli;
- Proprioceptive matching: the extent to which the participant's proprioceptive feedback about body movements matches the information generated on the displays;
- Extensiveness: the range of sensory modalities accommodated by the system;
- Plot: the extent to which there is a self-contained plot in which the participant can act and in which there is an autonomous response.

Finally, game research adopts a more holistic approach to immersion and looks at the player, rather than the game, as the primary focus of the investigation. As pointed out by Ermi & Mäyrä (2011), when it comes to immersive gameplay experiences, aspects like dimensions of the screen or high-quality audio are "by no means the only or even the most significant factor". In their conceptualization of game immersion, the audio-visual execution of the game is indeed seen as only one of the possible dimensions of the experience, which consist of:

- Sensory immersion: the extent to which the audio-visual execution of the game surrounds the player and causes him to be "entirely focused on the game world and its stimuli";

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

- Challenge-based immersion, experienced when there is a balance between challenges and abilities;
- Imaginative immersion, experienced when the player is absorbed in the game world and/or emotionally connected with a game character.

Results from the preliminary study that Ermi & Mäyrä conducted to validate their model, not only support the soundness of these three dimensions of immersion but also provide interesting insights into their individual significance, as well as into the way they may influence each other. For example, the authors argue that challenge-based immersion plays a particularly essential role as it promotes a flow-like experience - i.e., when the challenges are in balance with the players' skills and abilities. Moreover, factors related to the audio-visual design (sensory immersion) appear to contribute to generating imaginative immersion too. Such a connection between immersion and players' senses, skills, and to some extent imagination, emerges in other works (Brown & Cairns, 2004; Jennett et al., 2008; Weibel et al., 2008; Weibel & Wissmath, 2011). Jennett et al., (2008), for example, conducted a study aimed at evaluating the effectiveness of subjective measures in assessing game immersion. For that purpose, the authors elaborated an ad hoc questionnaire, whose items were derived from tools designed to measure (i) flow, (ii) presence (intended as vividness), and (iii) cognitive absorption (the player's attitude towards the game). Similarly, Weibel & Wissmath (2011), conducted a study to investigate the specific effect that flow and spatial presence (meant as vividness and realism of the game world) have on immersion in computer games and found empirical evidence that both are key concepts to explain such an experience.

1.2. Immersion in Web Design and HCI

Despite the extensive body of literature on users' immersion with media, the nature of such experience on the Web has received scant attention. To the best of our knowledge, existing Design and HCI research on the topic is very limited and still at an early stage.

In one of the few works dealing with this subject, Jennings (2000) draws on an extended concept of aesthetics (including perceptual, cognitive, and affective components) to propose a framework for designing immersive websites, which is nevertheless specific to a single web genre: e-commerce websites. In particular, Jennings outlines five principles that should be applied to e-commerce websites design:

- Unity, which relates to the wholeness of the experience; the coherence and completeness of the content;
- Attention or object directedness: the use of elements that bring about focus or a desire to proceed with the activity;
- Active discovery: "the process of actively seeking answers or resolutions to cognitive challenges;"
- Affect: the "emotional investment that helps create a personal link to an experience or activity;"
- Intrinsic gratification: the "feeling of pleasure, reward and satisfaction" resulting from the experience.

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

Coyle & Thorson (2001) adopt a more empirical approach to the subject matter. In their study, the authors examine the effects of interactivity and vividness in commercial websites. Using the model proposed by Steuer (1992), they manipulated the levels of vividness and interactivity of four websites and tested how those changes impact perceived telepresence and, more in general, users' attitudes towards the website. By doing so, they provided empirical evidence that perceived telepresence grows stronger as the levels of interactivity and vividness of a website increase.

In a recent study, Emanuel et al., (2015) investigate web-immersion by analyzing the so-called "rhetoric of interaction". Albeit acknowledging that multimedia cues and vividness are equally important in designing immersive websites, the authors postulate the crucial role of interaction (intended as a rhetorical element) in bringing users "into the action, the narrative, or the message". Based on the Aristotelian concepts of classical rhetoric, the authors attempt to explore how different interactive design solutions may influence users' experience with websites. Specifically, they seek to understand how interaction appeals to 'pathos' - i.e., the emotions of the audience. To do so, they analyze three very different websites and elaborate on the ways interactive features can be used to support the message. The third case study, for example, is the website of a company that sells lifejackets. Here, users are presented with a first-person-perspective video of a man, Julian, that accidentally falls off the boat on which he was traveling. The user is asked to help him stay on the surface by keeping scrolling or swiping. After five minutes, regardless of the user's effort, the video ends with Julian drowning. As pointed out by Emanuel and colleagues, the use of a first-person perspective clearly helps the visitor connect with the character. However, it's the interactive features that make the experience 'ring true'. There is indeed a strong consistency between users' physical actions and character's virtual movements. Also, after five minutes of page-scrolling, the user will experience actual physical tiredness, which enhances the emotional connection with the character and his struggles. Although this study offers useful insights into how different interactive features could generate an immersive experience, it's still preliminary and doesn't provide an actual framework to follow. This aspect is acknowledged by the authors themselves, who stress the need for developing such a framework for the evaluation of immersive websites.

Given the heterogeneity of studies dealing with immersion, it isn't possible to provide a comprehensive overview of the subject (which would merit an article itself). However, a few important aspects do emerge from our review of the literature. First, formal and interactive features of the media are widely recognized as the key aspects of an immersive experience. Second, there is no unique approach to the study of immersion. The way the experience is investigated (and even named) depends on the media context. Finally, the shortage of literature on web-immersion provides a stimulating research opportunity for the design community.

2. METHODOLOGY

This study explores users' perception of web-immersion. Specifically, we seek to develop a measurement instrument that identifies and assesses the 'immersive features' of websites - i.e., those design attributes that promote immersion. Due to the complexity of the subject matter, we adopted an exploratory approach to the study. In this section, the methodology used for the design and evaluation of the scale is described.

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

2.1. Items Generation

The questionnaire items were generated following a three-step process. First, we performed an extensive review of existing research and speculations about the factors that engender a sense of immersion in interactive media users. These sources were identified by searching the ACM digital library, Springer Link database, and Google Scholar. The search strings used included “immersion”, “presence”, “telepresence”, “immersive experiences”, and “immersive websites”. For each article returned we checked the content of the abstracts. In order to be selected for full-text analysis, the article had to focus on one (or more) of the following subjects:

- Conceptualization(s) of immersion;
- Approach(es) or framework(s) for the analysis of immersion;
- Measurement tools to assess perceived immersion;
- Empirical studies to validate measurement tools and/or theoretical frameworks.

References of the selected articles were cross-checked to identify additional studies. A total of twenty-seven peer-reviewed articles were analyzed paragraph-by-paragraph, looking for the main characteristics associated with immersive media. Through this operation, we were able to extract a total of 318 'immersive features'. This initial list was reduced to 42 items by removing those that:

- Depend on the characteristics of the hardware – e.g., screen resolution;
- Require the use of devices other than a computer screen and a set of headphones;
- Cannot be designed because depend on the users’ characteristics (e.g., motivation and interest in the content).

The 42 remaining features were then analyzed using affinity diagrams during focus group sessions with experts in the field of Design and HCI. Those characteristics that were identified as having similar connotations were combined. Any disagreements were discussed until consensus was reached and a final list, consisting of 17 immersive features, was agreed upon. Finally, we formulated a set of questions aimed at assessing users' perception of the 'immersive features' so identified. The resulting questionnaire consisted of 20 closed-ended questions, rated on a 7-point Likert scale.

To ensure clarity and accuracy of the items, the first version of the questionnaire was pilot tested on a small sample of researchers and Ph.D. students at the Interactive Technologies Institute (Madeira, Portugal). For this pilot, we adopted the think-aloud method, which has been widely used in assessing self-report questionnaires and is particularly useful to test the respondents' understanding of the items (Sudman et al., 1996). Based on pilot results, several items were reworded (or supplemented with comments in brackets) and one was removed. The refined items and corresponding 'immersive features' can be found in the Appendix.

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

2.2. Questionnaire Evaluation

Reliability of the Immersive Features Questionnaire (IFQ) was tested using Cronbach’s α. We then explored the dimensionality of the scale by using Exploratory Factor Analysis (EFA) via Principal Component Analysis (PCA). Finally, validity (discriminant and concurrent) was

assessed by examining the relationship of the IFQ with two related but theoretically different constructs, which are widely recognized as the key components of immersion (Ermi & Mäyrä, 2007; Jennett et al., 2008; Weibel & Wissmath, 2011): Spatial Presence (SP) and Flow. SP is defined as the perceptual illusion of non-mediation (Lombard & Ditton, 1997), a sense of spatial immersion in a mediated environment (Weibel & Wissmath, 2011). The sense of presence is experienced when the mediated environment engages the user's senses (Witmer & Singer, 1994; Sheridan, 1992), thus, depends on the perceived quality and richness of the multimedia content. Flow (Csikszentmihalyi, 1990), on the contrary, is defined as the feeling of being "simultaneously cognitively efficient, motivated, and happy" (Moneta & Csikszentmihalyi, 1996). Such a construct refers to the mental state in which a person is fully immersed in what he/she is doing and can be used to assess and describe the quality of users' interaction with technology (Agarwal & Karahanna, 2000). For the purpose of this study, SP and Flow were measured using, respectively, the Presence Questionnaire (PQ) (Kim & Biocca, 1997) and the Flow Short Scale (FSS) (Rheinberg et al., 2002). We choose to use these scales as (i) they both have been used together to measure users' immersive tendency and found to be valid and reliable (Weibel & Wissmath, 2011); and (ii), like the IFQ, they're composed of closed-ended questions rated on a 7-point Likert scale.

In order not to limit our tool to a specific web genre, we performed three studies, using the questionnaire to evaluate different types of websites:

- Study 1: a virtual walk (based on Google Street View technology);
- Study 2: an interactive music video;
- Study 3: a multimedia web-documentary about population decline in rural America.

Sample. Participants were design students and professionals, recruited through snowball sampling. They all signed an informed consent form and took part in the study voluntarily, without receiving any reward.

- Ninety-nine subjects (forty-one males and fifty-eight females) aged from 19 to 35 years (average age = 26.29 SD = 4.367) took part in study 1.
- Thirty-six participants (twenty males and sixteen females) aged from 19 to 35 years (average age = 27.86 SD = 4.051) took part in study 2.
- Thirty-four subjects (twenty males and fourteen females) aged from 19 to 35 years (average age = 27.76 SD = 4.164) took part in study 3.

Procedure. After a brief introduction to the study, participants were given 15 minutes to freely browse the website (the study was conducted in an unsupervised setting to avoid any external influence) and then asked to complete an online questionnaire consisting of the FSS, PQ, and IFQ.

Data Analysis. All statistical analyses were performed using IBM SPSS Statistics 26.

3. RESULTS

3.1. Reliability

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

Reliability was tested using Cronbach's α. The IFQ achieved high internal consistency, with Cronbach's alpha coefficient of .86.

To further assess reliability, we examined the item-total correlation values. All items, except for item 5, appeared to be worthy of retention. The total-item correlation coefficient of item 5 was significantly below the threshold value of 0.30 (Cristobal et al., 2007). However, its removal would only increase the alpha to α = 0.87. Thus, further tests are needed to decide whether the item should be modified or removed.

3.2. Exploratory Factor Analysis

Prior to performing PCA, the suitability of data for factor analysis was assessed. Results from Bartlett's test of sphericity ($\chi 2$ = 1233.449, p<.001) and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (KMO = .847) indicated that the data set was appropriate for factor analysis (Hutcheson & Sofroniou, 1999). The anti-image correlation was further checked to assess the sampling adequacy of individual items. All individual items were all well above the acceptable limit of 0.5 (Field, 2009) (values ranging from r =.650 to r =.912). The only exception was item 5 (r =.489), which only approached that limit.

Factor extraction was based on Kaiser's criterion, scree test, and interpretability. The EFA extracted five factors based on the Kaiser's criterion (eigenvalues ≥ 1), which accounted for more than 62% of the cumulative variance (Figure 1).

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	6.144	32.336	32.336
2	1.819	9.571	41.907
3	1.660	8.736	50.643
4	1.230	6.472	57.115
5	1.007	5.301	62.416

Extraction Method: PCA.
Note: only factors with Eigenvalues above 1 are shown.

Figure 1. Total Variance Explained.

However, an inspection of the scree plot (Figure 2) indicated that the majority of variance could be accounted for with a two- or three-factor solution. Therefore, solutions for two, three, and five factors were each examined using Oblimin rotation.

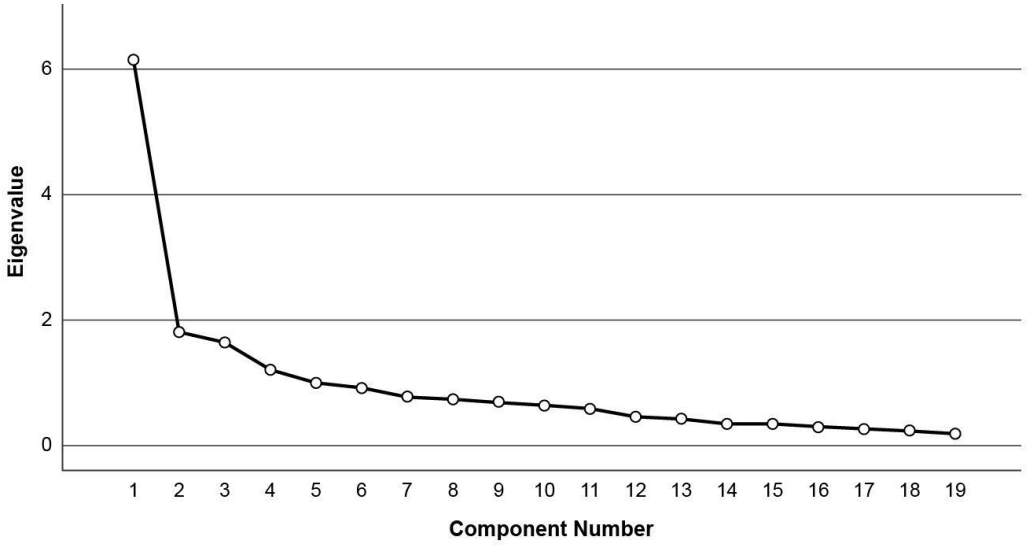

Figure 2. Scree plot.

The three-factor structure, which explained more than 50% of the variance, was preferred over the others because appeared to be the easiest to interpret and the most robust, with all primary factor loadings above .4 and few cross-loadings (Figure 3).

Item nº	Component		
	1	2	3
14	**.776**		
15	**.769**		
9	**.755**		
16	**.683**		
7	**.673**		
12	**.611**		
6	**.602**		
17	**.542**	.308	.302
13	**.490**	-.317	
3		**-.849**	
1		**-.778**	
2		**-.660**	
19		**-.603**	
4		**-.555**	
11		**-.442**	
5			**.659**
10			**.639**
18			**.620**
8			**.608**

Extraction Method: PCA. Note: Higher loadings appear in bold.

Figure 3. Pattern Matrix.

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

Items loading on the first factor mostly describe quality and richness of the multimedia cues and, more in general, the extent to which content presentation 'surrounds' the user and affects his/her mood. Thus, we labeled this factor “Perceptual Immersion” (PI). The second factor consisted of six items describing aspects related to usability and perceived control. Hence, it was labeled "Operational Immersion" (OI). The four items belonging to the third factor describe the extent to which both multimedia content and modes of interactions are consistent and don’t distract or interfere with the browsing experience. For this reason, we termed this factor "Cognitive Immersion" (CI).

PI investigates aspects like quality and richness of multisensory stimulation and degree of realism. It describes the ability of the media to 'surround' the users and make them feel 'there'; ‘present’ in the website. This dimension has several commonalities with factors that emerged in other studies. It includes most of the features that Lombard & Ditton (1997) categorize as "media form" variables. Also, it resembles the 'sensory immersion' advanced by Ermi & Mäyrä (2011). Most importantly, we assume that PI may contribute to Spatial Presence since the latter depends on the ability of a mediated environment to surround the users and engage their senses. Therefore, we expect to find a positive, high correlation between this dimension and the PQ.

OI is mostly associated with the interactive features of the websites, such as degree of control, responsiveness, usability, ease of use, etc., and seems to combine two of the dimensions of interactivity put forward by Tham (2018), namely navigability/accessibility and user control/personalization. It’s also postulated that OI would show a correlation with FSS. Several are indeed the items of the two scales that assess similar features, like perceived control and users' ability to predict the website's response to their actions.

Finally, the items belonging to the third form of immersion identified (CO) assess whether the website design interferes with the users' ability to focus on and interpret the content and/or achieve their goals. It presents some similarities with the notion of challenge-based immersion (Ermi & Mäyrä, 2011) and is therefore expected to show a correlation with the FSS.

3.3. Construct Validity

EFA was conducted on the items of IFQ and the two concurrent measures – PQ and FSS. For evidence of concurrent validity to emerge, the three subscales of our tool - PI, OI, and CI - would have to relate to PQ and FSS as hypothesized above. Evidence of discriminant validity will be established by finding a factor structure that corresponds to the different scales used in this study.

According to the literature, the items of both PQ (Kim & Biocca, 1997) and FSS (Engeser & Rheinberg, 2008) should be separated into two factors. Therefore, the EFA was conducted using seven factors for extraction with Oblimin rotation. Prior to performing the EFA, internal consistency (via Cronbach’s α) of PQ (α = .859) and FSS (α = .859) was assessed, and the data set was examined for sample adequacy through Kaiser-Meyer-Olklin test (KMO = .883) and by Bartlett's sphericity test ($\chi 2 = 3532.592$, $p = .000$).

The seven factors extracted accounted for more than 62% of the variance. As shown in Figure 4, we found partial correspondence between the resulting structure coefficients and the three subscales.

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

However, several items didn't have a simple structure, and a few of them loaded higher on other constructs. Such a result wasn't completely unexpected since the three scales have several semantically overlapping items and were assumed to be partially correlated. In particular, several items of the PI subscale had higher loadings on the Presence subscales than on their own. While two items of the OI subscale and one of the CI subscale loaded better on one dimension of Flow. To further assess concurrent validity, we analyzed the correlations (Spearman's rho) between PI, OI, CI, PQ, and FSS (Figure 5).

Item	Perceptual Immersion	Operational Immersion	Cognitive Immersion	Presence - Arrival	Presence - Departure	Flow - Fluency	Flow - Absorption
IFQ.06	.506	**.507**					
IFQ.07	.301			**.737**			
IFQ.09	.339			**.778**			
IFQ.12	**.781**						
IFQ.13	**.701**						
IFQ.14	.421			**.601**			
IFQ.15	.428			**.720**			
IFQ.16	.462			**.549**			
IFQ.17	**.628**						
IFQ.01		**.812**					
IFQ.02		**.766**					
IFQ.03		**.740**					
IFQ.04		.394				**.464**	
IFQ.11		**.597**					
IFQ.19		.352				**.647**	
IFQ.05			**.578**				
IFQ.08			**.710**				
IFQ.10			**.643**				
IFQ.18			.397			**.676**	
PQ.01				**.864**			
PQ.02				**.811**			
PQ.03				**.778**			
PQ.05				**.873**			
PQ.06				**.741**			
PQ.04					**.550**		
PQ.07					**.770**		
PQ.08					**.622**		
FSS.02						.397	**-.590**
FSS.04						**.564**	
FSS.05						**.696**	
FSS.07						.418	**-.645**
FSS.08						**.725**	
FSS.09						**.661**	
FSS.01							**-.657**
FSS.03							**-.665**
FSS.06				**.644**			-.544
FSS.10	**.590**						-.377

Note: Higher loadings appear in bold.

Figure 4. Structure Coefficients.

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

	FSS	PQ	PI	OI	CI
FSS	1.000	.559**	.660**	.568**	.394**
PQ		1.000	.781**	.354**	.152*
PI			1.000	.539**	.230**
OI				1.000	.334**
CI					1.000

** significant at the 0.01 level (two-tailed).
* significant at the 0.05 level (two-tailed).

Figure 5. Correlation Matrix.

Results from the correlation test helped interpret the output of the FA. As suggested by Kline (1998) discriminant validity can be demonstrated if the correlations between factors aren't greater than 0.85. Although the correlations between the dimensions of web-immersion and the two concurrent constructs are high (between .781 and .660), they don't exceed such a limit. It's also worth mentioning that, as hypothesized, OI and CI have a higher correlation with FSS than with PQ. While, according to our initial hypothesis, PI has a considerably high correlation with PQ (though it correlates significantly with FSS too).

4. DISCUSSION AND CONCLUSION

Web-immersion is becoming an increasingly relevant topic and certainly represents a fruitful area of investigation for the Design community. However, the limited literature available on the topic together with the lack of tools to assess and measure the 'immersive features' of websites, may limit future research in this area. To address this issue, we designed and conducted an initial evaluation of such a measurement tool.

Results from our study show that the IFQ has good internal consistency as measured by Cronbach's alpha ($\alpha = 0.86$). Moreover, EFA suggests that web-immersion may be divided into three dimensions. The first one is represented by the following features: sensory depth and breadth, degree of realism, depth and field of regard of the visual cues, and ability to elicit proprioceptive responses. This dimension seems to describe quality and richness of the multimedia cues, as well as the extent to which content presentation 'surrounds' the user. Hence, it was named Perceptual Immersion. The second dimension was labeled Operational Immersion since it's represented by items assessing usability and quality of the interaction, such as degree of control, immediacy of control, mode of control, and continuity. The third dimension consists of items that assess the extent to which a user can concentrate and perform the desired actions without being distracted by the attributes of the website; either those related to interactivity (e.g., mode of interaction) or those depending on vividness and content presentation (e.g., consistency of multimodal information). We named this dimension Cognitive Immersion. The dimensions of this three-factors structure show some similarities with findings from other studies, thereby lending partial support to the validity of the model, at least on a theoretical basis. Additional analyses were conducted to confirm discriminant and concurrent validity of the IFQ. EFA was performed to examine the relations between the three dimensions of web-immersion and other constructs commonly associated with the experience of immersion (flow and spatial presence). The factor structure resulting from the EFA had a moderate correspondence with the expected output. Although some items showed better loading on the concurrent validity measures, overall, all items had good loading onto

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

their own factor. This result wasn't unforeseen as we expected to find positive correlations between the different measures.

Although encouraging, our findings don't provide clear evidence of construct validity. This might be due to several limitations of our study. The first limitation is represented by the moderately small sample size. Although there's no general rule for determining the sample size, it's commonly understood that larger samples yield more reliable results (MacCallum et al., 1999). Taking as a reference the scale proposed by Comrey & Lee (1992) for a rough evaluation of sample size adequacy in factor analysis, our sample (N = 169) would be considered between "poor" (N = 100) and "fair" (N = 200). Further limitations relate to the three scales used, which have several semantically overlapping items and, obviously, have never been tested together before. Finally, it's worth mentioning that almost all participants in our study were 'experts' – i.e., design students and professionals. Testing the scale with naïve users may lead to different results.

The study described here is preliminary in nature. Thus, further investigation is needed to support our initial findings. First of all, a confirmatory factor analysis should be conducted on a new set of data to validate the three-factor solution obtained in this study. Also, it would be interesting to explore whether other factors (e.g., the website genre) influence users' perception of one or more of the three dimensions of web-immersion.

Designing a valid measurement tool is a necessary step toward a better understanding of web-immersion. By establishing the different dimensions of web-immersion, our study provides a common framework for future research on the subject. Moreover, it outlines a set of distinguishable, measurable characteristics of immersive websites that could help inform design practitioners. To conclude, we should acknowledge that scale development and validation is an iterative process that never ends. This research represents just a first step in our quest to understand web-immersion and, perhaps, here lies its main contribution of this research.

REFERENCES

Agarwal, R., Karahanna, E. (2000). Time flies when you're having fun: Cognitive absorption and beliefs about information technology usage. *MIS quarterly*, 24(4): 665-694. https://doi.org/10.2307/3250951.

Brown, E., & Cairns, P. (2004). A grounded investigation of game immersion. In E. Dykstra-Erickson, & M. Tscheligi (Eds.), CHI'04 extended abstracts on Human factors in computing systems (pp. 1297-1300). USA: ACM.

Comrey, A.L., & Lee., H.B. (1992). *A first course in factor analysis*. USA: Erlbaum.

Coyle, J.R., Thorson, E. (2001). The effects of progressive levels of interactivity and vividness in web marketing sites. *Journal of advertising*, 30(3): 65-77. https://doi.org/10.1080/00913367.2001.10673646.

Cristobal, E., Flavian, C., Guinaliu, M. (2007). Perceived e-service quality (PeSQ). *Managing service quality: An international journal*, 17(3): 317-340. https://doi.org/10.1108/09604520710744326.

Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Experience*. USA: Harper & Row.

Emanuel, B., Rodrigues, C., & Martins, M. (2015). Rhetoric of interaction: Analysis of pathos. In A. Marcus (Ed.), Design, User Experience, and Usability: Design Discourse (pp. 417-427). Switzerland: Springer.

Engeser, S., Rheinberg, F. (2008). Flow, performance and moderators of challenge-skill balance. *Motiv. Emot.*, 32: 158–172. https://doi.org/10.1007/s11031-008-9102-4.

Ermi, L., & Mäyrä, F. (2011). Fundamental components of the gameplay experience: Analysing immersion. In S. Günzel, M. Liebe, & D. Mersch (Eds.), DIGAREC Keynote-Lectures 2009/10 (pp. 88-115). Potsdam: University Press.

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

Field, A. (2009). *Discovering statistics using SPSS*. London: Sage.

Gao, W., & Li, X. (2019). Building presence in an online shopping website: the role of website quality. *Behaviour & information technology*, 38(1): 28-41. https://doi.org/10.1080/0144929X.2018.1509127.

Huang, M.H. (2003). Designing website attributes to induce experiential encounters. *Computers in Human Behavior*, 19(4): 425-442 https://doi.org/10.1016/S0747-5632(02)00080-8.

Hutcheson, G.D., & Sofroniou, N. (1999). *The multivariate social scientist: Introductory statistics using generalized linear models*. London: Sage.

Jennett, C., Cox, A.L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T., Walton, A. (2008). Measuring and defining the experience of immersion in games. *International journal of human-computer studies*, 66(9): 641-661. https://doi.org/10.1016/j.ijhcs.2008.04.004.

Jennings, M. (2000). Theory and models for creating engaging and immersive ecommerce websites. In J. Prasad, & W. Nance (Eds.), Proceedings of the 2000 ACM SIGCPR conference on computer personnel research (pp. 77-85). USA: ACM.

Kim, S. (2019). Why should GUI designers create visual novelties?: The mechanisms of first impression formation in user experience. *Archives of Design Research*, 32(2): 31-43. http://dx.doi.org/10.15187/ adr.2019.05.32.2.31.

Kim, T., Biocca, F. (1997, September). Telepresence via television: Two dimensions of telepresence may have different connections to memory and persuasion. *Journal of Computer-Mediated Communication*, 3(2). Retrieved June 3, 2022, from https://academic.oup.com/jcmc/article/3/2/JCMC325/4080405.

Kline, R.B. (1998). *Principles and Practice of Structural Equation Modeling*. USA: Guilford Press.

Lombard, M., Ditton, T. (1997, September). At the heart of it all: The concept of presence. *Journal of computer-mediated communication*, 3(2). Retrieved June 3, 2022, from https://academic.oup.com/jcmc/article/3/2/JCMC321/4080403.

MacCallum, R.C., Widaman, K.F., Zhang, S., Hong, S. (1999). Sample size in factor analysis. *Psychological methods*, 4(1): 84-99. https://doi.org/10.1037/1082-989X.4.1.84.

Mendoza, A. (2013). *Mobile user experience: patterns to make sense of it all*. USA: Morgan Kaufmann.

Moneta, G.B., Csikszentmihalyi, M. (1996). The effect of perceived challenges and skills on the quality of subjective experience. *Journal of Personality*, 64(2): 275-310 .https://doi.org/10.1111/j.1467-6494.1996.tb00512.x.

Rheinberg, F., Engeser, S., & Vollmeyer, R. (2002). *Measuring components of flow: The Flow-Short-Scale*. In Proceedings of the 1st international positive psychology summit.

Schuemie, M.J., Van Der Straaten, P., Krijn, M., Van Der Mast, C.A. (2001). Research on presence in virtual reality: A survey. *CyberPsychology & Behavior*, 4(2): 183-201. https://doi.org/10.1089/109493101300117884.

Scuri, S. (2017). The experience of immersion in the web environment: An overview. In A. Biamonti, & L. Guerrini (Eds.), *Polimi design phd_017* (pp. 82-100). Milan: Franco Angeli.

Sheridan, T.B. (1992). Musings on telepresence and virtual presence. *Presence*, 1(1): 120-126. https://doi.org/10.1162/pres.1992.1.1.120.

Sheridan, T.B. (1996). Further Musings on the Psychophysics of Presence. *Presence*, 5(2): 241-246. https://doi.org/10.1162/pres.1996.5.2.241.

Slater, M. (2003). A note on presence terminology. *Presence Connect*, 3(3): 1-5. Retrieved June 3, 2022, from https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=ed277f9067a0b6aadd90c055d31aecc8ab92aa2f.

Slater, M., Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence*, 6(6): 603-616. https://doi.org/10.1162/pres.1997.6.6.603.

Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of communication*, 42(4): 73-93. https://doi.org/10.1111/j.1460-2466.1992.tb00812.x.

Sudman, S., Bradburn, N., & Schwarz, N. (1996). *Thinking about answers: The application of cognitive processes to survey methodology*. USA: Jossey-Bass.

Susanto, R.A. (2020). Engaging Students With Experiential Website Design As Online Learning Media: Comparative Studies of Interactive Parallax Scrolling Technique on Commercial Website. In J. Selamet, L.T. Pinasthika, & N.H. Ibrahim (Eds.), Proceedings of the International Conference of Innovation in Media and Visual Design (pp. 86-92). Paris, France: Atlantis Press.

Tham, J.C.K. (2018, February). Interactivity in an age of immersive media: Seven dimensions for wearable technology, internet of things, and technical communication. *Technical Communication*, 65(1): 46-65. Retrieved June 3, 2022, from https://www.allen-berry-phd.com/_files/ugd/006fd8_ca7d49cfba8143fb80ad692c42be10c4.pdf#page=52.

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.

Thielsch, M.T., Blotenberg, I., & Jaron, R. (2014). User evaluation of websites: From first impression to recommendation. *Interacting with Computers*, 26(1): 89-102. https://doi.org/10.1093/iwc/iwt033.

Weibel, D., & Wissmath, B. (2011, January). Immersion in computer games: The role of spatial presence and flow. *International Journal of Computer Games Technology*, 2011. Retrieved June 3, 2022, from https://dl.acm.org/doi/abs/10.1155/2011/282345.

Weibel, D., Wissmath, B., Habegger, S., Steiner, Y., & Groner, R. (2008). Playing online games against computer- vs. human-controlled opponents: Effects on presence, flow, and enjoyment. *Computers in human behavior*, 24(5): 2274-2291. https://doi.org/10.1016/j.chb.2007.11.002.

Witmer, B.G., & Singer, M.J. (1994). *Measuring immersion in virtual environments (ARI Technical Report 1014)*. Retrieved June 3, 2022, from https://apps.dtic.mil/sti/pdfs/ADA286183.pdf.

Wrede, E. (2018). *Research report: The Impact of Mobile Devise Usability Guidelines on the Design of Help Documentation for Evernote's iOS Application*. Retrieved February 18, 2023, from https://keep.lib.asu.edu/_flysystem/fedora/c275/wrede-spring-2018.pdf.

APPENDIX

Items and corresponding 'immersive features' of the final version of the questionnaire.

Item	Rating scale	Corresponding feature
Were you able to actively browse the website (e.g., select information of your interest, affect the content displayed, etc.)?	Not at all / Very much	Degree of control
Was the website responsive (i.e., reacted quickly and positively) to your actions?	Never / Always	Immediacy of control
Were you able to anticipate what would happen next in response to your actions (e.g., clicking a button, selecting a link, etc.)?	Never / Always	Anticipation
Did you feel you had the competencies (knowledge and skills) needed to interact with the website?	Never / Always	Mode of control
Did the interaction imply a mental effort to you (i.e., you had to learn new ways of interaction and/or actions to perform in order to interact with the website)?	Not at all / Very much	Mode of control
Were you satisfied or impressed with the quality and richness of the images/visual information provided?	Not at all / Very much	Sensory depth
During the browsing, were all of your senses completely engaged (i.e., for example, you have been able to imagine the smell, texture, or temperature of the scenes displayed)?	Not at all / Very much	Sensory breadth
How inconsistent or disconnected was the visual and auditory information?	Not at all / Very much	Consistency of multimodal information
I was completely engrossed in the website.	Strongly disagree / Strongly agree	Isolation and selective attention
Did the interface controls (e.g., menus, icons, arrows, and other navigation buttons) distract you or interfere with the browsing experience?	Not at all / Very much	Interface awareness
The multimedia contents were seamlessly blended together, so that the web page results smooth and continuous.	Strongly disagree / Strongly agree	Continuity
How realistic did the scene(s)/environment(s) portrayed appear to you?	Not at all / Very much	Realism of the scene
The content/story seemed believable to me.	Strongly disagree / Strongly agree	Realism of content
Did the browsing experience affect your mood?	Not at all / Very much	Psychological realism
I felt like I was actually present in the environment represented by the website.	Strongly disagree / Strongly agree	Proprioceptive / vestibular feedback
Size and aspect ratio of the images/videos made me feel surrounded by the computer-generated world.	Strongly disagree / Strongly agree	Field of regard
The visual elements (e.g., texts, pictures, graphics, etc.) were flat and missing in depth.	Strongly disagree / Strongly agree	Sense of depth
During the browsing, did you feel disoriented or lost in the website?	Not at all / Very much	Spatial awareness

I have been able to develop a mental map of the website.	Strongly disagree / Strongly agree	Spatial awareness

Scuri, S.; Nunes, N. J.; Nisi, V. (2023). A Questionnaire for Assessing Immersive Websites. Strategic Design Research Journal. Volume 15, number 02, April–June 2022. 150-166.
DOI: 10.4013/sdrj.2022.152.06.