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Virtual Reality Historical Event: Exploring Aesthetic Immersive Experience Dimensions using Exploratory Factor Analysis (EFA)

Noorazzahrawani Abdul Rani[1], Mohd Ekram AlHafis Hashim[1,*], Muhammad Zaffwan Idris[1], Rahina Nugrahani[2]

[1] Department of Creative Multimedia, Faculty of Art, Computing and Industry Creative, Universiti Pendidikan Sultan Idris, 35900 Tanjong Malim, Perak, Malaysia
[2] Faculty of Language and Arts, Universitas Negeri Semarang, Sekaran, Gunung Pati, Semarang City, Central Java 50229, Indonesia

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ABSTRACT

The virtual museum experience is pivotal to the human-computer interaction (HCI) field, which shapes immersive technology products' design and development methodology from both technicalities regarding user experience and aesthetic perspectives. However, valid tools examining both aesthetic and immersive experiences are lacking. Therefore, this study examined the dimensionality of the users' aesthetic immersive experience towards virtual reality (VR) historical events and developed a novel Aesthetic Immersive Experience Questionnaire based on cognitive, perception, and emotional dimensions. Then, data gathered to examine its reliability by employing Exploratory Factor Analysis (EFA). A previous study showed that EFA is a statistical method for most decisions in various research areas, among the best practices for gaining reliable empirical findings. Hence, this paper aims to report the process of EFA decisions upon constructs or dimensions, elements or sub-dimensions, and measurement items of aesthetic immersive experience to validate the VR historical event experience. The implementation of the method commenced with developing a novel questionnaire consisting of 3 dimensions and 16 sub-dimensions with 48 items constructed based on the aesthetic immersive experience sub-dimensions established from the literature review and expert consensus during the Fuzzy Delphi process. A total of 99 samples comprised of Generation Y and millennials who knew the creative fields and information technology were selected to answer the questionnaire after exploring VR historical event applications. The initial items were subjected to the EFA process through five primary decisions: the data inspection techniques, the factor analytic method, the factor retention method, the factor rotation method, and the factor loading cut-off. The EFA results revealed 3 dimensions; "Captivating", "Plausible", and "Interactive", with 7 sub-dimensions and a set of 39 items that become the 39 AIX items are reliable and valid for assessing the aesthetic immersive experience in virtual reality historical events environment

1. Introduction

* *Corresponding author.*
E-mail address: ekram@fskik.upsi.edu.my

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New media technology integrated into museum exhibitions has rationalised the development of the virtual museum, which has various influences on museum interpretation, shaping numerous studies on the visitor experience. The paradigm of museums is changing from object-centric to experience-centric [1]. A virtual museum is an online platform, digital entity, or application that complements, simulates, and enhances the characteristics of a traditional or physical museum. In other words, it attempts to replicate the experience of visiting a physical museum through virtual environment using device such as smartphone or laptop. Also, visitors can experience a virtual tour Still, the most interactive and immersive experience through augmented reality (AR), virtual reality (VR) or extended reality (XR) technologies [2-4]. Virtual museums are accessible to a global audience, including 24-hour accessibility, transcend geographical boundaries and time zones, offering the ability to explore content remotely, providing a convenient way for a wider demographic without the need for travel.

Museum exhibition technology has also been transformed by integrating reality-based technology such as AR, VR, and XR [5-7] for education and research purposes [8]. The transformation becomes the impetus for developing immersive experiences in the museum exhibition. The most immersive platform for virtual museum experience involves VR applications. The user or visitor's not only as a spectator, however has hold a new role as a spectActor in the virtual world word [9,10] Suh and Prophet [11] argued that individual differences have moderating effects between immersive system features and users' cognitive and affective reactions and the outcomes of immersive technology use. However, even though the immersive experience becomes prominent in the museum experience, another core experience that needs to be addressed is an aesthetic experience (AX).

Immersive heritage experiences through VR has allows the culture and history learning especially of past event by adopting multisensory interaction with natural interaction that replicates real-world situations [7,12]. Immersive VR headsets and handhelds bring a fully 360-degree atmospheric view, 3D space, 3D realistic manipulated objects, and multisensory channel input and output, giving a high degree of interactivity and embodiment [13-17] causing immersion [10,18-21]. A correspondingly virtual environment in VR is an artistic medium that reveals a sense of place, a sense of being there, realistic representation, a sense of agency, levels of agency, interaction method, types of navigation structure, travel techniques, wayfinding aids, self-transformation, enactment in VR [14].

The immersive narrative art form has transformed the actual historical objects into new interactive virtual exhibits, shifting visitor assessment into a new dimension involving aesthetic perception. The composition of the virtual environment as the stimulus is perceived as an aesthetic object that requires aesthetic evaluation without infringing on its context or content. The user's mind stimulated by aesthetic objects will psychologically assess the realism, beauty, or authenticity of the object that appears to the user that appears to the user, which then evokes certain emotional effects. The virtual object has become an aesthetic object or pleasure to the user [22] . Thus, the emotional effects can be classified as aesthetic emotions. The user is assessing the beauties of an object while experiencing AX [22-25]. Therefore, if the virtual environment is visually appealing, the user will progressively experience the virtual world, reach a fascinating state, become immersed, and feel enjoyment or undergo certain aesthetic emotions depending on how it perceives the virtual object. Furthermore, a virtual environment of VR consists of virtual objects, namely; graphics, 3D models, animation [26-28], programming algorithms, and interaction. VR interaction involves haptics, and gesture interaction is the unique virtual object that has been increasingly studied, and it is believed to evoke the AX [24.29].

Thus, the aesthetic immersive experience (AIX) model of virtual reality historical events for virtual museums has been developed using the Fuzzy Delphi Method (FDM), implementing expert’s consent

[30,31] shown in Figure 1. The central formulation of the model development is by unifying constructs of AX and IX in the context of Immersive Media Art [32]. The model focuses on cognitive, perception, emotional constructs, and elements of aesthetic experience (AX) and immersive experience (IX) examined from the literature review. The AIX model can be used among researchers, VR developers, and museum institutions to develop and evaluate VR historical-based applications. The result of this process is the initial AIX model, which comprises three (3) constructs and sixteen (16) elements yielded from formulation, namely; 1) Captivating constitutes five elements; Cultural Significant, Fidelity, Symbolic, Personal Value, and Formal, 2) Plausible which consists of seven elements; Creative, Encouraging, Degree of attention, Dynamic, Sense of exploration, Imaginary and Situational context, and 3) Interactive has four elements namely; Enjoyment, Feeling of union, Action, and Time. Each element will be assigned three items or indicators. As a result, forty-eight (48) items were designed for the AIX questionnaire.

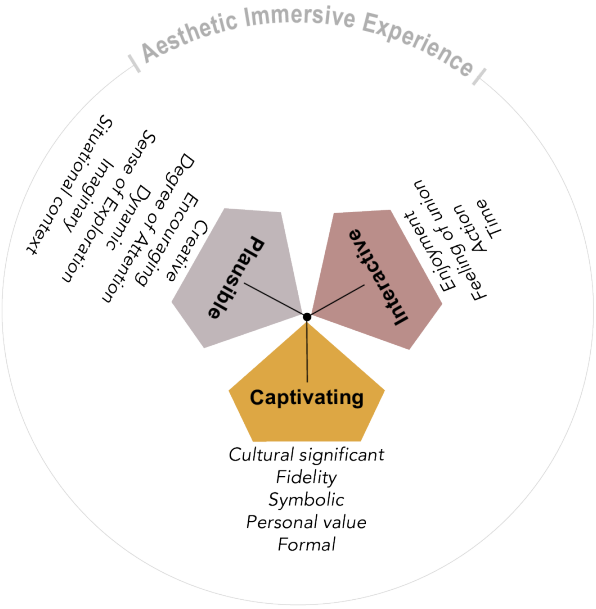

Fig. 1. The initial Aesthetic Immersive Experience (AIX) model

Research on factors that influence immersion in museum VR exhibitions affects the emotional experience of tourists [33]. Eventually, immersion and aesthetics are the two sub-dimensions of emotional experience. Appraising AX and IX scores against virtual historical objects depend on what elements evoke the user's emotion. Emotion becomes the output of the process when the user values and appreciates the virtual historical representation and narrative experience. The emotions and feelings aroused are classified as aesthetic emotions. Research on factors that influence immersion in museum VR exhibitions affects the emotional experience of tourists [33]. Eventually, immersion and aesthetics are the two sub-dimensions of emotional experience. Appraising AX and IX scores against virtual historical objects depend on what elements evoke the user's emotion. Emotion becomes the output of the process when the user values and appreciates the virtual historical representation and narrative experience. The emotions and feelings aroused are classified as aesthetic emotions. In essence, the richness of the experience cannot be adequately captured through a single dimension of assessment. In this case, a multidimensional evaluation framework is required to measure the quality of VR applications. Thus, this indicates the research gap between AX and IX when managing art and technology-based products like VR historical events, so that needs a solution by developing a new integrative AIX model by unifying AX and IX elements and a set of

questionnaires to measure the aesthetic and immersive experience. In this study, the aesthetic emotions, Aesthemos survey by Schindler *et al*., [34] is used as the basis for the development of the measurement items for measuring emotional dimensions of the VR experience.

The development of items should undergo the appropriate process in order to obtain high-quality dimensions for measuring the AIX. The initial AIX model could be a subject of user experience evaluation related to any immersive product. Its practicality has to be proven by real application and implementation in the field. Eventually, the initial AIX model should be used as a reference for VR historical event development. A prototype of a VR historical event has been built, and its application as a stimulus for collecting data from user testing in actual situations is a requirement in order to gain empirical validation of the model. The data was collected after the participant had tested the VR application by answering the AIX questionnaire.

The data will definitely need to be validated using the data analysis technique. Validation is an analytical process that empirically confirms the final vital dimensions and sub-dimensions that are reliable in the measurement of immersive technology-based applications or products. More previous research on user perception, attitude, and experience has shown high interest in implementing EFA [35-38]. For that purpose, the validation of the AIX dimensions, sub-dimensions and items is conducted based on Exploratory Factor Analysis (EFA) [39-42].

In multivariate statistics, exploratory factor analysis (EFA) is a statistical method used to uncover the underlying structure of a relatively large set of variables. EFA is a technique within factor analysis whose overarching goal is to identify the underlying relationships between measured variables. The EFA decision is conducted using a guide based on recommendations for EFA decisions by Howard (2016) [43], which involve five main steps; 1) data inspection, 2) factor analytic method, 3) factor retention method, 4) factor rotation method, and 5) factor loading cutoff. In particular, researchers have to report the five primary decisions for best practices in presenting EFA results.

Therefore, the objective of this research is to report the process of obtaining EFA decisions based on aesthetic immersive dimensions, sub-dimensions, and, specifically, measurement items to validate the virtual museum experience. By doing so, the main goal is to develop a novel Aesthetic Immersive Experience (AIX) Questionnaire based on cognitive, perception, and emotional dimensions while exploring a VR historical event environment. Besides, this study supports the development of a measuring scale for assessing the quality of immersive technology products.

2. Methodology

2.1 Sampling and Sample Size

Before performed the EFA, the data is set for screening and cleaning up process. A total of 102 questionnaires were collected in this study. Screening involves inspection for discovering and correcting errors in the data file through preliminary analysis taken on the data such as the missing value analysis (MVA) and assessment of outliers. The data entered by researcher in IBM-SPSS 27.0. She thoroughly examined, make sure, and correctly entered the respondents 'responses to all items in the questionnaire into the data file. Nonetheless, before the analysis of the missing values was performed, the researcher had rejected three questionnaires that have more than 15% missing values by not responding to the items. Therefore, three (3) questionnaires were discarded due to incomplete responses regarding MVA. It is applicable to have about minimum of 100 responds to run EFA using SPSS software. With a total of 99 cases, is sufficient for the researcher to proceed with the intended analysis [40,44,45].

2.2 Normality Test

The data of 99 respondents are subjected to the exploratory factor analysis (EFA) also reliability analysis is performed. The results of exploratory factor analysis (EFA) of the three (3) constructs were discussed in the following subtopics according to 1) data inspection, 2) factor analytic method, 3) factor retention method, 4) factor rotation method, and 5) factor loading cutoff.

The measure of skewness for each item of data is used to test for normality where the value of skewness between ±2.0 infer that the data is normally distributed[46]. The scores of mean, standard deviation, skewness, and kurtosis are used to determine the normality of the data set. For all 48 items in the data set (Table 1), mean values range from 3.66 to 4.34, standard deviation values start from 0.604 to 0.857, skewness values run from -1.075 to 0.043 and kurtosis values stretch from -0.964 to 3.018. Hence, strong evidence of normality was established when the values of the skewness of all items in the data were within the range of the absolute value of 1 (-1.075 to 0.043).

Table 1
Test of normality

Mean	3.9958
Std. Deviation	.48993
Skewness	-.515
Std. Error of Skewness	.243
Kurtosis	1.934
Std. Error of Kurtosis	.481

2.3 The EFA

The EFA operation starts data inspection by determining the sample size. Among the most popular recommendations for minimum sample size are 200 to 500 participants (depending on commonalities and other factors; and between a 5-to-20 and participant-to-variable ratio [47,48] Most authors accept a minimum sample size of 200 and a 5-to-1 participant-to-variable ratio, whichever is greater. Although some may consider this cutoff conservative. The current article supports use of small sample size which applicable for this study [40,44,45].

Therefore, for this study, researchers have checked their data for violations of statistical assumptions by performing both Bartlett's Test of Sphericity [49,50] and Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy [51] in order to test whether sufficiently large relationships exist within the data set of interest to perform EFA. Then, the principal components analysis was performed using the factor analytic method. Researchers used the Kaiser criterion (Eigenvalue < 1 rule) for the factor retention method. The Kaiser information has enough to provide statistical assumptions. Next, this study used orthogonal rotation by performing a varimax rotation for the factor rotation method. This method is used as it aligns with the expected correlation of the factors. Finally, the factor loading cutoff for items was loaded more than .50 on their primary factor. In addition, researchers have ensured that all the primary decisions of EFA have followed scholars' suggestions and guidelines [43].

2.3.1 Kaiser–Meyer–Olkin (KMO) Measure of Sampling Adequacy

Alternatively, the KMO Measure of Sampling Adequacy is an indicator of common variance within a data set, which indicates that latent factors may be present and EFA may be performed [51,52]. In general, the results of Bartlett's test of sphericity and the KMO Measure of Sampling Adequacy are

very similar, but the latter provides various ranges of acceptable variance rather than simply significant or nonsignificant. Generally, the metrics are as follows (Table 2):

Table 2
KMO Measure of Sampling Adequacy

0.00 through 0.50 – Unacceptable – Bad
0.50 through 0.60 – Miserable – Bad
0.60 through 0.70 – Mediocre – Okay
0.70 through 0.80 – Middling – Okay
0.80 through 0.90 – Meritorious – Good
0.90 through 1.00 – Marvelous – Great

Given these, authors should seek KMO Measure of Sampling Adequacy above .60 before performing their EFA [51]. If a lower value is obtained, variables with small intercorrelations can be removed to improve suitability for EFA.

2.3.2 Bartlett's test of sphericity

Bartlett's test of sphericity checks whether the observed correlation matrix is an identity matrix, which holds the property of having all off-diagonal values of zero [49]. Given that factor analysis explains the relationships of variables, a complete lack of relationships within a data set (i.e., an identity matrix) prevents EFA from being performed. If Bartlett's test of sphericity is significant, the results indicate that the data are not an identity matrix and appropriate for EFA. Although this test is successful in checking for violations of EFA assumptions, authors have noted that virtually all data sets are significantly different from an identity matrix, and the Bartlett's test of sphericity is rarely nonsignificant [50,51]. Nevertheless, the test may detect problematic data sets, and it should be performed prior to EFA.

2.3.3 Principal components analysis (PCA)

Principal components analysis conducted is based on Kaiser criterion with Eigenvalue < 1 rule [53]. The Kaiser information have enough to provide statistical assumptions.

2.3.4 Factor rotation method

Factor rotation method involves orthogonal rotation by performing varimax rotation of functional principal components [54]**.**

2.3.5 Factor loading cutoff

All the items complied with the factor loading cutoff of 0.50 [39]. If items were loaded below 0.50, the item would be eliminated. Besides, if the items loaded more than 0.50 on their primary factor, they will categorised on a dimension or a construct.

2.4 Reliability

According to DeVellis [55] offer the following rules of thumb in gauging the level of reliability: (1) above 0.90 is excellent/strongly reliable, (2) between 0.80 and 0.90 is good/highly acceptable, (3)

between 0.70 and 0.80 is acceptable, (4) between 0.65 and 0.70 is minimally acceptable, (5) between 0.60 and 0.65 is undesirable/questionable, and (6) below 0.60 is poor/unacceptable.

The reliability analysis for the constructs and its sub-constructs for this study were presented as below (Table 3), with sample size was n=99. From the EFA results being conducted on all constructs and sub-constructs, 39 items were retained for reliability analysis. In general, the values of the reliability of the constructs and sub-constructs are between the values of above 0.90 and 0.80; meaning that the items representing the constructs and sub-constructs are strongly reliable and highly acceptable, respectively. Up to this point, the 39 items used to measure the constructs have a reliability value of 0.80 to 0.9 and above, implying that the items are good.

Table 3
Reliability Analysis

Construct/ Sub-construct	No. of Items	Cronbach's Alpha
Captivating	14	0.908
Cultural Significant	8	0.871
Fidelity	6	0.829
Plausible	16	0.927
Dynamic	5	0.859
Degree of attention	6	0.850
Sense of Exploration	5	0.836
Interactive	9	0.895
Feeling of Union	5	0.855
Time	4	0.838

3. Results

3.1 Captivating construct

The first run of EFA for the Captivating construct has shown the value of the KMO was 0.893 (Meritorious); this value is higher than the threshold value of 0.6. The Bartlett's Test of Sphericity was also significant (Chi-square = 691.955, p-value < 0.001). Certainly, when KMO value is close to 1.0, and the significance value of Bartlett's Test of Sphericity is close to 0.0, it can be concluded that the Captivating construct with 15 items was adequate to proceed with factor analysis.

However, the rotated component matrix result has shown 1 item needs to be deleted which is FOR2 with factor loading below than 0.5, and 1 component extracted only 2 items. Therefore, researcher decided to eliminate FOR2, and run EFA again with Extraction with fixed number of factors; factors to extract = 2 with 14 items.

For second EFA of Captivating in Table 4, the value of the KMO was 0.893 (Meritorious) [43]. The Bartlett's Test of Sphericity was also significant (Chi-square = 648.621, p-value < 0.000). Certainly, when KMO value is close to 1.0, and the significance value of Bartlett's Test of Sphericity is close to 0.0, it can be concluded that the Captivating construct with 14 items was adequate to proceed with factor analysis.

Table 4
KMO and Bartlett's Test for Captivating

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.893
Bartlett's Test of Sphericity	Approx. Chi-Square	648.621
	df	91
	Sig.	< .000

Table 5 showed the PCA with varimax rotation result for the fourteen (14) items under the Captivating construct. The result revealed that the PCA procedure has extracted two distinct dimensions with eigenvalue exceeding the value of 1.0, with the total variance explained for all three components to be 54.922%, exceeding the fifty per cent value as the minimum percentage of acceptable variance explained in factor analysis for a construct to be valid. Explicitly, the two-factor component explained a total of 54.922% of the variance, with Factor 1 contributing 31.033% and Factor 2 contributing 23.889%.

Table 5
Total Variance Explained (TVE) for Captivating

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.494	46.389	46.389	6.494	46.389	46.389	4.345	31.033	31.033
2	1.195	8.533	54.922	1.195	8.533	54.922	3.345	23.889	54.922

Extraction Method: Principal Component Analysis.

Next, corresponding to the rotated component matrix result for the Captivating construct in Table 6, all fourteen (14) items were divided into two (2) components.

Table 6
Rotated Component Matrix – Captivating

Rotated Component Matrix[a]		
	Component	
	1	2
FOR1	.615	
FOR3	.515	
CUL1	.645	
CUL2	.512	
CUL3	.722	
PER1	.770	
PER2	.687	
PER3	.852	
FID1		.770
FID2		.560
FID3		.607
SYM1		.766
SYM2		.587
SYM3		.655

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

All items have a factor loading more than 0.5, which factor loading ranging between 0.504 - 0.847. All the items are remained and arranged according to the stated two sub-constructs of Captivating construct. The two sub-construct is labelled as cultural significant (CUL) and fidelity (FID).

In summary, the EFA results showed that the Captivating in Table 7 with 14 items has only two sub-constructs namely; cultural significant (CUL) and fidelity (FID). The sub-constructs and items are directed to proceed to the next level of analysis of this research.

Table 7
Final EFA Result for Captivating

Rotated Component Matrix[a]					
No.	Element	Item Label	Item Statement	Component	
				1	2
1	Cultural signifycant (CUL)	FOR1	I found the weapon's form ugly.	.615	
2		FOR3	I found the heroes' costume design distasteful.	.515	
3		CUL1	The woven pattern of the boat filled me with awe.	.645	
4		CUL2	I liked the villagers' headdress.	.512	
5		CUL3	The patterns on the weapon impressed me.	.722	
6		PER1	Staying engaged throughout the scenes fascinated me.	.770	
7		PER2	I felt confused by the virtual events flow.	.687	
8		PER3	The close look at the weapon made me curious.	.852	
9	Fidelity (FID)	FID1	The village surroundings moved me deeply.		.770
10		FID2	I felt indifferent towards the river-side surroundings.		.560
11		FID3	The design of the historic figures delighted me.		.607
12		SYM1	The animated scene made me angry.		.766
13		SYM2	I felt oppressive towards the heroes.		.587
14		SYM3	Getting close to the assassination site touched me emotionally.		.655

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

3.2 Plausible construct

The first run of EFA for the Plausible construct, the value of the KMO of Plausible construct was 0.920 (Marvelous), this value is higher than the threshold value of 0.6. The Bartlett's Test of Sphericity was also significant (Chi-square = 1275.507, p-value < 0.000). Certainly, when KMO value is close to 1.0, and the significance value of Bartlett's Test of Sphericity is close to 0.0, it can be concluded that the Plausible construct with 21 items was adequate to proceed with factor analysis. However, corresponding to the rotated component matrix result has shown ENC1 and DOA2 had factor loading below than 0.5, while CRE1, CRE3 and SIC2 were items that loading on 2 factors. Hence, these 5 items; ENC1, DOA2, CRE1, CRE3 and SIC2 were eliminated. Therefore, researcher decided to run EFA again with 16 items.

Thus, the final EFA result to verify the Plausible construct was suitable for factor analysis is disclosed in Table 8. The value of the KMO of Plausible construct was 0.896 (Meritorious); this value is higher than the threshold value of 0.6. The Bartlett's Test of Sphericity was also significant (Chi-square = 840.081, p-value < 0.000). Certainly, when KMO value is close to 1.0, and the significance value of Bartlett's Test of Sphericity is close to 0.0, it can be concluded that the Plausible construct with 16 items was adequate to proceed with factor analysis.

Table 8
KMO and Bartlett's Test of Plausible

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.896
Bartlett's Test of Sphericity	Approx. Chi-Square	840.081
	df	120
	Sig.	< .000

Table 9 shows the PCA with varimax rotation result for the 16 items under the Plausible construct. The result revealed that the PCA procedure has extracted 3 distinct dimensions with eigenvalue

exceeding the value of 1.0, with the total variance explained for all 3 components to be 61.775%, exceeding the fifty per cent value as the minimum percentage of acceptable variance explained in factor analysis for a construct to be valid. Explicitly, the three-factor component explained a total of 61.775% of the variance, with Factor 1 contributing 21.940%, Factor 2 contributing 21.597%, and Factor 3 contributing 18.237%.

Table 9
Total Variance Explained (TVE) of Plausible

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.826	48.911	48.911	7.826	48.911	48.911	3.510	21.940	21.940
2	1.037	6.483	55.394	1.037	6.483	55.394	3.455	21.597	43.537
3	1.021	6.381	61.775	1.021	6.381	61.775	2.918	18.237	61.775

Extraction Method: Principal Component Analysis.

Table 10
Rotated Component Matrix of Plausible

Rotated Component Matrix[a]			
	Component		
	1	2	3
DYN1	.573		
DYN2	.805		
DYN3	.710		
IMA3	.617		
SIC3	.716		
SOE2		.728	
DOA1		.600	
DOA3		.514	
CRE2		.574	
IMA1		.755	
SIC1		.507	
SOE1			.708
SOE3			.573
ENC2			.815
ENC3			.611
IMA2			.517

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

Refers to Table 10, all items have a factor loading more than 0.5, which factor loading ranging between 0.507 - 0.815. Thus, the 16 items are remained and arranged according to the stated 3 sub-constructs of Plausible construct. The 3 sub-construct is labelled as dynamic (DYN), degree of attention (DOA) and sense of exploration (SOE).

In summary, the EFA result indicates that the Plausible in Table 11 with 16 items has only 3 sub-constructs namely: dynamic (DYN), degree of attention (DOA) and sense of exploration (SOE). The sub-constructs and items are directed to proceed to the next level of analysis.

Table 11
Final EFA result of Plausible

Rotated Component Matrix[a]						
No.	Element	Item Label	Item Statement	Component 1	2	3
1	Dynamic (DYN)	DYN1	The historical event presented bored me.	.573		
2		DYN2	Interacting within the scene moved me deeply.	.805		
3		DYN3	The virtual storytelling felt wonderful to me.	.710		
4		IMA3	I felt the exploration of exhibits bored me.	.617		
5		SIC3	The historical objects sparked my interest.	.716		
6	Degree of attention (DOA)	SOE2	The ending of the animated scene made me curious.		.728	
7		DOA1	The artefact manipulation fascinated me.		.600	
8		DOA3	Reading the information do not bore me.		.514	
9		CRE2	The characters' personalities enchanted me.		.574	
10		IMA1	The background music invigorated me.		.755	
11		SIC1	The narration conveyed a deeper meaning to me.		.507	
12	Sense of exploration (SOE).	SOE1	I was mentally engaged on the animated scene.			.708
13		SOE3	The village environment caught my interest.			.573
14		ENC2	Participating in the virtual exhibition motivated me.			.815
15		ENC3	Watching the animated scene energised me.			.611
16		IMA2	The flow of the scene motivated me to act.			.517

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

3.3 Interactive Construct

The first EFA result to verify the Interactive construct with the value of the KMO was 0.883 (Meritorious); this value is higher than the threshold value of 0.6. The Bartlett's Test of Sphericity was also significant (Chi-square = 733.016, p-value < 0.000). Certainly, when KMO value is close to 1.0, and the significance value of Bartlett's Test of Sphericity is close to 0.0, it can be concluded that the interactive construct with 12 items was adequate to proceed with factor analysis. However, corresponding to the rotated component matrix result for the Interactive construct, all items have a factor loading more than 0.5, which factor loading ranging between 0.510 - 0.854. However, ENJ1, ENJ2, ACT1 and ACT2 were items that loading on 2 factors. However, since ENJ1 still had highest value of factor loading on component 2 which is 0.644, thus researcher decided to remain ENJ1 on component 2. Meanwhile, ENJ2, ACT1 and ACT2 were removed. Therefore, researcher decided to run EFA again with 9 items.

Thus, the final EFA result to verify the Interactive construct was suitable for factor analysis is disclosed in Table 12. The value of the KMO of Interactive construct was 0.844 (Meritorious); this value is higher than the threshold value of 0.6. The Bartlett's Test of Sphericity was also significant (Chi-square = 474.781, p-value < 0.000). Certainly, when KMO value is close to 1.0, and the significance value of Bartlett's Test of Sphericity is close to 0.0, it can be concluded that the Interactive construct with 9 items was adequate to proceed with factor analysis.

Table 12
KMO and Bartlett's Test of Interactive

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.844
Bartlett's Test of Sphericity	Approx. Chi-Square	474.781
	df	36
	Sig.	< .000

Table 13 shows the PCA with varimax rotation result for the 9 items under the Interactive construct. The result revealed that the PCA procedure has extracted 2 distinct dimensions with eigenvalue exceeding the value of 1.0, with the total variance explained for all 2 components to be 67.325%, exceeding the fifty per cent value as the minimum percentage of acceptable variance explained in factor analysis for a construct to be valid. Explicitly, the two-factor component explained a total of 67.325% of the variance, with Factor 1 contributing 35.929%, and Factor 2 contributing 31.396%.

Table 13
Total variance explained of interactive

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.959	55.095	55.095	4.959	55.095	55.095	3.234	35.929	35.929
2	1.101	12.230	67.325	1.101	12.230	67.325	2.826	31.396	67.325

Extraction Method: Principal Component Analysis.

Refer to the rotated Component Matrix for Interactive in Table 14, all items have a factor loading more than 0.5, which factor loading ranging between 0.594 - 0.864. Thus, all 9 items are remained and arranged according to the stated two sub-constructs of Interactive construct. The two sub-construct is labelled as feeling of union (FOU) and time (TIM).

Table 14
Rotated Component Matrix of Interactive

Rotated Component Matrix[a]

	Component 1	2
ENJ3	.800	
FOU1	.776	
FOU2	.648	
FOU3	.860	
TIM3	.594	
ENJ1		.621
ACT3		.805
TIM1		.727
TIM2		.864

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

In summary, the EFA result displays that the Interactive in Table 15 with 9 items has 2 sub-constructs, namely; feeling of union (FOU) and time (TIM). The sub-constructs and items are directed to proceed to the next level of analysis of this research.

Table 15
Final EFA result of interactive

Rotated Component Matrix[a]

No.	Element	Item Label	Item Statement	Component	
				1	2
1	Feeling of union (FOU)	ENJ3	Navigating around the village felt wonderful to me.	.800	
2		FOU1	The village's landscape made me felt sublime.	.776	
3		FOU2	The villagers' actions spurred me on.	.648	
4		FOU3	Entering the village scene calmed me.	.860	
5		TIM3	The unlimited time to explore the scene relaxed me.	.594	
6	Time (TIM)	ENJ1	The interactivity surprised me.		.621
7		ACT3	Holding the historical weapon gave me sudden insights.		.805
8		TIM1	Travelling into the past historical village made me feel nostalgic.		.727
9		TIM2	The audio makes me feel sentimental.		.864

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

3.4 The AIX model based on EFA

After conducted EFA, the constructs, elements and items of AIX are confirmed. The Table 16 lists the final dimensions, sub dimensions and items of AIX questionnaire.

Table 16
List of dimensions, sub dimensions and items of AIX questionnaire

No.	Dimension/ Construct	Sub-dimension/ Element	Item Statement
1	Captivating	Cultural significant (CUL)	I found the weapon's form ugly.
2			I found the heroes' costume design distasteful.
3			The woven pattern of the boat filled me with awe.
4			I liked the villagers' headdress.
5			The patterns on the weapon impressed me.
6			Staying engaged throughout the scenes fascinated me.
7			I felt confused by the virtual events flow.
8			The close look at the weapon made me curious.
9		Fidelity (FID)	The village surroundings moved me deeply.
10			I felt indifferent towards the river-side surroundings.
11			The design of the historic figures delighted me.
12			The animated scene made me angry.
13			I felt oppressive towards the heroes.
14			Getting close to the assassination site touched me emotionally.
15	Plausible	Dynamic (DYN)	The historical event presented bored me.
16			Interacting within the scene moved me deeply.
17			The virtual storytelling felt wonderful to me.
18			I felt the exploration of exhibits bored me.
19			The historical objects sparked my interest.
20		Degree of attention (DOA)	The ending of the animated scene made me curious.
21			The artefact manipulation fascinated me.
22			Reading the information do not bore me.
23			The characters' personalities enchanted me.
24			The background music invigorated me.
25			The narration conveyed a deeper meaning to me.
26			I was mentally engaged on the animated scene.
27			The village environment caught my interest.

28		Sense of exploration (SOE).	Participating in the virtual exhibition motivated me.
29			Watching the animated scene energised me.
30			The flow of the scene motivated me to act.
31	Interactive	Feeling of union (FOU)	Navigating around the village felt wonderful to me.
32			The village's landscape made me felt sublime.
33			The villagers' actions spurred me on.
34			Entering the village scene calmed me.
35			The unlimited time to explore the scene relaxed me.
36		Time (TIM)	The interactivity surprised me.
37			Holding the historical weapon gave me sudden insights.
38			Travelling into the past historical village made me feel nostalgic.
39			The audio makes me feel sentimental.

4. Conclusions

The EFA result presented in this paper reveals 3 dimensions; "Captivating", "Plausible", and "Interactive", with 7 sub-dimensions and a set of 39 items that become the 39 AIX items are reliable and valid for assessing the aesthetic immersive experience in virtual reality historical events environment.

This study has met the research objective; to examine the dimensionality of the users' aesthetic immersive experience towards virtual reality (VR) historical events and to develop a novel Aesthetic Immersive Experience (AIX) Questionnaire based on cognitive, perception, and emotional dimensions using EFA. Researchers conducted an exploratory factor analysis to develop the "Aesthetic Immersive Experience (AIX) Questionnaire for the assessment of user VR experience" (AIX) questionnaire, which is designed to assess the museum experience of virtual museum visitors. In doing so, researchers found that the construct represented by the questionnaire can be divided into 3 dimensions with overall 7 factors that influence individuals' response on VR experience items; Cultural Significant, Fidelity, Dynamic, Degree of attention, Sense of Exploration, Feeling of Union, and Time. Therefore, the model can be abbreviated as the Triad AIX model. This study provides initial evidence that the 39 AIX items are reliable and valid for assessing the user's emotional experience in the virtual museum. Another goal of this paper is to provide a short overview of analytical method applications in different scientific fields which have been applied through EFA. As the aim of this paper is to report the development of the AIX questionnaire using EFA, thus this EFA report can become a guideline to novices of researcher to implement the EFA procedure in their research. Within this overview, particular attention is dedicated to the applications from the field of supply chain management. Herein, especially those applications that analyse the impact of integration between individual players on the supply chain performance. The EFA is a validating tool that uses the Principal Component Analysis method to facilitate the decision-making process for developing a questionnaire by attaining the total variance extracted from sample responses.

This study examines the potential unification of two theories, AX and IX, about VR historical events using emotional dimension. This study is also subject to constraints and flaws. Therefore, more experiments are needed to verify the AIX dimensionality with more samples. Further research is needed to evaluate whether the results found in our study can be replicated and are representative of a certain population of VR users. This study's primary weakness is that the sample included individuals with prior knowledge and expertise in the creative sector and HCI and those immediately engaged in this domain. Future studies should broaden their scope to include samples outside the creative and HCI domains or to compare experiences between samples in those sectors and other

disciplines and aim for a larger sample size to enhance the reliability and validity of the findings. The larger number of samples will support more generalisable results across different populations.

This study examines VR historical events stimuli as a research subject applicable to numerous creative extended-reality (XR) products for future investigation. This study focuses mostly on 3D historical events as an art form, while numerous other art forms could serve as research subjects to yield diverse outcomes. The animated content in this study is three-dimensional. Future research could explore alternative art forms and recommend producing three-dimensional animated content, incorporating special effects or motion graphics. The AIX model and the questionnaire can be extended for applications by integrating them with the primary model in game creation, artificial intelligence (AI) and creative content to ensure its applicability and adaptability.

Finally, the researcher of this study would like to encourage all researchers in the field of HCI and art to use AIX questionnaires to assess the immersive experience of individuals and groups and evaluate the outcomes related to immersive technology applications.

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