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Exploring Gen-Zers' Flow Experience and Participation Intention in VR-based Communication of Cultural Heritage: A Study of Hoa Lo Prison Relic, Hanoi, Vietnam

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ABSTRACT: *This research looks at how Generation Z interacts with and participates in virtual reality (VR) based cultural communication at the Hoa Lo Prison relic in Hanoi. Using the Theory of Planned Behavior, self-efficacy theory, and flow theory, the self-administered questionnaire of 298 Gen Z VR users and participants is analyzed using PLS-SEM techniques. The study indicates that self-efficacy and subjective norm have positive VR communication qualitatively and flow experience positive influences. VR communication refers to the intention of participation and holds the strongest influence, while the flow experience is a moderate influence. Self-efficacy indirectly influences participation by all three—VR communication, flow, and participation. The results underscore the importance of virtual reality to the preservation and education of cultural and traditions, suggesting skillful narratives, immersive virtual reality technologies, and educational storytelling to empower, engage, and energize the youth.*

KEYWORDS: *Flow experience; Generation z; Participation intention; Self-efficacy; Virtual reality (vr).*

I. INTRODUCTION

Virtual reality (VR) has become a powerful medium for cultural heritage preservation and communication, providing immersive and interactive experiences that enhance understanding of historical narratives [1, 2]. Integrating VR into heritage communication increases authenticity and engagement, creating dynamic learning environments that extend beyond traditional museum or on-site visits [3, 4]. As VR applications expand, analyzing user experience and participation intention is essential for designing effective cultural heritage programs [5].

Generation Z, defined as individuals born after the mid-1990s, demonstrates strong digital literacy and rapid adaptability to emerging technologies [6, 7]. These characteristics position this cohort as a key audience for VR-based cultural heritage communication [8, 9]. Previous studies highlight that Gen-Z participants value interactive and vivid digital experiences and are more likely to engage when content is socially endorsed [3, 10].

The Hoa Lo Prison Relic in Hanoi, a historic site symbolizing Vietnam's revolutionary struggle, offers an ideal setting for applying VR to cultural heritage communication [11]. VR-based communication can present the site's historical significance through rich audiovisual content, enabling users to experience the past in a lifelike environment and reinforcing cultural identity [2, 10]. By providing authentic and engaging representations, VR supports both heritage education and sustainable tourism development [7, 12].

Empirical research demonstrates that self-efficacy, subjective norm, and flow experience are significant predictors of participation intention in technology-mediated cultural activities. The Theory of Planned Behavior underscores the influence of perceived behavioral control and social norms on intention formation [13]. Self-efficacy theory emphasizes confidence in technological skills as a key determinant of effective interaction with digital environments [1, 14, 15]. Flow theory describes the psychological state of deep immersion, concentration, and enjoyment during appropriately challenging activities [6, 12]. Studies on virtual tourism and cultural heritage confirm that flow experience positively affects visit intention and user satisfaction [16, 17].

Applying these theories to VR-based communication at the Hoa Lo Prison Relic contributes both theoretical and practical insights. Theoretically, this study extends understanding of how technology-related factors and social influences shape Generation Z's behavioral intention [18, 19]. Practically, it provides guidance for heritage managers and policymakers to design engaging VR programs that promote education, preserve cultural identity, and foster sustainable tourism [4].

This research investigates Generation Z's flow experience and participation intention in VR-based communication of cultural heritage at the Hoa Lo Prison Relic, Hanoi, Vietnam. By integrating the Theory of Planned Behavior, self-efficacy theory, and flow theory, the study offers an empirical foundation for enhancing the effectiveness of VR applications in cultural heritage preservation and dissemination.

II. Theoretical Background

The Theory of Planned Behavior (TPB) explains the link between attitude, subjective norm, and perceived behavioral control in predicting behavioral intention [5]. Within VR environments, social norms and perceived control significantly shape participation in cultural heritage communication.

Self-efficacy, as proposed by Bandura (1977) and further developed by Cao, Qu et al. 2024, refers to an individual's belief in personal capability to perform a specific task. Confidence in using and navigating VR environments strongly affects interaction quality and sustained engagement, which in turn enhances participation intention [14, 18].

Flow experience, conceptualized by Csikszentmihalyi (1988, 2000), describes a psychological state of deep immersion where challenges align with personal skills. In VR contexts, immersion, a sense of control, and enjoyment foster flow, which strengthens intention to revisit and recommend the experience [6, 17].

Research on digital heritage communication highlights that VR provides interactive and authentic cultural experiences, enhances educational value, and encourages positive attitudes toward heritage preservation [1, 2]. Information quality and VR's immersive characteristics significantly influence both flow and participation intention, especially among Generation Z users who are native to digital environments [3, 9].

The integration of these theories and findings underscores strong relationships among self-efficacy, subjective norm, flow experience, and participation intention in VR-based cultural heritage communication. This framework forms the foundation for examining Generation Z's participation in VR communication of the Hoa Lo Prison Relic and expands understanding of VR applications in cultural heritage promotion [3, 18].

III. Research Methodology

A quantitative research design was employed to test hypotheses concerning factors influencing flow experience and participation intention in VR-based cultural heritage communication.

Participants and Sample

The study focused on Generation Z individuals who had previous experience with or exposure to virtual reality technology and were potential visitors to the Hoa Lo Prison Relic in Hanoi. The questionnaire allowed respondents to select their age from four categories: under 18 years, 18–21 years, 22–25 years, and above 25 years. A total of 298 valid responses were collected, ensuring sufficient sample size for multivariate statistical analysis [3, 18].

Measurement Instruments

The survey contained two sections: demographic information and constructs measured on a five-point Likert scale (1 = "Strongly disagree," 5 = "Strongly agree"). The constructs included:

VR-based Communication (VRC): Perceived vividness, interactivity, and effectiveness of VR in conveying cultural heritage [1].
Self-efficacy (SEL): Confidence in operating and exploring VR applications [4].
Subjective Norm (SNO): Social influence encouraging VR participation [13].
Flow Experience (FEX): Absorption, enjoyment, and sense of control during VR engagement [12].
Participation Intention (PAI): Willingness and plan to engage in or recommend VR-based cultural heritage programs [17].

Data Collection and Analysis

Data were collected online and in person from May to July 2025. A pilot test ensured clarity and reliability of the questionnaire. After data cleaning and coding, SPSS and SmartPLS were used for descriptive analysis, reliability testing with Cronbach's alpha, exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and structural equation modeling (PLS-SEM).

Reliability and Validity

Reliability was evaluated using Cronbach's alpha and composite reliability, while convergent and discriminant validity were examined using average variance extracted (AVE) and factor loadings. PLS-SEM allowed hypothesis testing and model fit evaluation [6, 20].

Proposed Research Model

The proposed model builds on the Theory of Planned Behavior [13], self-efficacy theory [14, 18], and flow theory (Csikszentmihalyi, 1988, 2000). Prior studies on VR applications in heritage communication provide empirical support for the model structure [1, 3, 17, 18].

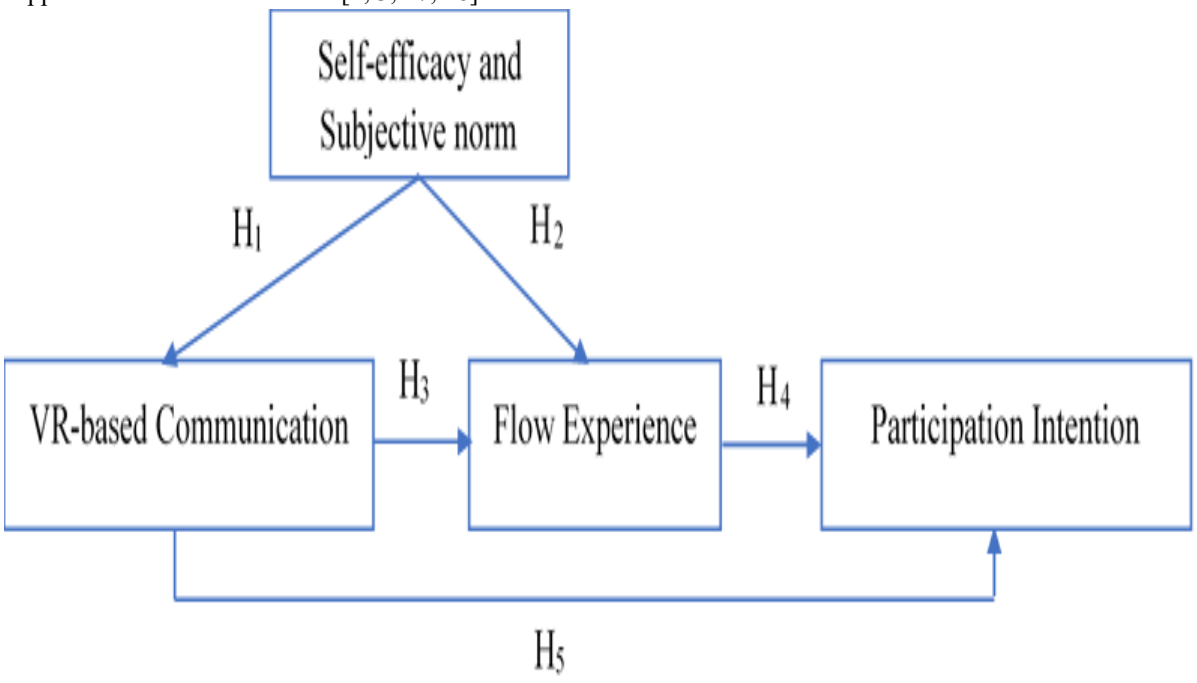

Figure 1. Proposed Research Model of the Author

Hypotheses

H1: Self-efficacy and Subjective Norm positively influence VR-based Communication.
H2: Self-efficacy and Subjective Norm positively influence Flow Experience.
H3: VR-based Communication positively influences Flow Experience.
H4: Flow Experience positively influences Participation Intention.
H5: VR-based Communication positively influences Participation Intention.

This model highlights the roles of self-efficacy and subjective norm in shaping VR-based communication quality, which subsequently enhances flow experience and reinforces participation intention. The framework offers theoretical and empirical insights for promoting VR-based cultural heritage communication at the Hoa Lo Prison Relic.

IV. Results and Discussion

A. Descriptive statistics

1) Sample Characteristics

The study conducted a survey with a total of 298 respondents, with a relatively balanced distribution between genders. Males accounted for 153 respondents (51.3%), and females accounted for 145 respondents (48.7%), indicating that the sample is fairly representative in terms of gender.

Table 1. Sample Distribution by Gender

Gender	Frequency	Percentage (%)	Valid Percentage (%)	Cumulative Percentage (%)
Female	145	48.7	48.7	48.7
Male	153	51.3	51.3	100
Total	**298**	**100**	**100**	

Regarding age, the 22-25 age group had the highest representation with 109 respondents (36.6%), followed by the over-25 age group with 90 respondents (30.2%). The 18-21 age group included 88 respondents (29.5%), while only 11 respondents (3.7%) were under 18. This distribution aligns with the target population of Generation Z, primarily concentrated in the 18-25 age range.

Table 2. Sample Distribution by Age

Age Group	Frequency	Percentage (%)	Valid Percentage (%)	Cumulative Percentage (%)
18-21	88	29.5	29.5	29.5
22-25	109	36.6	36.6	66.1
Over 25	90	30.2	30.2	96.3
Under 18	11	3.7	3.7	100
Total	**298**	**100**	**100**	

In terms of educational attainment, the majority of respondents were at the university level, with 208 respondents (69.8%). The group with high school education or below comprised 76 respondents (25.5%), while only 14 respondents (4.7%) had postgraduate education. This structure reflects the age group surveyed, with most respondents being in the university education phase.

Table 3. Sample Distribution by Educational Attainment

Educational Level	Frequency	Percentage (%)	Valid Percentage (%)	Cumulative Percentage (%)
Postgraduate	14	4.7	4.7	4.7
High School or Below	76	25.5	25.5	30.2
University	208	69.8	69.8	100
Total	**298**	**100**	**100**	

The level of VR technology usage among the sample indicates a positive trend. The majority of respondents used VR frequently, with 214 respondents (71.8%). The group using VR occasionally included 74 respondents (24.8%), and only 10 respondents (3.4%) rarely used VR. No respondents reported never using VR, suggesting that VR technology is quite prevalent among this age group.

Table 4. Sample Distribution by Frequency of VR Usage

Frequency of VR Usage	Frequency	Percentage (%)	Valid Percentage (%)	Cumulative Percentage (%)
Frequently	214	71.8	71.8	71.8
Occasionally	74	24.8	24.8	96.6
Rarely	10	3.4	3.4	100
Total	**298**	**100**	**100**	

2) Scale Characteristics

Descriptive statistics for the observed variables show that all 298 respondents fully completed the survey questions, with no missing values. The variables had mean values ranging from 3.20 to 3.45 on a 5-point scale, indicating a moderately high level of agreement among respondents.

Table 5. Descriptive Statistics of Observed Variables

Variable	N	Minimum	Maximum	Mean	Standard Deviation
SEL1	298	2	5	3.31	0.786
SEL2	298	1	5	3.31	0.756
SEL3	298	1	5	3.27	0.809
FEX1	298	2	5	3.37	0.747
FEX2	298	1	5	3.4	0.79
FEX3	298	1	5	3.42	0.731
FEX4	298	1	5	3.45	0.76
VRC1	298	1	5	3.38	0.825
VRC2	298	2	5	3.38	0.787
VRC3	298	1	5	3.42	0.708
VRC4	298	1	5	3.35	0.812
PAI1	298	2	5	3.32	0.793
PAI2	298	1	5	3.3	0.749
PAI3	298	1	5	3.31	0.777
PAI4	298	1	5	3.2	0.813

In the self-efficacy (SEL) group, SEL1 and SEL2 had the same mean value of 3.31, while SEL3 was slightly lower at 3.27. The standard deviation ranged from 0.756 to 0.809, indicating a relatively consistent level of dispersion among the observed variables in this group.

The flow experience (FEX) group had higher mean values, ranging from 3.37 to 3.45. FEX4 had the highest mean (3.45), while FEX1 had the lowest (3.37). The standard deviation in this group was relatively low, ranging from 0.731 to 0.790, suggesting consistency in respondents' evaluations.

For the VR-based communication (VRC) group, the variables had relatively uniform mean values ranging from 3.35 to 3.42. VRC3 had the highest mean (3.42), while VRC4 had the lowest (3.35). The highest standard deviation was for VRC1 (0.825), indicating greater variation in respondents' evaluations of this aspect.

Finally, the participation intention (PAI) group had the lowest mean values among all groups, ranging from 3.20 to 3.32. PAI4 had the lowest mean (3.20) with the highest standard deviation (0.813), suggesting significant variation in respondents' intentions to use VR to explore other cultural relics.

B. Scale evaluation

1) Reliability Testing and Exploratory Factor Analysis

The study conducted reliability testing for each scale separately using Cronbach's Alpha coefficient and exploratory factor analysis (EFA) to confirm the unidimensionality of the scales. Prior to EFA, the study verified the necessary conditions through the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity.

Table 6. Results of Reliability Testing and Factor Analysis

Scale	Variable	Cronbach's Alpha	Item-Total Correlation	Factor Loading	Factor
Participation Intention (PAI)		**0.812**			**1**
	PAI1		0.615	0.524	1
	PAI2		0.612	0.7	1
	PAI3		0.668	0.689	1

	PAI4		0.628	0.808	1
VR-Based Communication (VRC)		**0.777**			**2**
	VRC1		0.574	0.652	2
	VRC2		0.543	0.623	2
	VRC3		0.567	0.543	2
	VRC4		0.645	0.836	2
Flow Experience (FEX)		**0.773**			**3**
	FEX1		0.599	0.775	3
	FEX2		0.557	0.659	3
	FEX3		0.537	0.547	3
	FEX4		0.609	0.691	3
Self-Efficacy (SEL)		**0.699**			**4**
	SEL1		0.491	0.541	4
	SEL2		0.539	0.712	4
	SEL3		0.518	0.648	4

Table 7. EFA Evaluation Metrics and Extracted Variance

Metric	**Value**	**Standard**	**Conclusion**
KMO	0.877	> 0.5	Very Good
Bartlett's Test Chi-Square	1520.775		
Degrees of Freedom	105		
Significance Level	0	< 0.05	Suitable for EFA
Extracted Variance by Factor:			
Factor 1	32.29%		
Factor 2	7.99%		
Factor 3	5.29%		
Factor 4	3.58%		
Total Extracted Variance	**49.16%**	> 50%	Acceptable

The KMO value of 0.877 (> 0.5) indicates a very good level, allowing for factor analysis. Bartlett's Test yielded a Chi-Square value of 1520.775 with a significance level of 0.000 (< 0.05), rejecting the null hypothesis that the correlation matrix is an identity matrix, confirming the data's suitability for EFA.

The EFA results extracted four factors with eigenvalues > 1, where Factor 1 explained 32.287% of the variance, Factor 2 explained 7.994%, Factor 3 explained 5.292%, and Factor 4 explained 3.583%. The total extracted variance was 49.156%. Although this is below the ideal threshold of 60%, it is still acceptable in social science research when the number of variables is not overly large.

The results indicate that all scales have reliability ranging from acceptable to good. The Participation Intention (PAI) scale had the highest reliability with a Cronbach's Alpha of 0.812, followed by VR-Based Communication (VRC) at 0.777 and Flow Experience (FEX) at 0.773. The Self-Efficacy (SEL) scale had a Cronbach's Alpha of 0.699, exceeding the minimum threshold of 0.6 and deemed acceptable due to having only three observed variables.

Item-total correlations ranged from 0.491 to 0.668, all exceeding the 0.3 threshold, indicating appropriate contributions of each variable to its respective scale. Factor loadings ranged from 0.524 to 0.836, all > 0.5, ensuring statistical and practical significance. The grouping of observed variables into four factors as initially designed confirms the unidimensionality and discriminant validity of the scales.

All 15 observed variables met the requirements for reliability and unidimensionality, with no variables needing to be removed from the research model. These results allow for further analyses in the structural equation model.

2) Scale Evaluation Using PLS-SEM

After confirming the scale structure through EFA, the study proceeded to evaluate scale quality using the Partial Least Squares Structural Equation Modeling (PLS-SEM) method. This approach enables simultaneous evaluation of both the measurement model and the structural model, making it particularly suitable for exploratory research and moderate sample sizes. The evaluation of scale quality in PLS-SEM focuses on three main aspects: scale reliability, convergent validity, and discriminant validity.

Evaluation of Reliability and Convergent Validity

Table 8. Outer Loadings Matrix

Variable	FEX	PAI	SEL	VRC
FEX1	0.785			
FEX2	0.739			
FEX3	0.763			
FEX4	0.798			
PAI1		0.816		
PAI2		0.777		
PAI3		0.823		
PAI4		0.78		
SEL1			0.809	
SEL2			0.789	
SEL3			0.771	
VRC1				0.767
VRC2				0.733
VRC3				0.78
VRC4				0.817

The outer loadings reflect the extent to which each observed variable contributes to measuring its corresponding latent construct. The results show that all outer loadings exceeded the recommended threshold of 0.7, ranging from 0.733 to 0.823. This indicates high reliability of the observed variables in measuring their constructs. The Participation Intention (PAI) scale had the highest and most consistent loadings, ranging from 0.777 to 0.823, demonstrating high consistency in measurement. The variable PAI3 had the highest loading (0.823), highlighting the importance of VR re-experience in participation intention. Conversely, VRC2 had the lowest loading (0.733) but was still acceptable, indicating that the effectiveness of VR compared to traditional media still holds some significance in measuring the VR-Based Communication construct.

Table 9. Scale Reliability and Convergent Validity

Scale	Cronbach's Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	AVE
FEX	0.773	0.776	0.854	0.595
PAI	0.813	0.82	0.876	0.639
SEL	0.7	0.706	0.832	0.624
VRC	0.778	0.78	0.857	0.6

Cronbach's Alpha assesses the internal consistency of the scales, with all values ranging from 0.700 to 0.813, exceeding the acceptable threshold of 0.7. The PAI scale had the highest reliability (0.813), followed by VRC (0.778) and FEX (0.773). The SEL scale had the lowest Cronbach's Alpha (0.700) but still met the acceptable threshold, possibly due to its limited number of observed variables (only three) and the complex nature of the self-efficacy construct.

Composite Reliability (CR) is preferred over Cronbach's Alpha in PLS-SEM as it does not assume equal weight for all variables. The results show that all scales had CR > 0.8, ranging from 0.832 to 0.876, indicating good reliability. The small difference between Cronbach's Alpha and CR suggests stable scale structures.

Average Variance Extracted (AVE) measures the proportion of variance explained by the construct relative to the variance due to measurement error. The PAI (0.639), SEL (0.624), and VRC (0.600) scales all met the recommended threshold of 0.6. The FEX scale had an AVE of 0.595, slightly below the threshold but still acceptable when combined with other metrics. The highest AVE for PAI (0.639) indicates that this construct was measured most accurately, while FEX had slightly higher noise.

Evaluation of Discriminant Validity

Discriminant validity ensures that each construct measures distinct aspects and does not overlap with other constructs in the model.

Table 10. Discriminant Validity Assessment

Fornell-Larcker Criterion	FEX	PAI	SEL	VRC

FEX	0.771			
PAI	0.401	0.799		
SEL	0.471	0.467	0.79	
VRC	0.375	0.555	0.343	0.775
HTMT Ratio	**FEX**	**PAI**	**SEL**	**VRC**
PAI	0.499			
SEL	0.635	0.614		
VRC	0.482	0.686	0.462	

The Fornell-Larcker criterion compares the square root of the AVE (values on the diagonal) with the correlations between constructs. The results show that all diagonal values were higher than the corresponding correlations, confirming good discriminant validity. The highest correlation was between VRC and PAI (0.555), indicating a strong but distinct relationship between VR-Based Communication and Participation Intention.

The Heterotrait-Monotrait (HTMT) ratio is a stricter criterion for discriminant validity. All HTMT values were < 0.9, with the highest being 0.686 between VRC and PAI, confirming discriminant validity. The relationship between SEL and FEX had an HTMT of 0.635, reflecting a logical connection between self-efficacy and flow experience.

Table 11. Cross Loadings Matrix

Variable	FEX	PAI	SEL	VRC
FEX1	0.785	0.342	0.345	0.253
FEX2	0.739	0.243	0.357	0.258
FEX3	0.763	0.343	0.381	0.298
FEX4	0.798	0.302	0.37	0.342
PAI1	0.348	0.816	0.417	0.52
PAI2	0.303	0.777	0.292	0.411
PAI3	0.351	0.823	0.437	0.426
PAI4	0.272	0.78	0.334	0.401
SEL1	0.412	0.363	0.809	0.31
SEL2	0.346	0.377	0.789	0.263
SEL3	0.351	0.37	0.771	0.233
VRC1	0.286	0.412	0.284	0.767
VRC2	0.304	0.35	0.274	0.733
VRC3	0.283	0.524	0.219	0.78
VRC4	0.291	0.42	0.291	0.817

The cross-loadings matrix shows that each observed variable had the highest loading on its intended construct and significantly lower loadings on other constructs. This further confirms discriminant validity and unidimensionality. Notable cross-loadings, such as PAI1 with VRC (0.520) and VRC3 with PAI (0.524), reflect logical relationships between VR-Based Communication and Participation Intention but remain lower than the primary loadings.

Collinearity Assessment

Table 12. Collinearity Assessment (VIF)

Measurement Model	VIF	Structural Model	VIF
FEX1	1.561	FEX → PAI	1.163
FEX2	1.483	SEL → FEX	1.133
FEX3	1.433	SEL → VRC	1
FEX4	1.593	VRC → FEX	1.133
PAI1-PAI4	1.607-1.828	VRC → PAI	1.163
SEL1-SEL3	1.320-1.410		
VRC1-VRC4	1.424-1.730		

The Variance Inflation Factor (VIF) assesses the level of collinearity in the model. All VIF values were < 3, indicating no serious collinearity issues. In the measurement model, the highest VIF was 1.828 for PAI3, still within the safe range. In the structural model, all relationships had VIF < 1.2, demonstrating good independence among constructs.

In summary, the PLS-SEM analysis confirms that the scales are of high quality in terms of reliability, convergent validity, and discriminant validity. All 15 observed variables are suitable and reliable for use in subsequent structural model analyses. The metrics either met or were close to the recommended thresholds, providing a solid foundation for testing the research hypotheses.

C. Impact estimation

1) Direct and Indirect Impact Coefficients

The study estimated the relationships in the structural model using the Bootstrapping method with 5,000 resamples to ensure the reliability of the estimates. The results show that all hypotheses were supported with high statistical significance.

Table 13. Direct Impact Coefficients

Relationship	Impact Coefficient (β)	Sample Mean	Standard Deviation	t-Value	P-Value	Conclusion
SEL → FEX	0.388	0.389	0.055	7.03	0.000***	Supported
SEL → VRC	0.343	0.346	0.062	5.54	0.000***	Supported
VRC → FEX	0.242	0.243	0.051	4.71	0.000***	Supported
VRC → PAI	0.471	0.475	0.061	7.756	0.000***	Supported
FEX → PAI	0.225	0.224	0.055	4.081	0.000***	Supported

*Note: *** $p < 0.001$*

The results indicate that all direct relationships are statistically significant at $p < 0.001$. The strongest relationship is from VRC to PAI with a coefficient of $\beta = 0.471$, demonstrating that VR-based communication has the most significant impact on users' participation intention. This aligns with the study's focus, as VR is the primary technology creating experiences and driving participation intention.

The impact of SEL on FEX has the second-highest coefficient ($\beta = 0.388$, $t = 7.030$), indicating that self-efficacy plays a crucial role in generating flow experience. Users who are confident in their ability to use VR are more likely to achieve a state of immersion and enjoy the experience.

SEL also has a significant impact on VRC ($\beta = 0.343$, $t = 5.540$), showing that self-efficacy not only directly affects the flow experience but also influences how users evaluate the quality of VR-based communication. Confident VR users tend to rate the technology's information delivery capabilities more highly.

The relationship from VRC to FEX has a coefficient of $\beta = 0.242$ ($t = 4.710$), indicating that the quality of VR-based communication contributes to the flow experience. Finally, FEX to PAI has a coefficient of $\beta = 0.225$ ($t = 4.081$), confirming the role of flow experience in promoting participation intention.

Table 14. Indirect Impact Coefficients

Indirect Relationship	Impact Coefficient (β)	Sample Mean	Standard Deviation	t-Value	P-Value	Conclusion
SEL → VRC → PAI	0.161	0.164	0.035	4.651	0.000***	Significant
SEL → FEX → PAI	0.087	0.088	0.028	3.08	0.002**	Significant
SEL → VRC → FEX	0.083	0.085	0.026	3.167	0.002**	Significant
VRC → FEX → PAI	0.054	0.054	0.018	3.062	0.002**	Significant
SEL → VRC → FEX → PAI	0.019	0.019	0.008	2.296	0.022*	Significant

*Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$*

The analysis of indirect impacts shows that self-efficacy can influence participation intention through multiple pathways. The strongest indirect impact is SEL → VRC → PAI with a coefficient of β = 0.161, indicating that self-efficacy primarily affects participation intention by improving the evaluation of VR-based communication quality.

The indirect impact of SEL → FEX → PAI has a coefficient of β = 0.087, demonstrating the mediating role of flow experience in the relationship between self-efficacy and participation intention. This suggests that users with high self-efficacy have a better flow experience, which in turn increases their participation intention.

The relationship SEL → VRC → FEX (β = 0.083) shows that self-efficacy can influence flow experience by improving the evaluation of VR-based communication. The pathway VRC → FEX → PAI has a coefficient of β = 0.054, indicating the mediating role of flow experience in the relationship between VR-based communication and participation intention.

Finally, the three-step indirect impact SEL → VRC → FEX → PAI has a coefficient of β = 0.019, which, although small, is still statistically significant. This suggests that self-efficacy can influence participation intention through a complex chain: improving the evaluation of VR-based communication, which enhances the flow experience, and ultimately promotes participation intention.

2) Predictive Coefficients and Model Fit

The model's explanatory and predictive power was evaluated using the R^2, Adjusted R^2, f^2, and Q^2 metrics.

Table 15. Coefficient of Determination (R^2) and Model Fit

Dependent Variable	R^2	Adjusted R^2	Explanatory Level
FEX	0.273	0.268	Moderate
PAI	0.351	0.347	Moderate
VRC	0.118	0.115	Weak

The R^2 coefficient indicates the extent to which independent variables explain the variance of the dependent variable. PAI has the highest R^2 (0.351), showing that 35.1% of the variance in participation intention is explained by the model's factors. This level is considered moderate according to Cohen's (1988) standards, suitable for the complex nature of user behavior in the context of new technology.

FEX has an R^2 of 0.273, indicating that 27.3% of the variance in flow experience is explained by self-efficacy and VR-based communication. This level is also moderate, reflecting the significant role of these two factors in creating flow experience.

VRC has the lowest R^2 (0.118), with only 11.8% of the variance explained by self-efficacy. This suggests that the evaluation of VR-based communication is influenced by many other factors beyond self-efficacy, such as content quality, interface design, or prior technological experiences.

Table 16. Effect Size (f^2)

Relationship	f^2	Effect Size
SEL → FEX	0.183	Moderate
SEL → VRC	0.133	Small to Moderate
VRC → FEX	0.071	Small
VRC → PAI	0.294	Moderate to Large
FEX → PAI	0.067	Small

The f^2 coefficient evaluates the effect size of each independent variable on the dependent variable when removed from the model. VRC has the largest effect on PAI ($f^2 = 0.294$), confirming its critical role in promoting participation intention.

SEL has a moderate effect on FEX ($f^2 = 0.183$) and a small to moderate effect on VRC ($f^2 = 0.133$). VRC has a small effect on FEX ($f^2 = 0.071$), while FEX has a small effect on PAI ($f^2 = 0.067$). These results indicate that, although all relationships are statistically significant, their practical effect sizes vary considerably.

Table 17. Model Predictive Power (Q^2)

Construct	SSO	SSE	Q^2	Predictive Power
FEX	1192	1001.774	0.16	Small
PAI	1192	935.458	0.215	Small to Moderate
VRC	1192	1109.94	0.069	Very Small
SEL	894	894	0	Not Applicable

The Q^2 metric evaluates the model's predictive power using the Stone-Geisser method. A Q^2 value > 0 indicates that the model has better predictive power than a baseline model. PAI has the highest Q^2 (0.215), indicating small to moderate predictive power. FEX has a Q^2 of 0.160 (small), while VRC has a Q^2 of 0.069 (very small). SEL has no Q^2 as it is an exogenous variable in the model.

In summary, the research model demonstrates acceptable explanatory and predictive power. All hypothesized relationships are supported with high statistical significance, with VR-based communication playing the most critical role in promoting Generation Z's participation intention in cultural heritage activities through VR technology.

D. Hypothesis testing and discussion of results

Based on the results of the PLS-SEM structural model analysis, the study proceeded to test each hypothesis and discuss the findings in the practical context of Vietnam, particularly in the case of the Hỏa Lò Prison relic.

Table 18. Summary of Hypothesis Testing Results

Hypothesis	Relationship	Coefficient (β)	t-Value	P-Value	Result	Impact Level
H1	VRC → FEX	0.242	4.71	0.000***	Supported	Moderate
H2	SEL → FEX	0.388	7.03	0.000***	Supported	Strong
H3	VRC → PAI	0.471	7.756	0.000***	Supported	Very Strong
H4	FEX → PAI	0.225	4.081	0.000***	Supported	Moderate
H5	SEL → VRC	0.343	5.54	0.000***	Supported	Strong

*Note: *** $p < 0.001$*

H1: VR-Based Communication Positively Impacts Flow Experience (VRC → FEX): SUPPORTED

The results show that H1 is supported with $\beta = 0.242$, $t = 4.710$, $p < 0.001$. This confirms that the quality of VR-based communication positively affects users' flow experience. In the context of the Hỏa Lò Prison relic, this finding has significant practical implications. When the VR system realistically recreates areas such as prison cells, the exercise yard, or exhibition spaces, Generation Z users can achieve a deep state of immersion. This differs significantly from traditional visits that rely solely on informational panels and static artifacts.

For example, when experiencing a VR recreation of the daily life of political prisoners, users can vividly sense the cramped space, dim lighting, and ambient sounds. This interaction creates a flow experience where users become fully focused on the historical content, losing track of time and their surroundings. However, the moderate impact level ($\beta = 0.242$) suggests that the current quality of VR-based communication still needs improvement to optimize the flow experience.

H2: Self-Efficacy Positively Impacts Flow Experience (SEL → FEX): SUPPORTED

H2 is strongly supported with $\beta = 0.388$, $t = 7.030$, $p < 0.001$, representing the second strongest relationship in the model. This result aligns with the characteristics of Generation Z, who were born and raised in the digital age. In Vietnam, Generation Z has a high level of familiarity with technological devices, from smartphones to gaming consoles, providing a foundation for confidence when engaging with VR.

In the practical context of the Hỏa Lò Prison relic, young users with experience in VR gaming or other virtual reality applications can easily adapt to the system's controls, navigate 3D spaces, and interact with virtual objects. This confidence enables them to quickly move past the initial learning phase and achieve a flow state. Conversely, those with less experience may face initial difficulties, affecting the quality of their experience.

This suggests that relic site managers should implement appropriate training programs and design user-friendly interfaces to enhance users' self-efficacy before they begin the full VR experience.

H3: VR-Based Communication Positively Impacts Participation Intention (VRC → PAI): SUPPORTED

H3 is supported with the strongest impact in the model ($\beta = 0.471$, $t = 7.756$, $p < 0.001$). This is the study's most significant finding, indicating that the quality of VR-based communication directly determines Generation Z's intention to participate in cultural heritage preservation activities.

In the context of Vietnam, where historical sites like Hỏa Lò face challenges in attracting young visitors, this result offers a new solution. When VR systems vividly and interactively recreate historical narratives, Generation Z—accustomed to multimedia content and digital experiences—will be strongly motivated to engage further.

For example, instead of merely reading about the lives of national heroes imprisoned at Hỏa Lò, users can "walk" through prison cells, "witness" daily activities, or even "participate" in resistance plans. Such experiences not only evoke strong emotions but also foster a sense of responsibility for heritage preservation, encouraging users to share their experiences with friends and family.

H4: Flow Experience Positively Impacts Participation Intention (FEX → PAI): SUPPORTED

H4 is supported with $\beta = 0.225$, $t = 4.081$, $p < 0.001$. Although the impact is moderate, this result confirms the critical role of flow experience in forming participation intention. When users achieve a state of complete immersion in historical content, they experience positive emotions and a desire to continue exploring.

At the Hỏa Lò Prison relic, flow experiences may occur when users are fully "immersed" in the stories of political prisoners, feeling their pain, hope, and resilience. This state creates a deep emotional connection to national history, thereby promoting participation intentions in activities such as joining other guided tours, learning more about history, or sharing knowledge with others.

However, the moderate impact level suggests that flow experience is only one of many factors influencing participation intention. This may be due to Generation Z's characteristics, as they have numerous entertainment options and typically shorter attention spans, making it challenging to sustain a flow state.

H5: Self-Efficacy Positively Impacts VR-Based Communication (SEL → VRC): SUPPORTED

H5 is supported with $\beta = 0.343$, $t = 5.540$, $p < 0.001$. This result indicates that users with high self-efficacy in using VR technology evaluate the quality of VR-based communication more positively. This reflects

a common psychological phenomenon: when users are confident and proficient with a technology, they tend to perceive its features and benefits more favorably.

In Vietnam's practical context, Generation Z exhibits varying levels of technological proficiency. Those experienced with VR gaming or digital educational applications are more likely to appreciate the interactivity, graphic realism, and creative content presentation. Conversely, those with less experience may struggle with operating the equipment or fully understanding its features, leading to lower evaluations of the system's quality.

This finding has significant implications for designing user training and support programs at relic sites. Enhancing self-efficacy through detailed guidance and practice sessions can significantly improve users' evaluations of VR-based communication quality.

Discussion of Indirect Impacts

In addition to direct impacts, the study identified significant indirect impacts. Notably, self-efficacy influences participation intention through two main pathways: through VR-based communication (SEL → VRC → PAI: $\beta = 0.161$) and through flow experience (SEL → FEX → PAI: $\beta = 0.087$).

The stronger pathway through VR-based communication suggests that enhancing users' self-efficacy leads to more positive evaluations of the VR system, thereby increasing participation intention. This implies that relic site managers should invest in training users' VR skills before they begin the full experience.

V. CONCLUSIONS

The study's results highlight the significant potential of applying VR in communicating cultural heritage in Vietnam to attract Generation Z. However, success depends on designing high-quality VR systems and providing appropriate user support programs. For the Hỏa Lò Prison relic and other sites, the study recommends: Investing in advanced VR technology with realistic graphics and high interactivity. Developing short training programs to enhance users' self-efficacy. Designing VR content with engaging storytelling to create flow experiences. Combining VR with real-world activities to sustain and expand users' participation intentions.

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