

The Rasa-Śarīra Scale: development and validation of a culturally grounded instrument for measuring embodied aesthetic learning in architectural heritage games

Sneha Maji

snehamaji@igdtuw.ac.in

Indira Gandhi Delhi Technical University for Women

Akhil Das

Guru Gobind Singh Indraprastha University

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Tables are available in the Supplementary Files section.

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Abstract

Background. Game-based learning in architectural heritage education aspires to more than conceptual recall; its ambition is embodied aesthetic understanding — the felt, sensorimotor, contemplative engagement that classical Indian aesthetic theory places at the centre of artistic encounter. The instruments routinely used to evaluate such learning were built for neighbouring constructs — discrete emotion, presence, flow, awe, avatar embodiment — and do not measure it, which helps explain a persistent pattern in which serious-games research reports null cognitive-test effects while qualitative accounts testify to powerful bodily learning. The gap is sharpest in Indian architectural pedagogy, where a regulatory culture organised around quantitative minimum standards meets a national policy turn towards Indian Knowledge Systems, together exposing the absence of any validated, culturally grounded instrument for assessing how the body learns architecture.

Methods. We developed the *Rasa-Śarīra* Scale (RSS), a 25-item instrument grounded in classical Indian aesthetics — Bharata's *Nāṭyaśāstra* and Abhinavagupta's *Abhinavabhāratī* — and in contemporary embodied-cognition theory. Its items are organised as a five-stage phenomenological progression (Kāma-Sparśa, Līlā-Gati, Anubhava-Śarīra, Māyā-Vismaya, Yoga-Sthāna), each carrying an explicit somatic anchor. Validation proceeded in three stages: content validation by five subject-matter experts; psychometric validation in 250 students following a photogrammetric heritage game, including internal-consistency analysis, confirmatory factor analysis of five-factor, unidimensional and higher-order models, and known-groups validity; and an experimental application in which 100 architecture students were randomised to an embodied game ($n = 50$) or a matched passive walkthrough ($n = 50$) of the Vijaya Vittala Temple, Hampi.

Results. The RSS demonstrated excellent content validity and internal consistency. It behaves empirically as a unidimensional measure of embodied aesthetic experience with theoretically organised content, and showed strong known-groups validity. In the application study, the embodied game outscored the matched walkthrough on the composite and on all five subscales, while the two items targeting somatic channels that headset-and-controller virtual reality cannot

physically deliver — thermal contrast and respiratory modulation — showed null effects, evidence of the instrument's mechanistic specificity.

Conclusions. The RSS offers architectural pedagogy, serious-games research and embodied-cognition studies a first validated, culturally grounded instrument for measuring how the body learns architecture, with its five Sanskrit-named stages retained as a theoretical and design heuristic.

Keywords: Embodied cognition; Rasa theory; Architectural heritage; Serious games; Instrument validation; Content validity index; Confirmatory factor analysis; Indian Knowledge Systems; Architectural pedagogy; Vijaya Vittala Temple

1. Background

For two decades the serious-games community has asked a deceptively simple question: do immersive, navigable, embodied digital reconstructions of historic architecture teach more effectively than conventional instruction [1, 2]? The accumulated answer is awkward. Systematic reviews of game-based heritage learning find, with uncomfortable regularity, that immersive games raise self-reported engagement and motivation but seldom produce a statistically reliable advantage on the outcomes researchers actually measure — factual recall, multiple-choice comprehension, written transfer [3, 4, 5]. Taken at face value this reads like a verdict: for all their technical sophistication, heritage games deliver little of educational value beyond novelty. The qualitative record refuses that verdict. Ask students who have completed an immersive heritage encounter what they took from it, and they answer in the body. They describe remembering the feel of column rhythm, the weight of stone in the hand, the involuntary hush of an inner sanctum, the way a corridor's proportions answered their stride [2, 6]. These are not vague impressions. They are durable, specific, pedagogically consequential forms of understanding — and they are also, almost without exception, invisible to the instruments deployed in our quantitative work. Our argument begins from the suspicion that the instruments are themselves part of the problem. We ask cognitive questions because cognitive instruments are what the discipline has inherited. The Differential Emotions Scale [7], the Positive and Negative Affect Schedule [8], the Witmer–Singer Presence Questionnaire [9], the Dispositional Flow Scale [10], the Tellegen Absorption Scale [11], the Awe Experience Scale [12], the Aesthetic Emotions Scale (AESTHEMOS) [13] and the Virtual Embodiment Questionnaire [14] are each rigorous and well validated. Not one was designed to measure embodied aesthetic learning, and not one does. They measure emotion, presence, absorption, flow, awe, aesthetic appreciation or avatar ownership — meaningful constructs, all of them adjacent to, and none congruent with, what students report when they tell us what their bodies have learned inside a heritage game. What is needed is an instrument that takes the body as its object: not what the participant felt *about* the architecture, but what the participant's body *did* in response to it, and what that body now knows as a consequence. This paper develops and validates such an instrument, the *Rasa-Śarīra Scale* (RSS).

1.1 The Indian architectural-pedagogy context: a missing instrument

The measurement gap just described is general, but it is felt with particular force in the setting from which this instrument emerged — architectural education in India. The absence is not incidental: it is produced by the way the discipline is regulated, by what its assessment apparatus

is built to register, and, increasingly, by a national policy that asks for exactly the kind of instrument the field does not have.

Architectural education in India is governed by the Council of Architecture, a statutory body that prescribes the minimum standards to which every recognised programme must conform [15]. The standards have given the discipline a shared scaffold, but their gravitational pull is quantitative: contact hours, subject heads, studio-to-theory ratios, infrastructure norms. The most pointed internal critiques converge on this characterisation. Khan and Khan, writing in a symposium on reforming architectural education across the Global South, trace a structural malaise in which the apparatus audits the countable while the substance of an architectural education — judgement, sensibility, the making of meaning — goes untended [16]. Kohale and colleagues put the same point in the idiom of assessment reform: Indian architectural education, they argue, has been "largely dominated by the quantitative and technical aspects of its regulating framework," and needs a competency-based turn capable of registering knowledge, skills, attitudes and values rather than measurable inputs alone [17]. The shared diagnosis is not that Indian schools fail to teach the qualitative substance of architecture — many teach it superbly — but that the machinery of assessment has no purchase on it.

This is not a marginal pedagogical complaint, because the studio — the heart of architectural training — teaches through the body. Students learn proportion by walking it, scale by standing beneath it, threshold by passing through it. The most influential account of how design expertise forms describes precisely this kind of reflective, situated, embodied knowing, acquired in action rather than transmitted as proposition [18]; the architectural phenomenology that follows it insists that buildings are met through the whole-body sensorium — the eyes of the skin — and not through vision alone [19]. The knowledge an architecture student accumulates is, in large part, a sedimented bodily literacy. Yet the instruments available to an Indian educator who wishes to *evidence* such learning — who wishes to demonstrate, in the language of accreditation, that graduates have acquired embodied architectural understanding — are imported affect and presence questionnaires that ask the wrong question of the wrong organ. The gap is therefore doubly cultural. It is a gap in *what* is measured (embodied rather than cognitive learning) and a gap in *whose* theory does the measuring (Western affect theory rather than the aesthetic tradition native to the heritage being studied).

That second gap has become harder to ignore. India's National Education Policy 2020 makes the integration of Indian Knowledge Systems a central commitment of higher education, directing institutions to recover and teach the country's own intellectual traditions and naming architecture

explicitly among the domains in which this indigenous corpus is to be revived [20]. The policy creates an unusual predicament: a national mandate to ground pedagogy in Indian knowledge, met by an assessment toolkit that contains almost nothing Indian. The classical Indian theory of aesthetic experience — *rasa*, set out in Bharata's *Nāṭyaśāstra* and elaborated by Abhinavagupta — is among the most developed accounts of embodied artistic encounter in any tradition [21, 22, 23], and a modest interpretive literature has read architecture through it. But that literature is essayistic and hermeneutic; to our knowledge no one has operationalised *rasa* as a measurement instrument, validated it psychometrically, or used it to evaluate a designed pedagogical intervention. The result is a striking absence. In a country with a two-thousand-year-old theory of how the body relishes art, and a policy environment now actively demanding the use of such theory, the architecture educator has no validated, culturally grounded instrument for measuring the embodied aesthetic learning that the studio has always cultivated and never been able to assess.

There is precedent for closing a gap of this shape. Zheng and colleagues recently developed and validated an embodied-cognition scale specifically for Chinese university students, grounding it in the Confucian principle of body–mind unity rather than retrofitting a Western measure, and showing that a culturally specific theoretical foundation can anchor a psychometrically sound instrument [24]. The RSS pursues the same logic in a different tradition and a different domain. It asks whether *rasa* theory, joined to contemporary embodied cognition, can serve as the engine of a rigorous instrument for architectural heritage learning — and whether that instrument can do what imported scales cannot: detect the bodily learning the field has long observed qualitatively and never been able to quantify.

1.2 Theoretical foundation: *rasa*, *śarīra* and the embodied aesthetic encounter

The RSS draws its structure from the *rasa* theory of Bharata's *Nāṭyaśāstra* (c. 200 BCE – 200 CE) and Abhinavagupta's eleventh-century *Abhinavabhāratī* [21, 22, 23]. The choice is theoretically motivated, not decorative. In *rasa* theory, aesthetic experience is constituted through the interplay of five elements: *vibhāva*, the evoking object — here, the architecture itself; *anubhāva*, the consequent bodily response of posture, gesture, breath and gaze; *vyabhicāri bhāva*, the transient emotional fluctuations that modulate the dominant sentiment; *sādhāraṇīkaraṇa*, the universalisation by which intensely personal feeling becomes shareable aesthetic experience; and *tanmayatā*, the dissolution of the subject–object boundary in which spectator and object become one.

Three features of this framework matter for the present project. The body's response is not an epiphenomenon of aesthetic experience but constitutive of it: *anubhāva* is not what happens after one cognises beauty — the bodily resonance *is* the aesthetic event. The framework is developmental, an encounter that unfolds through stages, beginning with the body's drawing towards the object and ending with the loss of separation between them. And it is universalising; though felt by an individual, *rasa* is a shareable, generalisable form of refined experience rather than idiosyncratic emotion. To this *rasa* armature the RSS adds *śarīra* — the body as the locus of aesthetic knowing, drawn from the yoga and tantra traditions — and integrates the synthesis with contemporary embodied-cognition research.

The contemporary partners are chosen on principle. Lakoff and Johnson establish that meaning-making is grounded in sensorimotor engagement with the world [25, 26]. Sheets-Johnstone argues that animate movement is the originary site of the self–other distinction, and therefore of any later cognition [27]. Damasio's somatic-marker hypothesis grounds these phenomenological claims in neurobiology, treating the body's interoceptive signals as constitutive of the meaning-making that consciousness experiences as its own [28, 29]. The enactivist programme makes the same wager from within cognitive science [30], as do ecological accounts of perception built on affordances [31] and Merleau-Ponty's phenomenology of the lived body [32]. Developed in conversation with Western phenomenology and neuroscience, these frameworks converge on precisely what the *rasa* tradition has held for two millennia: that the body is not an obstacle to aesthetic experience but its medium.

1.3 The five-stage phenomenological progression

From the synthesis of *rasa* theory and embodied cognition we derive a five-stage developmental sequence of embodied architectural encounter (Fig. 1), each stage operationalised by five items anchored to specific body regions.

Each stage is operationalised by five RSS items anchored to specific body regions



Pre-reflective attraction → embodied attunement → sedimented knowing → rupture/wonder → dissolution of subject-object boundary

Fig. 1. The five-stage phenomenological progression of embodied aesthetic encounter, named according to classical Indian aesthetic philosophy. Each stage maps to a *rasa*-theoretic element and a cluster of somatic anchors, and is operationalised by five RSS items.

Kāma-Sparśa (Desire to Touch). Pre-reflective attraction. The body is drawn towards surface, threshold and detail; the hand reaches, the torso leans, the feet step closer. This is the *vibhāva* phase of contact-seeking, the somatic correlate of architectural intentionality.

Līlā-Gati (Playful Movement). As the body engages with space, *līlā* (sacred play) becomes *gati* (purposeful movement). Walking pace modulates with the rhythm of columns; the spine adjusts to ceiling heights; the body cranes and bends to follow architectural narrative. Architecture is read through gait.

Anubhava-Śarīra (Body Knowledge). From movement comes sedimented knowing. The weight of stone is felt in the hands; the thermal contrast of granite is held in the skin; the acoustic shape of a *maṇḍapa* is encoded by ear and skin together. This is a non-discursive *vidyā* — a form of knowing that does not pass through language.

Māyā-Vismaya (Embodied Wonder). The body is ruptured by what it encounters: breath catches, goosebumps rise, vertigo flickers, an involuntary stillness arrests motion before the mind decides to stop. This corresponds to the *rasa* of *adbhuta* (wonder), but located unambiguously in *anubhāva*.

Yoga-Sthāna (Union with Place). In the final stage *tanmayatā* is achieved: the boundary between body and architecture blurs. The participant feels the space was made for their body; the proportions respond; description shifts from the visual to the felt. This is *sādhāraṇīkaraṇa* in architectural form.

1.4 Why existing scales are insufficient

A new instrument has to justify itself against what already exists, so we audited six families of adjacent measures and concluded that none, alone or in combination, captures embodied aesthetic learning in architectural heritage games.

Aesthetic-emotion scales. The DES [7] measures ten discrete basic emotions, PANAS [8] two broad affective dimensions, and AESTHEMOS [13] nine art-specific emotions including beauty, being-moved and awe. The Aesthetic Experience Questionnaire extends this family with a flow-centred, multidimensional account of art viewing — emotional, perceptual, semantic and flow facets [33] — and is among the most carefully validated instruments of its kind. All are rigorous, and all conceptualise aesthetic response as emotional and cognitive-evaluative. Their items ask what the participant felt *about* the work ("I found this beautiful"; "this moved me"), not what the

body did. The difference is sharp: a participant who endorses AESTHEMOS's "I felt deeply moved" has reported a strong emotion, not what their breath did, where their feet stopped, how their head tilted, whether their skin warmed or cooled. In these scales the body is a receiver of emotion, not an organ of aesthetic understanding.

Presence and immersion scales. The Witmer–Singer Presence Questionnaire [9] and the Slater–Usch–Steed scale [34] measure the sense of "being there," focusing on technological factors — visual fidelity, response delay, the realism of self-movement. Embodied aesthetic experience is theoretically independent of this: one can feel high presence in a perceptually convincing but architecturally banal environment and little bodily resonance, while a low-fidelity environment with rich architectural intentionality can elicit deep engagement. These instruments measure whether the technology convinces, not whether the architecture is learned through the body.

Absorption and flow scales. The Tellegen Absorption Scale [11] measures a stable personality trait; the Dispositional Flow Scale [10] measures focused, intrinsically rewarding engagement. Both are domain-general, neither calibrated to architectural encounter, and neither addresses the body's role in the experience.

Awe and transcendence scales. The Awe Experience Scale [12] is the closest extant instrument: its six facets include a "physical sensations" subscale that overlaps modestly with our *Māyā-Vismaya* construct [35]. But the AWE-S is grounded in a Western, broadly Kantian tradition of awe theorising; its operationalisation of physical sensation is brief and incidental rather than central; and it conceptualises awe as a discrete momentary state rather than as a developmental progression of embodied encounter.

Embodiment scales in VR. The Virtual Embodiment Questionnaire [14] measures three dimensions of avatar embodiment — body ownership, agency and self-location. These concern whether the avatar's body feels like one's own, not whether the architecture feels embodied; the same is true of the embodied-design tradition in immersive learning, which theorises gesture and hand-controls without an instrument for the aesthetic learning they are meant to produce [37]. Outside VR, the Experience of Embodiment Scale offers a rigorously validated, multifactor measure of the felt quality of inhabiting one's body [36]; but it was developed in the clinical-developmental tradition of body image and embodied wellbeing, and it measures connection to and agency over one's own body, not how a body comes to know an environment.

Embodied-cognition scales in heritage and architecture. The closest existing work sits in the recent built-heritage literature, where embodiment has begun to be operationalised quantitatively. A 2025 structural-equation study of embodied cognition in Macau's historical architecture models embodied immersion, architectural design and historical-resource use as predictors of learning satisfaction and effectiveness [38]; an extended-reality design-studio model evaluates embodied learning within architectural education through an action-research protocol [39]; and a heritage-tourism study links embodied cognition to place attachment and supportive behaviour towards historic buildings [40]. These studies establish that embodiment can be measured and that it matters for architectural learning. But each treats embodiment as a *predictor* of conventional outcomes — satisfaction, effectiveness, attachment, behavioural intention — rather than as the aesthetic learning itself; none anchors its items to specific somatic channels such that one can read off which bodily registers an intervention reaches; and none is grounded in a culturally specific theory of aesthetic experience. Beyond the Confucian body–mind scale built for general Chinese student populations [24], we are aware of no validated instrument that operationalises a non-Western aesthetic framework — and none at all that operationalises an Indian one — for the embodied aesthetic learning of architecture. On present evidence the RSS is the first.

The pattern across all six families is consistent: each measures something real, but the locus of measurement is wrong — none measures what the body, in architectural encounter, learns.

2 Aims

The study had four aims: to establish the content validity of the RSS through expert review; to evaluate its psychometric properties in a large sample ($N = 250$), including confirmatory factor analysis of the theorised five-stage structure; to demonstrate its utility in an experimental comparison of an embodied game against a passive walkthrough of the same heritage environment; and to generate concrete recommendations for instrument refinement (RSS v2) from the convergence of expert feedback and psychometric findings.

3 Methods

3.1 The Rasa-Śarīra Scale: instrument design

The RSS comprises 25 items, five per theorised stage, each accompanied by a body anchor naming the somatic region the item addresses (Table 1). For the psychometric validation (Stage 2) items were rated on a 5-point Likert scale (1 = Not at all; 5 = Extremely). For the experimental application (Study B) a 7-point scale (1 = Strongly disagree; 7 = Strongly agree) was used, to

permit finer discrimination across the narrower range expected of a between-conditions comparison. The full instrument appears in Table 1.

3.2 Validation design

A three-stage protocol was adopted (Fig. 2), each stage building on its predecessor. Expert content validation establishes the theoretical and conceptual basis of the items; psychometric validation tests their empirical structure and reliability; the application study tests whether the instrument responds to a designed pedagogical intervention as theory predicts. Together the three stages provide converging evidence of instrument quality rather than relying on any single line of argument.

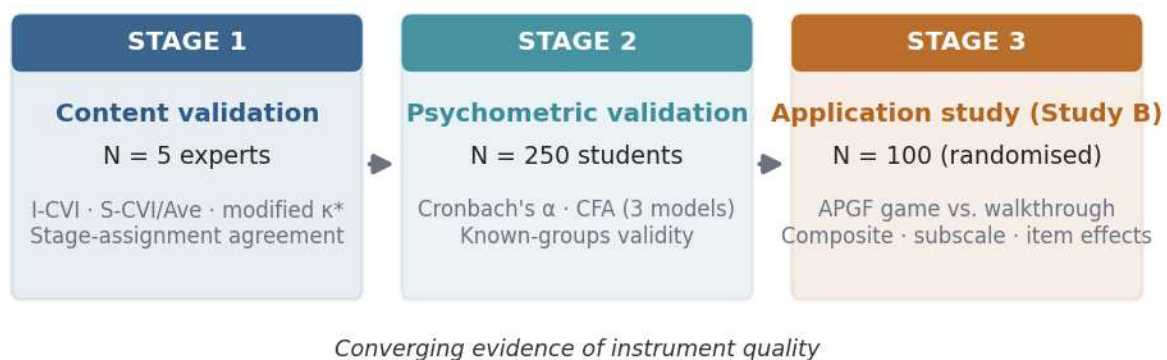


Fig. 2. Three-stage validation protocol, proceeding from content validation through psychometric validation to experimental application, each stage supplying converging evidence of instrument quality.

3.3 Stage 1: expert content validation

Five experts were recruited for disciplinary fit across architecture, embodied cognition, Indian aesthetics, heritage gaming and instructional design; with five raters the item-level retention threshold is $I-CVI \geq 0.78$ [41]. Each rated all 25 items for relevance and clarity on parallel 4-point scales and assigned every item to one of the five stages, with free-text scope for rewording, relocation or deletion. The item- and scale-level content-validity indices (I-CVI, S-CVI/Ave) and the chance-adjusted modified kappa κ^* were computed following Polit and Beck [41] (full panel administration in Supplementary §S1.1; index formulae in §S2; interpretive bands and the complete expert commentary in §S4.1).

3.4 Stage 2: psychometric validation

Two hundred and fifty undergraduate architecture and heritage-studies students from Indian institutions (aged 18–58) took part voluntarily; 168 (67.2%) had visited at least one architectural heritage monument during the current semester and 82 (32.8%) had not, supplying the basis for

known-groups testing. All completed an identical 15–20-minute photogrammetric heritage-game experience of a Hindu temple complex and then the 25-item RSS online, in stage-grouped order, with no missing data (full administration protocol in Supplementary §S1.2).

Internal consistency was estimated by Cronbach's α (total and subscales) with 95% confidence intervals by the Feldt–Woodruff method [42], alongside corrected item-total and observed-score subscale intercorrelations. Confirmatory factor analysis used maximum-likelihood estimation with the Wishart objective in semopy [43], comparing three models — a five-factor correlated model, a unidimensional model and a higher-order model — against the Hu and Bentler benchmarks (CFI, TLI $\geq .95$; RMSEA $\leq .06$; SRMR $\leq .08$; $\chi^2/df < 3.0$) [44], with non-nested models ranked by AIC and BIC [45]. Multivariate normality was checked against the Curran thresholds and Mardia's statistic [46]. Known-groups validity used Welch's t [47] with Cohen's d [48], corroborated by Mann–Whitney U with rank-biserial r and a 10,000-resample bootstrap 95% confidence interval for d . All estimator formulae are compiled in Supplementary §S2.

3.5 Stage 3: Application of the scale-A study comparing game vs simple walkthrough condition in identical virtual reality environment.

Stage 3 was a two-group, between-subjects experiment comparing a designed embodied game with a passive walkthrough of an identical virtual environment (Fig. 3). Holding the visual environment, hardware and population constant means any between-condition difference on the RSS is attributable to the embodied-mechanics layer rather than to visual fidelity or novelty [4, 49]. One hundred architecture students, none of whom had visited the Vijaya Vittala Temple, were assigned by block randomisation to the walkthrough ($n = 50$) or the game ($n = 50$); sample size was fixed a priori (51 per cell for 80% power to detect $d = 0.50$ at $\alpha = .05$) [48].

Both conditions ran on a Meta Quest 3 headset in a photogrammetric Unity reconstruction of the Vijaya Vittala Temple complex (Hampi, Karnataka), differing only in the interactive layer: the walkthrough offered free locomotion with no task or mechanic-triggered events, whereas the game added five embodied mechanics — scale-anchored object manipulation, material-contrast attention cueing, pace-modulated progression gating, proprioceptive posture prompts and memory-consolidation checkpoints — on the identical geometry (full environment specification and mechanic descriptions in Supplementary §S1.3).

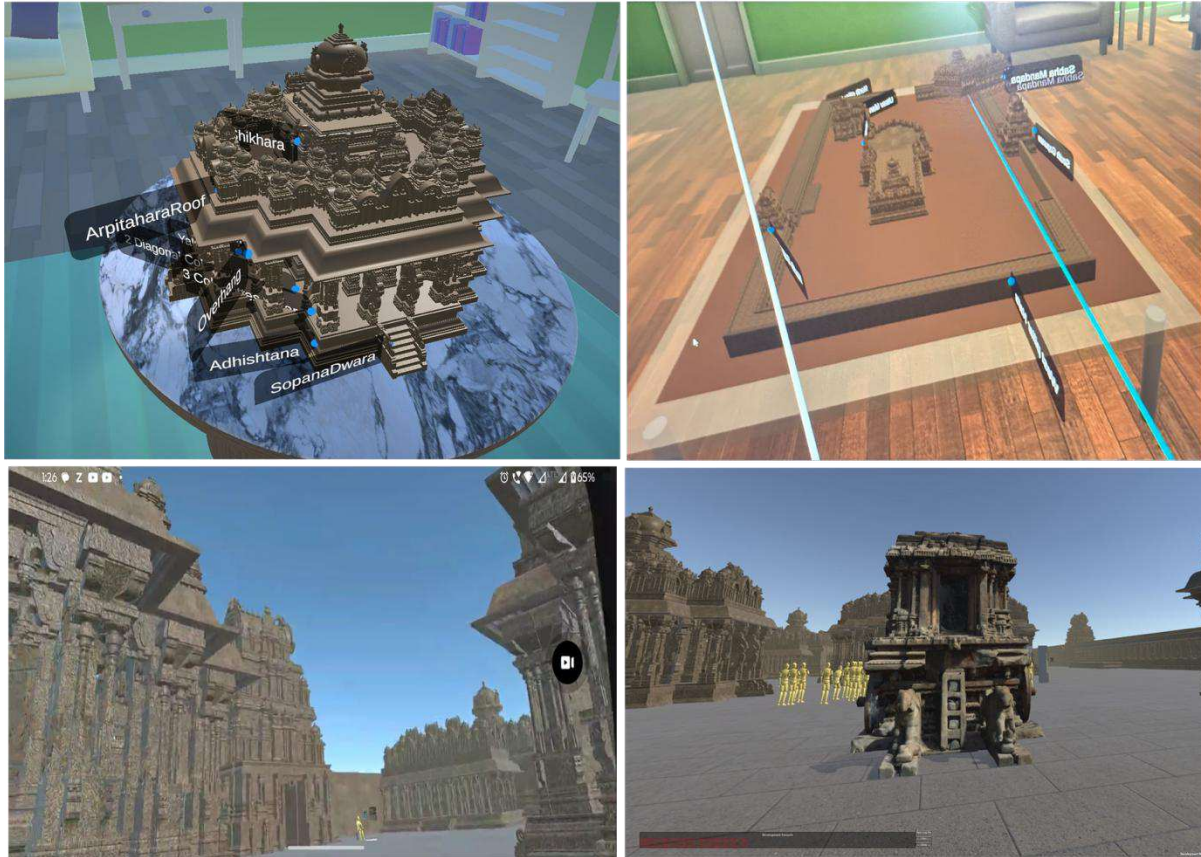


Fig. 3. The view of the game condition and VR environment, source: author

Sessions were run individually (briefing, written consent, a five-minute familiarisation, the 12–15-minute assigned session, then the 7-point RSS and a background form). Per the pre-registered plan, Welch's t-tests compared conditions on the composite and each subscale with Cohen's d, a 2 (Condition) $\times$ 5 (Stage) mixed ANOVA tested whether the advantage was uniform, and item-level Welch's t-tests examined all 25 items; all tests were two-tailed at $\alpha = .05$ (session protocol in §S1.3; estimator formulae in §S2).

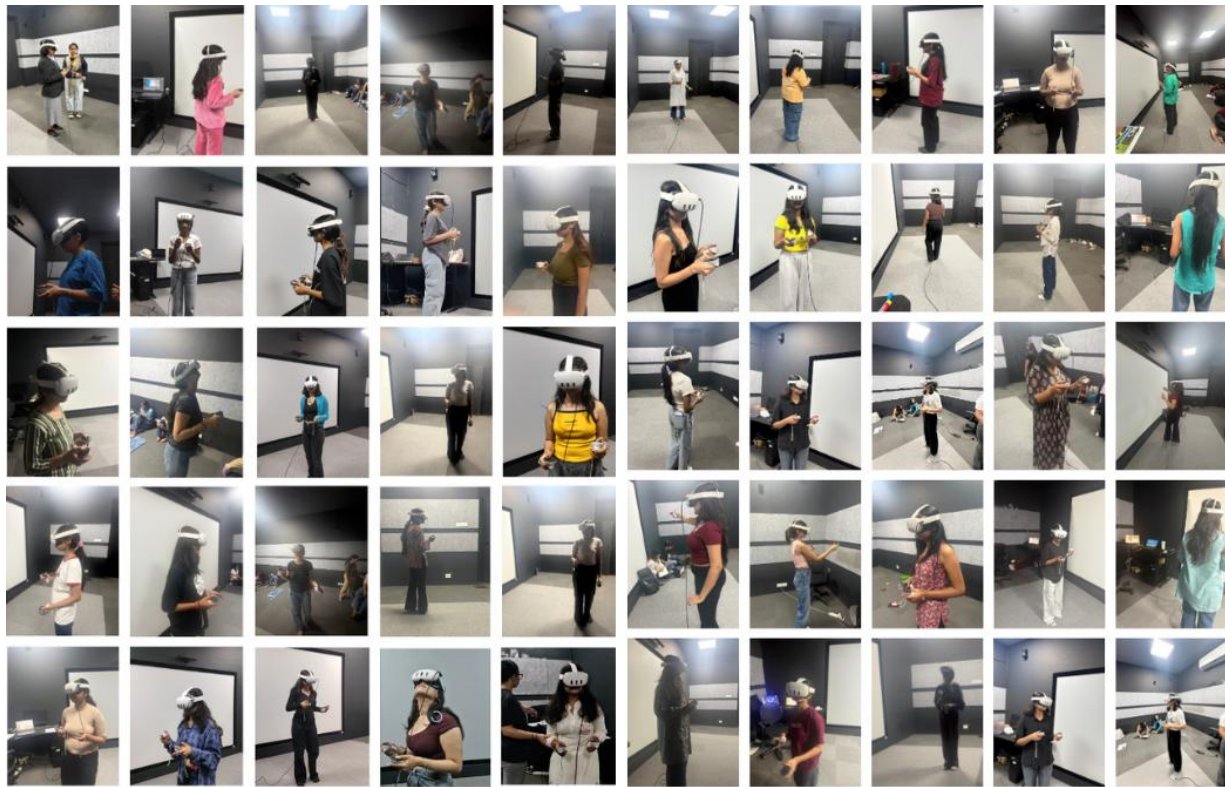


Fig. 4. Images of group play session with n=50, participants exploring VR and Vitthalapura game, source: author

4 Results

4.1 Expert content validation

Both content-validity indices comfortably exceeded the 0.90 benchmark: S-CVI/Ave was 0.944 for relevance and 0.984 for clarity. Every item achieved excellent modified kappa ($\kappa^* > 0.74$), indicating that the agreement was not attributable to chance; eighteen items reached $\kappa^* = 1.000$ (unanimous endorsement) and seven reached $\kappa^* = 0.763$ (four of five experts). Item-level results appear in Fig. 5 and Table 2. At the subscale level, *Yoga-Sthāna* drew the highest combined ratings (M relevance = 4.12; M clarity = 4.16) and *Anubhava-Śarīra* the lowest while still clearing every threshold (M relevance = 3.76; M clarity = 3.80) — an interpretable pattern, since union-experience items are evocative and conceptually rich whereas body-knowledge items must articulate a non-discursive form of knowing that resists easy linguistic capture.

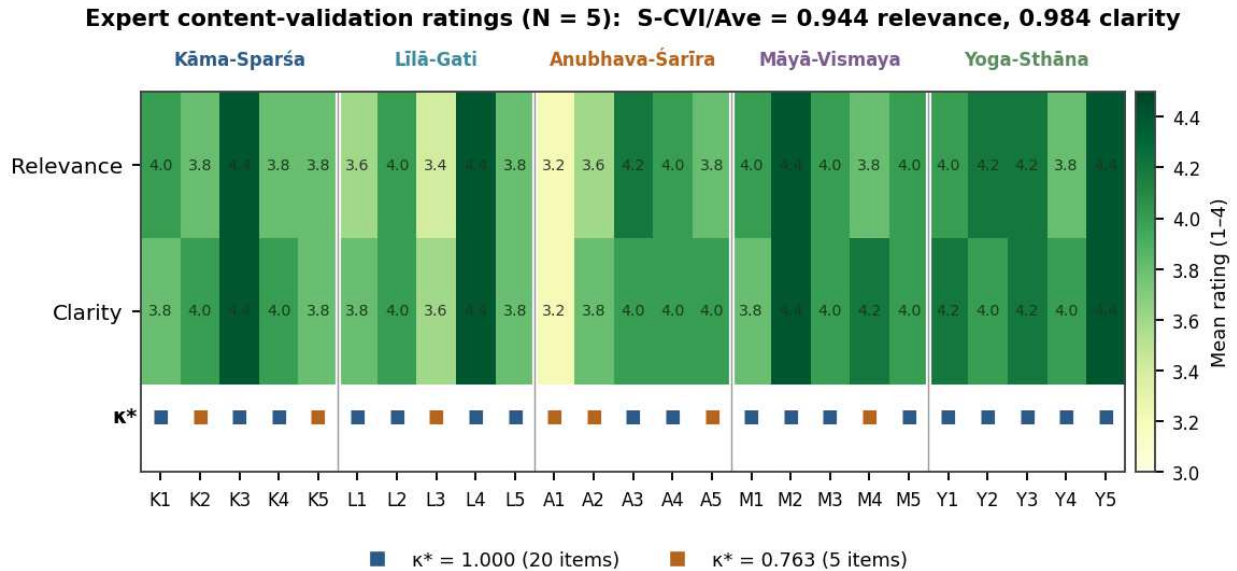


Fig. 5. Expert content-validation ratings for the 25 RSS items across five experts. Cell shading shows the mean relevance and clarity rating (1–4); the lower strip marks each item's chance-adjusted modified kappa. All items reached the excellent band ($\kappa^* > 0.74$).

The written commentary, though quantitatively supportive, surfaced refinements for a second version: minor resequencing views, five items flagged for rewording or stage reassignment (K5, L5, the A3 anchor, Y2 and Y4), and four embodiment channels identified as absent — olfactory, temporal, social and proprioceptive-disorienting. Perfect stage agreement held on roughly 60% of items, indicating that the stage boundaries are theoretically meaningful but not rigid, foreshadowing the factor-analytic result below. These observations feed the RSS v2 recommendations (Table 8); the full panel commentary appears in Supplementary §S4.1.

4.2 Psychometric validation

4.2.1 Descriptive statistics and internal consistency

Item means ranged from 3.08 (K5) to 3.44 (K2) on the 5-point scale, with standard deviations in a narrow band (1.31–1.49); all items used the full response range, with neither floor nor ceiling effects. Subscale means clustered tightly around a common centre (Table 3), suggesting that no stage is artificially harder or easier to endorse than the others. Internal consistency for the full scale was excellent (Cronbach's $\alpha = 0.918$, 95% CI [0.902, 0.934]).

Fig. 6b is displayed as a dot plot showing all 25 items with their corrected item-total correlations. All 25 items exceed the .30 minimum, with the vast majority above .50. Subscale alphas were moderate and acceptable for five-item subscales (.644–.706; Table 4), with *Yoga-Sthāna* weakest at .644 — converging with the expert view that Y2 and Y4 would benefit from language refinement.

Corrected item-total correlations ranged from .48 (Y4) to .64 (A1), median .59; all exceeded the .30 retention threshold, and none was a candidate for removal.

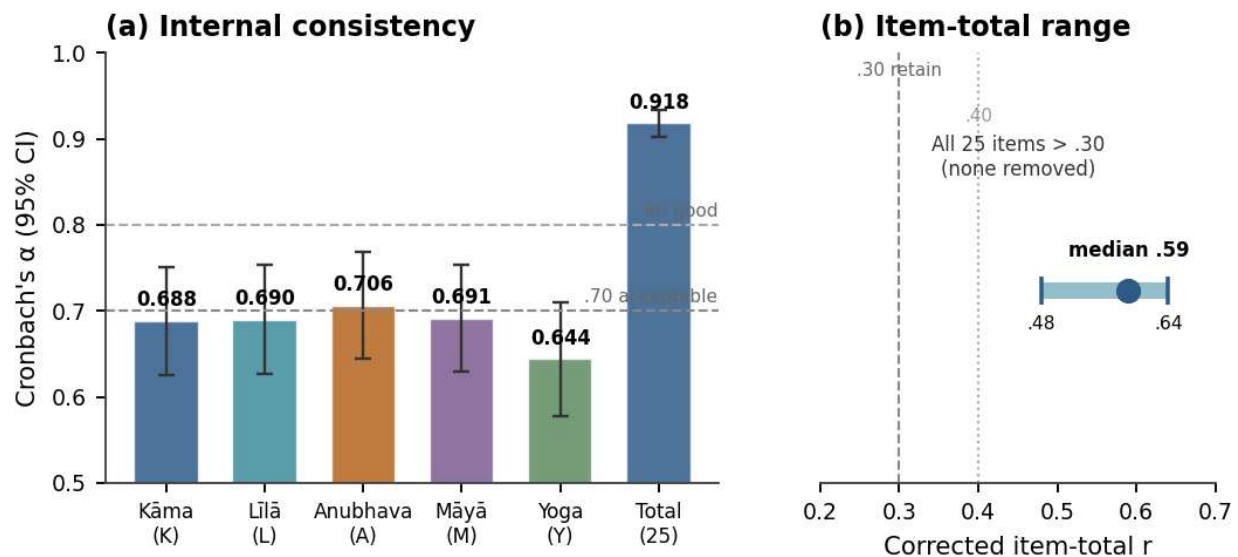


Fig. 6. Internal-consistency analyses. (a) Cronbach's α for each subscale and the total scale, with 95% confidence intervals and the conventional .70 and .80 thresholds; the total-scale α of 0.918 is excellent. (b) Range and median of corrected item-total correlations; all 25 items exceed the .30 retention threshold.

4.2.2 Factor structure

Observed-score subscale intercorrelations were substantial ($r = .66-.76$, all $p < .001$), averaging about .71 — high, but not on its own diagnostic of unidimensionality. Item-level skewness ranged from -0.42 to -0.11 and kurtosis from -1.42 to -0.94 , well within the Curran thresholds for maximum-likelihood estimation [46]; Mardia's multivariate skewness ($\chi^2 = 85.4$, $df = 2,925$) was small relative to its degrees of freedom, consistent with mild but tolerable departures from multivariate normality, so the Wishart-based ML approach was retained. All three competing models achieved excellent global fit: the five-factor model returned $\chi^2/df = 1.05$, CFI = 0.991, TLI = 0.990, RMSEA = 0.015; the unidimensional model $\chi^2/df = 1.05$, CFI = 0.992, TLI = 0.991, RMSEA = 0.014; the higher-order model $\chi^2/df = 1.06$, CFI = 0.990, TLI = 0.989, RMSEA = 0.016. Complete model-comparison statistics appear in Supplementary Table S3.1, and the standardised inter-factor correlation diagnostics in Table S3.2.

By global indices alone the five-factor model clears every Hu and Bentler threshold and would conventionally be reported as a successful confirmation of the theorised structure. Two converging diagnostics overturn that reading (Fig. 7, Fig. 8). First, the information criteria favour the unidimensional model: it returns the lowest AIC (97.7 vs. 117.8) and the lowest BIC (273.8 vs. 329.1), a BIC difference of 55.3 that, on Raftery's interpretive scale, constitutes very strong

evidence against the more parameterised solution [50]; the 25 additional free parameters of the five-factor model are not earning their keep. Second, the five-factor solution produces Heywood cases: six of the ten standardised inter-factor correlations exceed 1.0 and the remaining four exceed 0.95. A standardised correlation above 1.0 is mathematically impossible for genuinely distinct latent variables, and its appearance indicates that the five proposed stage factors are not empirically separable. Taken with the observed-score intercorrelations averaging .71, the evidence warrants a clear conclusion: in these data the five stages do not function as separable latent factors. The 25 items are best modelled as indicators of a single embodied-aesthetic-experience construct, with the Sanskrit-named stages retained as theoretical and design-oriented organisers. Standardised loadings on the unidimensional model ranged from 0.44 (Y4) to 0.63 (M4), median 0.55, all $p < .001$, with no item requiring removal.

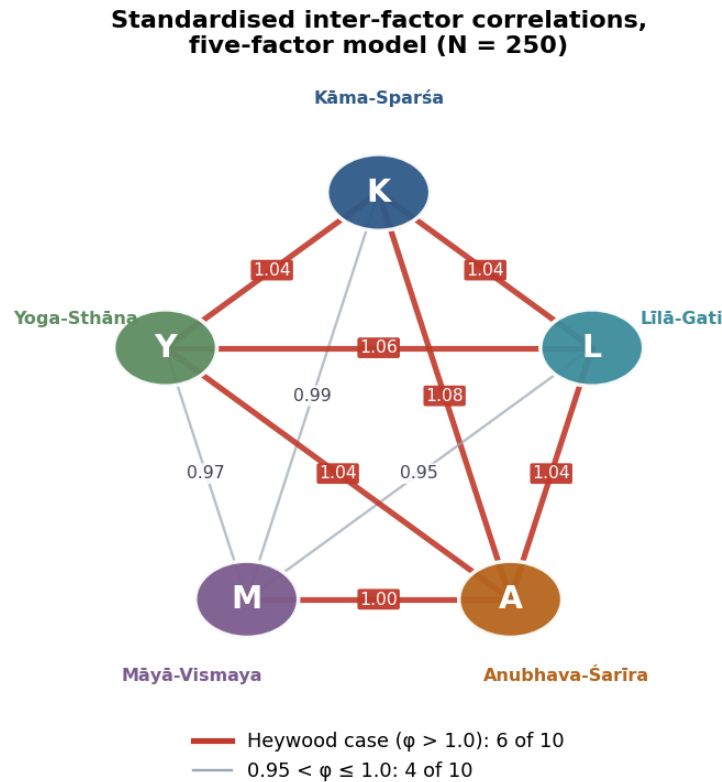


Fig. 7. Standardised inter-factor correlations from the five-factor model. Six of the ten correlations exceed 1.0 (Heywood cases, red), and the remaining four exceed 0.95, indicating that the five theorised stages are not empirically separable latent factors.

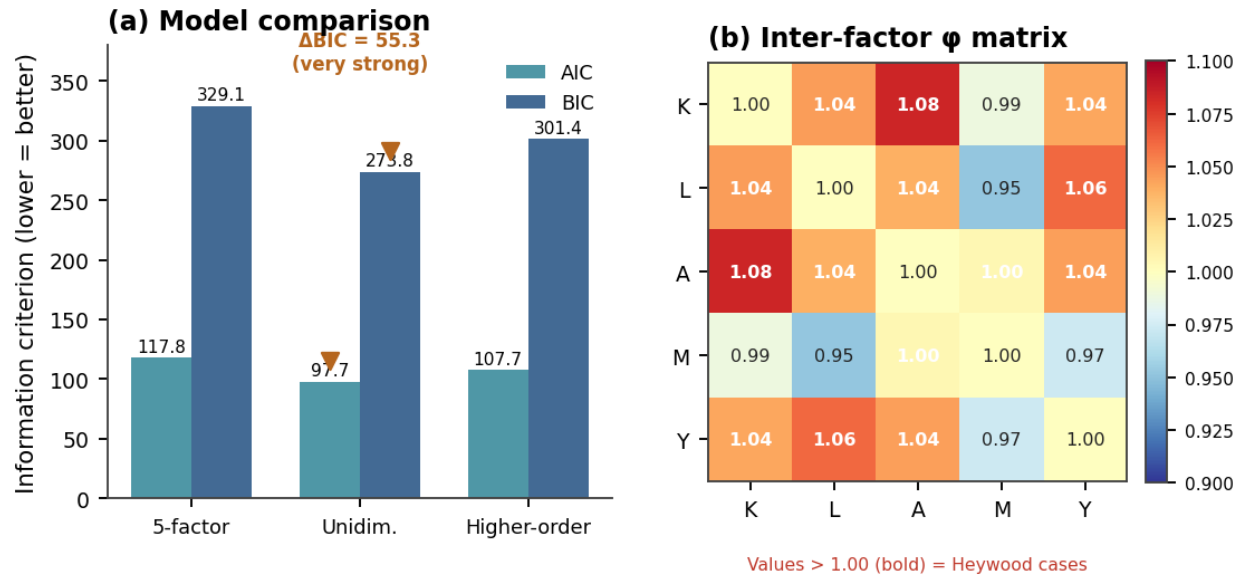


Fig. 8. Confirmatory factor analysis. (a) AIC and BIC for the three competing models; the unidimensional model is lowest on both, with $\Delta BIC = 55.3$ (very strong evidence). (b) The standardised inter-factor correlation matrix; values above 1.00 (bold) are Heywood cases.

This pattern is the rule rather than the exception in its neighbourhood: the Awe Experience Scale is widely used unidimensionally despite its six-factor design [12], AESTHEMOS reports nine factors over a dominant general factor [13], and the Differential Emotions Scale collapses onto general affect factors in many samples [7]. The RSS result is therefore consistent with the regularities of scale development in this domain rather than anomalous to it.

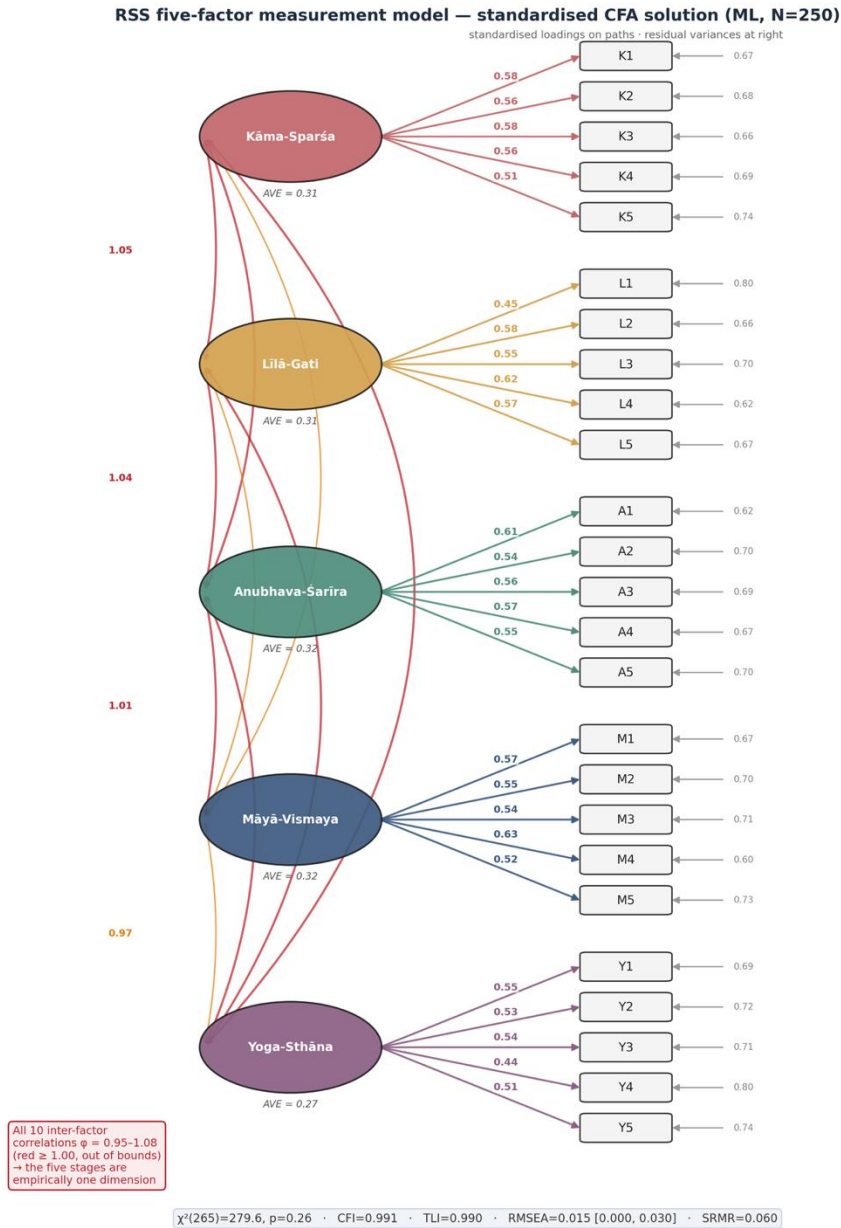


Fig.9. Measurement-model path diagram — the standardised five-factor solution: 25 indicators with loadings on the paths, residual variances at right, and the ten inter-factor correlations as arcs on the left (red ≥ 1.00). The collinearity is visible at a glance.

4.2.3 Known-groups validity

Known-groups validity was tested by contrasting students with and without a prior heritage visit. Prior-visit participant group ($n = 168$), who had visited at least one architectural heritage monument during the current academic semester, scored a mean RSS total of 3.81 (SD = 0.21). No-visit participant **group** ($n = 82$) who had not, scored 2.13 (SD = 0.22). The distributions show

near-perfect separation with virtually no overlap (Fig. 10a) — a striking discriminant-validity result, indicating that the RSS differentiates experienced from inexperienced participants in embodied architectural engagement.

Bootstrap resampling (IBM SPSS Statistics, 10,000 resamples) was used to produce 95% confidence intervals for Cohen's d , providing a robust estimate of effect-size stability (Welch's $t(248) = 57.55$, $p < .001$, Cohen's $d = 7.75$ visualised in Fig. 10b). The non-parametric analysis corroborated (Mann–Whitney $U = 13,776$, $p < .001$; rank-biserial $r = 1.00$ — no participant without a visit surpassed any participant with a prior visit in total RSS), and the bootstrap 95% confidence interval for d , $[7.10, 8.58]$, validated the robustness of the estimate. The impact was consistent across all five subscales (subscale $d = 5.05$ – 5.61); based on the factor-analytic evidence, this consistency suggests that prior embodied experience enhances a singular underlying construct. This magnitude of effect is atypical for experiential measurement; its interpretation is taken up in §6.4.

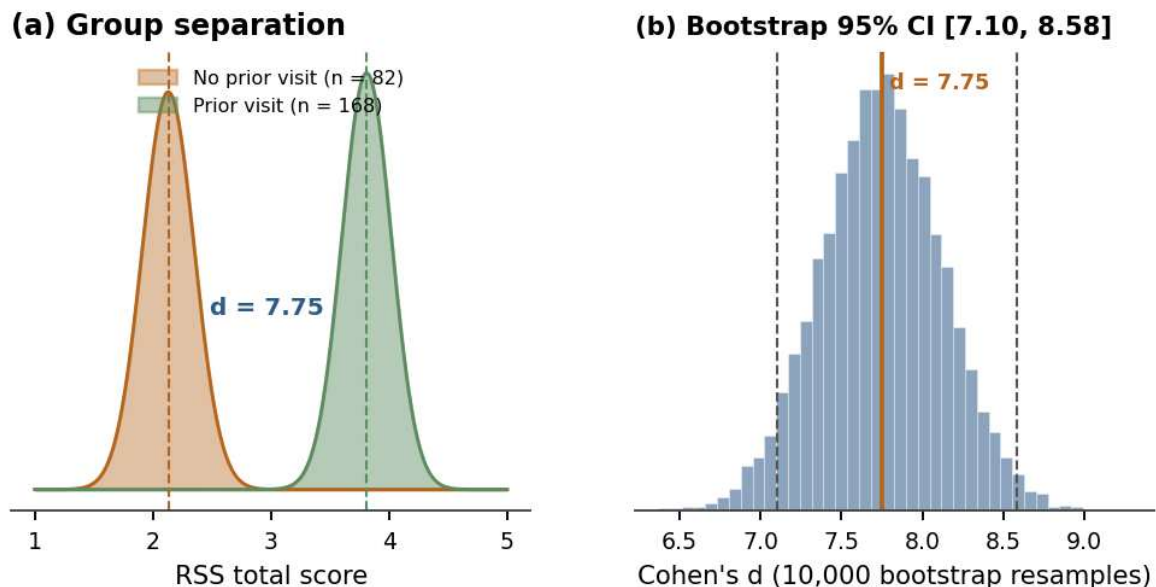


Fig. 10. Known-groups validity by prior heritage visit. (a) RSS total-score distributions reconstructed from group means and standard deviations, showing near-complete separation. (b) Bootstrap distribution of Cohen's d (10,000 resamples); the observed $d = 7.75$ sits at the centre of a 95% CI of $[7.10, 8.58]$.

5 Application study findings

5.1 Reliability and primary outcome

Internal consistency was excellent in the experimental sample (combined-sample $\alpha = .966$ for the 25-item scale; subscale alphas .69–.94 across conditions). The pre-registered primary hypothesis was confirmed: the game group ($M = 5.54$, $SD = 1.00$) scored higher than the walkthrough group ($M = 4.77$, $SD = 1.19$) on the composite, a difference of 0.77 scale points on the 7-point metric.

Welch's $t(95.9) = 3.46$, $p = .001$, Cohen's $d = +0.70$, 95% CI $[+0.29, +1.10]$ — medium-to-large by Cohen's benchmarks [48], with observed power near 92%.

5.2 Stage-level and item-level effects

All five subscales demonstrated a notable advantage for the game condition, with effect sizes varying from +0.49 (Māyā-Vismaya) to +0.76 (Līlā-Gati), each meeting or surpassing the medium-effect threshold (Fig. 11a–b; Table 6). The benefit was consistent across all five stages, largest for Līlā-Gati ($d = +0.76$) and smallest for Māyā-Vismaya ($d = +0.49$), with Kāma-Sparśa (+0.59), Anubhava-Śarīra (+0.67) and Yoga-Sthāna (+0.67) intermediate; the composite advantage was $d = +0.70$.

The 2×5 mixed ANOVA validated this consistent pattern: a significant, substantial main effect of Condition ($F(1, 98) = 12.25$, $p < .001$, $\eta^2 = .111$) and a non-significant Condition $\times$ Stage interaction ($F(4, 392) = 1.14$, $p = .338$, $\eta^2 = .011$). All confidence intervals exclude zero, indicating that the game's advantage was relatively uniform across stages rather than concentrated in a single one, as predicted by a unitary underlying construct. The item-level effects (Panel c) represent the most robust evidence of construct validity in the study (Fig. 11c; Table 7). Of the 25 items, 15 reached significance. The two largest effects aligned directly with the targeted mechanics: A3 (corporeal diminutiveness before the gopuram; $d = +1.08$), driven by scale-referenced object manipulation, and L4 (physically rotating and bending; $d = +1.06$), driven by proprioceptive postural cues. The two null effects are equally informative: A2 (thermal contrast between warm courtyard and cool sanctum stone; $d = +0.11$, $p = .570$) and L5 (respiratory modulation in open versus enclosed space; $d = +0.22$, $p = .264$) target somatic channels that headset-and-controller VR cannot physically deliver. That the scale registers 15 positive effects yet classifies these two as null indicates mechanistic specificity rather than uniform elevation: it discriminates between mechanically accessible and inaccessible somatic channels, ruling out response-style artefacts and matching Wilson's distinction between situated (mechanics-reachable) and off-line embodied cognition.

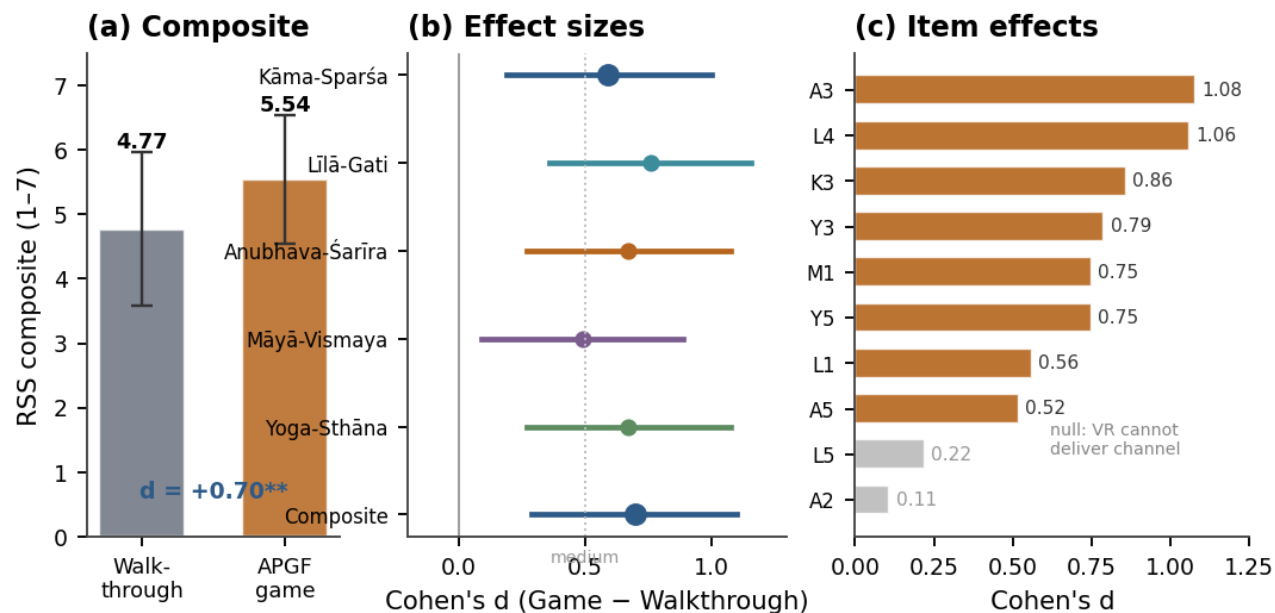


Fig. 11. Study (N = 100). (a) RSS composite by condition, with standard-deviation bars; the game exceeds the matched walkthrough ($d = +0.70$). (b) Forest plot of Cohen's d with 95% confidence intervals across the five subscales and the composite. (c) Item-level effect sizes; the two null effects (L5, A2) target somatic channels that headset-and-controller VR cannot physically deliver.

6 Discussion

6.1 Principal findings

The RSS was validated across three converging lines of evidence — expert content validation (N = 5), psychometric validation (N = 250) and an experimental application (N = 100) — yielding four claims. It achieves excellent content validity (S-CVI/Ave = 0.944 / 0.984; all items $\kappa^* > 0.74$); it functions empirically as a unidimensional measure of embodied aesthetic experience ($\alpha = 0.918$), with all three confirmatory models fitting well but the information criteria and Heywood cases favouring the unidimensional solution ($\Delta\text{BIC} = 55.3$); it shows strong known-groups validity ($d = 7.75$); and it detects an embodied-learning advantage of the game over a matched walkthrough (composite $d = +0.70$), uniform across subscales.

6.2 Theoretical contributions

The instrument makes three contributions. The first is to culturally grounded measurement. Where the available instruments are built on Western affect theory, presence research, flow research or avatar embodiment, the RSS shows that classical Indian aesthetic philosophy can be the theoretical engine of a contemporary, psychometrically rigorous measure. The Sanskrit stage names are not ornamental: they encode a phenomenological developmental progression with distinct anchors in the *Nāṭyaśāstra* and the *Abhinavabhāratī*. Methodologically this extends the

logic of the recent culturally grounded scale for Chinese students [24] to the architectural-heritage domain. Cross-cultural psychology has long debated whether non-Western frameworks should be operationalised through Western measurement structures or whether the measurement apparatus must itself be adapted. The RSS takes a hybrid position — a fully Indian theoretical framework, a conventional psychometric validation framework — and this is defensible precisely because classical Indian aesthetics, in Abhinavagupta's elaboration, makes universalising claims (*sādhāraṇīkaraṇa*) that sit comfortably with the quantitative-validation impulse.

The second contribution is to treat embodiment as the primary construct rather than a site of reception. Existing instruments register the body as a receiver of emotion, a perceiver of immersion, or an owner of an avatar; the RSS treats it as the locus of aesthetic understanding itself, asking not what the participant felt about the architecture but what the body did and what it now knows. This reorientation is motivated by *rasa* theory's identification of *anubhāva* as constitutive of aesthetic experience, and it is empirically productive, producing measurable effects that conventional cognitive outcomes miss. The third contribution is diagnostic specificity for design. The study item-level analysis shows that the RSS can identify which embodied channels a given intervention does and does not reach — the thermal and respiratory null findings, sitting beside large proprioceptive and postural effects, function as construct-validity evidence and as actionable feedback for designers. Where the recent built-heritage instruments enter embodiment into a structural model as a single predictor block [38], the RSS resolves it into channel-specific effects tied to particular mechanics. That a self-report instrument can localise mechanism in this way is, to our knowledge, unique in the heritage-games measurement landscape.

6.3 Interpreting the unidimensional structure

The finding that the five stages do not separate as latent factors sits, on its face, in tension with the theoretical framework; we address it rather than minimise it. Three considerations soften it. Classical Indian aesthetic theory does not commit to factor separability in the modern psychometric sense; the five-stage progression is a phenomenological sequence, not a typology of orthogonal traits, and *Abhinavagupta* in particular stresses the continuous, mutually implicating character of the stages — a single deepening engagement rather than five discrete buckets. The empirical pattern is, as noted, the norm for aesthetics-and-emotion scales, in which theoretically separable facets collapse onto a strong general factor because aesthetic experiences are unified events. And the design utility of the five-stage organisation does not depend on factor separability: the item-level results show that mechanics built to activate a given channel produce their largest effect on the corresponding item, so the stages are validated as a design heuristic even where

they are not validated as separable factors. The honest position is that the RSS is a unidimensional measure of a phenomenologically rich construct, organised into five stages whose theoretical and pedagogical value remains intact.

6.4 The unusually large known-groups effect

The $d = 7.75$ known-groups effect is the most unusual result in the paper. Effects of this size imply essentially perfect group separation (rank-biserial $r = 1.00$), which is more characteristic of measurements with strong demand characteristics than of nuanced experiential phenomena. Two non-exclusive readings bear consideration. On the first, the heritage-visit variable captures a genuine pre-existing somatic vocabulary: participants who have repeatedly engaged with real heritage architecture have trained the bodily skills of attention, dwelling and postural adjustment that the RSS measures, and they transfer that capacity to the digital environment, while those without it respond more flatly. On the second, more sceptical reading, a self-consistency response style is at work — participants who endorsed a recent visit endorsed embodied items uniformly high, and non-visitors uniformly low, inflating the effect beyond pure construct variance. Two facts cut in different directions. The study result — a strong response ($d = +0.70$) to a designed intervention under random assignment — argues for the first reading, because self-consistency cannot easily explain an effect when participants did not pre-select their condition. The unidimensional structure and the unusually small within-group standard deviations (0.21–0.22 on a 5-point scale) argue for the second. We do not adjudicate on present evidence; triangulating the self-report against behavioural and psychophysiological measures is the priority, extending the convergent-and-discriminant logic that has anchored construct validation since Campbell and Fiske [52].

7 Limitations

Several limitations require plain acknowledgement. The unidimensional empirical structure means the five-stage labels should be retained as theoretical and design organisers, not reported as separable subscales. The validation-sample subscale alphas (.64–.71) are acceptable for five-item subscales but indicate that within-subscale items are not yet as tightly coherent as one might wish, Yoga-Sthāna being weakest. The known-groups effect size, as discussed, warrants careful interpretation pending triangulation. Expert review identified four embodiment channels not yet captured — olfactory, temporal, social and disorienting — which are extension targets for RSS v2 rather than failings of v1. The samples in Stages 2 and 3 were architecture and heritage-studies students in Indian institutions engaging with Hindu temple architecture; the five-stage structure should transfer in principle, given the universalising claims of the theory, but confirmation in non-

Indian heritage, non-religious built environments and non-architectural learners is needed. The instrument captures what participants can articulate about bodily experience, not the experience itself — the mechanism-specific item pattern is the strongest current evidence that the self-report tracks real phenomenological variation, but psychophysiological corroboration remains outstanding. And the scale is currently administered only immediately post-experience; test–retest stability and the durability of embodied learning over time — a property theoretically distinguishing embodied from cognitive learning — require longitudinal study.

8 Implications

Beyond the instrument, the study carries a methodological lesson for serious-games and heritage-education research. With environment, hardware and population held constant, the only difference between conditions was the embodied-mechanics layer, and that layer produced a robust medium-to-large advantage that conventional cognitive measures would likely have missed. The familiar pattern of null cognitive-test results in serious-games research is not necessarily evidence of pedagogical failure; it may indicate that the field has been measuring the wrong outcome. Where the instrument fits the design, embodied-aesthetic measurement should sit alongside cognitive testing. For heritage research specifically, the RSS opens an empirical route to a long-standing theoretical claim — that the meaning of built heritage is partly carried in bodily memory and the felt continuity between past and present users [19] — by providing a way to ask whether, and how far, contemporary participants access that dimension.

For game and VR design, the diagnostic specificity is the practical payoff: weak Anubhava-Śarīra scores point to neglected body-knowledge channels (material, acoustic, thermal), weak Yoga-Sthāna scores to pacing too goal-driven for dwelling, weak Kāma-Sparśa scores to insufficient tactile affordances at thresholds. Even as a single construct, the conceptual groupings work as design heuristics, and the mechanism-to-item mapping makes the RSS usable in iterative design cycles — prototype a mechanic, test the targeted item, refine, retest.

For architectural pedagogy, and for Indian architectural pedagogy in particular, the instrument legitimises embodied understanding as a learning outcome worth designing for and measuring. The studio has always known implicitly that architects are trained through the body [18]; the RSS gives that implicit knowledge an explicit assessment vocabulary — and, crucially, one drawn from the aesthetic tradition native to the heritage being studied rather than imported wholesale. Administered before and after site visits, it could track the cultivation of embodied architectural literacy across a degree; used on a designed prototype, it could complement formal critique by capturing what a design does to the body of a viewer, not only what it means cognitively. In a

policy environment that now asks Indian schools to ground teaching in Indian knowledge while assessing it through imported instruments, a validated, culturally grounded measure of embodied learning is a direct response to the gap that motivated this work.

9 Conclusions

The *Rasa-Śarīra* Scale is a content-valid, internally consistent and criterion-valid instrument for measuring embodied aesthetic learning in architectural heritage games. Its expert content validity (S-CVI/Ave = .94 / .98), excellent internal consistency ($\alpha = .918$), strong known-groups validity ($d = 7.75$, with non-parametric and bootstrap verification) and sensitivity to a designed intervention in study (composite $d = +0.70$, with a mechanism-specific item-level pattern) together support its use as a primary outcome instrument in serious-games and heritage-pedagogy research. Its five Sanskrit-named stages operate empirically as theoretically meaningful organisers rather than as separable latent factors — a finding reported transparently, consistent both with the regularities of analogous scales and with a phenomenological reading of *rasa* theory itself. The RSS is best used as a unidimensional measure of embodied aesthetic experience, with the five stages retained as design-oriented and pedagogical principles. Future work will revise the items flagged by expert review for RSS v2, add items for the missing embodiment channels, broaden validation to non-Indian heritage contexts and non-architectural learners, re-test factor separability at the v2 stage, and triangulate the self-report against psychophysiological and behavioural measures. More broadly, the instrument contributes to re-centring the body in our understanding of aesthetic encounter — drawing on a philosophical tradition native to the heritage being studied, and giving educators and designers the diagnostic tools they need to cultivate, and to credit, forms of learning that have long been invisible to assessment.

Declarations

Ethics approval and consent to participate

This study was determined to be exempt from full institutional review by the Indira Gandhi Delhi Technical University for Women (IGDTUW) because it used anonymous, non-invasive participant surveys. All participants gave written informed consent before participation, no parental consent was required as all participants were above the age of 18 years. Indira Gandhi Delhi Technical University for Women (IGDTUW) maintains an Institutional Ethics Committee (IEC) registered with the Department of Health Research (DHR) to review biomedical, health, and technological research involving human participants. The committee operates in compliance with the Indian Council of Medical Research (ICMR) National Ethical Guidelines.

Consent for publication

Not applicable. No individually identifiable personal data are reported.

Availability of data and materials

The datasets generated and analysed during the current study (raw and processed), the full survey instrument and administration protocols, a complete variable codebook, and the analysis scripts and formulae are openly available in the Open Science Framework repository at https://osf.io/7gw6s/overview?view_only=b9b9fe9631e3419e8510e1f3a8d76f7a released under a Creative Commons Attribution 4.0 licence. All statistics reported in this article are reproducible from the deposited raw data using the deposited analysis scripts. A complete manifest of the deposited files is provided in Supplementary §S4.2.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

The first author conceptualised the instrument and study design, developed the items and drafted the manuscript. The first author contributed to the validation design, conducted the statistical analyses and revised the manuscript. The second author contributed to expert content validation, theoretical framing and critical revision. All the authors read and approved the final manuscript.

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Abbreviations

AESTHEMOS: Aesthetic Emotions Scale; AIC: Akaike Information Criterion; AWE-S: Awe Experience Scale; BIC: Bayesian Information Criterion; CFA: confirmatory factor analysis; CFI: comparative fit index; DES: Differential Emotions Scale; I-CVI: item-level content validity index; IKS: Indian Knowledge Systems; NEP: National Education Policy; PANAS: Positive and Negative Affect Schedule; PQ: Presence Questionnaire; RMSEA: root mean square error of approximation; RSS: Rasa-Śarīra Scale; S-CVI/Ave: scale-level content validity index, averaging method; SRMR: standardised root mean square residual; TLI: Tucker–Lewis index; VEQ: Virtual Embodiment Questionnaire; VR: virtual reality.

References

1. Anderson EF, McLoughlin L, Liarokapis F, Peters C, Petridis P, de Freitas S. Developing serious games for cultural heritage: a state-of-the-art review. *Virtual Real.* 2010;14(4):255–75. doi:10.1007/s10055-010-0177-3.
2. Mortara M, Catalano CE, Bellotti F, Fiucci G, Houry-Panchetti M, Petridis P. Learning cultural heritage by serious games. *J Cult Herit.* 2014;15(3):318–25. doi:10.1016/j.culher.2013.04.004.
3. Connolly TM, Boyle EA, MacArthur E, Hainey T, Boyle JM. A systematic literature review of empirical evidence on computer games and serious games. *Comput Educ.* 2012;59(2):661–86. doi:10.1016/j.compedu.2012.03.004.
4. Hamilton D, McKechnie J, Edgerton E, Wilson C. Immersive virtual reality as a pedagogical tool in education: a systematic literature review. *J Comput Educ.* 2021;8(1):1–32. doi:10.1007/s40692-020-00169-2.
5. Radianti J, Majchrzak TA, Fromm J, Wohlgenannt I. A systematic review of immersive virtual reality applications for higher education: design elements, lessons learned, and research agenda. *Comput Educ.* 2020;147:103778. doi:10.1016/j.compedu.2019.103778.
6. Sylaiou S, Mania K, Karoulis A, White M. Exploring the relationship between presence and enjoyment in a virtual museum. *Int J Hum Comput Stud.* 2010;68(5):243–53. doi:10.1016/j.ijhcs.2009.11.002.
7. Izard CE. Human emotions. New York: Plenum Press; 1977. doi:10.1007/978-1-4899-2209-0.
8. Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: the PANAS scales. *J Pers Soc Psychol.* 1988;54(6):1063–70. doi:10.1037/0022-3514.54.6.1063.
9. Witmer BG, Singer MJ. Measuring presence in virtual environments: a presence questionnaire. *Presence Teleoperators Virtual Environ.* 1998;7(3):225–40. doi:10.1162/1054746985656686.
10. Jackson SA, Eklund RC. The flow scales manual. Morgantown: Fitness Information Technology; 2004.
11. Tellegen A, Atkinson G. Openness to absorbing and self-altering experiences ("absorption"): a trait related to hypnotic susceptibility. *J Abnorm Psychol.* 1974;83(3):268–77. doi:10.1037/h0036681.
12. Yaden DB, Kaufman SB, Hyde E, Chirico A, Gaggioli A, Zhang JW, Keltner D. The development of the Awe Experience Scale (AWE-S): a multifactorial measure for a complex emotion. *J Posit Psychol.* 2019;14(4):474–88. doi:10.1080/17439760.2018.1484940.
13. Schindler I, Hosoya G, Menninghaus W, Beermann U, Wagner V, Eid M, Scherer KR. Measuring aesthetic emotions: a review of the literature and a new assessment tool. *PLoS One.* 2017;12(6):e0178899. doi:10.1371/journal.pone.0178899.
14. Gonzalez-Franco M, Peck TC. Avatar embodiment: towards a standardized questionnaire. *Front Robot AI.* 2018;5:74. doi:10.3389/frobt.2018.00074.
15. Council of Architecture. Minimum standards of architectural education regulations. New Delhi: Council of Architecture, Government of India; 2020.
16. Khan S, Khan H. Nemesis in the genesis: reforming architectural education in India. *New Design Ideas.* 2019;3(2):148–53.
17. Kohale N, Kini P, Mohammed C. Relevance of competency based education for architectural education in India. *F1000Res.* 2024;13:835. doi:10.12688/f1000research.148617.2.
18. Schön DA. The reflective practitioner: how professionals think in action. New York: Basic Books; 1983.
19. Pallasmaa J. The eyes of the skin: architecture and the senses. 3rd ed. Chichester: Wiley; 2012.
20. Ministry of Human Resource Development, Government of India. National Education Policy 2020. New Delhi: Government of India; 2020.
21. Bharata Muni. Nāṭyaśāstra (Ghosh M, Trans.). Calcutta: Asiatic Society; 1951.
22. Pandey KC. Comparative aesthetics, Vol. 1: Indian aesthetics. Varanasi: Chowkhamba Sanskrit Series; 1959.
23. Gnoli R. The aesthetic experience according to Abhinavagupta. Rev. ed. Varanasi: Chowkhamba Sanskrit Series; 1985.

24. Zheng Z, Wang Y, Zhao J. Development and validation of the embodied cognition scale for Chinese university students. *Front Psychol.* 2025;16:1682631. doi:10.3389/fpsyg.2025.1682631.
25. Lakoff G, Johnson M. *Metaphors we live by*. Chicago: University of Chicago Press; 1980.
26. Lakoff G, Johnson M. *Philosophy in the flesh: the embodied mind and its challenge to Western thought*. New York: Basic Books; 1999.
27. Sheets-Johnstone M. *The primacy of movement*. 2nd expanded ed. Amsterdam: John Benjamins; 2011. doi:10.1075/aicr.82.
28. Damasio A. *The feeling of what happens: body and emotion in the making of consciousness*. New York: Harcourt Brace; 1999.
29. Damasio A. *Self comes to mind: constructing the conscious brain*. New York: Pantheon; 2010.
30. Varela FJ, Thompson E, Rosch E. *The embodied mind: cognitive science and human experience*. Cambridge: MIT Press; 1991. doi:10.7551/mitpress/6730.001.0001.
31. Gibson JJ. *The ecological approach to visual perception*. Boston: Houghton Mifflin; 1979.
32. Merleau-Ponty M. *Phenomenology of perception* (Smith C, Trans.). London: Routledge & Kegan Paul; 1962.
33. Wanzer DL, Finley KP, Zarian S, Cortez N. Experiencing flow while viewing art: development of the Aesthetic Experience Questionnaire. *Psychol Aesthet Creat Arts.* 2020;14(1):113–24. doi:10.1037/aca0000203.
34. Slater M, Usoh M, Steed A. Depth of presence in virtual environments. *Presence Teleoperators Virtual Environ.* 1994;3(2):130–44. doi:10.1162/pres.1994.3.2.130.
35. Keltner D, Haidt J. Approaching awe, a moral, spiritual, and aesthetic emotion. *Cogn Emot.* 2003;17(2):297–314. doi:10.1080/026999303002297.
36. Piran N, Teall TL, Counsell A. The experience of embodiment scale: development and psychometric evaluation. *Body Image.* 2020;34:117–34. doi:10.1016/j.bodyim.2020.05.007.
37. Johnson-Glenberg MC. Immersive VR and education: embodied design principles that include gesture and hand controls. *Front Robot AI.* 2018;5:81. doi:10.3389/frobt.2018.00081.
38. Zhao J, Lee M, Li X. Embodied cognition and built heritage education: a case study of Macau's historical architecture. *Buildings.* 2025;15(18):3350. doi:10.3390/buildings15183350.
39. Lee JM. Embodied learning in architecture: a design studio model utilizing extended reality. *Buildings.* 2025;15(13):2158. doi:10.3390/buildings15132158.
40. Cai S, Hu Y, He J, Li K. The impact of embodied cognition on place attachment and supportive behavior toward historic buildings in heritage sites: exploring the moderating role of resident identity climate. *Front Psychol.* 2025;16:1702052. doi:10.3389/fpsyg.2025.1702052.
41. Polit DF, Beck CT. The content validity index: are you sure you know what's being reported? Critique and recommendations. *Res Nurs Health.* 2006;29(5):489–97. doi:10.1002/nur.20147.
42. Feldt LS, Woodruff DJ, Salih FA. Statistical inference for coefficient alpha. *Appl Psychol Meas.* 1987;11(1):93–103. doi:10.1177/014662168701100107.
43. Igoalkina AA, Meshcheryakov G. semopy: a Python package for structural equation modeling. *Struct Equ Modeling.* 2020;27(6):952–63. doi:10.1080/10705511.2019.1704289.
44. Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Struct Equ Modeling.* 1999;6(1):1–55. doi:10.1080/10705519909540118.
45. Burnham KP, Anderson DR. Multimodel inference: understanding AIC and BIC in model selection. *Sociol Methods Res.* 2004;33(2):261–304. doi:10.1177/0049124104268644.
46. Curran PJ, West SG, Finch JF. The robustness of test statistics to nonnormality and specification error in confirmatory factor analysis. *Psychol Methods.* 1996;1(1):16–29. doi:10.1037/1082-989X.1.1.16.
47. Welch BL. The generalization of "Student's" problem when several different population variances are involved. *Biometrika.* 1947;34(1–2):28–35. doi:10.1093/biomet/34.1-2.28.
48. Cohen J. *Statistical power analysis for the behavioral sciences*. 2nd ed. Hillsdale: Lawrence Erlbaum; 1988. doi:10.4324/9780203771587.

49. Mayer RE. Computer games in education. *Annu Rev Psychol.* 2019;70:531–49. doi:10.1146/annurev-psych-010418-102744.
50. Raftery AE. Bayesian model selection in social research. *Sociol Methodol.* 1995;25:111–63. doi:10.2307/271063.
51. Wilson M. Six views of embodied cognition. *Psychon Bull Rev.* 2002;9(4):625–36. doi:10.3758/BF03196322.
52. Campbell DT, Fiske DW. Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychol Bull.* 1959;56(2):81–105. doi:10.1037/h0046016.

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