The Design Journal
An International Journal for All Aspects of Design

ISSN: 1460-6925 (Print) 1756-3062 (Online) Journal homepage: www.tandfonline.com/journals/rfdj20

A communication-driven method for enhancing user participation in the design process

Busra Gumusay Ozbek, Halime Demirkan & Owain Pedgley

To cite this article: Busra Gumusay Ozbek, Halime Demirkan & Owain Pedgley (26 Nov 2025): A communication-driven method for enhancing user participation in the design process, The Design Journal, DOI: 10.1080/14606925.2025.2587667

To link to this article: https://doi.org/10.1080/14606925.2025.2587667

Published online: 26 Nov 2025.

THE DESIGN JOURNAL
https://doi.org/10.1080/14606925.2025.2587667

A communication-driven method for enhancing user participation in the design process

Busra Gumusay Ozbek[a], Halime Demirkan[a] and Owain Pedgley[b]

[a]Department of Interior Architecture and Environmental Design, I.D. Bilkent University, Ankara, Turkey; [b]Department of Industrial Design, Middle East Technical University, Ankara, Turkey

ABSTRACT

Design processes generally try to align user requirements with design solutions. Communication gaps between designers and users, nevertheless, may lead to mismatches between intended user experience and eventual perception by end users. This study presents a communication-driven method for enhancing user participation in the design process and formally incorporating user feedback. The method identifies and resolves user experience discontinuities by eliciting and consolidating qualitative and quantitative user appraisals. Building on the Semantic Discontinuity Detection method, the method (i) integrates user feedback into an iterative design process, and (ii) uses virtual reality simulations for design communication to detect and resolve discontinuities. The discontinuity results are communicated to designers, for improving correspondence between design outcomes and user experiences. Revised designs are evaluated for improved alignment, indicating validation of the method. The results show that communication-centered design effectively reduces experience inconsistencies, increases the engagement of users, and improves design outcomes.

ARTICLE HISTORY
Received 26 February 2025
Accepted 4 November 2025

KEYWORDS
Design process, interior design, semantics, user-experience, participatory design

1. Introduction

Understanding and analyzing users' impressions and experiences in the interior design process is important to create collaboration between designers and users for enhancing well-defined spaces. However, most post-occupancy evaluations indicate that end-users have dissatisfactions with their living spaces (Ghomeshia and Jusan 2012; Gifford et al. 2002; Rahanjam and Ilbeigi 2021). Gifford et al. (2002) conducted a study to compare architects' expressions and nonarchitects' impressions toward building aesthetics, highlighting

CONTACT Busra Gumusay Ozbek busra.gumusay@bilkent.edu.tr Department of Interior Architecture and Environmental Design, Bilkent University, Ankara, Turkey.

disagreements regarding the aesthetics of modern buildings. The study by Siltanen, Oksman, and Ainasoja (2013) also confirms that consumers (users) and professionals (designers) have different visual understandings of interior design. Khalaj and Pedgley (2019) state that scholars have repeatedly emphasized that discrepancies are likely to arise between the intended character of a product, as envisioned by the designer (referred to as intended product semantics), and how users perceive or construct the same product's character (known as realized product semantics), drawing upon foundational studies by Crilly, Maier, and Clarkson (2008), Hsu, Chuang, and Chang (2000).

Lack of communication or consultation during the design process can cause mismatches between expression and impression. Eckert and Clarkson (2011) call these kinds of misunderstandings 'design failures' attributable to poor project management. They identify five categories as the origin of design failures: structural, evaluation, interaction, management, and marketing. A sixth category, 'experiential failures', can cover differences between intended and realized user experience (UX). The user experience of a designed outcome (for example, a product, interior, service, app, or brochure) encompasses both practical utility and communicative impact (Khalaj and Pedgley 2019). In its broadest sense, UX design is defined as shaping a person's overall experience through direct or indirect use of a system, product, content, or service (Norman and Nielsen 2017). UX design covers sensory perception, emotion, thought, reaction, and behavior.

The method presented in this study was conceived to improve alignment between the UX of a designed space and the UX intentions stated in an interior design brief and expressed by a designer. It adapts the Semantic Discontinuity Detection (SDD) method developed by Khalaj and Pedgley (2019), which serves designers by identifying the severity and origin of discontinuities between intended expression (by designers) and evaluated impressions (by users). Specifically, the method in this paper extends the SDD method in three critical ways: (i) application to a new area (designed spaces, rather than physical products), (ii) uses VR (virtual reality) representations of design proposals (rather than materialized artifacts), and (iii) placed within a live design project with stated UX goals and a design revision/iteration phase (rather than an appraisal of completed designs).

2. User-oriented design models in spatial design processes

User-centered design (UCD), participatory design (PD), and co-design are user-oriented design models that offer various ways of integrating 'the user' into an iterative design process. Several points of these models were analyzed to help define early versions of the method proposed in this paper. UCD is a general approach adopted amongst the design professions, considering users as passive voices that designers act upon (Botero et al. 2020; Sanders 2002;

Sanders and Stappers 2008). PD is used more selectively according to projects and practices, empowering users to act within a design process (Greenbaum 1998). UCD and PD were considered foundational to the current method development. Implementing UCD and PD requires a design process involving prototype creation and testing, followed by gathering user impressions and feedback to help designers reach a refined final proposal (Putnam et al. 2009). Furthermore, there is a necessity for systematic evaluation of subjective responses when implementing PD (Kesdi and Gunes 2025; Bossen, Dindler, and Iversen 2018).

Wilkinson and De Angeli (2014) state that traditional UCD is limited in integrating user feedback in each stage of the design process, and hence, PD or co-design is needed. PD in principle is deployed from the earliest stages of design, within ideation or conceptual development, so that it effectively and positively influences end outcomes (Greer and Lei 2012; Wilkinson and De Angeli 2014). Co-design has become prominent as a design model to respond to criticisms of UCD and PD. It has roots in PD since it uses user knowledge during design (Lee et al. 2018; Smeenk, Sturm, and Eggen 2019; Voinov et al. 2018). Moreover, the iterative cycles of UCD, including testing, evaluation, and redesign, are a means to check that intended user experiences are likely to come about in a final design (Li et al. 2022; Viudes-Carbonell et al. 2021). Cárdenas Merino, Arias Jiménez, and Burdiles Allende (2025) emphasized communication failures between architects and users during the design process, suggesting that PD and co-design tools could aid communications by providing more closer-to-reality prototyping tools.

3. Communicative aspects of design

By focusing attention on UX, designers must directly tackle the issue of how a design solution communicates to its users and the messages and meanings contained therein. In the semiotic approach to design communication (Fiske 1990), designers and users are seen as active participants in creating meaning. Visual design elements are often the primary channel for conveying meanings, with less attention given to touch, sound, or other sensory modalities. In constructing the SDD method, Khalaj and Pedgley (2019) gathered principles of designer-user communication from various sources, mostly within product design, including from Hsu, Chuang, and Chang (2000), Hu, Zhao, and Zhao (2013), and Khalaj and Pedgley (2014). Products and interior designs have similar visual cues (e.g. shape, material, and color). However, other parameters contribute to the messages conveyed within spatial settings. To confidently extend the SDD method into the domain of interior design, it was necessary to review the use of visual elements to communicate meaning within designed spaces.

The fundamental principles of the semiotic school of communication, combining the 'signifier' and 'signified,' can be readily applied in interior design. Physical forms and elements (signifiers) affect users' attribution of meaning and concepts (signified) (Jie 2018). Several studies adopt semiotics in interior design cases to analyze how physical forms and elements can impress users (Holt 2017; Kuksa and Childs 2014; Nehme, Rodríguez, and Yoon 2020). Studies have considered various parameters including layout (Moscoso et al. 2021; Obradovic et al. 2021; Zou and Ergan 2021), color and material preferences (Chowdhury, Noguchi, and Doloi 2020; Ergan, Shi, and Yu 2018; Zhang et al. 2022), and lighting conditions (Chowdhury, Noguchi, and Doloi 2020; Ergan, Shi, and Yu 2018; Moscoso et al. 2021; Obradovic et al. 2021). Each of these affects visual communication and influences users' impressions.

4. Virtual spaces in user experience research

The potential of designing spaces where there is a focus on user experience is widely acknowledged (Nehme, Rodríguez, and Yoon 2020; Riener et al. 2021; Sharif 2020), often requiring prototype user testing during the design process. Since full-scale physical prototypes are impractical for interior design, alternative approaches, such as the use of VR, have become essential for stimulating spatial experiences. VR has proven valuable in architectural research, offering insights into spatial cognition, perception, and behavior (Brade et al. 2017; Higuera-Trujillo, López-Tarruella Maldonado, and Llinares Millán 2017; Paes, Arantes, and Irizarry 2017; Paes, Irizarry, and Pujoni 2021).

VR enables the assessment of architectural variables while controlling others, overcoming the challenges of altering real spaces (Kuliga et al. 2015). For instance, Brade et al. (2017) found that virtual environments (VEs) communicate hedonic qualities (associated with emotions and impressions) better than real environments, which communicate pragmatic qualities (associated with tasks and usability) better. Similarly, Higuera-Trujillo, López-Tarruella Maldonado, and Llinares Millán (2017) showed that VR generally elicits physiological responses close to real environments if the fidelity is sufficient, while 360-degree VR panoramas evoke psychological responses even closer to reality. This current study leverages VR as an immersive medium for users to experience spatial designs, offering a level realism and immersion that surpasses screen-based renders.

5. The method

The method presented in this paper provides designers with user feedback on visual space impressions, helping them to understand why their designs may fail to convey an intended expression and guiding them to make revisions that reduce the gap between expression and impression. The method includes quantification of the gap, pinpoints discontinuities, and highlights design elements requiring attention, ultimately providing designers with a means to achieve the user experience goals included in a design brief.

The published SDD method (Khalaj and Pedgley 2019) comprises four stages: assessing designers' intended expressions, examining users' first impressions, and twice making reciprocal evaluations of semantic perceptions (user vs. designer, and designer vs. user). The proposed method distributes the SDD stages within a new three-phase process. Phase 1, 'UX Requirements and Design Brief,' focuses on defining UX goals, drafting briefs, creating initial designs, and extending the original SDD framework to be applicable to newly commissioned design projects. Phase 2, 'Interior Design SDD Method (First Design),' applies the SDD method to initial designs, while Phase 3, 'Interior Design SDD Method (Revised Design),' evaluates iterative design outcomes from Phase 2, checking that alignment between expression and impression has been improved (Figure 1).

To clarify, the proposed method expands and contributes to the original SDD method in several critical ways:

- *Defining and delivering user-derived keywords* to the designer as starting points for semantic understanding within a *newly commissioned design project* (Phase 1).
- Making user experience appraisals of *the first interior design concepts* presented *via VR* within the *interior design process* and asking for *concept revisions* based on the discontinuity insights (Phase 2).
- Making user experience appraisals of *revised interior design concepts* presented *via VR* within the *interior design process* and reaching a *quantified statement of discontinuities* to demonstrate the gap reduction or elimination between design intent and actual user experience (Phase 3).

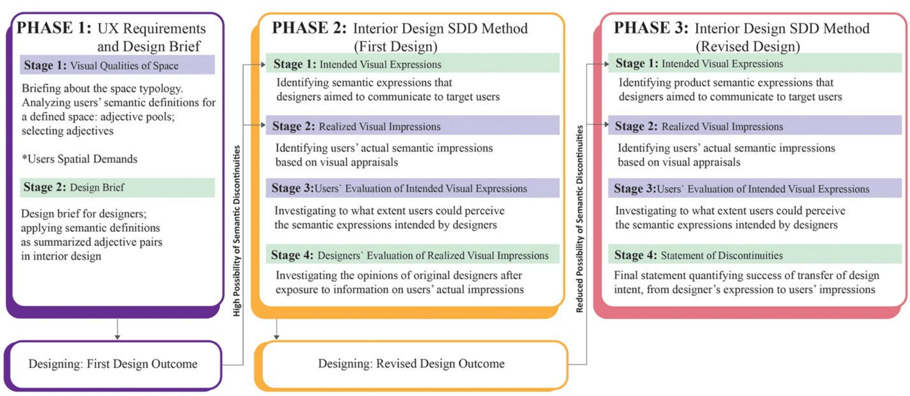

Figure 1. Phases 1–3 with integral stages for the method.

5.1. Participants

Two groups of participants were required for implementation: designers and users. The user participants ($n=45$) were secured voluntarily amongst second and third-year undergraduate design students of the Department of Interior Architecture and Environmental Design at Baskent University (fall semester, 2023–2024). The age range of the users was 19 to 33 years ($M_{age}=23.2$), covering twenty-seven females and eighteen males. The designer participants were three professional interior designers from Ankara, Turkey. The designers' age range was 32 to 34 years ($M_{age}=33$), with 8 to 10 years of work experience ($M_{we}=9$). All three had previously worked on projects with similar settings and design constraints as defined for the research.

5.2. Experimental setting and design constraints

The implementation of the method proceeded as a design research experiment. Phase 1 was conducted in a studio environment, while Phases 2 and 3 used VR to communicate design concepts. In Phase 1 – Stage 1, user participants were given a presentation to introduce key aspects of *socializing spaces*. The researcher then interviewed users individually, face-to-face and over Zoom, to understand their needs for such an environment. A thematic analysis (TA) was made to reach a set of UX specifications (Braun and Clarke 2006). In Phase 1 – Stage 2, the UX specifications were prepared as a design brief for designers, to be worked on for two weeks, and delivered as a first design outcome.

The design brief was for a socializing space in a well-known office building in the Çankaya region of Ankara city. The space was located on the second floor of the building, with a floor area of 57 m^2 and ceiling height of 340 cm. The space had a glass wall on the northern side, and the east and the west sides had no openings. The entrance door was located on the south side. There was a balcony, and a door was provided on the north side for balcony access. Using 3DS Max, designers were permitted to change the glazing with colored glass or to use covers. The sun's position in 3DS Max was fixed, and designers were prevented from changing the daylight setup. However, placement of artificial lighting fixtures was permitted. The researcher pre-arranged the 3DS Max cameras for rendering; all designers used the same camera angles and locations to make their renders. All these 3DS Max constraints were made to provide a reasonable level of consistency amongst the different interior designs and their visualizations, to avoid UX effects from lighting, camera, and rendering settings. A pool of 3DS Max models of semantically similar office resting area furniture was provided: designers could choose furniture only from this pool to avoid visual impression effects caused by using wildly different furniture styles.

5.3. Procedure

The Ethics Committee of I.D. Bilkent University approved the study (No: 2024_04_16_01). The study used a mixed methods approach and involved two external participant groups (designers and users), with the first author participating as the research manager, facilitator, and data analyst. The procedures for the user and designer groups were conducted at different times and involved different tasks. Figure 2 describes the complex flow of tasks undertaken by participants as well as the research instruments deployed. The procedure is coded using Phase-Stage-Task nomenclature (e.g. P1-S1-U1 refers to Phase 1, Stage 1, User Task 1). Users conducted six tasks to evaluate the UX of the first design outcome, followed by three tasks to evaluate the UX of the revised design outcome. Designers conducted seven tasks in total; the researcher conducted eleven. The researcher's tasks often took the form of preparations between the users' and designer's tasks.

For task U1 users joined the interview as small groups and shared their ideas in verbal and written explanations; in task U3, they experienced spaces

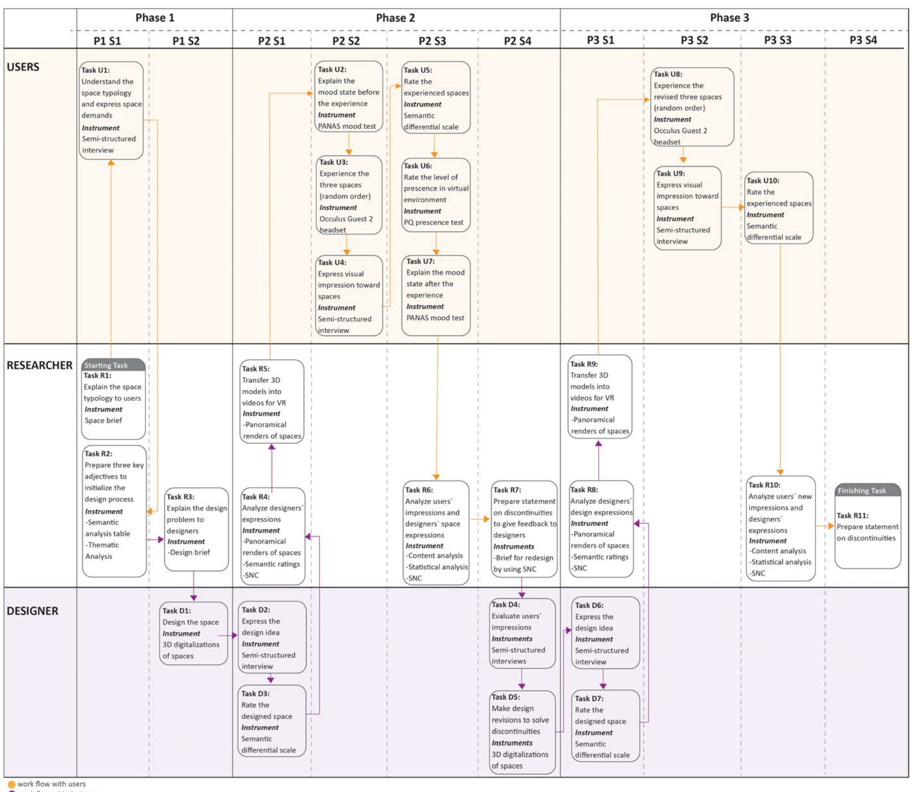

Figure 2. Overview of the procedure, including flow of tasks carried out by users, the designer, and the researcher, with indication of research instruments used.

Table 1. Data collection and analysis.

Phase (P) Stage (S) Participants	Type of Data	Collection Method	Collection & Analysis Instrument(s)	Description
P1-S1	Qualitative	-Verbal Response Measurement	-Space Brief for Users -Semi-Structured Interview with Users -Researcher's Semantic Analysis Table -Thematic Analysis	The researcher explained space typology and asked for users` needs; prepared themes with adjectives
P1-S2	Qualitative	-Verbal and Visual Response Recording	-Design Brief for Designers -3D Digitalization of Spaces	Researcher explained the task to designers and gave design briefs to designers
P2-S1 **P3-S1**	Quantitative, Qualitative	-Written and Verbal Response Measurement	-Semi-Structured Interview with Designers -Semantic Differential Scale -Descriptive Statistics -Semantic Network Clustering	Designers were asked to fill out a questionnaire with Likert scale items and open-ended questions
P2-S2 **P3-S2**	Qualitative	-Written and Verbal Response Measurement	-Semi-Structured Interview with Users -Content Analysis -Semantic Network Clustering	The researcher created semantic network clusters with adjectives and definitions
P2-S3 **P3-S3**	Quantitative	-Written and Verbal Response Measurement	-Semi-Structured Interview with Users -Semantic Differential Scale -PANAS Mood Test (P2-S3 only) -PQ Presence Test (P2-S3 only) -Descriptive Statistics -Paired T-Test -Semantic Network Clustering	Users were asked to fill out a questionnaire with Likert scale items and open-ended questions
P2-S4	Qualitative	-Verbal Measurement	-Design Brief for Designers for Iterative Process -Semi-Structured Interview with Designers - Semantic Network Clustering	Researcher gave information to designers about users` impressions by showing semantic clustering analysis

with VR glasses. Designers defined their verbal and written expressions and were interviewed by the researcher.

For the tasks in the three phases, various sets of qualitative and quantitative data were generated with various data collection and analysis instruments (Table 1).

6. Results

The results are presented separately through Phases 1, 2, and 3.

6.1. Results from Phase 1

In Phase 1 – Stage 1, users' spatial demands were collected *via* interviews and processed using thematic analysis to reach summaries in the form of adjectives.

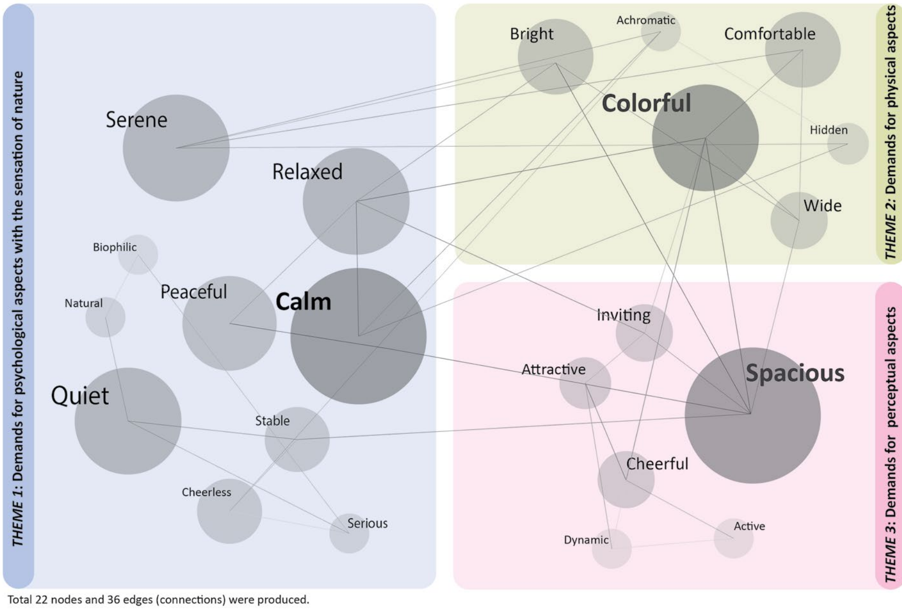

Figure 3. Thematic map showing users' needs for a socializing space.

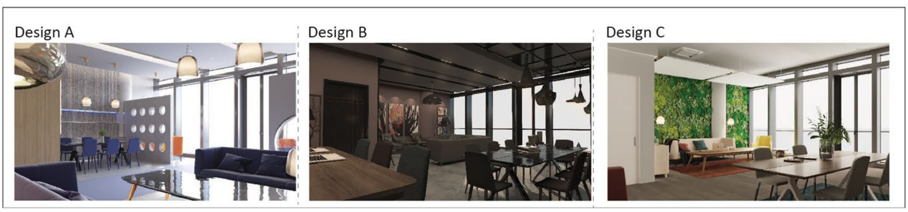

Figure 4. Three design solutions for socializing spaces expressing 'calm', 'colorful', and 'spacious'.

Braun and Clarke (2006) six-step approach for thematic analysis was adopted. Firstly, all data were collected and transcribed; initial codes were transferred into the Natural Language Toolkit library in Python software, which led to tokenizing sentences as adjectives. Thirdly, with the aid of the software, initial themes were formed from collections of adjectives having similar meanings. In the fourth step, themes were reviewed, with definitions and theme-naming determined in the fifth step. Lastly, all results were reported in the sixth step. With this analysis, users' spatial needs for a socializing space were found to be located under three themes: *psychological aspects*, *physical aspects*, and *perceptual aspects*. 'Calm' was the most used adjective for psychological aspects with the sensation of nature; 'colorful' was the most used for physical aspects, and 'spacious' was the most used for perceptual aspects (Figure 3).

For Phase 1 – Stage 2, designers were given a design brief for the socializing space, integrating the themes from Stage 1. The researcher informed the designers about the design challenge and the need to convey the meanings of 'calm', 'colorful', and 'spacious' through their solutions. Three socializing spaces were generated, one per designer (Figure 4).

6.2. Results from Phase 2

The researcher interviewed the designers about how they embodied the expressions within the design brief into their solutions. As well as open-ended questions, the interview included a rating of semantic differentials, including the three initializing adjectives (calm, colorful, spacious), using a 5-point Likert scale. After experiencing the socializing spaces through a VR headset, users rated their impressions on the same 5-point Likert scale, including ratings for the three initializing adjectives.

To understand if users' mood states influenced impression levels, a pre-/post-experience Positive and Negative Affect Schedule (PANAS) test was administered (Watson, Clark, and Tellegen 1988). The results revealed that mood states did not have a significant effect on users' impressions. Since users experienced the design outcomes in a VR environment, self-reported presence levels of users were gathered *via* a presence questionnaire (Paes, Irizarry, and Pujoni 2021). The mean value for all questionnaire criteria showed that users rated presence higher than five points (on a 7-point Likert scale). Also, there were no significant correlations between users' impressions of calm, colorful, spaciousness, and presence levels.

Descriptive statistics, including mean, median, and standard deviations, were calculated to compare relative impressions between the designs. However, to identify semantic discontinuities, specific levels and categories were used based on median values for ratings (Table 2). If the value for impression (u, from user) and expression (d, from designer) is the same, there is no discontinuity. If the values have a difference of one, there is a minor discontinuity; if the difference is more than one, there are major discontinuities. Discontinuity levels were calculated for each user independently. Then, the distribution of discontinuity levels across all users was calculated as a percentile (percentiles for design solutions pre-iteration and post-iteration are detailed in Table 3). Discontinuities were prevalent across all three

Table 2. Categories tied to ten levels of semantic discontinuity (Khalaj and Pedgley 2019, 55).

Semantic discontinuity category	Numerical level
Continuity	$u = d$
Minor discontinuity	$u = d + 1$ or $u = d-1$
Major discontinuity	$u = d + 2$ or $u = d-2$
	$u = d + 3$ or $u = d-3$
	$u = d + 4$ or $u = d-4$
	$u = d-5$

Table 3. Changes in percentiles of discontinuities before and after iterative design.

		Discontinuity analysis		
	Adjective	Category	First design %	Revised design %
Design A	Calm	Major discontinuity	96%	13%
		Minor discontinuity	4%	36%
		Continuity	–	51%
	Colorful	Major discontinuity	–	–
		Minor discontinuity	76%	33%
		Continuity	24%	67%
	Spacious	Major discontinuity	71%	15%
		Minor discontinuity	29%	36%
		Continuity	–	49%
Design B	Calm	Major discontinuity	97%	33%
		Minor discontinuity	3%	56%
		Continuity	–	11%
	Colorful	Major discontinuity	100%	5%
		Minor discontinuity	–	33%
		Continuity	–	62%
	Spacious	Major discontinuity	97%	11%
		Minor discontinuity	3%	69%
		Continuity	–	20%
Design C	Calm	Major discontinuity	61%	–
		Minor discontinuity	39%	40%
		Continuity	–	60%
	Colorful	Major discontinuity	40%	–
		Minor discontinuity	56%	59%
		Continuity	4%	41%
	Spacious	Major discontinuity	41%	33%
		Minor discontinuity	54%	18%
		Continuity	5%	49%

first designs: on average (mean calculation), 4% continuity, 29% minor discontinuity, and 67% major discontinuity. In all cases of discontinuity, users detected the adjectives in the design outcomes as weaker than the designers intended.

After these analyses, a content analysis of the qualitative data from user and designer interviews was conducted to understand where and why discontinuities occurred. Prasad's (2008) six steps for data collection and analysis were followed. In the first step, the research question was developed, focusing on how choices of design elements underly designers' space expressions and users' space impressions. Then, interview questions were constructed, including queries about which elements were used for expression (designers) and which elements led to impressions (users). In the third step, content analysis categories were established for layout, usage of furniture, material preferences, color preferences, and the amount of artificial lighting. In the fourth step, units of analysis were finalized, and semantic network clustering (SNC), a technique developed by Khalaj and Pedgley (2019) for clustering and visualizing adjective relations, was carried out. The SNC process involved circling adjectives to indicate the number of participants mentioning the adjectives, while arrows were used to convey the relationship or 'storyline' between adjectives. For example, thirty-two users mentioned that they found the

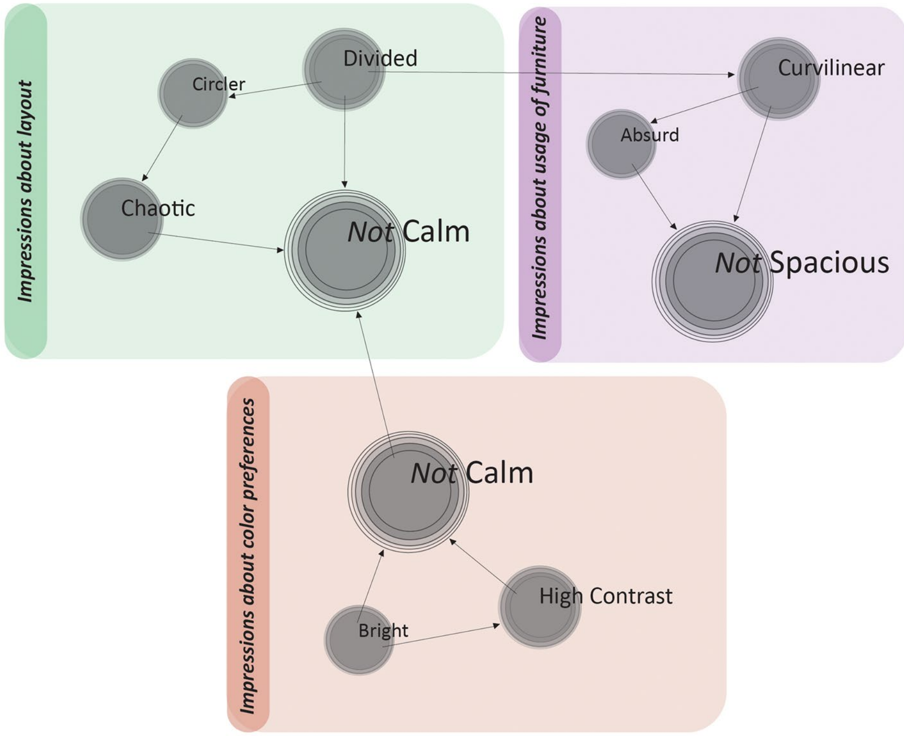

Figure 5. Example semantic network clusters establishing prevalent reasons behind users' impressions of Design A.

layout of Design A to be *divided* into *curvilinear* forms, creating a *chaotic* environment and a *not calm* atmosphere. The most frequently mentioned adjectives (by six or more people) were located under clusters. Three example semantic network clusters for Design A are shown in Figure 5.

At the fifth step, pilot testing was used to measure impressions and expressions on three initializing adjectives. For impressions, pilot testing was conducted with 12 users, to measure whether users' impressions were consistent with each other considering the rankings of the three adjectives. A reliability analysis was conducted, with Cronbach's Alpha measured using SPSS software. The intraclass correlation value was measured as 0.981. This finding showed a strong case for accepting users' adjective measurements as a reliable indicator of user impressions. In the last step of the analysis, summaries of all the semantic network clusters were combined into a master diagram. Not all clusters were relevant to all three Designs A, B, and C. Absences show that no designer or user raised semantic considerations relevant to the cluster (see Figure 6 for first and revised designs).

The discontinuity values, semantic network clusters, and master diagrams were presented to the designers to highlight where semantic discontinuities had occurred and why. The designers were then invited to make iterative

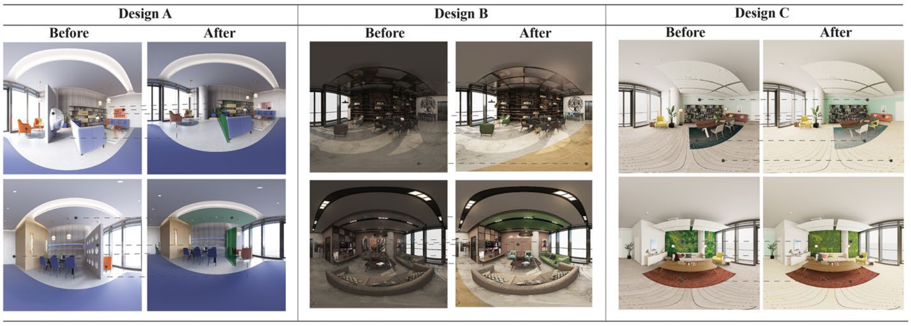

Figure 6. Design changes (before/after) made after receiving feedback from Phase 2.

design revisions to reduce or eliminate discontinuities. Figure 6 demonstrates the changes in panoramic renders.

6.3. Results from Phase 3

Phase 3 involved analyzing the revised designs. Designers explained their expressions again, and users re-experienced the designs following the same steps as Phase 2, except that PANAS and presence tests were omitted. The distribution of discontinuity categories for the revised designs was calculated (Table 3). In all cases, discontinuities were reduced. As with the first designs, all discontinuities of the revised designs had negative values, showing that users detected the adjectives in the design outcomes as weaker than the designers intended. There were no instances where users detected an adjective more strongly than the designers intended.

At this point, an inferential statistical analysis (paired samples t-test) was made to understand whether the differences in semantic impression for the first and revised designs (and, therefore, the discontinuity reduction) were significant. All impressions increased significantly except for the adjective 'spacious' for Design C. Hence, all discontinuities decreased significantly after the design revisions, with a confidence level of 95% ($p = 0.05$) (Table 4).

Median impression values before and after revisions were compared with designers' grades for expression. Line graphs demonstrate changes in these results (Figure 7). All revised spaces, except for Design C, conveyed a higher correspondence to initial adjectives.

After these quantitative analyses, the qualitative data from the interviews were analyzed using the same steps as in Phase 2. Semantic network clustering was re-conducted, and the semantic network clusters were modified to demonstrate changes in the adjectives used (Figure 8).

In the first Design A, users considered the layout to be not calm because of the circular forms used. After revisions, the designer eliminated the circular

Table 4. Paired samples T-test results for all designs.

	Adjective	Mean	STD	T value	df	Sig. (2-tailed)
Design A	Pre-calm	2.56	0.785	−17.064	44	0.0001
	Post-calm	4.38	0.716			
Design A	Pre-colorful	4.24	0.435	−4.313	44	0.0001
	Post-colorful	4.67	0.477			
Design A	Pre-spacious	3.04	0.737	−8.344	44	0.0001
	Post-spacious	4.33	0.739			
Design B	Pre-calm	2.56	0.785	−5.406	44	0.0001
	Post-calm	3.60	0.915			
Design B	Pre-colorful	1.56	0.586	−32.638	44	0.0001
	Post-colorful	4.58	0.583			
Design B	Pre-spacious	2.38	1.211	−8.447	44	0.0001
	Post-spacious	4.09	0.557			
Design C	Pre-calm	3.22	1.396	−6.304	44	0.0001
	Post-calm	4.60	0.495			
Design C	Pre-colorful	3.91	0.973	−3.755	44	0.001
	Post-colorful	4.56	0.503			
Design C	Pre-spacious	4.04	0.796	−0.607	44	0.547
	Post-spacious	4.16	0.903			

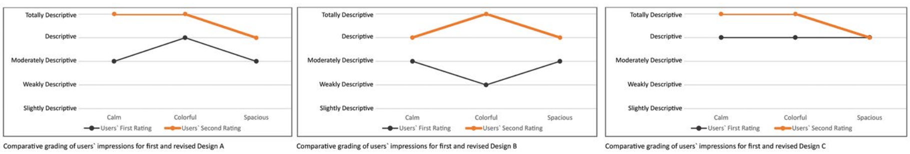

Figure 7. Line graphs demonstrating changes in impressions.

forms and located transparent green partitions. Users' impressions changed to visible, calm, and spacious for the layout of the revised Design A.

For furniture usage, in design B preferred decorative paintings are preferred on the walls, but they left an impression of being crowded and not calm on users. After feedback, the designer eliminated some of these decorations; users found the furniture of the revised Design B colorful.

Before revisions, users found the material usage of Design C to be dense and not calm. After feedback, the designer changed the hue of the green wall as it became more saturated and the color of the floor material. These changes gave users a spacious impression of the material usage of the revised Design C.

7. Discussion

The method for user experience-oriented interior design presented in this study applies user-oriented design models in new ways while including some common points and differentiation. The intention has been to contribute to better communication in the interior design process by drawing upon UX models and focusing on realizing design intent through iterative design. The method has been shown to work effectively. All three designers involved in the study were able to significantly improve the communication of their

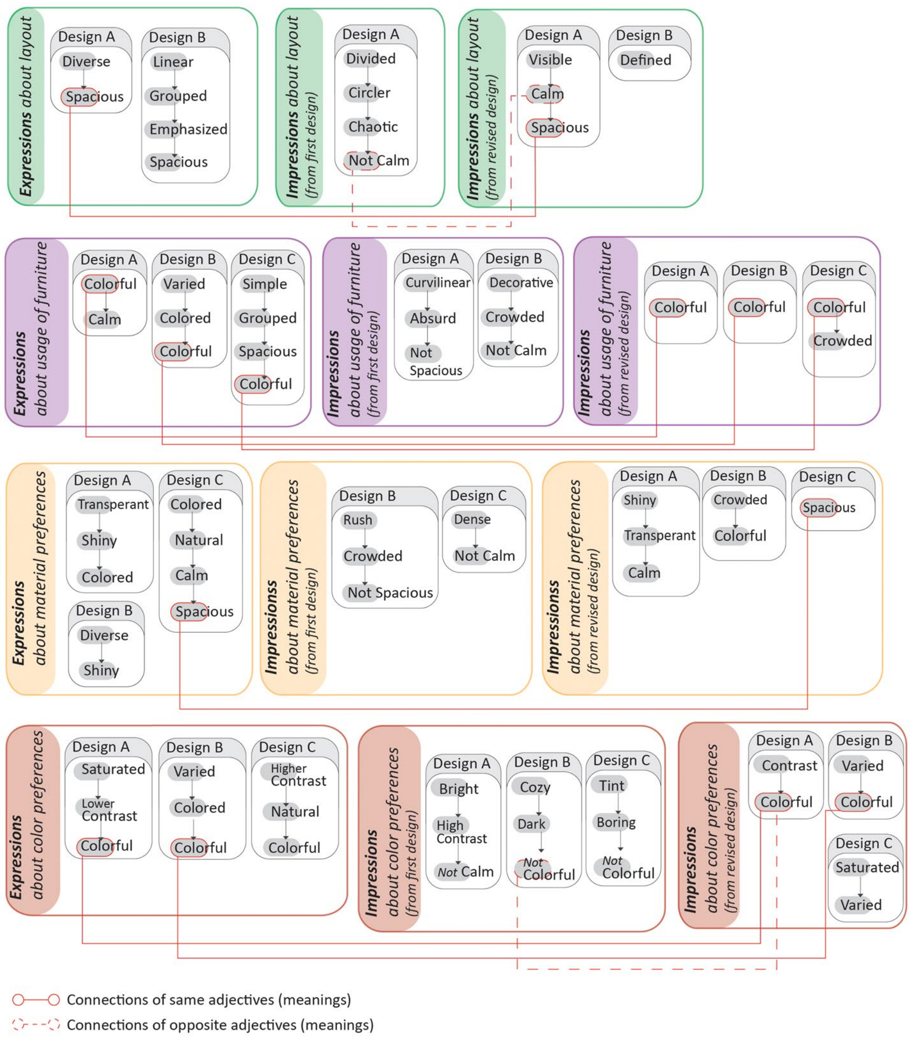

Figure 8. Master diagram showing semantic network cluster summaries for Designs A, B, and C, tied to (i) designer expression, (ii) user impressions of first design, and (iii) user impressions of revised designs.

design intent after the iteration of their first designs, guided by the activities and results of the method.

7.1. Integration of the SDD method in the interior design process

The original SDD method explored how users' impressions of visual design qualities differ from designers' intended expressions, identifying semantic discontinuities and ways to reduce them (Khalaj and Pedgley 2019). Originally applied to product design, its authors proposed broader applications across design fields with larger user groups. Based on this, the current research adapted the SDD method for iterative interior design processes, creating a framework to integrate it. Unlike the original SDD method, which evaluated completed designs, this adaptation involved a live design project, beginning with defining a design brief for a socializing area in an office setting. The study involved 45 participants (compared to 12 in the original), increasing its robustness.

The new method was structured across three phases. In Phase 1, qualitative data from user interviews were analyzed using thematic analysis (Braun and Clarke 2023) to identify adjectives representing users' spatial demands. These adjectives became UX objectives for designers. Phase 2 replicated the four stages of the original SDD method, using Semantic Network Clustering to visualize discontinuities and guide design iterations. The iterative process enabled designers to adjust spaces based on user feedback. This adaptation transitions the SDD method from a post-design critique tool to a practical tool for live projects. It aligns with user-centered design principles (Sanders and Stappers 2008), incorporating user input early in the design process. As with participatory design (Greer and Lei 2012; Wilkinson and De Angeli 2014), it emphasizes user feedback in iterative stages. Phases 1 and 2 involve user-driven insights, while Phase 3 integrates these into design revisions, supporting Vaajakallio and Mattelmäki (2014) vision of designing as rethinking, envisioning, and making.

7.2. Contributions to communication and UX design models

Khalaj and Pedgley (2019) demonstrated that design researchers could equip designers with tools to analyze and shape users' experiences and impressions in line with design intent. This research adapts their SDD method by incorporating digital tools: Python coding replaced manual Semantic Network Clustering (Phase 1 – Stage 1), while VR simulations replaced physical artifacts (Phase 2 – Stage 2, Phase 3 – Stage 2). Despite literature favoring physical artifacts for stakeholder understanding (Isa and Liem 2021; Jensen, Elverum, and Steinert 2017; Sanders and Stappers 2014), presence test results in the current study showed that VR simulations provide a holistic spatial understanding comparable to physical experiences of interiors.

The method advances UX design by structuring qualitative and quantitative research, improving user-designer communication, and facilitating the creation of user impressions that align with designers' intentions. While prior studies highlight physical space qualities affecting impressions (Kuksa and Childs 2014; Moscoso et al. 2021; Obradovic et al. 2021; Wu and Wang 2015; Zhang et al. 2022), they lack a comparison between users' impressions and designers' expressions. This research addresses that gap, contributing to UX models for iterative spatial design processes.

7.3. Potential contributions to the design industry

The proposed method has the potential to enhance research-driven professional practices. In the design industry, research activities typically have a much shorter duration compared to creative activities (Khalaj and Pedgley 2019). However, larger, well-resourced design companies that serve extensive user groups could benefit significantly from the suggested methods, as they allow for quicker analysis of user demands and feedback, thereby expediting the design process. This method could be applicable across all design-oriented companies.

Eckert and Clarkson (2011) highlighted that design failures often stem from poor project management. The current method can be effectively applied at various stages of project management; through suggested iterations, it may help address design failures before they reach the materialization phase. Additionally, as emphasized by Cárdenas Merino et al. (2025), communication failures between designers and users during the design process can be mitigated. They suggest that improved participatory design and co-design tools (and hence methods) can improve communication between stakeholders.

A case study conducted with design professionals to test the applicability of the method demonstrated its effectiveness for understanding and summarizing a large number of user demands, based on both qualitative and quantitative results. Overall, the suggested method offers valuable contributions to the design industry in these areas.

8. Conclusions

The work highlights the positive impact of improving communication between designers and users in interior design projects by adopting the Semantic Discontinuity Detection method. By developing the method to be compatible with a live design project context reliant on design iterations, gaps between design intent and user impressions were shown to be significantly reduced. Essentially, the method provides designers with a means to test the effectiveness of their proposals in delivering intended user experiences. The findings emphasize the importance of structured semantic definitions and content clarity in participatory design, ensuring outcomes align with stakeholder satisfaction. Designers also noted that semantic discontinuity maps provided direct insights into user impressions, and semantic network clusters effectively summarized user feedback.

Some limitations of the research can be mentioned. The work requires a design researcher to collect data, analyze results, and guide the iterative process, which may be challenging in business contexts without in-house expertise or consultancy investment. Additionally, constraints on design elements, such as predefined furniture or fixed lighting in CAD models, were necessary to maintain experimental consistency for method development across Designs A, B, and C, but are not needed for method application.

Future research can explore the impact of designers' thinking and materialization skills on semantic discontinuities, examine relationships between convergent/divergent thinking and discontinuity levels, and expand the range of descriptors for layout, furniture, color, and material preferences to accommodate diverse user needs. Stylistic and cultural influences on semantic discontinuities also warrant further investigation.

Acknowledgements

This study is a part of Ph.D. thesis of first author.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Author contributions

CRediT: **Busra Gumusay Ozbek**: Writing, methodology, editing; **Halime Demirkan**: Supervision, Writing – review & editing; **Owain Pedgley**: Methodology, Writing – review & editing.

Notes on contributors

Busra Gumusay Ozbek received her BFA and MFA degrees from the Department of Interior Architecture and Environmental Design at Bilkent University. Currently a Ph.D. candidate at Bilkent University Department of IAED and instructor at Baskent University. Her academic research interests include design process, user experience design, and interior semantics (e-mail: busra.gumusay@bilkent.edu.tr).

Halime Demirkan is a Professor of Architecture in the Department of Interior Architecture and Environmental Design at I. D. Bilkent University, Turkey. Her research interests include creativity, architectural design, design education, and neuroarchitecture. She received her MS and BS in Industrial Engineering and PhD in Architecture at Middle East Technical University (e-mail: demirkan@bilkent.edu.tr).

Owain Pedgley is Professor of Industrial Design at Middle East Technical University. He received B.Sc. and Ph.D. degrees in Industrial Design from Loughborough University. His primary subject expertise is user experience, interfaces, and interaction, especially in the context of materials and design, whilst his primary methodological expertise is research through design (e-mail: pedgley@metu.edu.tr).

ORCID

Busra Gumusay Ozbek http://orcid.org/0000-0002-6832-4197
Halime Demirkan http://orcid.org/0000-0002-2055-3089
Owain Pedgley http://orcid.org/0000-0003-3557-7996

References

Bossen, C., C. Dindler, and O. S. Iversen. 2018. "Program Theory for Participatory Design." In Proceeding of Participatory Design Conference 2018, Hasselt and Genk.

Botero, A., S. Hyysalo, C. Kohtala, and J. Whalen. 2020. "Getting Participatory Design Done: From Methods and Choices to Translation Work across Constituent Domains." *International Journal of Design* 14 (2): 17–34. https://doi.org/10.34229/ijdesign.3781.

Brade, J., M. Lorenz, M. Busch, N. Hammer, M. Tscheligi, and P. Klimant. 2017. "Being There Again Presence in Real and Virtual Environments and Its Relation to Usability and User Experience Using a Mobile Navigation Task." *International Journal of Human-Computer Studies* 101: 76–87. https://doi.org/10.1016/j.ijhcs.2017.01.004.

Braun, V., and V. Clarke. 2006. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology* 3 (2): 77–101. https://doi.org/10.1191/1478088706qp063oa.

Braun, V., and V. Clarke. 2023. "Toward Good Practice in Thematic Analysis: Avoiding Common Problems and be(Com)Ing a Knowing Researcher." *International Journal of Transgender Health* 24 (1): 1–6. https://doi.org/10.1080/26895269.2022.2129597.

Cárdenas Merino, D., N. Arias Jiménez, and R. Burdiles Allende. 2025. "One to One: 2 Project Experiences and Analysis of 3 Codesign Tools." *CoDesign* 21 (3): 359–381. https://doi.org/10.1080/15710882.2024.2420210.

Chowdhury, S., M. Noguchi, and H. Doloi. 2020. "Defining Domestic Environmental Experience for Occupants' Mental Health and Wellbeing." *Designs* 4 (3): 26. https://doi.org/10.3390/designs4030026.

Crilly, N., A. Maier, and P. J. Clarkson. 2008. "Representing Artefacts as Media: Modeling the Relationship between Designer Intent and Consumer Experience." *International Journal of Design* 2 (3): 15–27. https://doi.org/10.1016/j.destud.2008.01.002.

Eckert, C., and J. Clarkson. 2011. "The Reality of Design." In *Design Process Improvement: A Review of Current Practice*, edited by J. Clarkson, and C. Eckert, 1–34. Cambridge: Springer.

Ergan, S., Z. Shi, and X. Yu. 2018. "Towards Quantifying Human Experience in the Built Environment: A Crowdsourcing Based Experiment to Identify Influential Architectural Design Features." *Journal of Building Engineering* 20: 51–59. https://doi.org/10.1016/j.jobe.2017.11.006.

Fiske, J. 1990. *Introduction to Communication Studies*. London, UK: Routledge.

Ghomeshia, M., and M. M. Jusan. 2012. "Investigating Different Aesthetic Preferences Between Architects and Nonarchitects in Residential Facade Designs." *Indoor and Built Environment* 22 (6): 952–964. https://doi.org/10.1177/1420326X12446634.

Gifford, R., D. Hine, W. Muller-Clemm, and K. Shaw. 2002. "Why Architects and Laypersons Judge Buildings Differently: Cognitive Properties and Physical Bases." *Journal of Architectural and Planning Research* 19 (2): 131–148. https://doi.org/10.1080/07344360209556383.

Greenbaum, T. L. 1998. *The Handbook for Focus Group Research*. Thousand Oaks, CA: Sage Publications.

Greer, C. R., and D. Lei. 2012. "Collaborative Innovation with Customers: A Review of the Literature and Suggestions for Future Research." *International Journal of Management Reviews* 14 (1): 63–84. https://doi.org/10.1111/j.1468-2370.2011.00306.x.

Higuera-Trujillo, J. L., J. López-Tarruella Maldonado, and C. Llinares Millán. 2017. "Psychological and Physiological Human Responses to Simulated and Real Environments: A Comparison between Photographs, 360° Panoramas, and Virtual Reality." *Applied Ergonomics* 65: 398–409. https://doi.org/10.1016/j.apergo.2017.05.006.

Holt, M. 2017. "Semiotics and Design: Towards an Aesthetics of the Artificial." *Design Journal* 20 (sup1): S332–S341. https://doi.org/10.1080/14606925.2017.1356280.

Hsu, S., M. Chuang, and C. Chang. 2000. "A Semantic Differential Study of Designers' and Users' Product Form Perception." *International Journal of Industrial Ergonomics* 25 (4): 375–391. https://doi.org/10.1016/S0169-8141(99)00051-2.

Hu, T., J. Zhao, and D. Zhao. 2013. "A Study on the Semantic Gap between Designer and User in Automobile Design." In IASDR 5th International Congress of International Association of Societies of Design Research, Tokyo, Japan.

Isa, S. S., and A. Liem. 2021. "Exploring the Role of Physical Prototypes during co-Creation Activities at LEGO Company Using Case Study Validation." *CoDesign* 17 (3): 330–354. https://doi.org/10.1080/15710882.2020.1829926.

Jensen, M. B., C. W. Elverum, and M. Steinert. 2017. "Eliciting Unknown Unknowns with Prototypes: Introducing Prototrials and Prototrial-Driven Cultures." *Design Studies* 49: 1–31. https://doi.org/10.1016/j.destud.2016.12.002.

Jie, W. 2018. "Applied Research on Semiotics in Interior Design." Doctoral diss., University of Pecs, Faculty of Engineering and Information Technology Breuer Marcel Doctoral School.

Kesdi, H. S., and S. Gunes. 2025. "An Evaluation Theory for Participatory Design: Design Empowerment Framework (DEF)." *CoDesign* 21 (3): 398–423. https://doi.org/10.1080/15710882.2024.2434971.

Khalaj, J., and O. Pedgley. 2014. "Comparison of Semantic Intent and Realization in Product Design: A Study on High-End Furniture Impressions." *International Journal of Design* 8 (3): 79–96. https://doi.org/10.51253/ijdesign.2014.1885.

Khalaj, J., and O. Pedgley. 2019. "A Semantic Discontinuity Detection (SDD) Method for Comparing Designers' Product Expressions with Users' Product Impressions." *Design Studies* 62: 36–67. https://doi.org/10.1016/j.destud.2019.01.004.

Kuksa, I., and M. Childs. 2014. *Making Sense of Space: The Design and Experience of Virtual Spaces as a Tool for Communication*. Oxford: Chandos Publishing.

Kuliga, S., T. Thrash, R. Dalton, and C. Hölscher. 2015. "Virtual Reality as an Empirical Research tool – Exploring User Experience in a Real Building and a Corresponding Virtual Model." *Computers, Environment and Urban Systems* 54: 363–375. https://doi.org/10.1016/j.compenvurbsys.2015.09.006.

Lee, J. J., M. Jaatinen, A. Salmi, T. Mattelmaki, R. Smeds, and M. Holopainen. 2018. "Design Choices Framework for Co-Creation Projects." *International Journal of Design* 12 (2): 15–31. https://doi.org/10.51253/ijdesign.2018.2782.

Li, R., H. Zhang, C. Liu, Z. C. Qian, and L. Zhang. 2022. "Bibliometric and Visualized Analysis of User Experience Design Research: From 1999 to 2019." *Sage Open* 12 (1): 1–17. https://doi.org/10.1177/21582440221087266.

Moscoso, C., K. Chamilothori, J. Wienold, M. Andersen, and B. Matusiak. 2021. "Window Size Effects on Subjective Impressions of Daylit Spaces: Indoor Studies at High Latitudes Using Virtual Reality." *LEUKOS* 17 (3): 242–264. https://doi.org/10.1080/15502724.2020.1726183.

Nehme, B. J., E. Rodríguez, and S. Y. Yoon. 2020. "Spatial User Experience: A Multidisciplinary Approach to Assessing Physical Settings." *Journal of Interior Design* 45 (3): 7–25. https://doi.org/10.1111/joid.12183.

Norman, D., and J. Nielsen. 2017. The Definition of User Experience. https://www.nngroup.com/articles/definition-user-experience/.

Obradovic, B., B. S. Matusiak, C. A. Klockner, and S. Arbab. 2021. "The Effect of a Horizontal Light Pipe and a Custom-Made Reflector on the User's Perceptual Impression of the Office Room Located at a High Latitude." *Energy and Buildings* 253: 111526. https://doi.org/10.1016/j.enbuild.2021.111526.

Paes, D., E. Arantes, and J. Irizarry. 2017. "Immersive Environment for Improving the Understanding of Architectural 3D Models: Comparing User Spatial Perception between

Immersive and Traditional Virtual Reality Systems." *Automation in Construction* 84: 292–303. https://doi.org/10.1016/j.autcon.2017.09.016.

Paes, D., J. Irizarry, and D. Pujoni. 2021. "Evidence of Cognitive Benefits from Immersive Design Review: Comparing Three-Dimensional Perception and Presence between Immersive and Non-Immersive Virtual Environments." *Automation in Construction* 130: 103849. https://doi.org/10.1016/j.autcon.2021.103849.

Prasad, B. D. 2008. "Content Analysis." In *Research Methods for Social Work*, edited by D. K. Lal Das and V. Bhaskaran, 1–20. New Delhi, India: Rawat Publications.

Putnam, C., E. Rose, E. J. Johnson, and B. Kolko. 2009. "Adapting User-Centered Design Methods to Design for Diverse Populations." *Information Technologies & International Development* 5 (4): 51–74. https://doi.org/10.1007/s41666-009-0006-2.

Rahanjam, A., and M. Ilbeigi. 2021. "Post-Occupancy Evaluation of Office Buildings' Indoor Environmental Quality from the Perspectives of Architects and Nonarchitects (Case Study: Iran)." *Journal of Building Engineering* 43: 1–11. https://doi.org/10.1016/j.jobe.2021.102875.

Riener, Andreas, Dominik Schlackl, Julia Malsam, Josef Huber, Benjamin Homm, Marion Kaczmar, Iris Kleitsch, et al. 2021. "Improving the UX for Users of Automated Shuttle Buses in Public Transport: Investigating Aspects of Exterior Communication and Interior Design." *Multimodal Technologies and Interaction* 5 (10): 61. https://doi.org/10.3390/mti5100061.

Sanders, E. 2002. "From User-Centered to Participatory Design Approaches." In *Design and the Social Sciences: Making Connections*, edited by J. Frascara , 1–18. London: Taylor and Francis.

Sanders, E. B.-N., and P. J. Stappers. 2008. "Co-Creation and the New Landscapes of Design." *CoDesign* 4 (1): 5–18. https://doi.org/10.1080/15710880701875068.

Sanders, L., and P. J. Stappers. 2014. "From Designing to co-Designing to Collective Dreaming: Three Slices in Time." *Interactions* 21 (6): 24–33. https://doi.org/10.1145/2678214.

Sharif, A. A. 2020. "Users as co-Designers: Visual Spatial Experiences at Whitworth Art Gallery." *Frontiers of Architectural Research* 9 (1): 106–118. https://doi.org/10.1016/j.foar.2020.03.001.

Siltanen, S., V. Oksman, and M. Ainasoja. 2013. "User-Centered Design of Augmented Reality Interior Design Service." *International Journal of Arts & Sciences* 6 (1): 547–558. https://doi.org/10.19030/ijas.v6i1.8032.

Smeenk, W., J. Sturm, and B. Eggen. 2019. "A Comparison of Existing Frameworks Leading to an Empathic Formation Compass for co-Design." *International Journal of Design* 13 (3): 53–68. https://doi.org/10.57643/IJD.2019.56.

Vaajakallio, K., and T. Mattelmäki. 2014. "Design Games in co-Design: As a Tool, a Mindset and a Structure." *CoDesign* 10 (1): 63–77. https://doi.org/10.1080/15710882.2014.881886.

Viudes-Carbonell, S., F. Gallego-Durán, F. Llorens-Largo, and R. Molina-Carmona. 2021. "Towards an Iterative Design for Serious Games." *Sustainability* 13 (6): 1–13. https://doi.org/10.3390/su13073879.

Voinov, A., K. Jenni, S. Gray, N. Kolagani, P. D. Glynn, P. Bommel, C. Prell, et al. 2018. "Tools and Methods in Participatory Modeling: Selecting the Right Tool for the Job." *Environmental Modelling & Software* 109: 232–255. https://doi.org/10.1016/j.envsoft.2018.09.016.

Watson, D., L. A. Clark, and A. Tellegen. 1988. "Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales." *Journal of Personality and Social Psychology* 54 (6): 1063–1070. https://doi.org/10.1037/0022-3514.54.6.1063.

Wilkinson, C. R., and A. De Angeli. 2014. "Applying User Centered and Participatory Design Approaches to Commercial Product Development." *Design Studies* 35 (6): 614–631. https://doi.org/10.1016/j.destud.2014.06.001.

Wu, T. Y., and S. G. Wang. 2015. "Effects of LED Color Temperature and Illuminance on Customers' Emotional States and Spatial Impressions in a Restaurant." *International Journal of Affective Engineering* 14 (1): 19–29. https://doi.org/10.5057/ijae.14.19.

Zhang, L., R. Li, H. Zhang, C. Liu, Z. C. Qian, and T. Zhang. 2022. "Research on Visual Comfort of Color Environment Based on the Eye-Tracking Method in Subway Space." *Journal of Building Engineering* 9: 1–15. https://doi.org/10.1016/j.jobe.2021.102911.

Zou, Z., and S. Ergan. 2021. "Evaluating the Effectiveness of Biometric Sensors and Their Signal Features for Classifying Human Experience in Virtual Environments." *Advanced Engineering Informatics* 49: 101358. https://doi.org/10.1016/j.aei.2021.101358.