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Pre-Occupancy Evaluation of Affective Experiences in Building Information Modeling Through SLR and an e-Delphi Survey

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Abstract: Building information modeling (BIM) is increasingly used during the conceptual design phase, which focuses on simulations such as energy usage analysis and comfort levels, like temperature and lighting conditions, to enhance user experience and well-being, which are key factors for meeting Sustainable Development Goal 3. This study employs a systematic literature review and an e-Delphi survey to explore how a pre-occupancy evaluation integrated within BIM frameworks addresses affective responses and suggests ways to improve design decisions that align with the UN's sustainable development goals. The study identified a research gap in how BIM evaluations are conducted during the conceptual design stage, including crucial sensory aspects for human well-being. The research suggests incorporating evidence-based design instruments like body sensor networks (BSN) and immersive virtual reality and methods like neurophenomenology to enhance the assessment of user interactions in the design process. Prioritizing the human-centered design approach right from the start can facilitate the integration of innovative workflows into architecture, engineering, and construction practices. Overcoming resistance to these workflows and methodologies is essential for advancing BIM's role in fostering spatial environments that support health, well-being, and positive affective experiences.

Keywords: building information modeling; sustainable design; well-being; pre-occupancy evaluation framework; affective experience; conceptual design; virtual reality

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1. Introduction

The environments where we reside and work have an impact on our health and mental happiness, as well as on our general sense of wellness. Within the realm of architecture, there is a rising acknowledgment that structures buildings should offer more than functionality. They should play a role in enhancing the well-being of their occupants. This research delves into the potential of building information modeling (BIM) and comparable tools in creating spaces that influence individuals' emotional well-being and mental health. Integrating conceptual design evaluation tools with BIM has the potential to foster spaces that enhance both physical and mental health. This approach resonates with the objectives of the sustainable development goals (SDG), especially SDG 3 which advocate for promoting good health and well-being [1].

Although SDG 3 does not explicitly discuss architecture as a factor, for holistic well-being, it is well-documented that thoughtful architectural designs can have an impact on mental health. A notable study by Mazuch and Stephen [2] focused on creating humanistic architecture that prioritizes the health and happiness of individuals. In this study, a

systematic literature review (SLR) and an e-Delphi survey are employed to explore how current BIM-based tools address the experiences of individuals. The present study aims to discover methods in BIM to assist architects and designers in crafting environments that promote wellness and enrich our lives, following SDG 3.

Architects and healthcare experts are both acknowledging the impact of the environment on our overall health and wellness [3–5]. Given that we spend a reasonable amount of time inside buildings [6,7], the configuration of these environments impacts us in many ways. It plays a crucial role in our physical well-being, as well as in our mental and emotional states [8,9]. This study explores methods of assessing the "affective" aspects of a spatial configuration within the BIM paradigm, specifically focusing on the conceptual design phase, focusing on the pre-occupancy evaluations (PrOE). Architectural professionals can use the affective PrOE frameworks to be aware of their bodily sensations when curating a design. The usual architectural design process tends to prioritize form, function, and cost-effectiveness while neglecting aspects of built environments on the public's well-being [10]. The role of architects is complex. They have to consider the needs of the various stakeholders, including designing for universal accessibility, addressing emergency safety concerns [11], and envisioning other probable design challenges that their design has to face. Typically, architects respond to climate conditions [12], building structures [13], the façade, [14] etc., among which health and well-being tools are limited and often overlooked. The existing tools and frameworks on health and well-being are largely centered around building sciences and indoor environmental quality (IEQ) [15] factors that, again, predominantly focus on factors like air quality [16], lighting and energy efficiency [17], materials [18], acoustics [19], and green building strategies [20], while neglecting the emotional ambiance of a space at an early design stage.

This study intends to identify a conceptual design evaluation framework that focuses on improving well-being by emphasizing a sense of coherence, taking inspiration from the "Salutogenic" approach [21] rather than solely concentrating on the practical needs of the project. It is of great significance to incorporate health-promoting concepts, such as biophilia [7], art [22], and optimal IEQ [23], at the onset of the design phase. Hence, architects and designers should have a framework or toolkit that helps them with key design decisions at the conceptual design stage [24], as decisions taken during this period significantly influence the ultimate outcomes.

Virtual design and construction (VDC) [25] tools such as BIM are increasingly empowering architects [26] to enhance their design choices with data-driven insights [27]. The latest progress in the IoT [28] and Industry 4.0 [29] has opened up opportunities for creating environments that cater to end-user requirements. Leveraging such technologies allows us to design for smart homes [30], ambient assisted living [31], and digital twins [32]. Despite this progress, the existing BIM paradigm views buildings as disembodied objects of analysis [33] and then as dynamic spaces where individuals engage emotionally. This emphasizes a significant gap in addressing the phenomenon of affective decision-making in the early stages of design and the process of evaluating and predicting how spatial configurations influence emotional and psychological responses during the early stages of design. While individual contributions in integrating BIM with immersive technologies [34], virtual reality (VR) for architectural design evaluation [35–37], and biometric tools like electroencephalogram and motion tracking have demonstrated the potential to capture nuanced user experiences [38–42], these methodologies remain fragmented. What is missing is a unified framework that converges these diverse tools to empower architects in designing spaces that enhance well-being and comfort. This research investigates whether such a framework currently exists, exploring its potential to integrate affective evaluations into

BIM workflows and address the emotional dimensions of spatial design, aligning with the objectives of SDG 3.

To truly improve the design process, architects and designers benefit from a tool that considers the architectural object from an embodied perspective within the BIM paradigm and functions at the strategic level of conceptual design decision-making [43], enabling more effective decision-making [44]. By integrating affective experiential data in the conceptual design phase, designers can predict how designers and end users will connect emotionally with space and enhance their overall well-being in the long run. When considering the embodied aspect in designing processes, evidence-based design (EBD) approaches from neuroscience [45,46] and cognitive science [47] provide perspectives on understanding human interactions within the built environment, as shown by studies [48–51].

These interdisciplinary methodologies should be appropriated for BIM to translate its ability to access architects' and designers' behavioral data [52–54], like cognitive modalities [55] in human perception, focus, action, interaction dynamics, environmental affordances, user experience, design ideation, and meaning [56]. Adding to the above, designing for well-being heavily relies on incorporating models and concepts, like biophilia [57], the notion of "wholeness" [58], and various wellness-integrating frameworks [59]. The impact of biophilia and its healing properties have been extensively explored in the literature [60]. So, to understand the affective gap in BIM, this study primarily delves into SLR and e-Delphi study for addressing the "affective" aspects of spaces in BIM during the conceptual design decision-making process. This understanding will help us meditate on existing frameworks and create new frameworks to empower architects with the ability to evaluate how a space could potentially evoke affective emotions within individuals residing within it before the conceptual design stage itself, ultimately leading to the development of spaces that promote overall well-being and positive experiences for their inhabitants. This study investigates the following overarching question setting this research: to what extent do current BIM-based PrOE frameworks consider affective spatial experiences in the conceptual stage of the design decision-making process to promote well-being in alignment with SDG 3? To answer this question, the following major and specific objectives were framed.

To explore how BIM-integrated PrOE frameworks assess affective spatial experiences during the conceptual design stage, using measurable criteria for well-being, and to identify opportunities for enhancing these frameworks to align with SSDG 3, the specific objectives are as follows:

- to conduct an SLR using predefined evaluation criteria to analyze existing BIM-based PrOE frameworks, focusing on their capacity to assess affective spatial experiences during the conceptual design stage and their contribution to well-being, as outlined by SDG 3;
- to collect and analyze expert opinions through qualitative and quantitative methods to evaluate the current capabilities of BIM tools to address affective spatial experiences, identify gaps, and propose enhancements to PrOE frameworks for improved alignment with SDG 3.

The research study is organized into five main sections, namely an Introduction, Methods, Results, Discussion, and Conclusion, as shown in Figure 1. Section 1 introduces the research context and objectives, setting the stage for the subsequent analysis. Section 2 outlines the methodological approach, detailing the SLR and e-Delphi survey processes. Section 3 presents the results, subdivided into key components such as the summary of the SLR, evaluation frameworks, parameters, sample sizes, and the findings from both the SLR and e-Delphi rounds. Insights from the iterative rounds of the e-Delphi survey are critically analyzed to provide nuanced perspectives. Section 4 synthesizes these findings in a comprehensive discussion, emphasizing their implications for the research problem.

Finally, Section 5 concludes by summarizing the key findings from both methodologies, highlighting their contributions, and suggesting directions for future research.

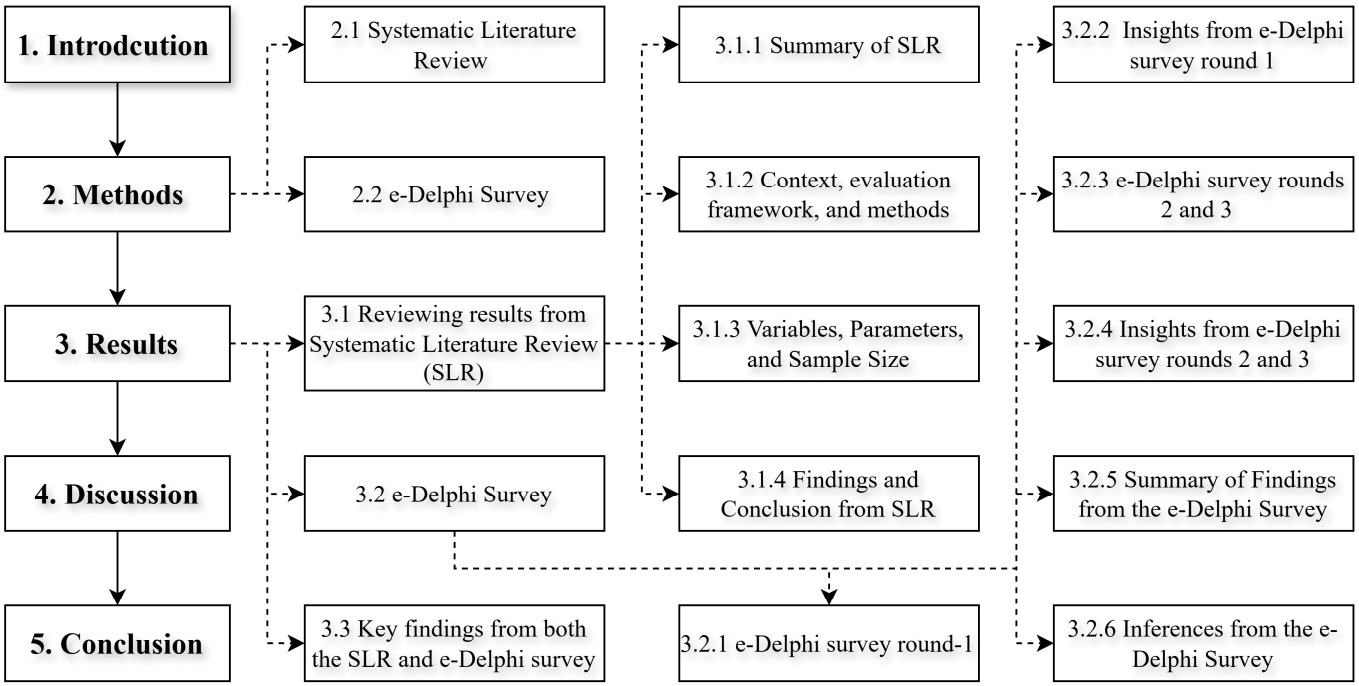

Figure 1. Structure of the present work.

2. Materials and Methods

This study employs a two-fold strategy to explore the capabilities and future potential of BIM in addressing affective spatial experiences. First, an SLR was conducted to identify trends and gaps in the literature concerning PrOE frameworks addressing affective spatial experiences in the conceptual design decision-making process. Second, an e-Delphi survey was conducted to further gather expert opinions on the existing frameworks and toolkits to aid decision-making and elevate the affective spatial experiences that align with SDG 3. Figure 2 outlines the research design used in this study.

2.1. SLR

The SLRs, in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines established by Moher in 2009 [61], were used in this systematic literature review to outline a structured and transparent process for identifying, screening, and including relevant studies. The guiding research questions for the SLR were: how has the existing literature addressed the development and implementation of BIM-based PrOE frameworks for assessing affective spatial experiences during the conceptual design phase to enhance well-being in compliance with SDG-3?

2.1.1. Search Strategy

The Scopus database is used in this study, and keywords with a specific focus on architecture, BIM, Conceptual design, and decision-making were selected. An advanced database search was conducted using the following terms: “Virtual Design and Construction” OR “VDC” OR “Building Information Modelling” OR “BIM” AND “Human Building Interaction” OR “Human experience” OR “Human centered building design” OR “Phenomenology” OR “Design decision” OR “Design cognition” OR “Spatial evaluation” OR “Evidence Based Design (EBD)“ OR “EBD” OR “Design evaluation” OR “Conceptual Design” OR neuro-architecture OR neuro-aesthetics OR neuro-design OR neuroscience OR

affective OR emotion* OR "feeling" OR cognitive-architecture OR "Neurophenomenology" OR "Biometric analysis" OR "Body Sensory Networks" OR "Body Area Network" OR "Wearable technology" OR "Immersive Virtual reality (IVR)" OR "IVR" OR "Virtual reality" OR "VR" OR "Serious Gaming" OR gami* AND well* OR heal* OR salutogen* OR wholeness OR sustainability" leading to the discovery of 313 articles.

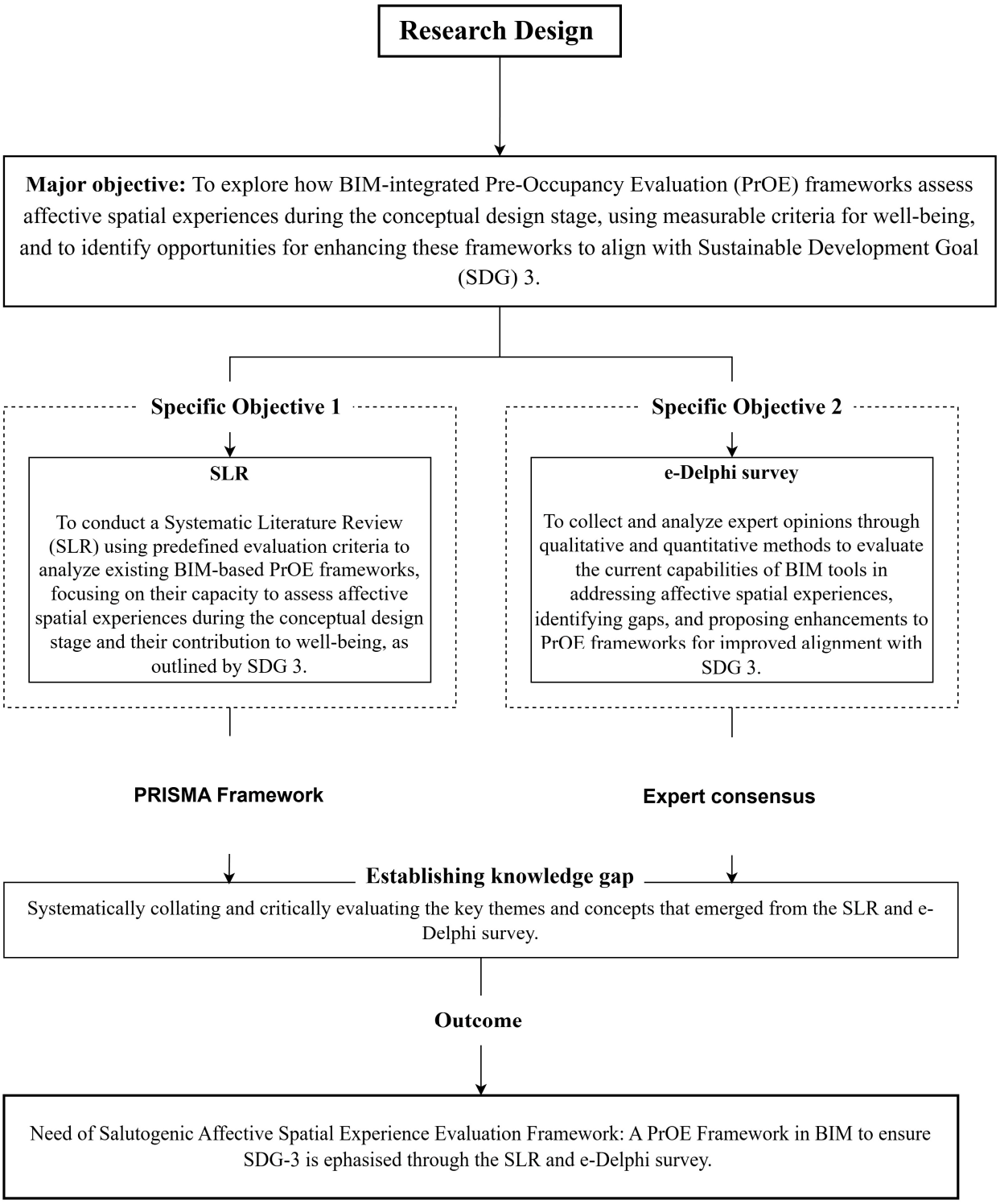

Figure 2. Outlines of the research design used in this study.

2.1.2. Inclusion and Exclusion Criteria

Adhering to the PRISMA framework, the systematic review process identified 313 records from the Scopus database using structured search strings. During the first screening, journal articles and conference proceedings published between 2014 and 2024 were included (n = 271). Given the accelerated development of BIM, VR, and body sensor networks (BSN) over the past decade, this period was deemed appropriate. Meanwhile, 45 records that did not meet this timeframe threshold were excluded. Additionally, three articles in languages other than English were excluded, leaving 268 articles for the next stage. These 268 articles were further evaluated in the second screening based on their titles and abstracts. This step identified 19 articles as relevant for full-text screening, while 249 articles were excluded due to a lack of relevance to the research focus, like not addressing the conceptual design phase or BIM frameworks or insufficient methodological rigor. The inclusion criteria at this stage ensured that only high-quality and relevant literature was carried forward. In the final screening phase, the 19 shortlisted articles underwent a detailed full-text review, excluding 9 articles that lacked alignment with the study objectives. Ten articles were included in the review, reflecting a rigorous and transparent filtering process that ensured the reliability and relevance of the selected studies. The entire SLR process followed is illustrated in Figure 3. During the data analysis phase of our study, information using VOSviewer version 1.6.20 software to generate a network map showing how keywords appear together in the abstracts helped uncover themes and connections within the research literature [62–64]. By evaluating the network clusters and the shortlisted journals from the SLR process, the larger trends and possibilities for new connections were identified.

2.2. e-Delphi Survey

An e-Delphi was conducted to gather insights from architects—both from industry and academia—to understand the existing tools and frameworks used to evaluate the affective experience of well-being in the space using BIM. The e-Delphi survey was chosen because of its iterative nature, allowing for methodological rigor and enhancement of expert perspectives [65–68]. This approach is well-suited for gaining insights on evolving subjects, such as decision-making using the BIM paradigm. In this study, three iterations of the e-Delphi survey were conducted, where expert panel members responded to the individual questions and based on the collective responses shared with them from the previous round, and experts can change their opinions. When the common consensus is achieved, the e-Delphi survey is stopped. The survey was shared with the expert panel members through email invitation.

The focus of each round was to evaluate BIM's condition and future possibilities in analyzing spatial experiences during the initial design stage. Necessary inquiries were centered around the capabilities of existing BIM tools for assessing experiences and the potential for creating a BIM-based PrOE framework that supports SDG 3 objectives to improve design decision-making. Data from every round were analyzed using Atlas.ti for assessment. Furthermore, a Sankey chart displayed trends and agreement development throughout the survey. The following questions were framed to guide the e-Delphi survey. How equipped are the current BIM-based tools and methodologies in assessing affective spatial experiences during the conceptual design phase? What are the expert perspectives on the necessity and feasibility of developing a BIM-based PrOE framework that aligns with SDG 3 goals to enhance design decision-making?

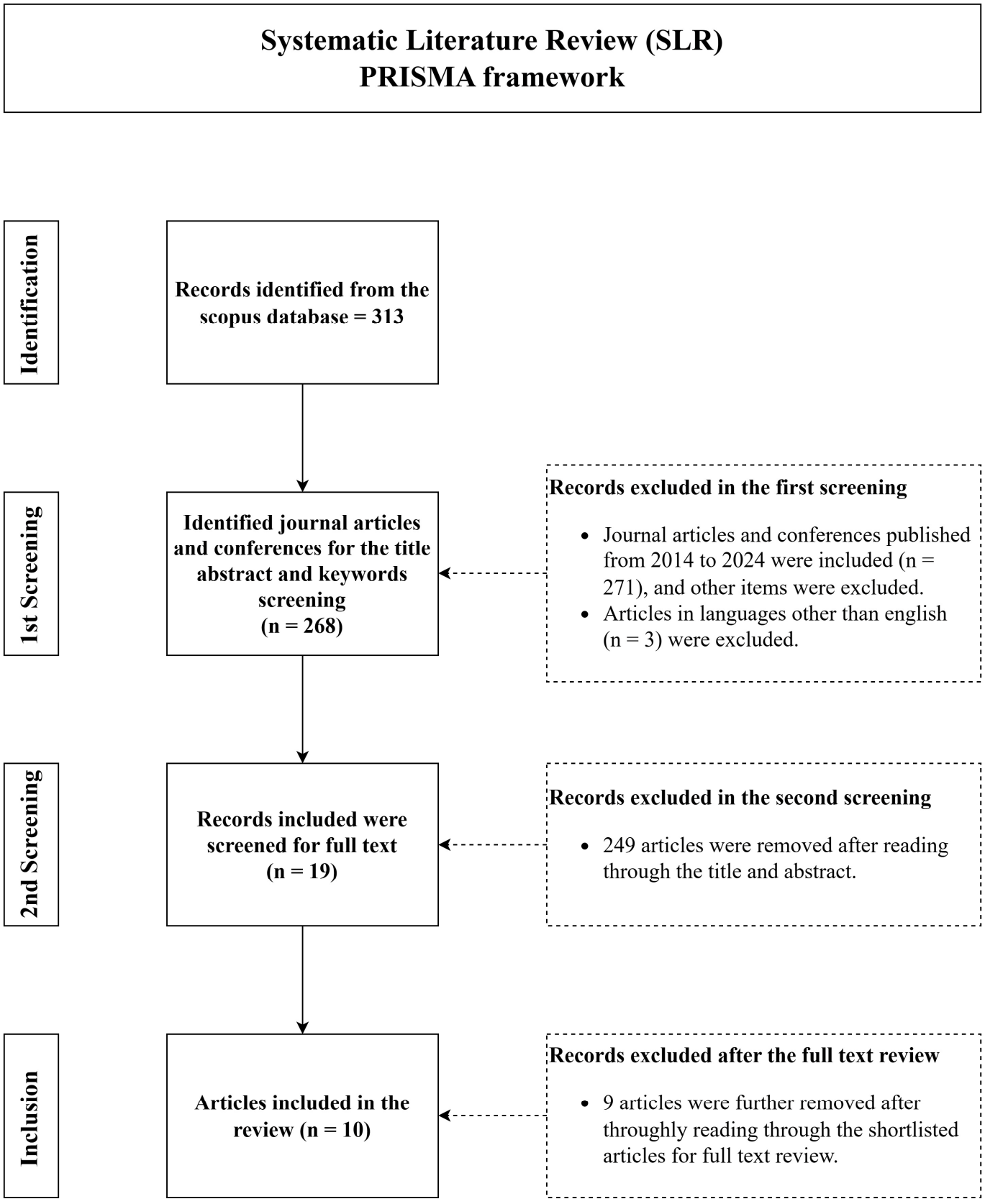

Figure 3. PRISMA flow chart of the SLR.

3. Results

3.1. Reviewing Results from SLR

A total of 268 research documents were identified through a quantitative literature analysis. To better understand the relationships and trends within the data, a network map was created by inputting bibliographic information into the VOS viewer tool [53–55]. These data were formatted as a comma-separated value file, allowing for an analysis of how frequently keywords from the abstracts appeared together. The purpose of this approach was to identify larger patterns, themes, and clusters of interconnected concepts across the literature. The results of the co-occurrence network analysis, presented in Figure 4, revealed a notable finding. There were no significant connections between the central concept of the BIM and other related topics, such as conceptual architectural design, decision support systems, VR, or healthcare. This lack of strong connections suggests that there is a gap in the research exploring the intersections of BIM with these other domains. The findings highlight areas in need of further investigation, particularly where multiple concepts could be integrated for more interdisciplinary research and innovation.

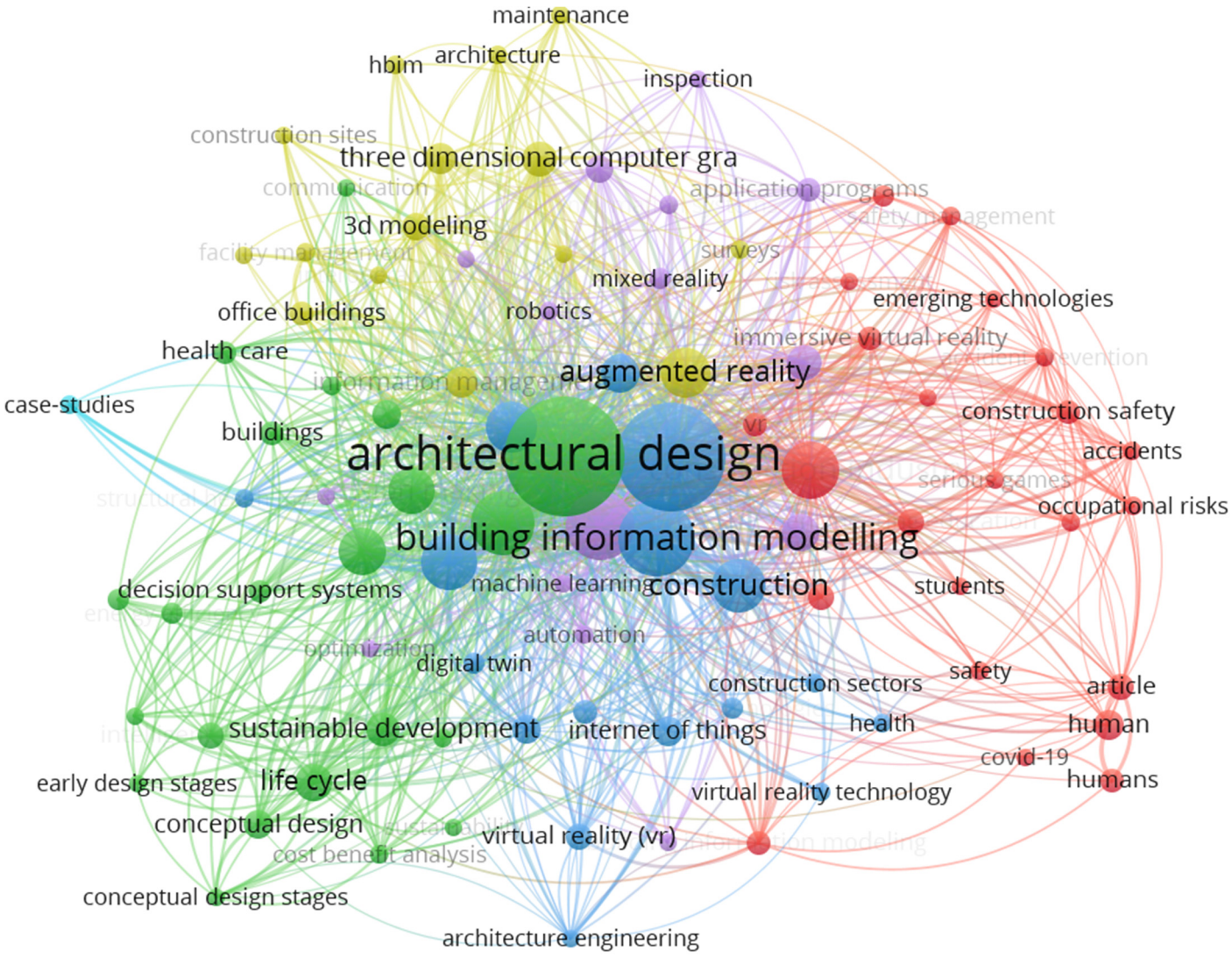

Figure 4. Network visualization of keyword co-occurrence analysis, map generated in VOS viewer.

3.1.1. Summary of SLR

This thorough literature review explores how advanced technologies, such as BIM, VR, BSNs, and neuroarchitecture, are combined to improve decision-making and user

experiences within architectural environments. When looking at how well-being is assessed in spatial experiences, the study points out a lot of research that focuses on using VR and putting users at the center to enhance healthcare settings [30,69–72]. These works highlight how VR can improve environmental interactions for people. Furthermore, the combination of lighting design, alongside BIM and VR, is recognized as an advancement in crafting tailored user interactions [73]. Moreover, the utilization of blockchain-integrated information modeling for design exemplifies how cutting-edge technologies can bolster architectural goals [74].

The review also mentions the initiatives to create BIM-based visualizations and interactive platforms for boosting stakeholder involvement in healthcare design projects. These platforms support communication and simulation procedures by integrating VR BIM technology, leading to a cooperative design stage. Research on semantic web technologies shows their effectiveness in forecasting IEQ satisfaction by incorporating human–building interaction in work environments and enhancing design approaches [75]. Furthermore, the SLR revealed how immersive virtual environments are tested for their ability to recreate emergencies, like virtual fire drills [76], and enhance the understanding of BIM metadata among project participants. Notably highlighted is the use of game engines and VR to enhance the realism of simulations and user involvement in the design process [77]. These studies together showcase how BIM VR and similar technologies are changing the game in architecture practice by improving decision-making processes and communication among stakeholders while creating user-sustainable spaces that cater to user needs and preferences effectively.

3.1.2. Context, Evaluation Framework and Methods

Table 1 presented in this study provides an overview of the literature scrutinized for the SLR conducted here. Noteworthy findings include a focus on BIM and well-being studies towards typologies such as healthcare architecture foremost; educational institutions and office spaces also garner attention in these studies. An outlier study delves into the indoor environments in general, as compared to the more specified areas mentioned above. During the SLR process, 10 studies were considered in total for detailed review. Out of these studies, two specifically concentrated on frameworks that integrate blockchain technology with BIM [74] and the incorporation of human building comfort with web-based ontologies to analyze and interpret human experiences. Additionally, another study examined user stress levels during a virtual fire situation in a school building modeled using BIM and a game engine for VR simulations. During the simulation session [76] various physiological responses, such as monitoring oxygen levels in the blood and heart rate, were noted. This was conducted using equipment like a pulse oximeter and wrist blood pressure monitor in conjunction with a smartwatch. In the remaining seven research documents [69–73,75,77], the study incorporated VR technology for perception feedback, in alignment with the design review methodology. Additionally, it was observed that, to create architectural assets, BIM-authoring software was widely used along with game engine platforms like Unity 3d and Unreal engine for VR simulations.

Table 1. Key findings from the SLR.

Ref.	Building Typology	Tools Integrated	Evaluation Method	Variables Measured	Sample Size
Yang et al. [78]	Healthcare architecture	BIM-Revit, VR, and game engine	Review of health care design in IVR through feedback.	Participants perception	44
Huang et al. [69]	Healthcare architecture	BIM-Revit, VR, and Unreal 4 game engine	Review of health care design in IVR through feedback.	Participants perception	NR

Table 1. *Cont.*

Ref.	Building Typology	Tools Integrated	Evaluation Method	Variables Measured	Sample Size
Lin et al. [70]	Healthcare architecture	BIM-Revit, VR, and game engine	Pilot case study validation approach through VR simulation	Participants perception	NR
Bjørn et al. [71]	Healthcare architecture	BIM-Revit, VR, and Unity 3D game engine	Review of health care design in IVR through feedback.	Participants perception	NR
Buchanan et al. [72]	Healthcare architecture	BIM-Revit, VR, and Unity 3D game engine	Review of design in IVR through feedback.	Task completion rate, System usability scale (SUS) score, Time taken, Participants' performances, and preferences for design reviews in VR	17
Wong et al. [73]	Lecture Hall	BIM-Revit, 3Ds max, VR, Unity 3D game engine, DIAlux, and LumneLights	Case study validation approach through VR simulation	Lighting instantiation, Lighting parameter, adjustment, Personalised lighting design, Video projecting, Energy consumption	NR
Liu et al. [74]	Universal	Information modeling and blockchain	Framework validation using a mixed method to construct the BC-HTD framework, through surveys and interviews with industry experts/academics.	NR	NR
Qiu et al. [75]	Indoor Environment	Semantic web technologies, Feedback through online survey on IEQ	Human comfort in building framework evaluation through queries and surveys.	Space recommendation and Building setting recommendation	NR
De Luca et al. [76]	School building	BIM-Revit, 3Ds max, VR and Unity 3D game engine	Review of school design in IVR through scenario validation and measuring physiological parameters.	Oxygen saturation, blood pressure, and heart rate were measured using an oximeter, wrist sphygmomanometer, and smartwatch	25
Heydarian et al. [77]	Office room	BIM-Revit, 3Ds max, and architecture interactive	Review of design in IVR through feedback.	NR	9

Note: NR-not reported.

3.1.3. Variables, Parameters, and Sample Size

Based on the SLR, the study discovered that multiple factors were investigated in research studies related to architectural and healthcare design, which showed the intricate and varied nature of this research area. Factors taken into consideration encompassed participants' perspectives [69–71,78] were the completion rates for tasks and ratings on the SUS [72], the time needed for task completion, and reflections on how participants perform and their preferences in VR design assessments. Numerous studies have explored the field of lighting design by investigating aspects such as the installation of lighting fixtures and adjusting to cater to preferences and requirements [73]. Furthermore, research has proposed customizing designs and architectural elements according to individuals' perceptions of

them. Physiological measurements like oxygen levels in the blood, saturation rate, and heart rate were observed during simulations utilizing tools, like oximeters, wrist blood pressure monitors, and smartwatches [76]. In the review of research documents, many studies did not provide details about the sample sizes they utilized [69–71,73–75]. Four out of the ten studies that made the shortlist provided details about their sample sizes; a study by Yang et al. [78] conducted in 2024 with 44 participants mentioned sample size information, followed by a study by Buchanan et al. [72] from 2023 with 17 participants mentioning theirs, as well as De Luca et al. [76]. The study from 2021 with 25 participants was by Heydarian et al. [77]. A study dating back to 2014 with just nine participants disclosed their sample sizes, while the rest of the studies did not mention theirs. This detailed review of the existing literature highlights the progress made in combining BIM VR and game engine technologies to investigate well-being, an area that is presently in the early stages of integration and speculative research studies.

3.1.4. Findings and Conclusion from SLR

The SLR analysis showed that there is no tool or framework using BIM to assess experiences related to health and well-being, as per SDG 3. This research underscores the range of uses and possibilities by combining BIM with VR and popular game engines, like Unity 3D or Unreal Engine for creating visualizations. Most of the research discussed in this SLR also depends on gathering feedback from users to explore how people perceive spaces to enhance decision-making processes and communication and increase user satisfaction in different design contexts, particularly within healthcare environments that are closely linked to SDG 3 of advancing wellness. Out of the ten selected studies examined here, one study utilized BSN devices to assess the experiences of individuals occupying these spaces [76]. The findings of the literature review are mentioned earlier. While the combination of BIM and VR is widely recognized in the field, there is a need for the standardization of workflows that incorporate BIM with BSNs. While BSN integration has been explored in research on user experiences in BIM applications, there is a lack of established guidelines and specific criteria for evaluating designs. It is worth noting that studies have not yet used neuroarchitecture within BIM to assess user experiences related to well-being; this underscores a gap in methodological approaches that could greatly contribute to achieving the goals outlined in SDG 3. Moreover, most research on BIM and well-being mainly depends on users' expressed thoughts shared with designers and decision-makers without utilizing techniques like BSN, neuroarchitecture, neurophenomenology, and natural language processing. This highlights the chance to improve the assessment of an experience's well-being in the design stages, significantly, by combining cutting-edge interdisciplinary methods.

3.2. e-Delphi Survey Results

The study using SLR showed promising opportunities to combine concepts like evaluating design and mapping affective experiences with aspects of well-being and VR, along with neuroarchitecture and neurophenomenological factors, within the realm of BIM. To collect expert opinions systematically and to understand the viewpoints of working architects, in this integration process, a comprehensive e-Delphi survey was carried out. The e-Delphi survey was selected for its design, which allows for collecting and enhancing expert perspectives effectively [65–68]. In comparison to survey methods, the e-Delphi technique involves multiple rounds of surveys (typically, between one and four rounds) where a panel of experts shares their insights until a consensus is reached after successive rounds. After each round, the responses were aggregated and shared with expert panel members while maintaining the respondents' anonymity. This process encourages experts to reconsider their views based on

the group's collective responses, thereby facilitating the convergence of opinions. The survey process continues until an expert consensus is achieved.

The e-Delphi survey was meticulously designed to engage architects with substantial expertise in both practice and academia, particularly those experienced in BIM. The following questions were framed to guide the e-Delphi survey. How equipped are the current BIM-based tools and methodologies in assessing affective spatial experiences during the conceptual design phase? What are the expert perspectives on the necessity and feasibility of developing a BIM-based PrOE framework that aligns with SDG 3 goals to enhance design decision-making? Figure 5 outlines the key processes and findings of the e-Delphi survey.

A purposive sampling approach was employed to identify and select experts, ensuring the inclusion of individuals with significant relevance to the study's focus on BIM's role in facilitating well-being during the preliminary stages of design. Invitations were sent to more than 40 identified experts as part of phase 1, the preparatory phase, of the survey. In this initial phase, the research problem, purpose of the study, and survey guidelines were communicated to the invited participants through detailed email communications, along with a consent form. Out of the invited experts, 22 accepted the invitation and participated in round 1 by responding to open-ended questions that explored the state of BIM usage and its potential to foster well-being during early-stage design processes.

In phase 2, the exploratory phase, the responses from round 1 were analyzed using Atlas.ti, a qualitative data analysis software, to identify patterns and recurring themes. These insights formed the basis for structuring the questionnaires for the subsequent rounds. The structured questions, designed on a five-point Likert scale, were accompanied by a summary of the findings from round 1, ensuring that the participants were informed of the evolving consensus and key themes identified in earlier iterations. This iterative feedback loop allowed participants to reflect on the collective insights and refine their responses in subsequent rounds.

In phase 3, the consensus phase, 12 structured questions were developed and shared with the 22 participants from round 1. However, the experts who failed to respond in round 2, despite repeated reminders, were excluded from the panel, resulting in a refined group of 15 participants who demonstrated consistent engagement and responsiveness. The retention of these 15 participants aligns with the established Delphi methodology, which emphasizes the importance of consistent participation to ensure reliable and meaningful consensus. Smaller engaged panels of 10–15 participants are considered adequate in specialized fields, as supported by research. While formal sample size calculations are not typically required for Delphi studies, careful consideration of the number and characteristics of panel members is crucial for methodological rigor. The literature emphasizes that the appropriate sample size depends on the study's purpose and the diversity of expert opinions required. For instance, small panels of 10–25 participants are often sufficient for homogeneous groups, while larger multistakeholder panels may need 60–80 participants to ensure robust results and replicability [79]. The "Wisdom of Crowds" theory, a foundational principle of Delphi, suggests that the collective intelligence of diverse experts can lead to more accurate outcomes. However, too few participants may compromise validity, while excessively large panels may yield diminishing returns beyond a certain point [80]. Ultimately, the key to a successful Delphi panel lies in selecting participants with relevant expertise and ensuring that their diversity aligns with the study's objectives [81–83].

In this case, the reduction in panel size enhanced the quality of insights while maintaining diversity in expertise. The e-Delphi process emphasizes the quality of input over the quantity of participants. When the experts are selected based on purposive sampling, their depth of knowledge compensates for the smaller sample size.

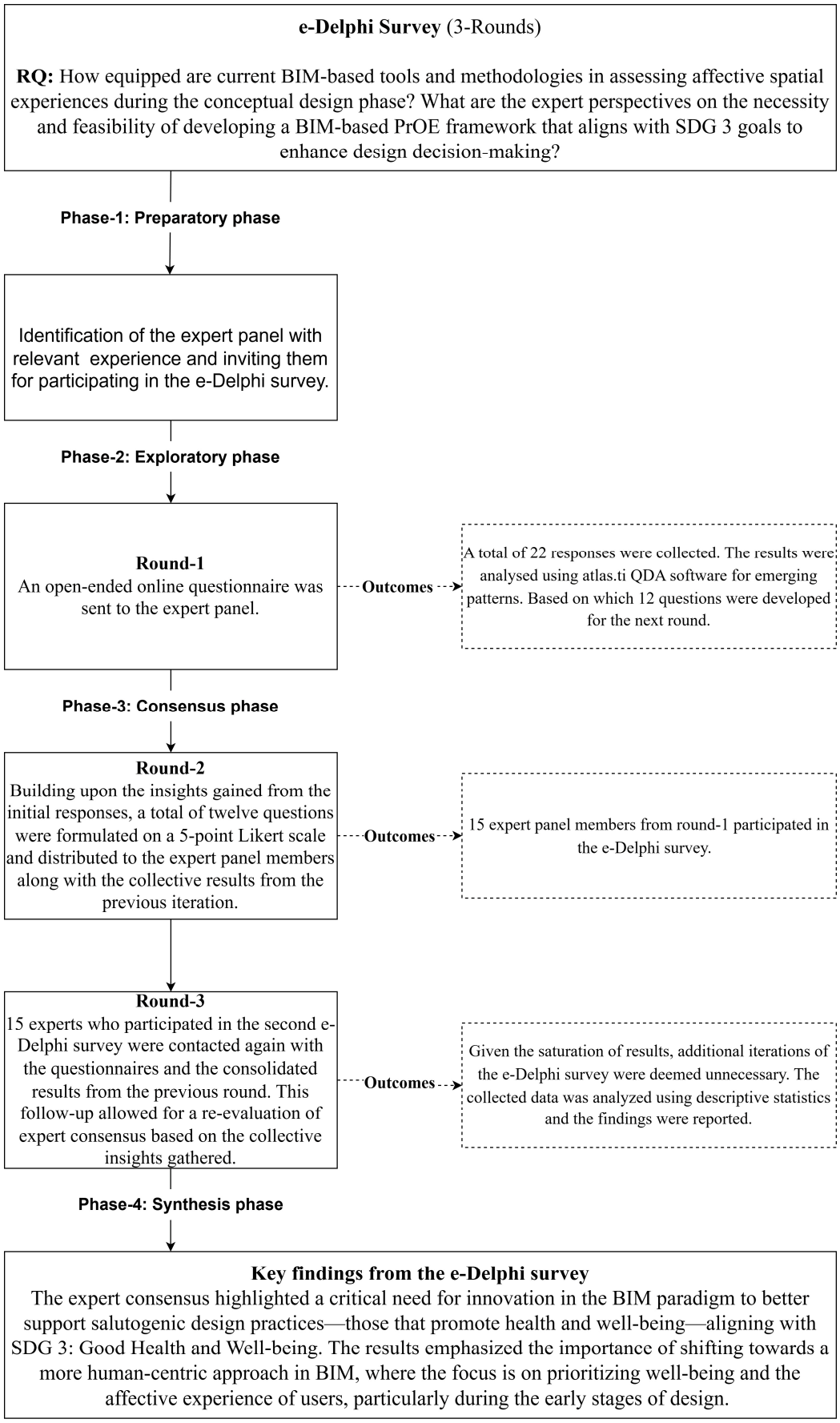

Figure 5. Overview of the results from the e-Delphi process (Round 1–3).

Consensus was achieved through iterative rounds, where the results from previous rounds were shared with the participants to provide a foundation for informed decision-making. The participants were encouraged to revise or reinforce their responses based on the collective patterns communicated to them at the beginning of each subsequent round. By the third round, the responses had reached saturation, indicating that no significant new insights were emerging, and the consensus process was concluded.

In phase 4, the synthesis phase, all responses were synthesized using statistical analysis to present the final patterns and insights. The structured and transparent four-phase process ensured that the survey results were grounded in high-quality expert input, with each step meticulously designed to uphold methodological rigor.

3.2.1. e-Delphi Survey Round-1

The first round of the e-Delphi Survey was a questionnaire aimed at gathering a ranging view on the use of BIM practices and the incorporation of well-being strategies during the initial conceptual design phase. The survey was shared with 22 individuals from backgrounds including full-time architects (59%) and academicians (41%), with a gender ratio of 73% male and 27% female. The participants had an average of six years of BIM experience. The demographic composition of the participants in e-Delphi survey-1 is presented in Table 2.

Table 2. Demographic composition of the participants in e-Delphi survey 1 (the total number of participants is 22).

Category	Description	No	Percentage
Gender	Male	16	73%
	Female	6	27%
Profession	Architects (Practicing architecture full-time)	13	59%
	Academicians (Practicing architecture part-time)	9	41%
Experience	Average years of BIM experience	6	

3.2.2. Insights from e-Delphi Survey Round 1

The first round of the e-Delphi Survey provided in-depth insights into the integration of BIM with well-being in the conceptual design stage. The survey involved 22 diverse participants with an average of six years of BIM experience. It highlights the importance of interconnected components such as analysis, brainstorming, stakeholder feedback, iteration, massing, and 3D visualization. Among these, the project brief and the client's conceptual design mandate were deemed the most critical. Architects consider a range of factors like aesthetics, function, climate, and budget constraints when designing buildings to ensure that they meet the requirements of the project effectively. During the assessment of designs discussed by participants, the importance of finding a balance between practical aspects and the overarching design concept they envision for the project was highlighted. The main aspects considered in the evaluations included meeting building regulation requirements, receiving feedback from clients, prioritizing sustainability practices, and ensuring appeal. The participants also emphasized the impact of emotions on design assessments, with a majority (91%) recognizing its significance. Experts pointed out that factors like incorporating biophilia, natural climate conditions, color choices, and user interactions all contribute to shaping reactions and influencing decision-making processes.

Everyone in the group acknowledged the importance of how architecture impacts health and happiness. Things like light and air flow play an important role in this regard, along with how people interact with the space and its overall appearance. Many of those

involved mentioned that they consciously consider well-being when designing spaces by including features like elements or taking client suggestions into account to promote sustainability. They often adhere to industry standards like Leadership in Energy and Environmental Design (LEED) or the Building Research Establishment Environmental Assessment Method (BREEAM) to guarantee outcomes for well-being initiatives, such as the Indian Green Building Council (IGBC) or the Green Rating for Integrated Habitat Assessment (GRIHA) and International WELL Building Institute (WELL) certification programs. Visual judgment has also been highlighted as a vital component in evaluating and refining conceptual designs, with tools such as 3Ds max and VR models aiding in this process.

Regarding BIM's role in conceptual design ideation and evaluation, the survey revealed that 59% of the participants used BIM for conceptual design tasks, leveraging its capabilities for visualization, iteration, massing, simulation studies, and sustainability. Although Revit 2025 emerged as the choice among BIM software users in this survey, many professionals had not yet tried out its generative plugins like Dynamo for facilitating design exploration further. Despite BIM's benefits, practitioners have indicated the need for more flexibility in modeling "unrealistic designs" and improvements in UI/UX for more effective conceptual exploration. Moreover, 68% of the individuals acknowledged the impact of BIM on place-making. However, their viewpoints differed regarding its efficacy in crafting appealing and emotionally captivating environments that boost overall well-being.

3.2.3. e-Delphi Survey Rounds 2 and 3

The initial feedback from the e-Delphi survey offered insightful perspectives regarding how BIM experts view the practicality of using BIM for assessing the experience of well-being during the conceptual design stages. To further explore these trends thoroughly, we formulated 12 questions based on the outcomes of the e-Delphi survey. These questions are evaluated using a Likert scale that spans from one (strongly disagree) to five (strongly agree). The survey was then distributed to 22 participants in the initial round, along with the results of the first survey. Despite repeated reminders, we received responses from only 15 participants; the same 15 participants were retained for round 3. The demographics of the respondents in rounds 2 and 3 are presented in Table 3.

Table 3. Demographic composition of the participants in e-Delphi survey 2 and 3 (the total number of participants in e-Delphi Survey rounds 2 and 3 is 15).

Category	Description	No.	Percentage
Gender	Male	9	60%
	Female	6	40%
Profession	Architects (Full-time practicing architecture)	8	53%
	Academicians (Part-time practicing architecture)	7	47%
Experience	Average years of BIM experience	7 years	

In rounds 2 and 3 of the e-Delphi survey, there were 15 participants, with 60 percent being male and 40 percent female. Among them, 53% were full-time architects while the remaining 47% were part-time practicing architects and full-time architecture educators, each having an average of 7 years of experience. You can find the questions from these survey rounds listed in Table 4. In the following section, insights from the descriptive statistical analysis of the e-Delphi survey rounds 2 and 3 are briefly presented.

Table 4. Questions framed for the e-Delphi survey rounds 2 and 3.

Question	Description
Q1	The conceptual design phase is the most important phase where key project-related decisions are taken.
Q2	Emotions and feelings are important to arrive at the conceptual design.
Q3	Visual judgement plays a paramount role in evaluating the conceptual design.
Q4	Visual aesthetics has a role in inducing the well-being of the occupants.
Q5	BIM can play a vital role in improving the conceptual design thinking process.
Q6	Architecture has an active role in human well-being.
Q7	Buildings should be explicitly designed for well-being in the conceptual design stage itself.
Q8	Well-being frameworks should be considered in conceptual design for healthy built environment design.
Q9	The current frameworks available within the BIM paradigm are enough for salutogenic design outcomes at conceptual design.
Q10	Current tools in BIM support emotions and feelings as tools to evaluate the conceptual design.
Q11	Current tools in BIM have the potential to record information regarding sensory experiences.
Q12	A new dimension (nD) of the BIM layer is needed to guide the conceptual design towards salutogenesis.

3.2.4. Results from e-Delphi Survey Rounds 2 and 3

The e-Delphi survey aimed to evaluate the expert consensus on critical aspects of the conceptual design phase, emphasizing its importance, the integration of well-being principles, and the role of BIM. Table 5 provides a summary of the statistical information obtained from the survey data. A statistical analysis of responses across rounds 2 and 3 revealed significant improvements in agreement, marked by upward trends in mean values, reductions in variability metrics such as standard deviation (SD), interquartile range (IQR), and coefficient of variation (CV), and consistency in mode values. Figures 6 and 7 show the key statistical data from e-Delphi survey rounds 2 (R2) and 3 (R3).

Table 5. The collective response from e-Delphi survey rounds 2 and 3.

QC	Mean		SD	SD	IQR		CV %		Mode	
	(R2)	(R3)	(R2)	(R3)	(R2)	(R3)	(R2)	(R3)	(R2)	(R3)
Q1	4	4.6	0.73	0.51	0	1	18.9	11.02	4	5
Q2	3.67	4.6	0.7	0.51	1	1	19.7	11.02	4	5
Q3	3.47	4.53	0.72	0.52	1	1	21.4	11.39	3	5
Q4	3.67	4.67	0.6	0.49	1	1	16.8	10.46	3	5
Q5	4.73	5	0.44	0	0.5	0	9.7	0	5	5
Q6	5	5	0	0	0	0	0	0	5	5
Q7	4.4	5	0.49	0	1	0	11.5	0	4	5
Q8	4.53	4.93	0.5	0.26	1	1	11.4	5.23	5	5
Q9	1.73	1.2	0.77	0.41	1	1	46.1	34.5	1	1
Q10	1.33	1.07	0.47	0.26	1	1	36.6	24.21	1	1
Q11	1.33	1.13	0.47	0.35	1	1	36.6	31.05	1	1
Q12	4.6	5	0.49	0	1	0	11	0	5	5

Note: question code: QC; R 2—round 2, R 3—round 3; SD; interquartile range: IQR; CV in %: CV. The results are based on a 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree).

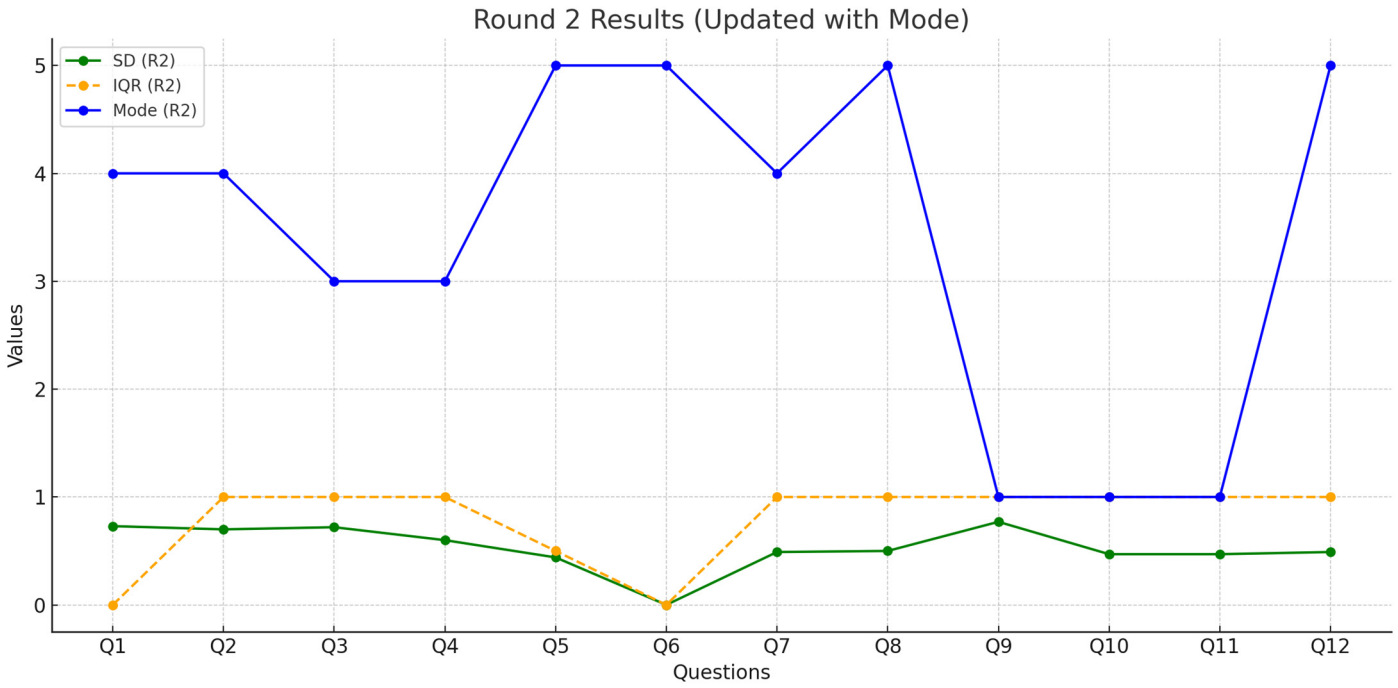

Figure 6. Representation of key statistical data of e-Delphi survey rounds 2 (R2).

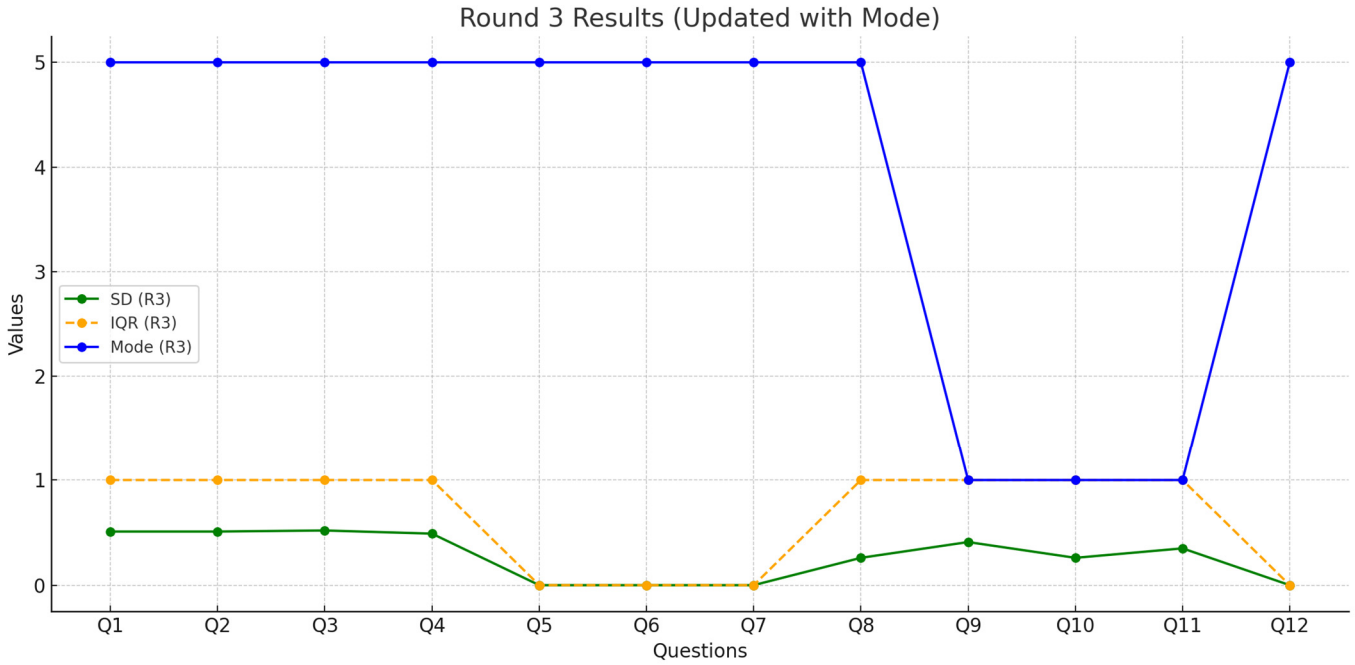

Figure 7. Representation of key statistical data of e-Delphi survey rounds 3 (R3).

Key findings on the importance of the conceptual design phase (Q1–Q4) reveal that experts increasingly recognize its role in making vital project decisions and promoting occupant well-being. For example, Q1's mean increased from 4.00 in round 2 to 4.60 in round 3, with a corresponding reduction in SD from 0.73 to 0.51, reflecting stronger alignment. Similarly, Q4, which highlights the role of visual aesthetics in occupant well-being, showed a rise in mean from 3.67 to 4.67, alongside a significant decrease in CV from 16.80% to 10.46%. Importantly, the mode values for Q1 and Q4 stabilized at five in round 3, reflecting a consistent consensus on the maximum agreement among participants. However, moderate variability in Q3, which focuses on the role of visual judgment, suggests an ongoing diversity in expert perspectives, with a high CV of 11.39% and a mode of five.

Regarding the integration of BIM in conceptual design (Q5 and Q9–Q12), the survey demonstrated strong consensus on its potential to enhance decision-making and support salutogenic outcomes. Q5 achieved the highest consensus, with the mean reaching 5.00, SD dropping to 0.00, and mode consistently at five, reflecting unanimous agreement. Similarly, Q12, which advocates for introducing a new BIM dimension (nD) for salutogenesis, showed strong support, with a mean increase from 4.10 to 4.80 and an SD reduction from 0.62 to 0.44. The mode value of five for both rounds indicates consistent agreement among experts.

The role of architecture and well-being frameworks in conceptual design (Q6–Q8) was also emphasized. Experts strongly agreed on architecture's active role in promoting well-being (Q6), with a mean increase from 4.00 to 4.80 and a CV dropping from 15.00% to 9.38%. Similarly, Q7, which stresses designing for well-being at the conceptual stage, showed improved consensus, with a mean rising from 3.80 to 4.50 and an SD decreasing from 0.55 to 0.40. The mode for Q6 and Q7 remained consistently at five, indicating high agreement. However, Q8, addressing the incorporation of well-being frameworks, retained moderate variability, suggesting that further exploration may be needed to align expert opinions.

Patterns across the survey reveal consistent improvement in consensus between rounds 2 and 3. High-consensus questions, such as Q5 and Q9, reflect strong alignment among experts, with minimal variability and convergence toward maximum ratings (mode = 5). Conversely, questions like Q3 and Q8 exhibited higher variability, with some divergence in opinions despite a consistent mode of five, suggesting areas for ongoing discussion and refinement. The key insights from the observed results are discussed in the following section.

3.2.5. Summary of Findings from the e-Delphi Survey

The examination of the e-Delphi survey findings revealed insightful patterns in the agreement levels among participants across the various survey rounds. A consistent increase in the average responses was observed from round 2 to round 3 for most questions, indicating a strengthening consensus as the survey advanced. For example, participants increasingly acknowledged the importance of the conceptual design phase as the most critical stage for making key project-related decisions (Q1), with the average score rising from 4.00 in round 2 to 4.60 in round 3. Similarly, the role of visual aesthetics in inducing the well-being of occupants (Q4) also saw greater agreement, with an increase in mean values from 3.67 to 4.67. These trends highlight the growing alignment of expert opinions over the rounds.

In contrast, questions addressing the active role of architecture in human well-being (Q6) and the potential for current tools in BIM to record information regarding sensory experiences (Q10 and Q11) showed minimal changes in the mean values between the rounds, reflecting stable or slightly adjusted viewpoints. This suggests that participant perspectives on these issues remained consistent throughout the survey.

The fluctuations in SD decreased for most questions in round 3 compared to round 2. This decrease in SD signifies a reduction in variability, indicating that participant responses became more uniform over time as their views became more harmonized. Similarly, the interquartile range (IQR) also decreased for most questions, suggesting that the middle 50% of responses were more closely clustered in round 3. This further supports the evidence of growing consensus among participants.

However, certain areas exhibited notable variations. Questions regarding the adequacy of current frameworks within the BIM paradigm for salutogenic design outcomes (Q9), the support of emotions and feelings in BIM tools (Q10), and the potential for BIM tools to record sensory experiences (Q11) showed enduring disagreement and fluctuation in responses. While the CV decreased between rounds 2 and 3, indicating improved agree-

ment levels, these questions continued to reflect variability and differences in participant viewpoints. This highlights the need for further exploration and refinement in these specific areas to address ongoing disparities in expert opinions.

Overall, the results of the survey demonstrate a clear trend toward greater consensus among participants, with more uniform responses and narrower interquartile ranges observed in round 3. However, areas such as the adequacy of current BIM frameworks for salutogenic design (Q9), the emotional and sensory capabilities of BIM tools (Q10 and Q11), and the need for a new BIM dimension (Q12) require additional attention. These findings provide a foundation for identifying critical gaps and opportunities for advancing BIM frameworks and tools to better support the conceptual design processes that promote human well-being.

3.2.6. Inferences from the e-Delphi Survey

The results underscored the importance of building configuration and aesthetic factors in design to promote health objectives in line with SDG 3, which centers on improving health and well-being outcomes for all individuals worldwide. Additionally, the survey pinpointed deficiencies in BIM software systems underscoring the necessity for approaches that support holistic health-centric design practices aimed at fostering overall wellness. The findings indicate a move towards a people-focused strategy for BIM, giving importance to wellness and user satisfaction in the design phases. This approach is in line with SDG 3, as it ensures that the built environment has a positive impact on well-being. Improving BIM capabilities to address these gaps will enhance its effectiveness in assessing the quality of designs and, ultimately, enhance occupant well-being while also supporting the goals of Sustainable Development Goal 3.

3.3. Key Finding from Both the SLR and e-Delphi Survey

The findings from the SLR, along with insights from the e-Delphi surveys depicted in Figure 8, reveal shortcomings in the incorporation of BIM with advanced architectural design approaches such as EBD. Both sources underscore the necessity for BIM practices by highlighting the absence of approaches for merging BSNs with methodologies such as neuroarchitecture and neurophenomenology within BIM systems. The research highlighted the importance of the design stage and stressed the need to compare processes that combine BIM with VR-focused game engine platforms while highlighting the significance of focusing on user satisfaction and health concerns. On the other hand, the findings from the e-Delphi survey propose a more people-centered approach to BIM by recommending the inclusion of emotional and aesthetic elements and suggesting advancements to address current limitations within BIM tools to promote comprehensive and health-promoting design methods. The findings indicate the importance of developing an approach to boost BIM's impact, shaping health-promoting spaces, and focusing on wellness and user satisfaction right from the initial design phases.

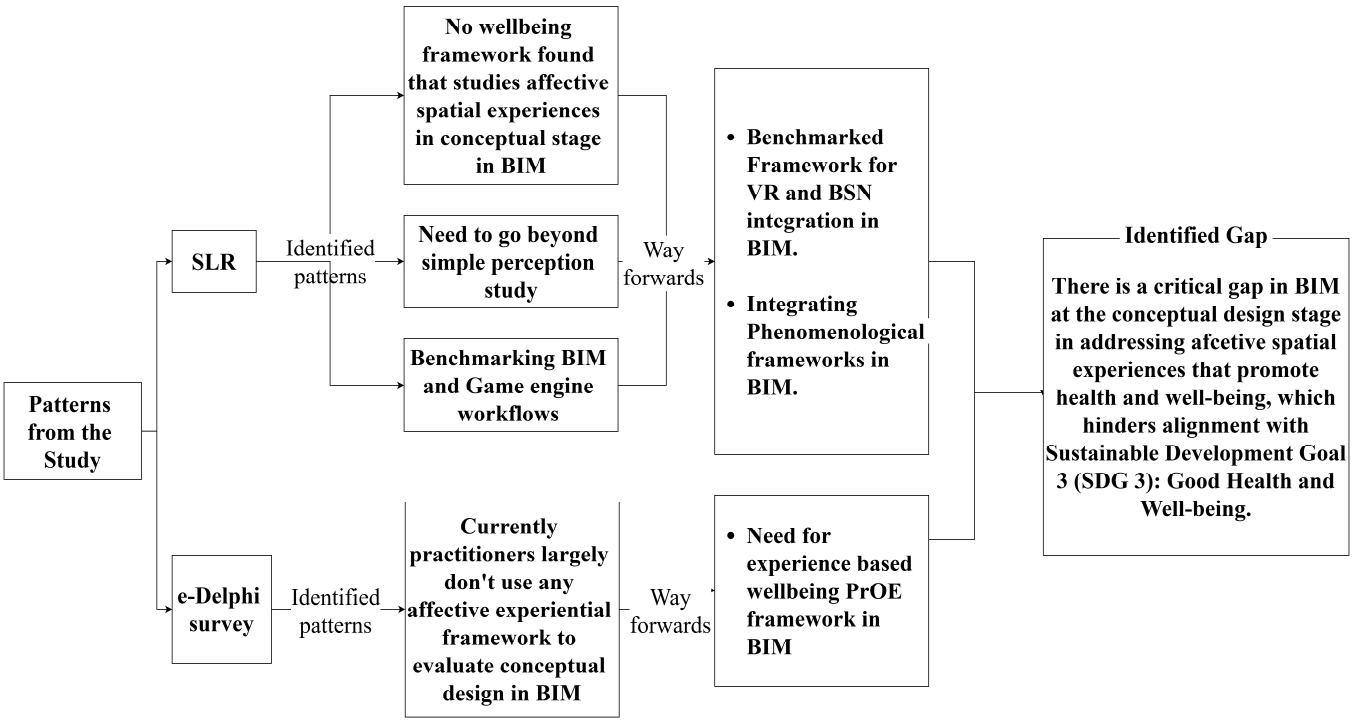

Figure 8. Findings from the SLR and e-Delphi survey.

4. Discussion

The knowledge gap highlighted by the SLR and e-Delphi survey pertains to Green BIM within the context of BIM maturity level 2. This gap is situated at the convergence of sustainable design principles, building performance analysis, and the utilization of BIM, in VDC. Green BIM focuses on energy performance and sustainability assessments by examining BIM's role in optimizing energy efficiency, predicting environmental impacts, and supporting sustainable building practices throughout a building's lifecycle [70]. Based on Hui [84], BIM has expanded beyond 3D modeling to 7D, incorporating elements such as time scheduling, cost estimation, sustainability, and facility management, as illustrated in Figure 9. Although there have been advancements, BIM methodologies still fall short in emphasizing spatial experiences centered around well-being during the initial design phases (LoDs 100 and 200).

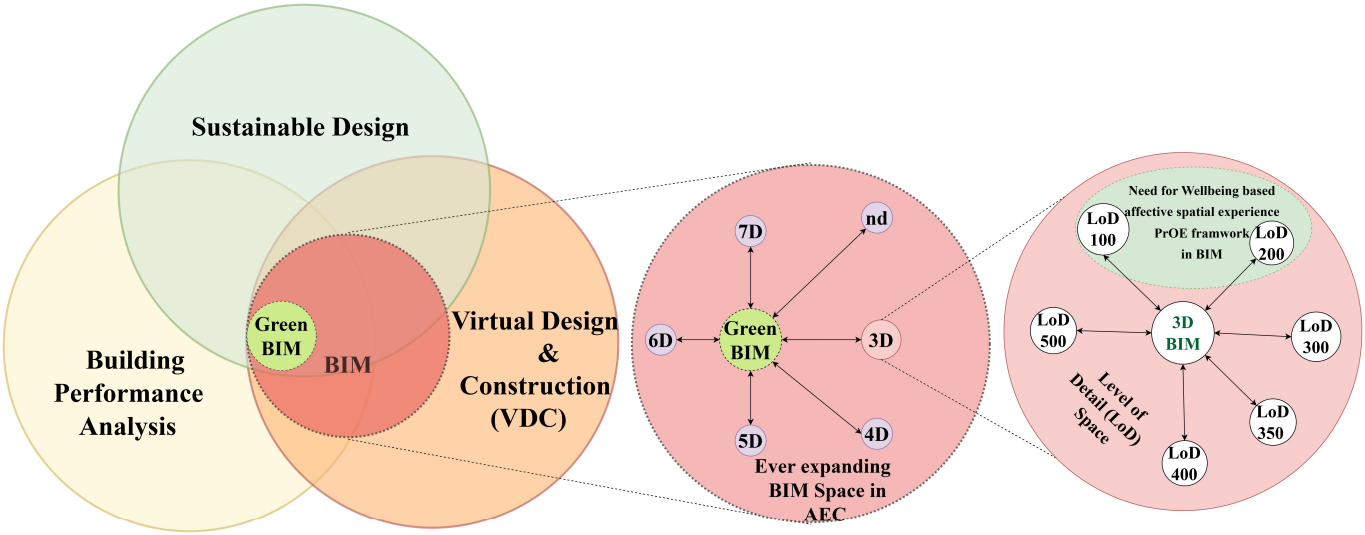

Figure 9. Locating the identified knowledge gap through SLR and e-Delphi survey.

The current BIM methods lack the incorporation of design principles that focus on promoting health and well-being—an essential goal outlined by SDG 3 concerning good health and well-being. While it is acknowledged that BIM methods currently lack an explicit focus on promoting health and well-being, it is important to dissect this limitation further. The results from the SLR and e-Delphi survey highlight the shortcomings of frameworks when addressing affective spatial experiences that play a role in user well-being, notably focusing on emotional and aesthetic aspects.

Furthermore, despite a few exploratory works, the absence of research on the integration of BSNs [50], neuroarchitecture [85] and neurophenomenology in BIM indicates an opportunity to enhance design methodologies focused on human needs. Addressing these shortcomings requires a change in a BIM strategy focused on the conceptual design stage by prioritizing frameworks that integrate well-being considerations from the outset. By adapting as a resource that includes design principles in its framework, BIM can go beyond being technically efficient to promoting spaces that support health and overall well-being, thus enhancing its contribution to global efforts towards sustainability and well-being goals. To move beyond technical efficiency, BIM frameworks could integrate principles from neuroarchitecture and biophilic design, focusing on factors such as natural light, sensory variability, and spatial connectivity. These principles could be operationalized through metrics such as daylighting analysis for mental health or spatial ergonomics for stress reduction. Furthermore, adopting user-driven metrics, such as comfort indices derived from BSNs, would provide a data-driven foundation to embed well-being directly into early-stage design workflows.

The need for enhanced tools to support conceptual design in BIM has been well-documented in the literature [29,86–91] and reinforced by the findings of the SLR and e-Delphi surveys. While recent developments have expanded BIM's capabilities—addressing indoor air quality [92] and real-time decision-making in ambient assisted living technologies [93]—a critical gap remains in BIM's ability to assist architects and designers during the conceptual phase when integrating an affective layer [44] to account for human well-being. The research gap has implications for creating environments that support the goals of SDG 3, which focuses on enhancing health and wellness. While some research has started to address this issue by considering aspects like agent-based simulations and multisensory immersive virtual environments [94], as well as tools that analyze spatial perceptions through eye tracking and qualitative aspects in recent years [95], there is still a gap in existing BIM frameworks when it comes to helping designers understand their affective states when they curate architectural spaces during the design phase [54].

Advancing these frameworks poses a challenge due to the hurdles that architecture, engineering, and construction experts encounter when trying to embrace novel methods and digital resources [96,97]. The resistance to adopting novel BIM methodologies is often rooted in a combination of technical, cultural, and economic barriers. For instance, architects and engineers may lack adequate training to incorporate advanced affective design principles into BIM workflows. Similarly, firms may be hesitant to invest in the upfront costs associated with integrating technologies like BSNs and immersive VR. Addressing these challenges requires targeted strategies, such as the development of simplified toolkits for early adoption, government incentives for firms embracing health-focused BIM practices, and cross-disciplinary training programs to familiarize professionals with emerging methodologies.

5. Conclusions

The research has effectively met the goals set in the introduction by highlighting how affective experiences play a part in BIM frameworks to enhance overall health in line with SDG 3. The major conclusions drawn from the present research are as follows.

Objective one was met by conducting SLRs that scrutinized prior studies regarding BIM-based pre-occupancy evaluation (PrOE) frameworks. This examination exposed notable gaps in how the affective aspects of spatial experiences are presently evaluated during the initial design phase. It was observed that existing frameworks primarily centered around technical aspects of the project and often overlooked the affective and sensory components that play a vital role in improving overall well-being. The outcomes of the SLRs offer insight into the current research landscape and emphasize the importance of incorporating affective considerations into BIM-enabled conceptual design practices.

The second objective was achieved using an e-Delphi survey to collect expert opinions on how well current BIM tools assess emotional spatial experiences and how they can be improved to align with SDG 3 more effectively. The survey findings gave directions for the development of future PrOE frameworks. The experts stressed the significance of integrating EBD tools like BSN and immersive VR to evaluate and enhance the aspect of spaces. This input is crucial for shaping advancements in BIM techniques that focus on improving occupant well-being.

Thus, this study emphasizes the limitations of BIM frameworks that are related to affective experiences and suggests practical ways to fill these gaps. This research is a work in progress, where the idea is to establish a knowledge gap for the development of the PrOE framework. Subsequent works are planned to frame the salutogenic affective spatial experience PrOE framework to address the early-stage design evaluation. This framework will be benchmarked, and suitable BIM workflows will be proposed. By incorporating affective well-being-based design principles at the beginning of the architectural design process, we can develop spaces that improve health and happiness. This research supports an approach to architectural design that centers on human experiences, thereby aligning with larger SDG 3 goals and promoting healthier living environments. In the future, researchers need to use these findings as a foundation for developing robust frameworks that enable architects and designers to make informed design choices that enhance the well-being of occupants.

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Abbreviations

BIM	Building Information Modeling
BREEAM	Building Research Establishment Environmental Assessment Method
BSN	Body Sensor Networks
CV	Coefficient of variation
EBD	Evidence-Based Design
GRIHA	Green Rating for Integrated Habitat Assessment
IEQ	Indoor Environmental Quality
IGBC	Indian Green Building Council
IQR	Inter-quartile range
IVR	Immersive virtual reality
LEED	Leadership in Energy and Environmental Design
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta Analyses
PrOE	Pre-Occupancy evaluations
SD	Standard deviation
SDG	Sustainable development goal
SLR	Systematic Literature Review
SUS	System Usability Scale
VDC	Virtual Design and Construction
VR	Virtual reality

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