

FULL-LENGTH ARTICLES

The Role of Participatory Design Methods in Lighting Research

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The work discussed in this article aims to present and reflect upon different levels of participatory design methods applied in indoor and outdoor lighting research projects. Papers selected through a systematic literature review covering the period from 2019 to 2024 were categorized by the level of participation and corresponding research stage. The four defined stages include: locating and defining issues or problems, collecting research data, interpreting research data, and reporting research findings. The theoretical framework suggested by Kaulio (1998) was adapted to categorize the studies. The framework distinguishes three levels of participant involvement: research for (no direct participant involvement), research with (active collaboration), and research by (participant-led collaboration). Results indicate that participatory design methods are most frequently employed during the data collection stage, whereas the initial and final stages of research typically remain researcher-led. This suggests that collaboration is valued but primarily concentrated in the middle phases of research. Greater integration of participatory methods in early and late stages could improve communication of research goals and outcomes to broader audiences. These findings provide a foundation/motivation for integrating participatory methods more holistically in lighting research, strengthening user participation and context-relevant proposals.

Introduction

Artificial lighting has become an essential component of contemporary environments, shaping them across both indoor and outdoor settings. Consequently, its impacts on people and the environment are increasingly recognized. Poorly planned or excessive lighting creates challenges that are difficult to ignore, including light pollution, ecological disruption, adverse health outcomes, and negative social experiences such as reduced perceptions of safety and comfort (Kyba et al., 2023; Tavares et al., 2021; Zielinska-Dabkowska et al., 2023). At the same time, lighting supports daily activities, enhances visual performance, and shapes how spaces are perceived and experienced, influencing atmosphere, behavior, and wellbeing (Boyce, 2019; Ebbensgaard, 2014; Trop et al., 2023). Balancing these benefits and adverse effects is therefore a significant challenge in lighting research and practice. As lighting is fundamentally designed for people, it becomes essential to account for their experiences, behaviors, and needs. However, traditional lighting approaches have largely prioritized technical performance and energy

efficiency, often overlooking subjective experiences and user perspectives (Yang & Kalms, 2022). In this context, participatory approaches offer a way to incorporate lived experience and user knowledge more systematically into lighting-related research and design.

Participatory Design (PD) is a research and design approach rooted in collaboration and co-creation that aims to include users' perspectives during a project's development to secure that outcomes align with the needs and experiences of those directly affected. It has been widely applied in fields such as urban planning, healthcare, education and digital design, where stakeholder knowledge is progressively recognized as essential for producing context-driven and socially relevant outcomes. In the process of engaging diverse stakeholder groups, such as residents, designers, and community organizations, PD methods can support innovation and promote more inclusive decision-making in both indoor and outdoor lighting contexts (Smith & Iversen, 2018). Furthermore, international organizations such as the International Network of Cities on Urban Lighting (LUCI) and the International Commission on Illumination (CIE) highlight the importance of public involvement in urban lighting design activities (Commission Internationale de l'Eclairage, 2019; Ross et al., 2023). According to them, community participation enables context-driven lighting solutions, brings valuable insights from lived experience, increases acceptance and legitimacy of interventions, and strengthens relationships between cities and their citizens.

Although the benefits of participatory approaches are acknowledged, their application in lighting research remains uneven. There are research projects that include PD methods during data collection or design interventions but rarely sustain participation throughout the entire research process. Previous studies have noted that participatory activities often concentrate on mid-project development of activities, in the form of workshops, interviews, or focus groups (Light & Akama, 2012). Thus, early and late stages of research tend to remain researcher-driven, leading to a limited understanding of how PD methods are distributed across research stages and the extent to which participants influence outcomes. In addition, there is a lack of systematic approaches for analyzing and comparing participation across these stages within lighting research.

To address this gap, the present study focuses on reviewing lighting-related research published between 2019 and 2024, focusing on how PD methodologies are employed across four research stages: (1) locating and defining issues or problems, (2) collecting data, (3) interpreting data, and (4) reporting findings. The theoretical framework developed and published by Kaulio (Kaulio, 1998) is adopted to categorize participation into three levels. These are defined as follows: *research for*, *research with*, and *research by*, mapped to different degrees of stakeholder involvement.

The objective of this paper is to analyze the distribution of participatory methods across these stages and levels of involvement, identifying where collaboration is most prevalent and where it remains limited, by attempting

to answer the following question: How are participatory design methods distributed across different stages of lighting research, and what levels of participant involvement characterize these stages?

The findings aim to provide insight into how participatory design can be systematically integrated throughout the lighting research process, thereby enhancing inclusivity, relevance, and communication between researchers and future end-users.

Theoretical Framework

Participatory design research (PDR) builds upon principles of collaboration and co-creation, aiming to include users' perspectives and feedback throughout the research process. Within lighting-related studies, the integration of participatory design methodologies has become important for researchers to align outcomes with end-users' feedback and needs. By actively involving participants in the research process, PD enhances both the relevance and the practical applicability of findings, while also fostering a sense of ownership and engagement among stakeholders. PD methods are inherently iterative processes that allow to be implemented in various stages of a research project (Björgvinsson & Hillgren, 2012). The iteration and constant implementation of participant-informed solutions corresponds to the model of design thinking, which highlights the progress from problem definition to design proposal (Dorst, 2011). By implementing both feedback activities, researchers can refine project goals and methods based on stakeholders' input. A central tradition informing this approach is Scandinavian Participatory Design (Gregory, 2003), which emerged during the 1980s and is grounded in principles of democratic participation and user empowerment. This approach emphasizes that participants should be active co-creators rather than passive informants, ensuring that design outcomes reflect shared values and collective decision-making.

While participatory approaches are increasingly applied in lighting design, there is a lack of established models for systematically analyzing levels of user participation within lighting research. To address this gap and analyze the levels of user participation, this study adopts the theoretical framework proposed by M.A. Kaulio. The framework was selected as it provides a clear and widely used conceptualization of different forms of user involvement, distinguishing between varying degrees of participation in design and development processes. Although originally formulated in the context of customer involvement in product development (i.e., in terms of design for, design with, and design by), in this study, the concept is extended to refer more broadly to participants, users, or citizens involved in lighting research. In Kaulio's model, these categories reflect increasing levels of involvement, ranging from no direct user participation (design for), to consultative or collaborative involvement (design with), and to active user-driven contributions (design by). This allows the framework to be applied across

diverse participatory contexts while maintaining a consistent structure for involvement analysis. The adapted model's levels of participant involvement that can occur across research and design processes are described below:

- *Research for* refers to studies conducted on behalf of future users, without their direct involvement or collaboration. In this level, researchers explore lighting-related problems independently, and outcomes are developed for the benefit of participants rather than with their input. In this study, this category serves as a baseline representing the absence of direct participation.
- *Research with* represents collaborative research that includes active engagement and partnership between researchers and participants. Stakeholders contribute to one or more stages of the research process (e.g., data collection, and analysis) through collaborative activities with researchers, leading to co-created insights that inform both research and practice.
- *Research by* describes projects that are led and conducted primarily by participants, with researchers taking on advisory roles. This highest level of involvement empowers participants to take ownership of the research process and its outcomes.

[Table 1](#) summarizes the three levels of involvement with corresponding definitions, explanations, and examples adapted by the authors to lighting research contexts. This framework provided the foundation for analyzing how participatory approaches and methods are employed across the selected studies and identifying opportunities for more integrated collaboration throughout the research process.

The three levels of participation are applied in the present study to evaluate how participatory methodologies are distributed across four stages of research. These stages provide a temporal and methodological structure for analyzing when and how participation occurs. The four stages are described as follows:

1. *Locating and Defining Issues or Problems.* This initial stage corresponds to the pre-design phase, where the focus lies on identifying key issues, formulating research questions, and defining project goals. Participatory methods such as interviews, surveys, and workshops, which can focus on co-design and co-creation, can be used to capture users' needs, preferences, and constraints. Collaboration at this stage helps ensure that research problems are based on real-world contexts and reflect the perspectives of those most affected by lighting interventions.

2. *Collecting Data.* This stage bridges the pre-design and intervention phases. The data are gathered to support the development and refinement of design concepts. Participatory data collection methods (e.g., observations, participatory mapping, usability testing, etc.) enable users to contribute directly to the evolution of design ideas. This iterative process strengthens the link between user experience and design implementation.
3. *Interpreting Research Data.* This stage corresponds to the intervention phase and involves the implementation and assessment of design solutions in real-world settings. Researchers, practitioners, and users collaboratively interpret data to evaluate how interventions perform in practice. Through feedback sessions, evaluation workshops, and discussion sessions, participants assist in identifying successes and potential challenges, enabling a deeper understanding of how lighting interventions can potentially affect comfort, perception, and behaviour among other factors.
4. *Reporting Research Findings.* The final stage corresponds to the post-evaluation phase. After interventions have been in place for a sufficient period, researchers gather additional feedback to assess long-term impacts, user satisfaction, and the sustainability of design solutions. Reporting in participatory research extends beyond traditional academic dissemination, and often includes community presentations, participatory exhibitions, or co-authored publications, ensuring transparency and recognition of participants' contributions.

Together, these four stages provide a structured lens for examining how participatory approaches are integrated throughout the research project's lifecycle. They enable a systematic evaluation of when and to what extent participation occurs, complementing Kaulio's model of participation levels. This integrated framework offers a comprehensive basis for analyzing participatory engagement across the selected studies as described in [Table 2](#). This analysis aims to identify opportunities for more inclusive and collaborative research practices.

Although the integration of Kaulio's (1998) three levels of participation with the four research stages provides a structured approach for evaluating participatory engagement, it is important to highlight certain limitations. Achieving the highest level of participation (*research by*) across all stages may not be feasible due to practical or resource-related constraints. Moreover, *research by* carries a pedagogic and educational character, in which participants are actively learning and co-producing knowledge. As a result,

Table 1. Levels of participant involvement: “research for”, “research with”, and “research by” with their definitions, explanations and examples.

Level of Participant Involvement	Definition	Explanation	Example
Research for	Research is conducted for participants without their direct involvement or collaboration.	This level involves researchers studying lighting issues without active engagement from the communities or stakeholders affected by the research. The focus is primarily on investigating lighting topics without integrating participant perspectives or contributions.	A lighting manufacturer conducts a study to assess the impact of new LED streetlights on energy efficiency and cost savings in urban areas. The study primarily focuses on technical performance metrics and economic outcomes without actively engaging local communities or stakeholders in the research process.
Research with	Research involves active engagement and partnership with participants.	At this level, researchers collaborate closely with participants, such as community members or stakeholders, throughout the research process. There is a shared effort to co-create research questions, gather data, and analyze findings. Participant perspectives and insights inform the research design and outcomes.	A research project aims to investigate the effects of different lighting designs on elderly residents' well-being in nursing homes. Researchers work closely with residents, caregivers, and lighting designers from the outset. They co-create research questions, conduct on-site observations, and gather feedback through interviews and focus groups. Residents and staff provide valuable insights that shape the study's direction and outcomes.
Research by	Research is led and conducted primarily by participants, with researchers in supportive roles.	In this highest level of participant involvement, participants take the lead in defining research goals, designing methods, and conducting data collection and analysis. Researchers provide support and expertise as needed, empowering participants to drive the research process and outcomes.	A community organization in a rural area initiates a project to improve street lighting safety in their neighborhood. Residents take charge of the research, conducting surveys to assess lighting needs, learning about lighting technologies, and organizing community meetings to discuss findings. They collaborate with researchers and lighting experts who provide technical advice and support, but the residents drive the project's goals and decision-making process. Ultimately, the community implements solutions based on their research findings.

Table 2. Synthesizing Kaulio's model of participation across the research project's phases.

Research stage	Research for	Research with	Research by
Locating and Defining Issues	Issues are defined by researchers without participant input and project statement is research-based.	Participants collaborate in identifying and framing lighting-related problems. Researchers and users co-define the research objectives.	Participants independently identify issues and formulate research goals with researchers offering advisory support.
Collecting Data	Researchers collect and analyze data independently. Participants act as data sources.	Participants are engaged in co-collecting and interpreting data through participatory tools (e.g., workshops, mapping activities)	Participants design and lead data collection, determining what needs to be studied. Researchers provide technical advice.
Interpreting Research Data	Data interpretation and conclusions are made solely by researchers.	Researchers and participants analyze and interpret findings through discussion sessions and co-analysis workshops.	Participants lead the interpretation process, determining meanings and implications. Researchers act as facilitators.
Reporting Research Findings	Reporting is academic or technical, prepared by the research group.	Participants contribute to co-authoring or co-presenting results, influencing dissemination and knowledge exchange.	Participants lead reporting and dissemination (e.g., community exhibitions, published reports). Researchers play supportive or editorial roles.

Table 3. The selection process to identify papers for the review.

	Initial screening	Additional keywords	Disciplines	Abstract evaluation
	"participation" OR "participatory design" AND "lighting"	<i>lighting, light, participation, participatory approach, participatory design, artificial lighting, artificial light at night, artificial light</i>	Physics, Mathematics, Chemistry, Medicine, Biochemistry, Agriculture	
Papers	197	73	35	22

only projects explicitly designed to educate and empower participants are likely to implement *research by participation* consistently throughout all four stages.

Methods

This paper reviews research on participatory approaches in lighting, built environments, and related contexts. The focus is on identifying whether and how participation is present across different research stages, as described in the previous section. The included studies span a variety of spatial contexts, including urban lighting, pedestrian environments, educational spaces, elderly care and ecological or animal-focused lighting, as represented in the identified papers.

Papers were selected from the Scopus database using the following search string: ("*participation*" OR "*participatory design*" AND "*lighting*"). The search was limited to documents published between 2019 and 2024, including both journal articles and conference papers, and restricted to publications in English. The selected timeframe aimed to capture recent developments in participatory design within lighting research, reflecting the increasing emphasis on user-centred approaches during this period. After the initial search, the results were refined using additional keywords, [*(lighting, light, participation, participatory approach, participatory design, artificial lighting, artificial light at night, artificial light)*] to ensure relevance to the research topic. Both indoor and outdoor studies were included in the final selection. Following the initial stage of paper collection, abstracts were evaluated to identify the most relevant studies (Table 3). In addition, key references cited within the selected papers were also reviewed and included in the analysis when applicable.

Each study was analyzed individually to extract key information on four dimensions. First, the context was noted, capturing the type of environment or application addressed in the study. Second, the participation methods employed in the study were recorded, including approaches such as intervention or field studies, workshops, observation, or interviews. Third, the level of participation was categorized according to a conceptual framework informed by Kaulio (1998). Finally, the reported outcomes or insights related to participation were noted, including improvements in usability, safety and learning as described in each paper.

After extracting these details, the studies were compared and synthesized to identify patterns and gaps across the literature. This synthesis was organized around three aspects. These were (a) the context, to highlight trends across different built environments and lighting applications, (b) the participation methods and levels to reveal common and under-represented approaches, and (c) the reported outcomes of participation, to identify repeating themes and areas where participation had crucial effects. The analysis is limited to the studies included in the reference list. The classification of participation levels relies solely on the information provided within these papers, and no additional studies or datasets were considered. These limitations are taken into account when interpreting the findings. The classification process was conducted by two reviewers independently, to ensure cross-checking and discussion of categorization decisions, enhancing the consistency of the analysis. Furthermore, the reviewed studies represent a variety of participation approaches, research contexts and conceptualizations of participatory methods.

Results and Discussion

The review of twenty-two lighting-related studies shows that participatory design (PD) methods are most commonly applied during data collection, while early stages (problem definition) and late stages (reporting) remain largely researcher-led. Most mid-project-stage activities correspond to the “research with” level of participation, while early and late stages correspond to “research for” levels. Only a few studies demonstrate “research by” participation, where stakeholders lead the research process. Contexts such as urban lighting, elderly care and pedestrian environments show higher engagement, while technically oriented studies tend to limit participant involvement. Overall, the findings indicate that while PD is recognized as a valuable methodology, its application is uneven across the research lifecycle, highlighting opportunities for more systematic stakeholder participation in all stages.

[Figure 1](#) illustrates the distribution of participatory design (PD) methods across the four research stages identified in this review. The horizontal axis represents the level of involvement based on Kaulio’s (1998) participation framework, while the vertical axis indicates the research stage. Each horizontal line corresponds to one of the twenty-two reviewed studies, and the orange path traces the average level of participation observed at each stage. The figure illustrates that participatory design methods are most frequently applied during the data collection stage, where participant engagement tends to reach the “research with” level. In contrast, the early phase of problem definition and the final stage of reporting findings remain primarily researcher-led, aligning with the “research for” level of participation. Only a small number of studies demonstrate “research by” participation, where stakeholders take an active leadership role in defining, conducting, and evaluating the research process.

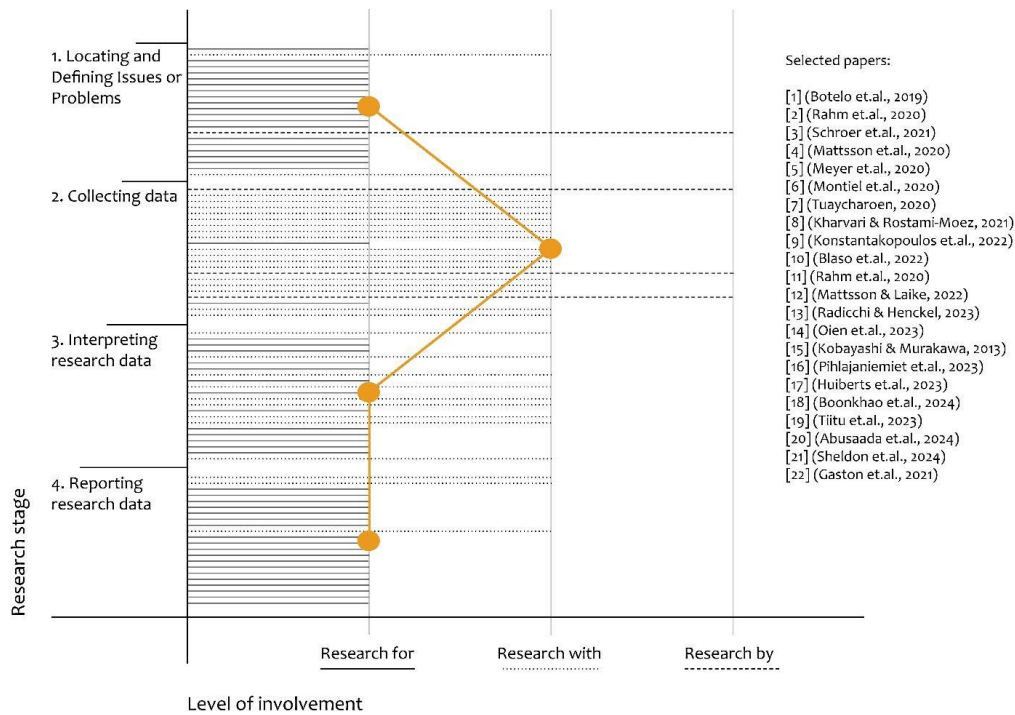


Figure 1. Graph illustrating the level of participation on each research stage for twenty-two published research articles.

This pattern suggests that collaboration and co-creation are primarily concentrated in the middle phases of research projects, particularly when gathering and interpreting user input, while stakeholders have limited influence over the initial framing of research objectives or the dissemination of outcomes. Examples include Rahm, Sternudd and Johansson (2020), who engaged residents through observations and interviews to assess perceptions of safety, and Schroer et al. (2021), where multi-stakeholder workshops informed insect-friendly urban lighting strategies.

The early and late stages largely incorporate activities linked to the “research for” approaches, where researchers independently define problems and report findings, as seen in studies of adaptive indoor lighting (Konstantakopoulos et al., 2022) and lighting energy assessments (Blaso et al., 2022). A smaller number of studies corresponds to “research by” participation, such as Kobayashi & Murakawa (2013), where residents led street lighting experiments, exemplifying participant-driven research in the urban lighting domain.

Overall, the distribution shown in [Figure 1](#) reveals that while the importance of participatory design is increasingly recognized in lighting research, its application remains uneven across the various stages. Participation is strongest during implementation and evaluation but relatively limited in defining and reporting phases. This imbalance highlights opportunities for future studies to adopt a more systematic and integrated approach to stakeholder collaboration, ensuring that end-users and communities contribute meaningfully to all stages of the research process.

Analysis of contexts (Tables 4, 5) showcases that participatory methods are applied across diverse settings, however, the frequency and nature of participation vary. Community-focused projects, particularly those addressing safety or accessibility, tend to involve higher levels of engagement, whereas technically oriented studies, such as adaptive lighting systems or energy evaluations, often limit participant involvement to observation and feedback. Schroer et al. (2021) demonstrates a highly collaborative “research with” approach through multi-stakeholder workshops, whereas Konstantakopoulos et al. (2022) represents a predominantly researcher-led technical evaluation, illustrating the diversity of participatory practices identified across the reviewed studies.

The prevalence of PD during the data collection stage suggests both advantages and constraints. Engaging participants in mid-project allows researchers to gather contextually informed insights that can potentially improve usability and comfort, as reported in studies by Mattsson et al. (2020) and Tuaycharoen (2020). However, it is important to highlight that limited early-stage participation may reduce alignment between research goals and user needs, and minimal engagement in reporting restricts participants’ influence on the interpretation and dissemination of findings. Integrating participatory methods in problem definition could ensure that research objectives reflect user priorities, while involvement could enhance communication and ownership of outcomes.

Figure 2 illustrates the variation in participation level across the four stages of the research process. Considering the limited number and heterogeneity of the reviewed studies, Figure 2 should be interpreted as a qualitative illustration of general tendencies rather than a quantitative measurement of participation levels. Each grey line represents one research stage, and the dashed red line indicates the average participation level to summarise overall trends among the studies. Participation is lowest (see Fig.2) during Stage 1 ($\mu=1.6$) and Stage 4 ($\mu=1.3$), increases during Stage 2 ($\mu=2.1$), and remains moderate in Stage 3 ($\mu=2.0$).

Overall, the results demonstrate that there is a need to extend PD across the full research processes to achieve more holistic and inclusive outcomes. By increasing participant engagement in early and late stages, researchers can better align objectives with user perspectives, co-create actionable insights, and strengthen collaboration between stakeholders and practitioners.

Figure 3 presents a mapping of tools and methods categorized across four stages of a research project. Each stage consists of a range of qualitative and quantitative methods. Colour coding (red, yellow and green) is used to further distinguish the level of participant involvement. This visual mapping showcases the continuity of participation within design research. The map provides a practical and conceptual guide for selecting and applying methods that align with the goals of participant inquiry, facilitating more inclusive and context-responsive research and practice-based proposals.

Table 4. Analysis of identified papers based on context, methods, tools, and outcomes.

Context	Study	Participation methods/Tool	Outcome/Insight
Urban Urban lighting / Perceived safety	Botello, Buehler, Hankey, Mondschein and Jiang (2019) Rahm et al. (2020)	Literature review + policy analysis Observation + Inter- views	Impact on walking and cycling through changes in infrastructure. Residents' perceptions of safety were influenced by lighting and greenery. The study can inform urban planning decisions.
Urban lighting	Schroer et al. (2021)	Multi- stakeholder workshops	Development of insect-friendly lighting strategies through participation-based activities.
Pedestrian lighting Research methodology/ Mobility studies Educational spaces Elderly care / Way finding	Mattsson, Johansson, Almén, Laike, Marcheschi and Ståhl (2020) Myers (2011) Montiel, Mayoral, Navarro Pedreño, Maiques and Marco Dos Santos (2020) Tuaycharoen (2020)	Intervention Study with visually impaired participants Participatory walk + observations Feedback sessions Observation + Inter- views	Improved usability, based on participants' feedback, and better navigation after dark. Showcases a methodology linking performance and research insights. Lighting and thermal comfort are linked to Sustainable Development Goals. Improved way finding in nursing homes through targeted lighting interventions.
Educational facilities / Visual comfort Indoor lighting / Adaptive systems Lighting & Energy assessment Preschool environments	Kharvari and Rostami-Moez (2021) Konstantakopoulos et al. (2022) Blaso et al. (2022) Mattsson et al. (2020)	Survey Experimental building control system Software evaluation Observation + Activities with children	Evaluated occupants' adaptive behavior. Limited user involvement. Demonstrates feasibility of adaptive lighting. Limited user involvement. Outlines a technical framework for lighting energy assessment. Children are taught about energy and lighting controls and behaviors.
Public spaces/ Pedestrians	Radicchi and Henckel (2023)	Design planning	Artificial light planning can affect pedestrians' visual diversity at night.
Vision impairment	Øien et al. (2023)	Lighting assessment	Participation can improve the quality of life and engagement for people with vision loss.
Urban lighting /Resident articipation Street lighting / Adaptive systems	Kobayashi and Mueakawa (2013) Pihlajaniemi, Luusua and Juntunen (2023)	Residentled street lighting experiments Interviews + Survey	Direct input from residents influenced lighting design. Inform presence sensitive adaptive lighting through user feedback.

Table 5. Analysis of identified papers based on context, methods, tools, and outcomes - Continued

Context	Study	Participation methods/ Tools	Outcome/Insight
Workplace lighting Indoor environment /Elderly housing Urban planning Urban lighting / Nighttime experience Guide dogs / Task performance Urban light pollution / Biological impacts	Huiberts et al. (2023) Boonkhao et al. (2024) Tiitu et al. (2023) Abusaada, Elshater, Neseem and Fouad (2024) Sheldon et al. (2024) Gaston et al. (2021)	Experimental intervention Observations + Surveys Interviews + Surveys (participatory) urban tool kit Observation & Experiment Literature synthesis	Explored low-dose UV-B lighting. Limited user participation. Lighting-related environmental factors influence the risk of falling among elderly people. Outlines differences among practitioners and residents. Strategies to develop atmospheres in historic areas. Explores lighting effects on performance. Reviews biological impact of electric light at night. Limited participation.

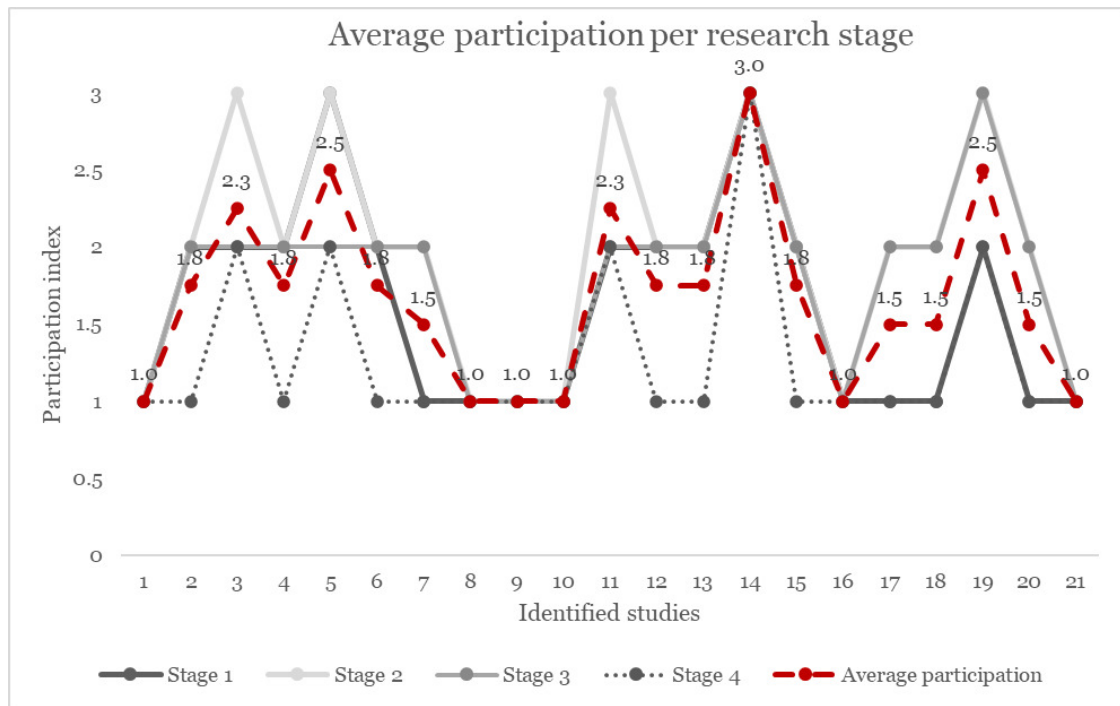


Figure 2. Illustration of participation levels across different research stages, highlighting general patterns identified in the reviewed studies.

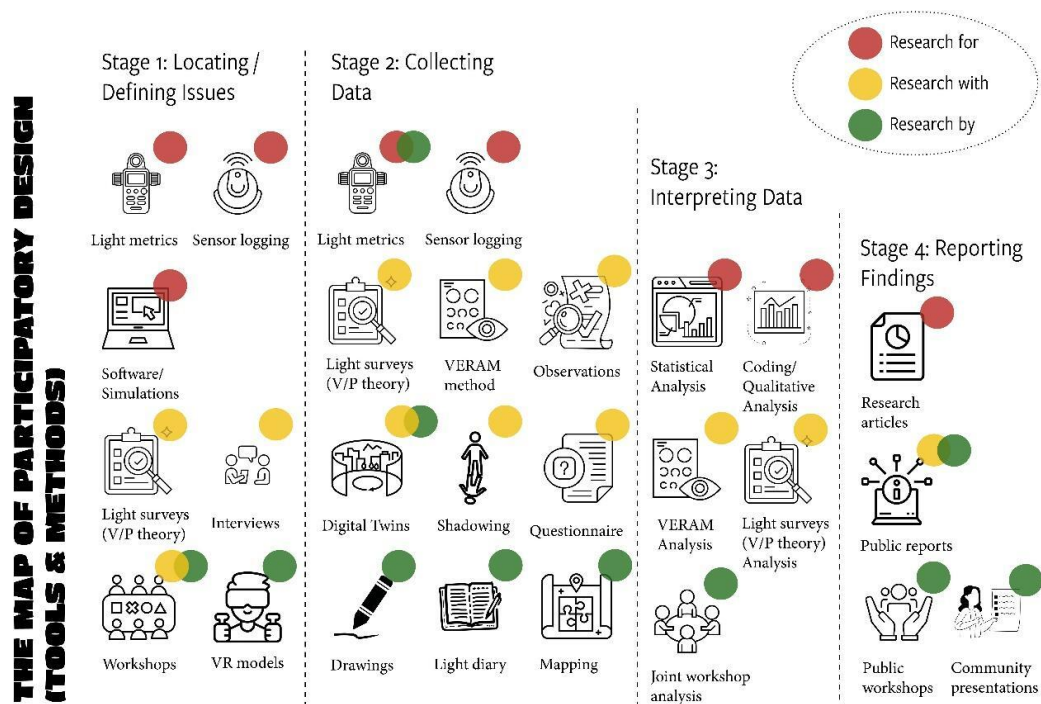


Figure 3. Illustration of mapping tools and methods across the four research stages.

It is important to note that the diversity of participatory approaches and research contexts that have been identified in this review has further implications for the way these findings can be interpreted. While the analysis reveals research patterns in the way participation is distributed across research stages, the heterogeneity of the reviewed studies limits direct comparability.

Thus, the results should be understood as indicative of general tendencies highlighting structural patterns and gaps in the current use of participatory design methods in lighting research that can further inform future work.

Implications for lighting research and practice

The proposed combined framework can be used to structure and outline future studies by identifying which stages and participation levels are used in a limited manner. Researchers can plan studies to increase engagement in early and late stages or justify why some stages should remain researcher-led. Involving participants in research by mode of research has an educational value, enhancing knowledge about lighting, energy efficiency or accessibility. Lighting research in schools, community projects or public spaces could use participatory design not just for data collection, but as a learning experience for stakeholders, potentially influencing behaviours and policy adoption.

Expanding participation and engagement to the early and late stages of lighting research raises important questions of feasibility and complexity. In early stages, such as problem definition and framing, participation can potentially support problem framing and contextualization, while improving the relevance and legitimacy of research. However, it may also introduce practical challenges, including increased demands on time, resources, and coordination, as well as conflicting stakeholder views. In the later stages, such as interpretation and reporting, participation can enhance the validity of findings through dialogue and translation of results into actionable insights. Although these processes can be resource and time-intensive, they can also result in different interpretations between researchers, practitioners, and participants.

This study contributes methodologically by applying a structured analytical framework to a heterogeneous group of studies. The combined use of participation levels and research stages enables the identification of patterns across diverse lighting projects. Furthermore, the approach involves interpretive decisions, particularly when studies do not explicitly define their participatory processes. The classification was performed by two reviewers, whose assessment was cross-checked for ambiguous cases, however, it relied on the methodological descriptions provided in the Methods section.

Limitations and Future Work

The present analysis is based on a limited number of studies within a defined timeframe (2019-2024), which may not capture the full range of participatory approaches in lighting research. In addition to the number of articles, their heterogeneity is acknowledged as a limitation. The articles differ in research context, participant groups, methodological approaches and intended outcomes. As a result, the categorization of participation levels required interpretive assessment, linked to two reviewers (i.e., the authors) independently, enabling cross-checking and discussion of categorization decisions in cases of ambiguity, thereby improving the consistency of the analysis. Thus, recurring trends across the reviewed studies suggest that

the analysis provides a useful overview of how participatory approaches are currently applied in lighting research. Furthermore, research projects often produce multiple publications that represent different stages of the same study, therefore, the papers analyzed in this work correspond to specific phases rather than complete research cycles. Establishing a system to track and link related publications would allow for a more comprehensive evaluation of participation across entire projects. The ambiguity of participation in certain research stages, particularly during the problem definition phase, where the level of user involvement is not always presented and described in each publication.

It should also be noted that the reviewed studies cover a period that overlaps with the COVID-19 pandemic, during which participatory activities, particularly in-person engagement, were often constrained. This may have influenced the extent and form of participation reported in the literature, potentially contributing to a lower representation of participatory approaches in certain research stages. In addition, the review is limited to academic publications, which may not fully capture participatory practices occurring outside formal research contexts. In particular, participant-led or informal forms of engagement may be underrepresented, as such processes are less frequently documented in peer-reviewed literature.

Future research could expand this work by identifying the particular techniques used and examining whether they rely on digital or traditional tools, thereby providing deeper insight into methodological diversity within lighting-related participatory design. Additionally, exploring factors that influence participation levels, such as project context and resource constraints, could further clarify why engagement tends to concentrate in mid-project stages. Addressing these limitations would help inform more systematic integration of participatory design throughout the research process. The visual mapping of methods and tools across the four stages could be further developed to include open-access tools (e.g., surveys, questionnaires or observation logs) for lighting practitioners, to better communicate and suggest ways for participant involvement, while taking into account time constraints.

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References

- Abusaada, H., Elshater, A., Neseem, A., & Fouad, M. (2024). Convivial evening atmospheres in Old Cairo: Urban planning and design toolkit. *Journal of Urban Planning and Development*, 150. <https://doi.org/10.1061/JUPDDM.UPENG-4587>
- Björgvinsson, E., & Hillgren, P. A. (2012). Design things and design thinking: Contemporary participatory design challenges. *Design Issues*, 28, 101–116. https://doi.org/10.1162/DESI_a_00165
- Blaso, L. (2022). Lenicalc software and guidelines for the evaluation of the lighting energy numeric indicator. *IEEE International Conference on Environment and Electrical Engineering*. <https://doi.org/10.1109/EEEIC/ICPSEurope54979.2022.9854409>
- Boonkhao, L. (2024). Home environmental factors associated with falls among elderly in Ubon Ratchathani, Thailand. *Journal of Multidisciplinary Healthcare*, 17, 1363–1373. <https://doi.org/10.2147/JMDH.S456128>
- Botello, B., Buehler, R., Hankey, S., Mondschein, A., & Jiang, Z. (2019). Planning for walking and cycling in an autonomous-vehicle future. *Transportation Research Interdisciplinary Perspectives*, 1, 100012. <https://doi.org/10.1016/j.trip.2019.100012>
- Boyce, P. R. (2019). The benefits of light at night. *Building and Environment*, 151, 356–367. <https://doi.org/10.1016/j.buildenv.2019.01.020>
- Commission Internationale de l'Eclairage. (2019). *A guide to urban lighting masterplanning* (Technical Report No. CIE 234:2019). Commission Internationale de l'Eclairage (CIE). <https://doi.org/10.25039/TR.234.2019>
- Dorst, K. (2011). The core of “design thinking” and its application. *Design Studies*, 32, 521–532. <https://doi.org/10.1016/j.destud.2011.07.006>
- Ebbensgaard, C. L. (2014). Illuminights: A Sensory Study of Illuminated Urban Environments in Copenhagen. *Space and Culture*, 18(2), 112–131. <https://doi.org/10.1177/1206331213516910>
- Gaston, K. J. (2021). Pervasiveness of biological impacts of artificial light at night. *Integrative and Comparative Biology*, 61, 1098–1110. <https://doi.org/10.1093/icb/icab145>
- Gregory, J. (2003). Scandinavian approaches to participatory design. *International Journal of Engineering Education*, 19(1), 62–74.
- Huiberts, L. M. (2023). Using a low-dose ultraviolet-B lighting solution during working hours. *PLoS ONE*, 18, e0283176. <https://doi.org/10.1371/journal.pone.0283176>
- Kaulio, M. A. (1998). Customer, consumer and user involvement in product development: A framework and a review of selected methods. *Total Quality Management*, 9, 141–149. <https://doi.org/10.1080/0954412989333>
- Kharvari, F., & Rostami-Moez, M. (2021). Assessment of occupant adaptive behavior and visual comfort in educational facilities: A cross-sectional field survey. *Energy for Sustainable Development*, 61, 153–167. <https://doi.org/10.1016/j.esd.2021.02.001>
- Kobayashi, S., & Mueakawa, K. (2013). The experiments giving illuminations to the street by residents participation. *Journal of Light & Visual Environment*, 37. <https://doi.org/10.2150/jlve.IEIJ120000491>
- Konstantakopoulos, I., Hamilton, K., Murthy, Y., Veeravalli, T., Spanos, C., & Dong, R. (2022). smartsdh: An experimental study of mechanism-based building control. *IEEE Systems Journal*, 16, 6289–6299. <https://doi.org/10.1109/JSYST.2022.3142443>

- Kyba, C. C. M., Altıntaş, Y. Ö., Walker, C. E., & Newhouse, M. (2023). Citizen scientists report global rapid reductions in the visibility of stars from 2011 to 2022. *Science*, 379(6629), 265–268. <https://doi.org/10.1126/science.abq7781>
- Light, A., & Akama, Y. (2012). The human touch: Participatory practice and the role of facilitation in designing with communities. In *Proceedings of the 12th Participatory Design Conference* (pp. 61–70). <https://doi.org/10.1145/2347635.2347645>
- Mattsson, P., Johansson, M., Almén, M., Laike, T., Marcheschi, E., & Ståhl, A. (2020). Improved usability of pedestrian environments after dark for people with vision impairment: An intervention study. *Sustainability*, 12. <https://doi.org/10.3390/su12031096>
- Montiel, I., Mayoral, A. M., Navarro Pedreño, J., Maiques, S., & Marco Dos Santos, G. (2020). Linking sustainable development goals with thermal comfort and lighting conditions in educational environments. *Education Sciences*, 10. <https://doi.org/10.3390/educsci10030065>
- Myers, M. (2011). Walking again lively: Towards an ambulant and conversive methodology of performance and research. *Mobilities*, 6, 183–201. <https://doi.org/10.1080/17450101.2011.552775>
- Øien, T. B. (2023). Impact of lighting assessment and optimization on participation and quality of life in individuals with vision loss. *Occupational Therapy in Health Care*, 37, 426–443. <https://doi.org/10.1080/07380577.2021.2020388>
- Pihlajaniemi, H., Luusua, A., & Juntunen, E. (2023). Drivers' experiences and informed opinions of presence sensitive lighting. *Smart Cities*, 6, 1879–1900. <https://doi.org/10.3390/smartcities6040087>
- Radicchi, A., & Henckel, D. (2023). Planning artificial light at night for pedestrian visual diversity in public spaces. *Sustainability*, 15. <https://doi.org/10.3390/su15021488>
- Rahm, J., Sternudd, C., & Johansson, M. (2020). “In the evening, I don’t walk in the park”: The interplay between street lighting and greenery in perceived safety. *Urban Design International*, 26, 42–52. <https://doi.org/10.1057/s41289-020-00134-6>
- Ross, P., Burton-Page, M., van der Pol, J., & Ferey, J. (2023). *Luci declaration for the future of urban lighting*. LUCI Association. <http://www.luciassociation.org/luci-declaration-for-the-future-of-urban-lighting/>
- Schroer, S. (2021). Towards insect-friendly road lighting—a transdisciplinary multi-stakeholder approach involving citizen scientists. *Insects*, 12. <https://doi.org/10.3390/insects12121117>
- Sheldon, E. L. (2024). Working dogs in dynamic on-duty environments. *PLoS ONE*, 19, e0295429. <https://doi.org/10.1371/journal.pone.0295429>
- Smith, R. C., & Iversen, O. S. (2018). Participatory design for sustainable social change. *Design Studies*, 59, 9–36. <https://doi.org/10.1016/j.destud.2018.05.005>
- Tavares, P., Ingi, D., Araújo, L., Pinho, P., & Bhusal, P. (2021). Reviewing the Role of Outdoor Lighting in Achieving Sustainable Development Goals. *Sustainability*, 13(22), 12657. <https://doi.org/10.3390/su132212657>
- Tiitu, M. (2023). Comparing city practitioners' and residents' perceptions of a liveable neighbourhood in Finland. *European Planning Studies*, 32, 1118–1145. <https://doi.org/10.1080/09654313.2023.2263053>
- Trop, T., Shoshany Tavory, S., & Portnov, B. A. (2023). Factors Affecting Pedestrians' Perceptions of Safety, Comfort, and Pleasantness Induced by Public Space Lighting: A Systematic Literature Review. *Environment and Behavior*, 55(1–2), 3–46. <https://doi.org/10.1177/00139165231163550>

- Tuaycharoen, N. (2020). Lighting to enhance wayfinding for Thai elderly adults in nursing homes. *Journal of Daylighting*, 7, 25–36. <https://doi.org/10.15627/jd.2020.3>
- Yang, H. B., & Kalms, N. (2022). Perceptions of safety in cities after dark. In S. Sumartojo (Ed.), *Lighting design in shared public spaces* (1st ed.). Routledge. <https://doi.org/10.4324/9781003182610-5>
- Zielinska-Dabkowska, K. M., Schernhammer, E. S., Hanifin, J. P., & Brainard, G. C. (2023). Reducing nighttime light exposure in the urban environment to benefit human health and society. *Science*, 380(6650), 1130–1135. <https://doi.org/10.1126/science.adg5277>