2025 European Conference on Computing in Construction

CIB W78 Conference on IT in Construction

Porto, Portugal
July 14-17, 2025

CO-CREATION OF PROSPECT: A BIM-BASED PLUGIN ENABLING ARCHITECTS TO EMBED SOCIAL DESIGN INTENTIONS IN BUILDING MODELS

Yazan N. H. Zayed[1], Aliakbar Kamari[2], and Carl Schultz[1]
[1]Department of Electrical and Computer Engineering, Aarhus University, Aarhus, Denmark
[2]Department of Civil and Architectural Engineering, Aarhus University, Aarhus, Denmark

Abstract

Bridging the gap between stakeholders in building projects is crucial to ensure a consistent and efficient flow of information during the design and planning stage of the project. One major and highly influential category of information is the social intentions, which reflect the overall comfort and well-being of building occupants. In this paper, we present our co-creation approach for developing a software tool "ProSpect Plugin" that will enable architects to explicitly document social design intentions in building models. The plugin is integrated into Autodesk Revit and is being developed iteratively through carefully planned rounds of co-creation activities with potential users.

Introduction

Building Information Modeling (BIM) provides a comprehensive representation of buildings in terms of 3D modeling, data communication, and facility management, among the wide variety of stakeholders in construction projects (Waas, 2022). The growing adoption of BIM and its ability to facilitate more efficient planning and delivery of construction projects make it a suitable environment for capability-extending functionalities through BIM-based plugin development (Saad et al., 2023).

In this paper, we investigate how architects' design intentions, which form the basis of their architectural decisions, can be integrated into BIM models, hence producing a model that is enriched with their logic and reasoning. The scope of this work covers ***social design intentions*** in buildings. Such intentions are comprised of two parts, the *design decision* and the *social intention*. That is, a physical design decision is intended to evoke a certain social effect. Consider the following example of a social design intention, referred to as the wall art example, *"installing wall art in the building will increase the occupants' sense of belonging when they walk around it and see it"*. The placement of the wall art (i.e, the design decision) in this case is intended to elicit a sense of belonging (i.e., the social intention) among building occupants.

Social design intentions are usually implicit and not specified clearly in the building model with all their components. Considering the wall art example, it is insufficient to focus only on the physical element (i.e., the wall art) and on which specific wall of the building it is placed. The richness of the intended social intention is in the region of space in which the occupant is located and from which the art can be seen, referred to in literature as spatial artifacts (Bhatt et al., 2010), (Bhatt et al., 2012), (Schultz and Bhatt, 2013). This region, if not defined explicitly in the building model, might be covered, blocked, or inaccessible to building occupants, and as a result the social intention will not be achieved.

Similar to the wall art example, we collected about 86 social design intentions that have already been implemented in 8 different locations in 2 countries. The main challenge regarding those collected instances is the way such subjective and qualitative data can be formalized and digitalized.

The current status of architecture software tools lacks the focus on socially oriented aspects that are directly involved in the well-being of occupants and the overall level of sustainability of buildings. The subjective and qualitative nature of such aspects makes them harder to define in a computer-readable format. Based on this research gap, the following research questions have been formulated:

- **RQ1** How can a software user interface be conceptualized for architects to capture and integrate social design intentions into digital building models?
- **RQ2** To what extent is a BIM-based software tool suitable for architects to specify social design intentions in digital building models?

To address the mentioned research questions, we present ***ProSpect Plugin***, a decision-support software tool that is being developed gradually with continuous expert feedback from architects and architecture academics.

The core of this research lies in the formalization of social design intentions using the novelty of our ***Product-Goal Causality Model***. That is, how this structure is used to represent social design intentions and their components, and how this formalized format can be conceptualized in a user interface that aligns with the architects' workflow. This is being ensured through our co-creation approach involving potential users in the research and development process.

Related work

The development of the definition of social sustainability and its criteria has been rapidly evolving over the recent years, and this development has affected almost all industries including the architecture and construction industry, mostly through assessment and evaluation frameworks (Kordi et al., 2021). Research that targets socially oriented aspects in buildings have been conducted to address user-centered design criteria especially those that affect occupants' well-being and overall comfort levels in buildings. An example of such work is the well-being valuation approach presented by (Watson, 2018) introducing a method to measure and quantify occupants' well-being on a multi-item scale.

Researchers have also implemented the plugin development approach to address aspects that we consider socially oriented according to our definition, such as daylight access (Miri and Ashtari, 2022), (Akin et al., 2021), thermal comfort, and optimized interior space design (Ma et al., 2019). Such aspects directly affect the overall well-being as well as thermal and visual comfort of building occupants, which are defined as social intentions in our work.

Another concept that we sought definitions from to represent social intentions is the assessment of buildings' social sustainability aspects (e.g., health, comfort, well-being, etc.) as addressed by (Ahmad and Thaheem, 2017).

Previous research contributions have also adopted a user-centered approach such as (Meoni et al., 2022), in which a tool was developed to monitor the performance of historical buildings, an aspect that we have also defined in our work as a social intention called the "sense of heritage".

Researchers have performed user experience (UX) testing in the form of workshops such as the work of (Akin et al., 2021). However, the major difference in our work is that we follow a co-creation approach throughout the whole research and development process. That is, actual potential users (e.g., architects) have been involved in all development stages and their role is not limited to usability testing, playing a major role in early-stage concept formation, definition of terms, and collection of sample cases where social design intentions have been already implemented. This has been done to investigate if the architects behind those decisions would have benefited from such tool to represent the logic and reasoning behind their intentions.

Methodology

The user-centered software development process presented in this paper follows a co-creation approach through an incremental process involving participants and using methods such as workshops (Kamari et al., 2021), semi-structured interviews (Longhurst, 2003), and focus groups (Kontio et al., 2004). The user-centered design definition of (Baecker et al., 1995), emphasizes four major stages of system development process, which are: analysis, design, development, and evaluation. Based on this, we represented our approach as illustrated in Figure 1.

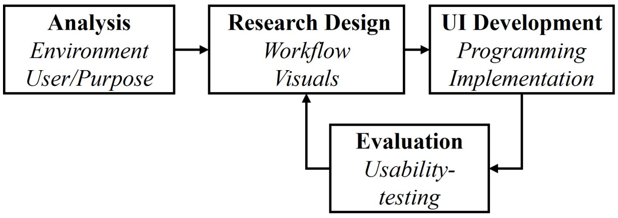


Figure 1: Four stages of ProSpect co-creation process, showing the feedback loop of design, development, and evaluation

Analysis

Stakeholders have a variety of goals and tasks to accomplish throughout the design and planning phase of the building project. Social design intentions, for example, might get lost during the transfer of building design documentation among various stakeholders, particularly in large-scale projects. This is because those intentions are usually implied and not made explicit in the project documentation or in the digital building model, due to their subjective and qualitative nature. The aim of our software tool is to enable stakeholders to capture and incorporate their social design intentions into digital building models, as current tools show lack of inclusion of such intentions. In order to define the scope of our work in terms of the purpose and the targeted use cases, we applied the *5Ws+1H* framework, as illustrated in Figure 2.

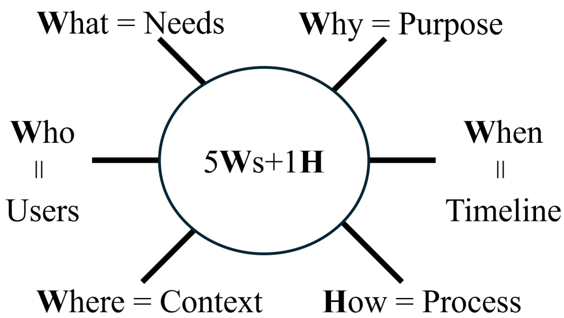


Figure 2: Applying the 5Ws+1H framework, defining the scope and aim of ProSpect Plugin

What: we identified a user need for a software tool that captures architects' social design intentions, allowing users to integrate such intentions into digital building models for better reasoning and communication.

Why: we pointed out the challenge of losing social design intentions in building designs because they are implicitly captured, undocumented properly, or do not exist at all. This can lead to contradiction or overriding of some design elements that elicit a certain feeling, encourage an experience, or improve occupants' well-being.

Who: the tool is intended to be used by stakeholders of building construction projects. This includes architects, designers, engineers, and facility managers.

When: we defined the point on the timeline of a construction project in which our tool provides the best value. That is, during the planning phase of the project as well as renovation phases, when original building models undergo up-dates and modification. This tool can also be used by facility managers during the building operation phase.

Where: we defined the tangible boundaries in terms of the software platform, into which our tool is integrated, and the applicability of the use case. The tool was designed as a plugin integrated into Revit, targeting users of BIM-based platforms. The tool also specifically targets instances wherein users attempt to explicitly and particularly capture social design intentions in building models.

How: we followed a co-creation approach, in which potential users of the tool were directly involved in the development process, which fosters user-centered system design. In this part we also decided on how users are going to interact with the developed tool which is achieved through rounds of prototype demonstrations, and interviews.

Research design

In our work we defined 5 areas, in which our co-creation approach provides contributions to the creation and representation of social design intentions, as illustrated in Figure 3. The first three areas (i.e, ***specifying***, ***exploring***, and ***analyzing***) are related to the development of the tool's user interface. We considered user-friendliness and simplicity as critical aspects in architects' potential adoption of a new tool that is intended to fit their current work patterns and complement it with the inclusion of social design intentions. The tool should be easy to use to represent qualitative data, widely applicable to capture a variety of social intentions, and implements a terminology that is compatible with architects' practice despite its subjective and human-centered nature. In addition, as a subsequent development of the tool, analytical features will be utilized to enrich the tool with meaningful statistics and calculations that can be converted into key performance indicators (KPIs), providing insights on the existence, distribution, and density of social design intentions in a certain area of a building.

The remaining two research contribution areas (i.e., ***communicating*** and ***improving***) are directly related to the current industry practice. We aim to investigate the impact of using our data structure to define social design intentions on the quality of communication among architects and multidisciplinary stakeholders, and how social design intentions could become more visible and unambiguous when they are captured in digital building models.

The lack of tools that directly and specifically target social design intentions was the main motivation towards following a co-creation approach. We argue that a good approach towards developing a novel tool is to involve its potential users early on in the research and development process. That is, one of our main contributions in this work is to incrementally and iteratively develop the tool with high stakeholder involvement. The co-creation process facilitated adapting a bottom-up approach, in which users are provided a domain-specific language or a structured format, in order to represent their social design intentions in a formalized way that clearly reflects their ideas digitally.

In the design stage of our co-creation approach, we decided to develop the tool to be integrated in Autodesk Revit, which is a building information modeling software that is used for architectural, structural, mechanical and electrical engineering tasks as well as by designers and contractors. Our decision to select a BIM-based platform was based on its ability to handle and store structured data, offering meaningful data links and potential expandability that can be utilized to capture social design intentions.

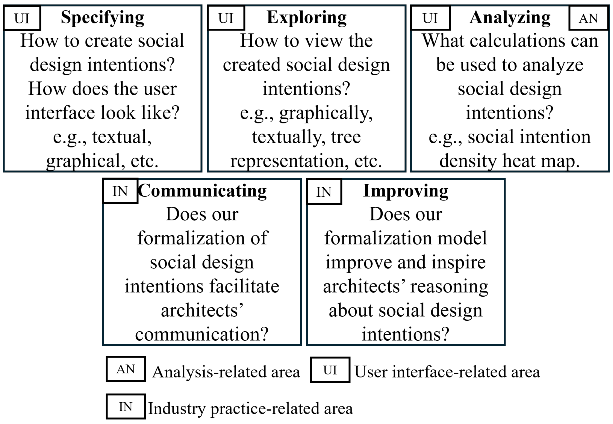


Figure 3: Five research contribution areas of the co-creation process of ProSpect Plugin

User interface development

The first version of the user interface was developed as a multi-step wizard, enabling the users to create social design intentions by following its 4 steps. This wizard approach allows users to complete the task by breaking down the process into a sequence of linear steps (Dryer, 1997). Principles of general system design as introduced by (Lee et al., 2010) were implemented in the design of the tool's user interface. The authors define principles such as ***consistency*** (in dialog boxes), ***visibility*** (functionalities are easy to find), ***feedback*** (highlighting and showing messages of selected elements), and ***recoverability*** (validity checking and undo selections). We also adhered to their user support principles such as ***familiarity*** (integrating the tool into a familiar environment), ***assistance*** (help button and user prompting), and ***minimalism*** (one dialog box is shown at a time). The wizard-based plugin was integrated into Revit and was developed in C#.

The core of the software implementation was our product-goal causality model (Zayed et al., 2024), which is shown in Figure 4. The model has three levels, ***the product level***, which contains the building elements involved in the social intention and the relationships between them and ***the goal level***, which contains the social intention itself. Additionally, ***the domain level*** serves as an intermediate level, specifying how a social intention is elicited from a design decision. This is represented using spatial artifacts (Bhatt et al., 2010), (Bhatt et al., 2012), which in our context represent the regions of space inside which the social intention is elicited (e.g., a light space of a lamp, a visible space of an artwork, a sound space of a device, etc.).

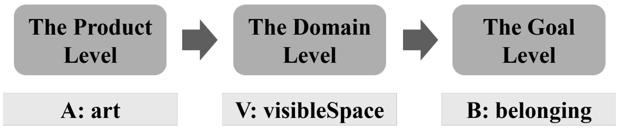


Figure 4: The product-goal causality model, illustrated using the wall art example, in which the visible space of the art contains the social value of eliciting a sense of belonging

Based on this model, we developed the plugin's class structure as shown in Figure 5. The structure contains a class of all created social design intentions "***SocialDesignIntentionSet***" and a class of each individual social design intention "***SocialDesignIntention***". The social intention class has two types of elements, ***objects*** (i.e., occupant profiles (e.g., elderly) and building products (i.e., spatial artifacts and building elements)), and ***relations*** (e.g., near, on, etc.).

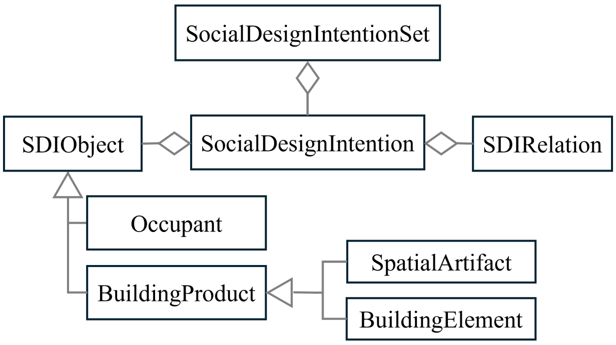


Figure 5: A simplified UML diagram of the plugin class structure

Evaluation

We have conducted two rounds of co-creation activities that already involved prototype demonstrations with potential users. At a later stage of the co-creation process and in multiple usability testing sessions, we will prepare prototypes that are fully functional to be tested by users (i.e., to create, export, and view social design intention).

Since the tool is specifically developed to create social design intentions, it is important to assess the accuracy of capturing such subjective and qualitative data in digital building models. This will not only verify the syntax of the created social design intentions (e.g., checking for non-existing or duplicating element IDs) but it will also validate that they accurately capture architects' logic (e.g., the definition of spatial artifacts and spatial relations).

ProSpect plugin

In this section, we present the ProSpect plugin user interface. Figure 6 shows screenshots of the main menu and the 4-step wizard. The main menu contains 3 buttons:

- **About**: a description and a step-by-step user manual.
- **New Social Design Intention**: the main button from which the user starts creating the social design intention.
- **Export Social Design Intention**: exports the social design intention as a text file.

After clicking on the "New Social Design Intention" button, the user is guided to select at least one building element, specify the types of the selected elements (e.g., wall, furniture, etc.), and give them unique reference identifiers (e.g, *W* denotes a wall and *L* denotes a light fixture).

In the second step, the user specifies the spatial relations between the selected building elements (if any). For example if a light fixture *L* is directed at a wall *W*, this is specified as "*L* is DirectedAt *W*".

In the third step, the user specifies at least one building occupant profile and give it a unique identifier. In this step the user also specifies the spatial artifacts. For example, if an occupant *O* is expected to move on a slab *S*, this is represented as "*M* is MovementSpace of *S* with respect to *O*". In this step, the user also specifies if there is any spatial relation (e.g., intersection, union, etc.) between artifacts.

In the fourth step, the user specifies the social intention by selecting and relating it to the spatial artifact or to the spatial relation specified in the previous step. Finally, the user gives a reference and a short description of the created social design intention before exporting it as a text file.

Using the ProSpect plugin, we digitalized 13 instances out of 86 formalized social design intentions. Those instances have been elicited in a case study that has been conducted to collect real-world cases from architects to experiment with and test the applicability of our approach.

The co-creation process

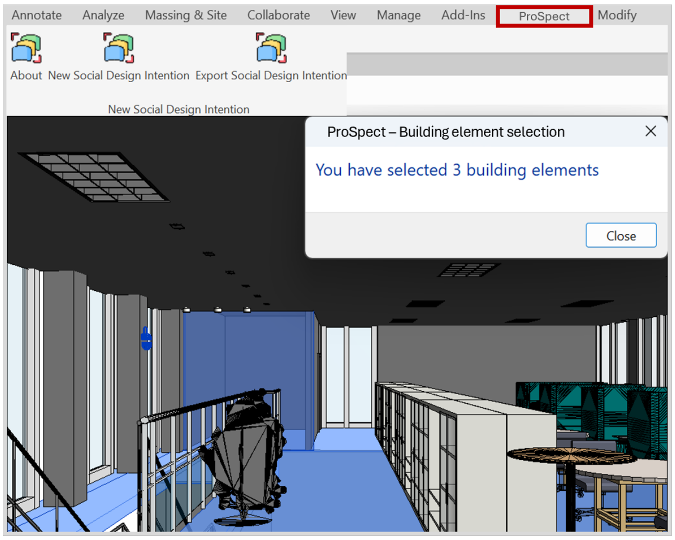
In this section, we present the overall plan and the current state of the co-creation process of the ProSpect plugin. The process consists of 7 rounds representing different potential users (i.e., academics in civil and architectural engineering, architects, and architecture students). The complete co-creation process is expected to take approximately 12 months (between October 2024 and September 2025). In this section we present the experiments that we conducted, and the full plan of the remaining future co-creation process as presented in Table 1.

Table 1: The 7 rounds of co-creation, rounds 1 and 2 are completed and presented in this paper, rounds 3-7 to be completed by September 2025

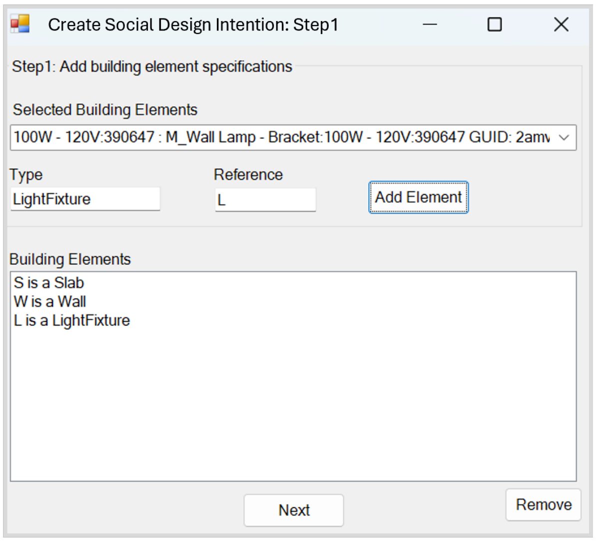
Rounds	Method	Participants	Dates
Round 1	Focus group	6 students	November 20th, 2024
Round 2	Semi-structured interview	2 architects	January 14th, 2025
Round 3	Semi-structured interview	1-2 architects	June 2025
Round 4	Semi-structured interview	1-2 architects/ academics	June 2025
Round 5	Interview	1-2 architects	July 2025
Round 6	Observation	Students	September 2025
Round 7	Observation	To be decided	September 2025

Co-creation - round 1

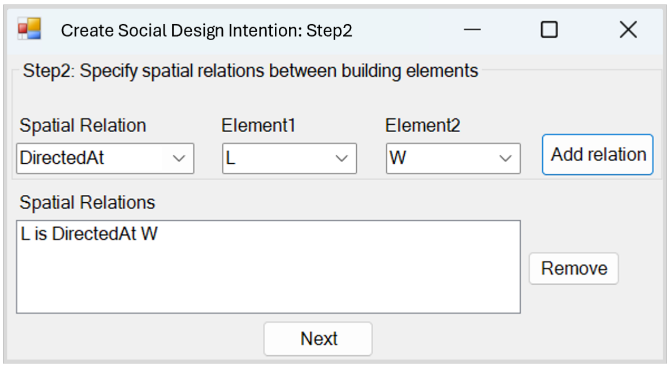
Setup - In this round we used the ***focus group*** method. The participants were 6 bachelor students enrolled in the



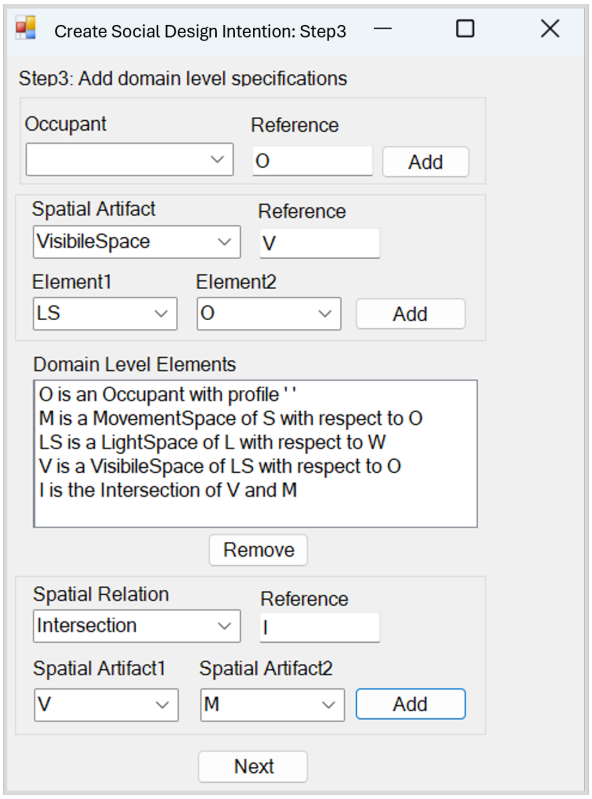
(a) Main menu and selecting building elements



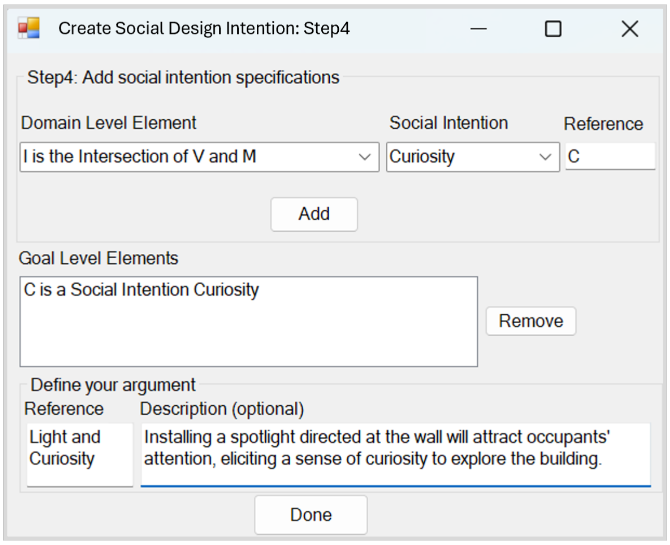
(b) Step1: Specify building elements



(c) Step2: Specify spatial relations



(d) Step3: Specify domain-level elements



(e) Step4: Specify the social intention

```
SOCIAL_DESIGN_INTENTION Library
DESCRIPTION Installing a spotlight directed at the wall will attract
            occupants' attention, eliciting a sense of curiosity to
            explore the building.
ELEMENT S Product BuildingElement Slab 2CQMTszC150A2zsOdY9rbf
ELEMENT W Product BuildingElement Wall 2CQMTszC150A2zsOdY9tEX
ELEMENT L Product BuildingElement LightFixture 2amvT4$Ab4zP4R0HcehaeG
RELATION DirectedAt L W
ELEMENT O Domain Occupant
ELEMENT M Domain MovementSpace S O
ELEMENT LS Domain LightSpace L W
ELEMENT V Domain VisibileSpace LS O
ELEMENT I Domain Intersection M V
ELEMENT C Goal SocialIntention Curiosity I
```

(f) The exported social design intention

Figure 6: Screenshots from the ProSpect Plugin, showing the steps of creating a new social design intention

"Integrated Building Design" course at the Department of Civil and Architectural Engineering at Aarhus University. The first author of this paper was the moderator of the activity and conducted it in two consecutive sessions, in a total duration of approximately one hour. The first session was a short presentation, introducing the tool and its current development stage. The second session was an interactive discussion, in which the participants were asked to answer 24 questions, their opinions on certain ideas were recorded and their perception of the tool was assessed.

The average participation rate was 72% (percentage of participants responding in each questions). Figure 7 illustrates the participants familiarity with Revit and BIM-based software. Regarding their potential career paths, 50% answered "structural engineer", which is a potential user of the tool. The rest showed interest in innovative design and indoor climate, which comprise social aspects.

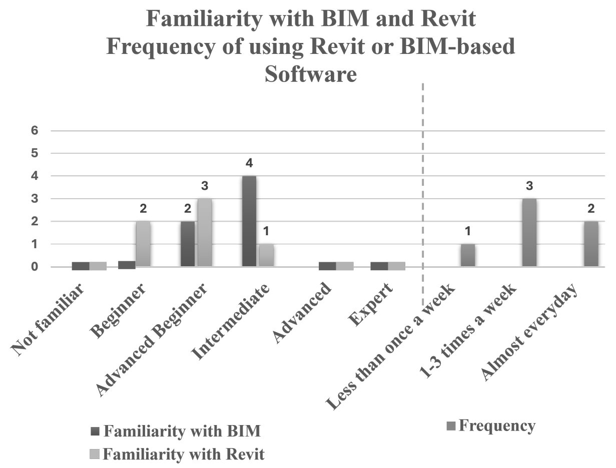


Figure 7: General questions regarding participants familiarity with Revit and BIM-based software

Results, discussion, and limitations - After explaining the concept of social design intentions in the first session, the participants provided 8 examples of cases they have encountered and fit the definition of a social design intention. This exercise aimed at assuring that they fully understand the concept before advancing with the session. The participants were then shown snippets of text, and were asked to identify social design intentions. The participants managed to exclude the snippets that targeted non-social (i.e., environmental or economical) intentions and the ones that do not specify the use of any building elements.

In the next stage of the second session, two exercises were introduced. In the first one (**E1**), the participants were shown the wall art example. They were asked 3 questions aiming to define the elements of the social design intention based on their understanding of the product-goal causality model defined in the previous session. The average percentage of correct answers in **E1** was 64%.

In the second exercise (**E2**), the participants were shown screenshots of the tool's user interface (as in Figure 6), and were asked to identify parts of the social design intention (e.g., building elements, spatial artifacts, spatial relations, etc.). The average percentage of correct answers in **E2** was 77%. The results of **E1** and **E2** are shown in Figure 8.

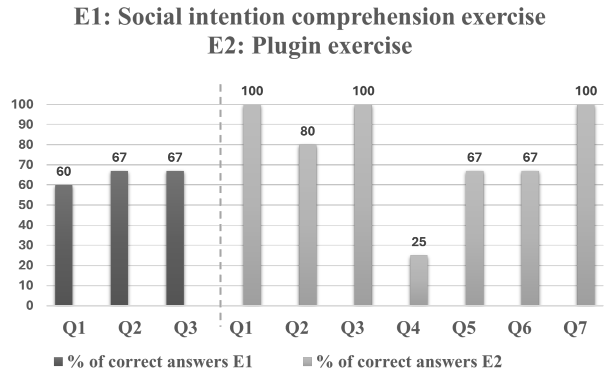


*Figure 8: Results of social intention comprehension exercise **E1** and plugin exercise **E2***

Among the key findings of the second session is the potential confusion between the spatial relations and the spatial artifacts. Some of the participants' responses in **Q4** of **E2** show that those terms have been used interchangeably, which affects the reasoning behind the social intention. As a result, we will discuss eliminating such confusion by introducing new names such as "domain space" or "spatial region" instead of spatial artifact.

In the last part of the session, the participants were asked to provide their opinions on how the created social design intentions can be saved and viewed later. The answers included visual representation in which building elements can be viewed along with their corresponding relations with other elements, and all to be viewed in the original BIM model. Other responses suggested a report-like representation (e.g., a table in a PDF file), or the use of Industry Foundation Classes (IFC) to represent the intentions.

A limitation of this study is that the focus group was preceded by a seminar introducing IFC and its properties, which might have created some bias among participants.

The participants were also asked to provide their opinions on the aspects that they think are currently good in the presented tool and the ones that they think need improvement. Figure 9 summarizes the results of this question.

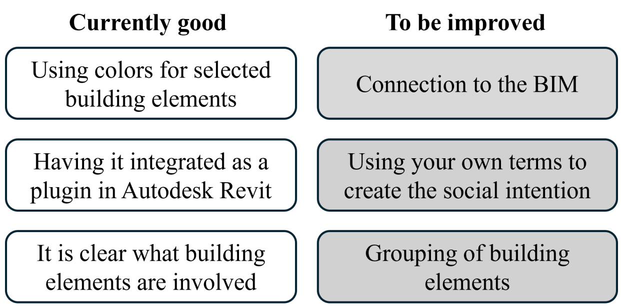


Figure 9: Participants' opinions on what is currently good and what can be improved in the presented tool

Connection to BIM and the possibility for architects to use their own terms to describe social design intentions is under discussion. As a future work, we will investigate integrating the intentions into open BIM standards with the help of IFC classes (e.g., IfcSpatialZone, IfcWall, etc.). Regarding social intention terminology, we plan to explore Universal Design (Goldsmith, 2007) and how we can adapt (some of) its principles to represent social intentions.

Regarding the possibility to check whether the social intention has been achieved in real-life, we argue that the main contribution of our work is to develop a domain-specific tool for architects to represent their social intentions. The actual achievement of the intentions falls into the scope of post occupancy evaluation (Meir et al., 2009) and psychological evidence in design (Krukar and Schultz, 2024).

Lastly, one advantage of focus groups is the possibility to conduct discussions with a group of people simultaneously instead of individually, saving time and effort. However, another limitation of the work was the high homogeneity of participants' backgrounds and visions, which might have limited the versatility of responses to some questions.

Co-creation - round 2

Setup - In this round, a 2-hour, semi-structured interview with 2 architects from an architecture firm was conducted. The participants were presented a brief overview of the tool, the overall co-creation process, and a live demo.

Results - The architects pointed out the following main points, all of which are going to be addressed and discussed in the upcoming stages of this work:

- There should be a clear distinction between early- and late-stage design decisions. Late-stage decisions, such as furniture placement, might not be represented in the initial building model. On the other hand, other decisions come as early ideas before the drawing stage.
- Architects use some tools that are not BIM-based. In addition, older buildings might not have BIM models, creating a challenge for architects in renovation projects.
- The current user interface requires the user to perform a relatively large number of clicks. The architects recommended to reduce the clicks needed to create a social design intention, referring to concepts like "friction" and "smoothness" of architectural software's user interface.

Discussion

The main objective of this work is to develop a structured format for architects to represent social design intentions. Although this paper presents the process of the software development of the tool, the novelty of this research lies in documenting and communicating social design intentions through integrating them into digital building models.

This contribution stems from the defined research gap regarding the scarcity of tools and frameworks that specifically target the social dimension of sustainability, compared to the well-represented economic and environmental dimensions. Most of the architecture software tools lack a dedicated approach to document social design intentions. Additionally, socially oriented aspects comprise mainly of qualitative and subjective criteria that are harder to define and integrate into architects' workflow, compared to the well-defined quantitative economic and environmental criteria (Kordi et al., 2024), (Kordi et al., 2025).

Leveraging our product-goal causality model, our tool provides a domain-specific language to create, store, and reason about social design intentions in a traceable and implementable way. This formalization data model represents the core contribution towards facilitating the integration of qualitative design criteria into digital building models. This will eventually enhance exchanging building projects' documentation between multiple stakeholders while minimizing the risk of losing social design intentions, due to their concrete definition and formal representation that provides better clarity and visibility.

To revisit our research questions, and based on the results of the conducted co-creation activities, we argue that the conceptualization of a software user interface to capture social design intentions (RQ1) has been addressed by our product-goal causality model, which explicitly provides the basic structure of the social design intentions. In addition, the first software plugin prototype, which is presented in this paper, takes into consideration user interface aspects as elicited from architects' feedback, ensuring smooth and consistent alignment with their workflow.

Regarding the suitability of a BIM-based software tool to specify social design intentions in digital models (RQ2), we argue that despite the current lack of mechanisms to integrate such design aspects into BIM models, BIM is well-suited to handle structured data through the possibility to extend its capabilities via APIs and plugin development. This is based on our ability to fully digitalize 13 instances of real-world social design intentions using our BIM-based ProSpect plugin, and BIM's wide adoption in architecture.

Conclusions

This paper introduced the development of a software tool "ProSpect Plugin", for capturing social design intentions in digital building models. The expert feedback that we received on the user interface showed that it can be utilized during the planning phase of construction project, providing a software solution to capture social design intentions in BIM models. The development of the tool followed a co-creation approach, maximizing user involvement. Initiated by meetings with an expert architect in renovation projects, we formed the point of departure towards the current status of the tool. Those meetings matured the concept of the tool and precisely defined clear and tangible objectives. The first two rounds of the co-creation process showed positive results on the compatibility of a BIM-based platform to represent social design intentions.

The co-creation process will proceed with the remaining rounds including usability testing and addressing the other research contribution areas mentioned in our methodology. We will refine our tool's functionality and add informative calculations for additional analytical services.

Acknowledgments

We gratefully acknowledge the funding support of the European Union Horizon 2020 research project PROBONO under grant agreement no. 101037075.

References

Ahmad, T. and Thaheem, M. J. (2017). Developing a residential building-related social sustainability assessment framework and its implications for BIM. Sustainable Cities and Society, 28:1–15.

Akin, S., Ergun, O., Surer, E., and Gursel Dino, I. (2021). An immersive performative architectural design tool with daylighting simulations: a building information modeling-based approach. Engineering, Construction and Architectural Management, 28(4):1319–1344.

Baecker, R. M., Grudin, J., Buxton, W. A. S., and Greenberg, S. (1995). Readings in Human-Computer Interaction: toward the year 2000. CA: Morgan-Kau man Publishers.

Bhatt, M., Hois, J., Kutz, O., and Dylla, F. (2010). Modelling functional requirements in spatial design. In Conceptual Modeling–ER 2010: 29th International Conference on Conceptual Modeling, Vancouver, BC, Canada, November 1-4, 2010. Proceedings 29, pages 464–470. Springer.

Bhatt, M., Schultz, C., and Huang, M. (2012). The shape of empty space: Human-centred cognitive foundations in computing for spatial design. In 2012 IEEE symposium on visual languages and human-centric computing (VL/HCC), pages 33–40. IEEE.

Dryer, D. C. (1997). Wizards, guides, and beyond: Rational and empirical methods for selecting optimal intelligent user interface agents. In Proceedings of the 2nd international conference on Intelligent user interfaces, pages 265–268.

Goldsmith, S. (2007). Universal design. Routledge.

Kamari, A., Jensen, S. R., Petersen, S., and Kirkegaard, P. H. (2021). Sustainability key performance indicators' (KPIs) assessment and visualization aimed at architects in (early) renovation design processes. NA, 33(2).

Kontio, J., Lehtola, L., and Bragge, J. (2004). Using the focus group method in software engineering: obtaining practitioner and user experiences. In Proceedings. 2004 International Symposium on Empirical Software Engineering, 2004. ISESE'04., pages 271–280. IEEE.

Kordi, N. E., Belayutham, S., and and, C. K. I. C. I. (2021). Mapping of social sustainability attributes to stakeholders' involvement in construction project life cycle. Construction Management and Economics, 39(6):513–532.

Kordi, N. E., Belayutham, S., and Che Ibrahim, C. K. I. (2024). Determination of scales and measures for assessing social sustainability practices in construction projects. Engineering, Construction and Architectural Management.

Kordi, N. E., Belayutham, S., and Che Ibrahim, C. K. I. (2025). Development and demonstration of a social sustainability assessment tool for the construction project life cycle. Construction Innovation, 25(1):161–186.

Krukar, J. and Schultz, C. (2024). Ecological validity of architectural cognition: a framework. Architectural Science Review, pages 1–8.

Lee, G., Eastman, C. M., Taunk, T., and Ho, C.-H. (2010). Usability principles and best practices for the user interface design of complex 3d architectural design and engineering tools. International journal of human-computer studies, 68(1-2):90–104.

Longhurst, R. (2003). Semi-structured interviews and focus groups. Key methods in geography, 3(2):143–156.

Ma, G., Liu, Y., and Shang, S. (2019). A building information model (BIM) and artificial neural network (ANN) based system for personal thermal comfort evaluation and energy efficient design of interior space. Sustainability, 11(18):4972.

Meir, I. A., Garb, Y., Jiao, D., and Cicelsky, A. (2009). Post-occupancy evaluation: An inevitable step toward sustainability. Advances in building energy research, 3(1):189–219.

Meoni, A., Vittori, F., Piselli, C., D'Alessandro, A., Pisello, A., and Ubertini, F. (2022). Integration of structural performance and human-centric comfort monitoring in historical building information modeling. Automation in Construction, 138:104220.

Miri, M. and Ashtari, E. (2022). Implementing a digital solution for architectural daylight analysis in BIM based projects by developing a new plugin. IOP Conference Series: Earth and Environmental Science, 1099(1):012013.

Saad, A., Ajayi, S. O., and Alaka, H. A. (2023). Trends in BIM-based plugins development for construction activities: a systematic review. International Journal of Construction Management, 23(16):2756–2768.

Schultz, C. and Bhatt, M. (2013). Inspace3d: A middleware for built environment data access and analytics. Procedia Computer Science, 18:80–89.

Waas, L. (2022). Review of BIM-based software in architectural design: Graphisoft archicad vs autodesk revit. Journal of Artificial Intelligence in Architecture, 1(2):14–22.

Watson, K. J. (2018). Establishing psychological wellbeing metrics for the built environment. Building Services Engineering Research and Technology, 39(2):232–243.

Zayed, Y. N. H., Kristoffersen, A. E., Lohm, G., Kamari, A., and Schultz, C. (2024). The anatomy of an architect's argument: Formally capturing socially-oriented design intentions in the built environment. In Proceedings of the 2024 European Conference on Computing in Construction.