Visual Thinking: A Methodological Approach to Age-Inclusive Housing Research

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Abstract: This research is placed in the arena of architectural education and its associated professional context, exposed to numerous urban challenges and influences, such as social transformation and uncontrolled urban growth, emphasized in the housing domain. Residential typologies are evolving and transforming in a continuous synergy of spatial and behavioral patterns influenced by contemporary lifestyles and corresponding morphological formats. Addressing these challenges and finding appropriate professional responses in housing practice necessitates considering methodological approaches that are flexible across different typologies and adaptable to various scales. The current Charter of Architectural Education (UIA/UNESCO) identifies understanding methods for research, imagination, and creative thinking as key educational goals. Additionally, the EAAE Charter for Architectural Research emphasizes the need to strengthen problem-based thinking. In this context, visual thinking serves as a bridge between problem-based and creative thinking. Therefore, this paper focuses on a methodological approach to researching age-inclusive housing related to visual thinking. This research is conducted within the framework of the international Erasmus+ project sUser (https://suserproject.org/), focused on Introducing User-Driven Design and Agile Development Skills in the Case of Sustainable Service Housing for Elderly. The paper provides an overview with a clustering structure that includes four design approaches (user-driven design, system thinking, eco-design, and agile methodologies) in relation to visual thinking. For each approach, the discussion centers on visual tools (such as drawings, diagrams, maps, etc.) and their explicit use concerning specific aspects explored in designing age-inclusive housing. The study's outcome presents a systematic overview of identified visual tools followed by a comparative discussion of the four recognized design approaches.

Keywords: architectural education; design methodology; aging society; user-driven design, system thinking, eco-design, agile methodologies

1. Background

In the current landscape of architectural education, practitioners and educators face several complex challenges. These stem from rapid urbanization, shifting social dynamics, environmental concerns, and the growing demand for sustainable housing solutions. As cities expand and societies evolve, housing typologies are continuously redefined (Nikezic, Ristic Trajkovic & Milovanovic, 2021), pushing architectural education to adapt to these transformations. One of the most pressing issues within this evolving context is the provision of inclusive housing (Elsinga et al, 2020), particularly for aging populations (McCall, 2022), which demands a profound reconsideration of traditional design methodologies.

A key challenge in architectural education is preparing students to think critically and creatively in response to these urban and societal demands. The UNESCO/UIA Charter for Architectural Education (UNESCO-UIA Validation Council for Architectural Education, 2017) underscores the importance of fostering research imagination and creativity among students, highlighting that traditional problem-solving approaches may no longer suffice. In parallel, the European Association for Architectural Education (EAAE, 2012) stresses the need for problem-based thinking, where designers address real-world complexities through adaptable, innovative methodologies.

In the face of these challenges, visual thinking has emerged as a crucial methodological tool in architectural education (Stanimirovic et al, 2023). Visual thinking bridges the gap between creative and problem-based thinking (Schnotale, 2022), providing a means for students to translate abstract ideas and complex systems into tangible, actionable designs. It is particularly valuable in addressing the multifaceted nature of housing design (Sylvestre, Czechowski, & Turner, 2024) for aging populations, where multiple variables—such as user needs, sustainability, and systems efficiency—must be considered simultaneously. The integration of visual tools such as diagrams, maps, and sketches enable us to conceptualize and analyze the interactions between space, behavior, and environmental factors in a way that traditional text-based methods cannot. Visual tools serve as mediators between theory and practice, offering insights into spatial relationships, user experiences, and systemic interdependencies. This is particularly critical in age-inclusive housing, where visual representations allow for the exploration of design solutions that cater to the specific needs of elderly residents.

2. Contextual and Conceptual Framework

2.1. Research Context: sUser Project

The paper is grounded within the scope of Erasmus+ Project sUser (Introducing user-driven design and agile development skills in the case of sustainable service housing for the elderly) which aims to develop and test design methodologies from the following aspects: 1) sustainable user-centered design, 2) eco-design, and 3) systems thinking and agile development skills and competencies. This approach is crucial for solving complex societal challenges, such as climate change, the depletion of energy and raw materials, and the aging of the population. Establishing an integrated approach that combines user-centered design and systems thinking, agile development, and an emphasis on sustainable innovation aims to educate young professionals to be agents of change for a sustainable future (more at suserproject.org).

2.2. Paper Concept: Research Design

The research design is established in line with the overall concept and context of the sUser project, which aims to establish a two-fold innovation: 1) in a *thematic sense* through research on housing for the elderly, and 2) in a *methodological sense* through testing innovative research tools in the educational process. The primary focus is on testing and applying visual thinking tools to enhance understanding of architectural design tailored to the needs of the elderly population. The methodological approach involves a multi-stage process that merges thematic research on housing for the elderly with the systematic use of visual tools across four distinct design approaches: user-driven design, systems thinking, eco-design, and agile methodologies.

The analyses employed in the manuscript are performed through qualitative research on visual methodologies, focusing on how 4 sUser design approaches and their corresponding tools could contribute to the development of age-inclusive housing. In writing the manuscript and collecting visual tools for each of the four design approaches, the following methods were employed to ensure a structured and comprehensive analysis:

- *Literature Review and Conceptual Framework Development*: The first step involved conducting a thorough literature review on existing research, methodologies, and best practices in housing design for the elderly. This helped define the key characteristics and objectives of each design approach. From this review, a conceptual framework was developed to guide the selection of appropriate visual tools for each approach, ensuring they aligned with the needs of elderly housing design.
- *Selection of Visual Tools*: This step was guided by the need to identify tools that not only visualize different aspects of the design process but also address the specific challenges of creating housing environments for elderly populations. The identified visual tools were distributed among 4 sUser design approaches to demonstrate how different tools can enhance the functionality of housing for the elderly.
- *Tool Evaluation and Comparative Analysis*: The third step involved evaluation of the effectiveness of the selected visual tools for each of the four design approaches in the context of elderly housing design. This comparative analysis provided insights into the strengths and limitations of each approach and tool, helping to refine the manuscript's recommendations for integrating these methodologies in future age-inclusive housing design.

3. Results and Discussion

The employed analyses focus on evaluating and integrating visual thinking tools within the framework of age-inclusive housing design. These analyses are structured around four distinct design approaches, each with its own set of visual tools and methodologies. Below is a description of the analyses employed. This study presents the relationship between visual thinking and 4 design approaches: user-driven, system thinking, eco-design, and agile methodologies.

3.1. User-Driven Design: Empowering Elderly Housing through Visual Tools

User-driven design is essential in addressing the specific needs of elderly housing (Architects' Council of Europe, 2022; Housing Europe, 2021; European Commission, 2020; Architects' Council of Europe, 2019a; Architects' Council of Europe, 2018; The European Committee of the Regions, 2018), ensuring that design decisions reflect the experiences, preferences, and challenges of the target users. In this sense, visual tools are crucial in facilitating this design approach by enabling practitioners to empathize with the elderly, anticipate their interactions with the space, and incorporate their feedback effectively. Accordingly, a poll of visual tools with different roles could be engaged to articulate the application of a user-centered approach. *User Journey Maps* (Endman & Keßner, 2016) are particularly useful in this context, as they chart the elderly user's experience and interactions within the housing environment. By mapping out daily routines and identifying pain points, these tools help architects understand how elderly residents will move through and use the space. *Personas* (Faily & Flechais, 2011) further enhance this understanding by creating fictional but representative characters embodying

different elderly users. These personas include detailed information on their behaviors, mobility challenges, and goals, allowing the design team to consider the diversity of needs in elderly housing. *Affinity Diagrams* (Schatz et al. 2022) and *Empathy Maps* (Ferreira et al. 2015) are also critical in collecting and synthesizing insights from user research. Affinity diagrams help organize ideas and observations gathered from interviews or surveys with elderly individuals, highlighting key themes such as safety, comfort, or ease of use. On the other hand, empathy maps capture users' feelings, thoughts, and experiences, giving the design team deeper insights into emotional needs. *Safety Diagrams* and *Accessibility Diagrams* (Evans, 2009) take this one step further by visualizing how the space accommodates safety and accessibility requirements essential for elderly populations. Safety diagrams can highlight areas where handrails, emergency exits, or well-lit paths are necessary, while Accessibility diagrams map how the design accommodates wheelchairs, walkers, and other mobility aids. By integrating these visual tools, the user-driven design approach ensures that housing for the elderly is empathetic, functional, and responsive to its residents' unique needs. Table 3.1 provides a broader list of visual tools with associated roles and applications in User-Driven Design.

Table 3.1. A broader list of visual tools with associated roles and applications in User-Driven Design

Tools Titles	**Roles and Applications**
User Journey Maps	User's experience and interactions within space.
Personas	Fictional characters; different types of users and their needs, behaviors, and goals.
Bubble Diagrams	Spatial relationships and functional zones.
Flow Diagrams	Movement of people and services within space.
Affinity Diagrams	Ideas and insights gathered from user research.
Scenario Planning	Narratives of how different user personas will interact with the space.
Site Analysis Diagrams	Physical context and environmental factors of the site.
Heat Maps	Visualize areas of high and low activity within the space.
Empathy Maps	Capture user feelings, thoughts, and experiences in relation to the space.
Accessibility Diagrams	How spaces accommodate mobility aids like wheelchairs and walkers.
Safety Diagrams	Highlighting safety features such as handrails, non-slip surfaces, and emergency exits.

3.2. Systems Thinking: Visualizing Interconnectedness in Elderly Housing Design

Systems thinking offers a holistic approach to housing design for the elderly (Architects' Council of Europe, 2019; Architects' Council of Europe, 2013) by focusing on the interrelationships between various building components and their environment. Visual tools in this approach help designers manage the complexity of these interactions, ensuring that the housing system functions efficiently while catering to the elderly's specific needs. *Systems Diagrams* (Jun, Kim, & Lee, 2011) are fundamental in systems thinking, as they provide a comprehensive overview of the components involved in elderly housing and how they interact and provide insight into a holistic context. Within the scope of housing for the elderly, such a map might visualize the relationship between heating, ventilation, and air conditioning systems, the residents' health needs, and external environmental factors. By identifying these interdependencies, designers can optimize the building's systems to ensure thermal comfort, indoor air quality, and energy efficiency—all critical for the well-being of elderly residents. *Causal Loop Diagrams* (Bala et al. 2017) further enhance this understanding by showing cause-and-effect relationships within the system. By understanding these relationships, designers can prioritize affordable solutions that reduce both environmental impact and operational costs, making housing more sustainable for elderly populations. *Universal Design Diagrams* (Null, 2013) are another crucial tool in systems thinking, particularly in elderly housing, where inclusivity is crucial. These diagrams visualize how various spaces within the housing complex—such as areas for daily and social activities, as well as private spaces and areas for nighttime activities — adhere to universal design principles, ensuring they are accessible to elderly individuals of all abilities. Additionally, *Stock-and-Flow Diagrams* (Bureš et al. 2020) are instrumental in managing resources such as energy, water, and materials within elderly housing. By visualizing the stocks (resources available) and flows (how these resources are used or replenished), designers can make informed decisions about resource allocation. By utilizing these visual tools, systems thinking allows for a more integrated, efficient, and sustainable approach to elderly housing design, ensuring that all components work together to enhance the residents' quality of life. Table 3.2 provides a broader list of visual tools with associated roles and applications in Systems Thinking.

Table 3.2. A broader list of visual tools with associated roles and applications in Systems Thinking

Tools Titles	Roles and Applications
Systems Maps	Components and their interactions within the architectural system.
Causal Loop Diagrams	Cause-and-effect relationships within the system.
Stock-and-Flow Diagrams	Stocks (resources) and flows (changes in resources) within the system.
Integration Diagrams	How different building systems integrate and work together.
Network Diagrams	Connections and dependencies between different elements of the building and its environment.
Scenario Planning Diagrams	Different future scenarios and their impact on the building system.
Functional Flow Block Diagrams	Functional relationships and flow of information or resources between system components.
Universal Design Diagrams	How spaces incorporate universal design principles to accommodate users with diverse abilities and ages.

3.3. Eco-Design: Visualizing Sustainability in Elderly Housing

Eco-design focuses on minimizing the environmental impact of housing projects by incorporating sustainability into every phase of the design process (Architects' Council of Europe, 2019; UN Nations, 2015, Housing Europe, 2012). This approach is especially important as it ensures that housing for the elderly is not only comfortable and accessible but also environmentally responsible. *Life Cycle Assessment (LCA) Diagrams* (Kiss & Szalay, 2019) are central to eco-design, as they visualize the environmental impact of a building throughout its entire lifecycle—from material extraction to construction, operation, and eventual demolition. For elderly housing, these diagrams can help identify materials or systems that have a lower environmental footprint while ensuring durability and safety. *Energy Flow Diagrams* (Suarez, 2022) are also crucial, as they map the sources, consumption, and distribution of energy within the building. In elderly housing, where temperature control is vital, such diagrams can highlight opportunities for integrating renewable energy sources. These tools help designers create buildings that are not only energy-efficient but also provide a healthier indoor environment for elderly residents. *Material Flow Diagrams* (Banerjee, Syal, & Hastak, 2006) offer similar benefits by mapping the flow of materials through the construction, renovation, and maintenance phases of the building's life. For elderly housing, these diagrams ensure that materials chosen for construction or renovation are sustainable, durable, and non-toxic, reducing the need for frequent maintenance and minimizing disruption for elderly residents. *Passive Design Strategies Diagrams* (Belmonte et al. 2021; Ganem-Karlen, & Barea-Paci, 2023) further support eco-design by visualizing strategies that reduce energy use without relying on mechanical systems. These might include the placement of windows to maximize natural light, the use of shading devices to prevent overheating, or the strategic orientation of the building to take advantage of prevailing winds for natural ventilation. For elderly housing, these passive design elements can create more comfortable living conditions while reducing energy consumption. Incorporating these visual tools into the eco-design process ensures that elderly housing is not only environmentally sustainable but also resilient, cost-effective, and comfortable for its residents. Table 3.3 provides a broader list of visual tools with associated roles and applications in Eco-Design.

Table 3.3. A broader list of visual tools with associated roles and applications in Eco-Design

Tools Titles	Roles and Applications
Energy Flow Diagrams	Mapping energy sources, consumption, and distribution within the building.
Environmental Impact Diagrams	Environmental impact of the building throughout its lifecycle.
Life Cycle Assessment (LCA) Diagrams	Environmental impact of a building throughout its entire lifecycle, from material extraction to construction, operation, and end-of-life.
Material Flow Diagrams	Flow of materials used in construction, renovation, maintenance, and demolition phases.
Renewable Energy Integration Diagrams	Integration of renewable energy sources into the building's energy system.
Daylighting Analysis Diagrams	Natural daylight penetration and distribution within the building.
Passive Design Strategies Diagrams	Passive design strategies that minimize energy use for heating, cooling, and ventilation.
Sustainability Scorecards	Communicate the overall sustainability performance of the building.

3.4. Agile Methods: Enhancing Flexibility and Collaboration in Elderly Housing Design

Agile methods prioritize flexibility (Housing Europe, 2012), collaboration (Architects' Council of Europe, 2022; Housing Europe, 2021; Architects' Council of Europe, 2016; UN Nations, 2015a), and continuous feedback throughout the design process. In the context of elderly housing, this approach ensures that design solutions can be quickly adapted to meet the evolving needs of the elderly population. Visual tools in agile methods facilitate communication among team members, stakeholders, and end users, while also ensuring that design progress is continuously monitored and refined. *User Story Mapping* (Molden, 2020) is a key visual tool in agile methods, particularly useful for aligning design features with the needs and expectations of elderly residents. This tool helps break down the design process into smaller, manageable increments; each focused on addressing a specific user need or improving a particular aspect of the housing environment. *Step-by-step diagrams* (Vidler, 2000) visualize the project's development and show how the design evolves over multiple iterations. In elderly housing, these diagrams allow the team to test and refine design solutions, such as adjusting the layout of communal spaces to suit better social interaction or tweaking room configurations to enhance accessibility (Architects' Council of Europe, 2019; Ministers Responsible for Urban Matters, 2016; UN Nations, 2016; Housing Europe, 2012). This iterative process ensures that the final design is functional and meets the specific needs of elderly residents. *Collaborative Design Diagrams* foster teamwork and communication among the design team, stakeholders, and users. In elderly housing projects, these diagrams facilitate discussions on critical issues such as safety, accessibility, and sustainability, ensuring that all perspectives are considered (Architects' Council of Europe, 2016; UN Nations, 2016; Housing Europe, 2012). They also help to maintain alignment between the project's goals and the needs of elderly residents, particularly when multiple stakeholders are involved. Finally, *Feedback Loop Diagrams* are a crucial visual tool in agile methods, highlighting the importance of continuous feedback throughout the design process. In elderly housing, this feedback can come from various sources, including elderly residents, caregivers, and healthcare professionals (Architects' Council of Europe, 2016; UN Nations, 2016; UN Nations, 2015a; Housing Europe, 2012). By visualizing these feedback loops, the design team can ensure that any issues—such as accessibility challenges or safety concerns—are quickly identified and addressed, resulting in a housing environment that is both functional and user-friendly. Through these visual tools, agile methods provide a flexible, collaborative, and user-centered approach to designing elderly housing, ensuring that the final product is both adaptable and responsive to the unique needs of its residents. Table 3.3 provides a broader list of visual tools with associated roles and applications.

Table 3.4. A broader list of visual tools with associated roles and applications in Agile Methods

Tools Titles	**Roles and Applications**
User Story Mapping	Architectural requirements and design features from the user's perspective.
Incremental Design Diagram	Visualize the incremental development and refinement of architectural designs over multiple iterations.
Visualization Diagrams	Visual representations of architectural concepts, design ideas, and project milestones.
Collaborative Design Diagram	Foster teamwork, communication, and collaboration among architectural team members and project stakeholders.
Feedback Loop Diagram	Continuous feedback loops with clients, stakeholders, and end users throughout the architectural project lifecycle.

4. Discussion

In summary, the visual tools across these four approaches complement each other by addressing different aspects of elderly housing design. For each approach, distinct tools and methodologies are employed to address different facets of architectural design.

User-driven design emphasizes empathy and direct engagement with users. It excels at tailoring environments to users' specific needs and relies heavily on personalization. This approach is particularly effective in elderly housing design, where visualizations are used to map out users' daily interactions and anticipate challenges, leading to more functional, inclusive spaces. The user-driven approach aligns closely with human-centered design principles and provides a deep understanding of individual needs, essential for creating environments that enhance comfort, safety, and accessibility for elderly residents.

Systems thinking provides a holistic understanding of how different systems within the building interact, ensuring efficient operation and comfort with a focus on managing complexity and interrelationships. In elderly housing design, systems thinking helps ensure that buildings operate efficiently while maintaining comfort and safety. This approach contrasts with the user-driven method by focusing less on the individual user and more on the overall system's functionality, ensuring that different building systems work harmoniously.

Eco-design prioritizes sustainability and emphasizes improving living conditions while reducing operational costs and environmental degradation. It diverges from user-driven design and systems thinking by placing sustainability at the forefront, considering not only the comfort of residents but also the broader ecological implications of architectural decisions.
Agile methodologies ensure flexibility and encourage iterative development and collaboration. This approach stands apart from the above-mentioned by promoting adaptability and real-time stakeholder engagement, making it ideal for projects requiring rapid adjustments based on user feedback. In contrast to the rigid, long-term focus of eco-design or systems thinking, agile methodologies allow for continuous improvement, ensuring that design solutions remain relevant and user-focused throughout the project's lifecycle.

5. Concluding Remarks and Future Directions

Integrating visual tools across these approaches allows architects to address the complexity of elderly housing design by balancing user needs, functionality, system efficiency, sustainability, and flexibility. Understanding the distinct yet interconnected roles of these approaches can guide more holistic and innovative solutions. Expanding participatory design practices within user-driven approaches could offer deeper engagement of elderly users in co-creating their environments. This paper presents a methodological framework proposing a set of approaches and demonstrates their application in the context of housing for the elderly. The same protocol can be applied to other typologies - spaces of different programs and scales, indoor or outdoor – with a slight adaptation to specific values and contextual indicators important for a particular typology.
Further research direction should also explore the long-term impacts of eco-design on elderly housing, particularly in relation to health outcomes, operational efficiency, and aging-in-place strategies. Additionally, agile methodologies could be adapted for retrofitting existing elderly housing, allowing for continuous improvement and rapid adaptation to residents' evolving needs. Finally, interdisciplinary collaboration between architects, healthcare professionals, urban planners, and policymakers should be further explored. This collaboration could foster frameworks for improving housing standards and informing policy development that better supports the elderly.

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