Understanding the Effects of Climate Information on Crowdsourced Schoolyard Design: A Study of Design Reasoning and Choices

By

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Abstract

Crowdsourcing has emerged as a valuable mechanism for capturing public preferences and attitudes, offering crucial insights for planning and design practice. While this approach has been extensively implemented at the urban scale, its effective application at the site scale urban greening remains largely unexplored. As communities increasingly confront climate change impacts, there is a strong need to adapt existing community spaces for enhanced resilience. This study examines how exposure to climate change information influences design decisions and reasoning in crowdsourced schoolyard design through Land.info, a Unity-based decision support system. Using a between-subjects experimental design, we provided one group of participants (n=97) with detailed climate impact projections for a southeast Michigan school, while the control group (n=90) received only basic site information before engaging in the design process. Our analysis reveals that while tool engagement patterns were comparable between groups, access to climate information produced distinct differences in design reasoning and object selection. Participants exposed to climate-related information prioritized environmental considerations and user comfort, incorporating higher proportions of vegetation and play equipment in their designs. Conversely, participants without climate information emphasized aesthetic quality and functional organization, favoring furniture and paving elements, characteristic of traditional schoolyard layouts. Notably, both groups maintained consistent inclusion of vegetation and demonstrated strong consideration for safety and visual appeal, suggesting that climate information integration enhances design thinking while preserving fundamental site planning priorities. These insights provide valuable direction for developing climate-informed crowdsourcing tools and facilitating meaningful public engagement in designing resilient community spaces.

Chapter 1 Introduction

Cities worldwide are facing escalating challenges driven by rapid urbanization, climate change, and social inequities (Buhaug & Urdal, 2013). Urban resilience has emerged as a critical framework for addressing these pressures—encompassing the capacity of urban systems to maintain essential functions amidst disturbances, adapt to evolving conditions, and transform restrictive systems to enhance future adaptability (Ribeiro & Pena Jardim Gonçalves, 2019). Achieving resilience requires a paradigm shift in urban ecosystems, recognizing cities as integral components of broader ecological networks (Ahern, 2013). To advance these goals, planners and designers employ green infrastructure and enhance greenspaces to create multifunctional urban landscapes (Elmqvist et al., 2015). Central to this approach is the concept of "nature near home," which emphasizes the importance of accessible greenspaces close to where people live (Ekkel & de Vries, 2017). These spaces provide diverse ecosystem services, including climate mitigation (e.g., carbon sequestration, urban cooling) and adaptation (e.g., flood control). Beyond their ecological benefits, greenspaces foster meaningful human-nature interactions, promoting mental health, social cohesion, and active lifestyles (Patino et al., 2023; Taylor & Hochuli, 2015), while also enhancing human health and well-being (Carrus et al., 2017; Standish et al., 2013). These spaces represent microcosms of urban resilience, where localized interventions amplify city-wide adaptability (Archer et al., 2014).

Realizing these initiatives presents significant challenges. Traditional urban greenspaces are often conceived as isolated units (Rey Gozalo et al., 2019), disconnected from broader ecological networks, while considerable resistance exists toward adopting more active ecological management techniques that could transform urban-nature relationships (Ershad Sarabi et al.,

2019). These challenges are compounded by governance structures that typically employ top-down processes, prioritizing bureaucratic expertise over input from communities who regularly use these spaces (Carmichael & McDonough, 2018). This exclusion of community perspectives has created several barriers to acceptance, including persistent distrust in municipal authorities, resistance to planners' recommendations, and concerns about personal safety and crime in greenspaces (Soto et al., 2018; Weber et al., 2017). The imperative of climate adaptation further amplifies these challenges. Future resilience depends not only on ecological transformations but also on social change, shifts in cultural norms, adaptive learning, and reaching social tipping points that fundamentally reshape urban-nature relationships (Otto et al., 2020). Moreover, acknowledging and incorporating cultural and provisioning ecosystem services—often overlooked by planners—can foster more socially acceptable, context-sensitive green spaces (McLain et al., 2014; van Berkel & Verburg, 2014).

Within this complex urban landscape, educational environments, such as schoolyards, are particularly significant as they serve as learning spaces and critical community hubs (Alemán & Lorena, 2023; Chawla, 2015; Dyment & Bell, 2008). Traditionally considered educational spaces, schoolyards now double as opportunities for urban greening and social integration. Greening these spaces yields numerous co-benefits, including reduced urban heat islands, improved stormwater management, enhanced air quality, and bolstered community cohesion (Flax et al., 2020; Ruiz-Mallén et al., 2023). These sites can model how local interventions advance systemic resilience and sustainability when integrated into broader urban landscapes. The concept of schoolyards as learning landscapes introduces a multidimensional role for these spaces—merging education, ecological design, and community engagement. By embedding sustainable practices such as native planting and nature-based play into daily schoolyard

activities, these spaces foster environmental stewardship among younger generations while reinforcing connections to nature (Moore & Cooper, 2014; Sabır Onat & Yirmibeşoğlu, 2022). However, the challenges of urban greening also extend to schoolyards. Schoolyard greening initiatives can face barriers such as limited funding opportunities for their improvement (van Dijk-Wesselius et al., 2020), distrust in the governing bodies responsible for implementing changes (Brink & Yost, 2004; Lopez et al., 2008), a lack of buy-in from critical stakeholders like parents, teachers, and local communities (Danks, 2010), and concerns over personal safety, including fears about crime spillover. These efforts could often be further constrained by top-down planning approaches that fail to incorporate the voices and values of the school community.

While these challenges require systemic solutions, effectively bridging the gap between city-wide initiatives and site-specific interventions remains crucial. Crowdsourcing has emerged as a transformative approach in design and urban planning, enabling practitioners to harness the collective intelligence of the public to inform and enhance decision-making processes (Brabham, 2009; Seltzer & Mahmoudi, 2013) and to understand public preferences and attitudes (Afzalan & Muller, 2018; Goodchild, 2007). By leveraging diverse perspectives, crowdsourcing can lead to more inclusive, innovative, and context-sensitive solutions that reflect the needs and preferences of communities (Surowiecki, 2005). In environmental planning, public engagement through crowdsourcing has been instrumental in addressing complex challenges in urban sustainability, resource management, and climate adaptation (Goodchild, 2007; Reed, 2008). While crowdsourcing has been widely applied at the urban scale—for instance, in large-scale mapping projects or city-wide sustainability initiatives (Certomà et al., 2015; Crooks et al., 2015; Mueller et al., 2018)—there remains limited understanding of how to effectively engage the public in

design processes at the site scale (Fox et al., 2022; Lindquist & Campbell-Arvai, 2021). Site-scale projects, such as redesigning a schoolyard, present unique challenges and opportunities for crowdsourcing design. These projects require more detailed and context-specific input, yet the impact of such input and design outcomes at this level are poorly understood.

Interactive Decision Support Tools (DSTs) offer promising approaches for addressing these challenges through inclusive landscape-level collaborative planning and design processes. These tools can facilitate the co-production of design solutions while increasing multifunctionality by incorporating community-identified values and uses in the configuration of urban greenspaces (Fischer & Eastwood, 2016). Land.Info (Figure 01) (Lindquist & Campbell-Arvai, 2021) exemplifies this approach, using video game technology to place users virtually within their community and enable participatory landscape design. The platform's 3D visualization provides an intuitive method to explore spatial designs while offering real-time multicriteria feedback based on design decisions (Campbell-Arvai & Lindquist, 2021).

While DSTs like Land.Info show promise for co-creating greenspace, there remains a limited understanding of how context-specific information influences public engagement and design decisions. Previous research has demonstrated that information provision can significantly impact environmental decision-making processes. For instance, (Campbell-Arvai et al., 2024) found that providing ecosystem service information affected individuals' tree selection preferences in virtual urban parks, with participants making significantly different choices when given functional information compared to those without such information. In the absence of functional information, users tended to rely heavily on visually salient characteristics and aesthetic preferences when making their design decisions. However, a critical gap remains in

understanding how exposure to climate change information—particularly when provided as external context rather than in-game feedback—affects public engagement patterns, design choices, and design reasoning at the site scale, especially in educational settings. While research has examined how information provision influences discrete choices such as tree selection, less is known about how it shapes more complex design decisions that involve multiple elements and their spatial relationships.

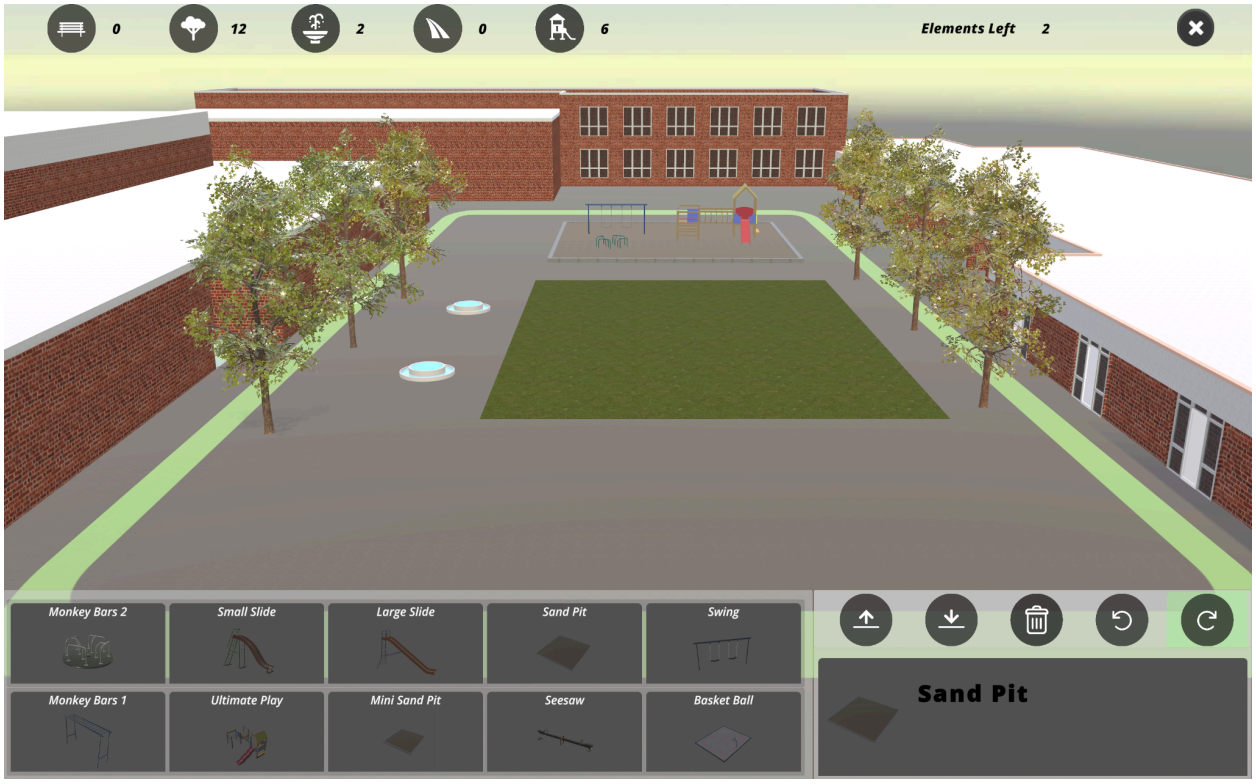


Figure 01: Land.Info Decision support Tool (DST) Interface

This exploratory study investigates how the provision of climate change information influences design choices and reasoning in a crowdsourced schoolyard design task. We engaged participants in designing a virtual schoolyard in southeast Michigan through Land.Info DST for interactive landscape design. Using a between-subjects experimental design, we compared

design choices and rationales between participants who received climate impact projections and those who received only basic site information, examining how contextual information shapes design priorities and decision-making processes. Our research provides empirical evidence on how information provision affects public engagement with interactive decision support tools in urban greening projects, particularly for schoolyard environments where stakeholder engagement remains challenging. Through this investigation, we address two fundamental research questions:

1. How does the provision of climate change information affect participants' design reasoning in a schoolyard design task?

We anticipate that participants exposed to climate information will incorporate more climate-related considerations in their design reasoning, focusing on elements that address environmental challenges. In contrast, we expect participants without climate information will emphasize traditional schoolyard design considerations such as functionality and aesthetics.

2. In what ways does climate information influence the selection of design elements (design choice) in a schoolyard design task?

We expect participants receiving climate information will incorporate more climate-adaptive elements in their designs, particularly increased vegetation and features that help mitigate climate risks. We anticipate that the design choices between the climate information and no-climate information groups will show distinct patterns, with the latter group focusing more on conventional schoolyard elements.

Chapter 2 Methods

2.1 Participants

We recruited 201 participants through CloudResearch Prime Panels using demographic quotas to ensure representation aligned with U.S. census demographics. The initial sample included 105 participants in the climate information group and 96 in the control group. After removing duplicate records, the final analytical sample comprised 187 participants (97 in the climate information group and 90 in the control group).

To verify representative sampling and account for potential influences on design choices, we collected participant demographics, including gender, age ranges, race/ethnicity, education level, and annual household income. We also recorded computing platform (desktop/laptop, PC/Mac) to account for technology-related variations in user experience. Descriptive analyses compared distributions between experimental groups to identify any sampling biases.

2.2 Material

2.2.1 Online Video Game based Decision support Tool (DST): Land.info

The delivery of the interactive 3D design environment used a modified version of Land.info, a Unity-based decision support tool developed collaboratively with Detroit residents (Lindquist & Campbell-Arvai, 2021). This application served as the primary tool for this site-level landscape design and crowdsourcing. While the platform typically offers information about available design objects for aided decision-making, we disabled this feature for the experiment, allowing participants to make unaided selections from the object library.

The core environment featured a 3D school model created in SketchUp based on photogrammetric measurements of the real-world site. We optimized the model with minimal polygons and HD textures to ensure smooth performance. Additional design objects were sourced from the Fantastic City Generator, SketchUp Warehouse, and custom-created models. The application was made accessible through web browsers (Google Chrome and Microsoft Edge) using WebGL (a technology that enables 3D graphics on websites without requiring additional software installation). The application collected user interaction data through standardized web communication protocols (REST API) and stored it in Firebase, a cloud-based database service.

2.2.2 School Orientation Video.

The control group watched a thirty second orientation video (link) that offered a basic overview of the school site, featuring drone imagery and a neutral narrative about the physical space. This video was created with Adobe Premiere Pro and voiced through Amazon Polly, an online voice-generation tool that converts text to speech.

2.2.3 Climate information Video

For the climate information group, we developed a two-minute and forty-five-second video (link) that combined drone footage of the school site with royalty-free content sourced from Pexels and Pixabay. The video was created in Adobe Premiere Pro, and the narrative was voiced using Amazon Polly. It drew from Great Lakes Integrated Sciences and Assessments (GLISA) climate scenarios (*Future Climate Scenarios for Great Lakes Cities | GLISA*, n.d.) to explain how flooding, drought, and heat could impact the schoolyard environment.

2.3 Procedure

We conducted the experiment through Qualtrics survey platform, using CloudResearch for participant recruitment. The experimental protocols remained identical for both groups, differing only in the video content they viewed. The groups were set up in CloudResearch to be mutually exclusive, participants were restricted to only participating in one group. The first group watched a climate information video with a required minimum viewing time of two minutes, while the second group viewed a school orientation video with a required minimum viewing time of 20 seconds. These minimum viewing times were implemented to ensure participants were adequately engaged with their respective video content before proceeding to the design phase.

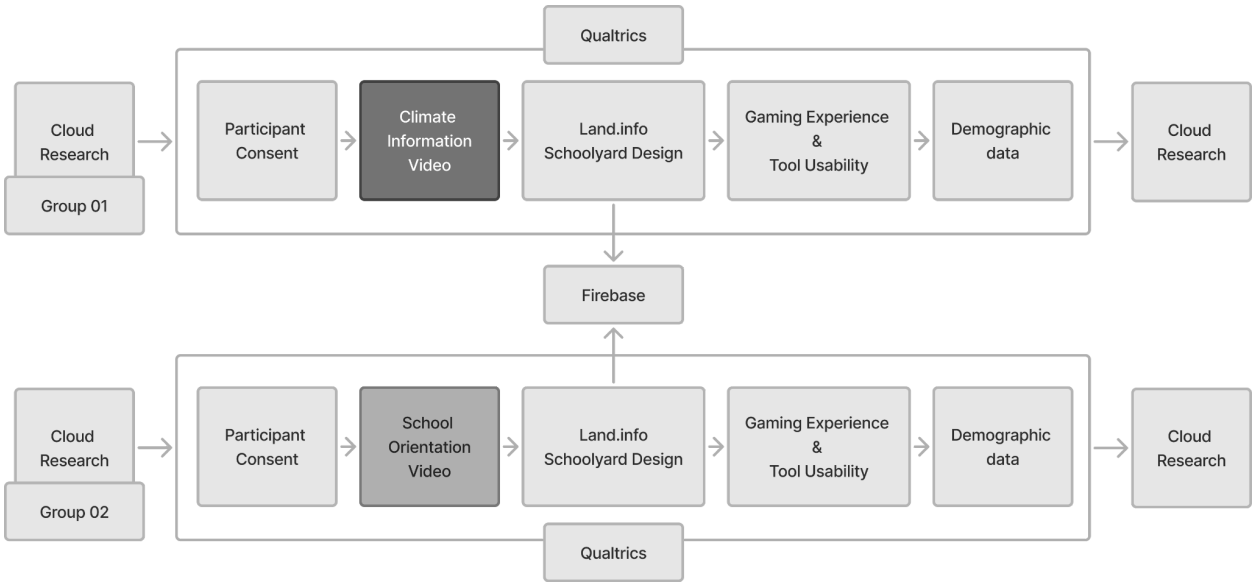


Figure 02: Overview of the experimental setup and survey elements.

Following the Information consent and the respective video, participants were introduced to Land.info for the schoolyard design task. We provided comprehensive instructions on the interface and functionality, including navigation controls, object placement, and deletion tools,

and changing the perspective option from the default bird's-eye view. The experimental setup and survey elements are outlined in Figure 02.

The design interface offered 50 objects across five categories (Appendix A): Vegetation (12 options), Paving (10), Furniture (10), Site Props (8), and Play Equipment (10). Participants could incorporate up to 20 objects in their design. While we required a minimum engagement time of one minute with the design tool, participants were encouraged to take additional time if desired. An exit option appeared in the top right corner after the one-minute threshold. Upon completion of the design phase, all interaction data was automatically transmitted to Firebase for storage. Participants then completed a post-design questionnaire covering their design rationale, software usability assessment, gaming experience and proficiency, and demographic information.

2.4 Data Analysis

Data processing and analysis tasks were conducted using R version 2024.09.0+375. The Final dataset encompassed multiple data attributes, outlined in figure 03.

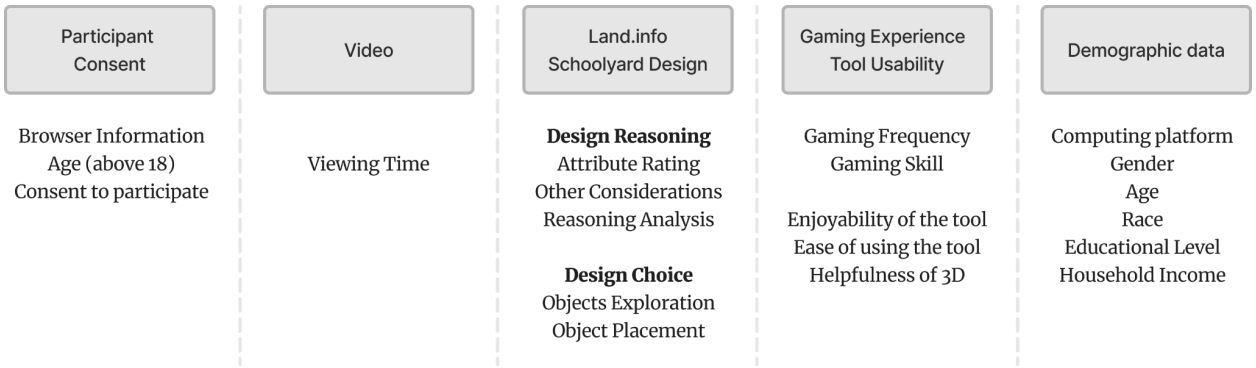


Figure 03: Overview of the data collected.

2.4.1 Participant Demographic and Gaming experience

We assessed the collected demographic data using descriptive statistics and compared distributions between experimental groups to account for sampling biases. The demographic data is presented in the results section.

Given the tool's game-like interface, we evaluated participants' gaming backgrounds using two four-point scales that measured gaming frequency (Never to Frequently) and self-reported proficiency (Beginner to Expert). These measures were chosen to understand the tool's general accessibility and how prior gaming experience might influence participants' interaction with the platform.

2.4.2 Design reasoning

Our analysis of participants' design reasoning combined quantitative and qualitative approaches to explore how climate information influenced design decisions.

Participants rated eight key attributes (Dry Weather, Hot Days, Flooding, Safe for Kids, Sit and Relax, Outdoor Learning, Physical Activities, and Visual Appeal) on a four-point Likert scale, responding to how frequently they considered each attribute during the design process ("Never" [1] to "Always" [4]). For the eight attributes, Shapiro-Wilk tests indicated non-normal distributions ($p < 0.001$), while Levene's tests confirmed the homogeneity of variance ($p > 0.05$). Based on the data characteristics, we employed Mann-Whitney U tests to analyze between-group differences, with significance set at $p < 0.05$.

We incorporated two open-ended questions in the survey to further examine participants' design reasoning. The first question probed for additional design considerations beyond the rated attributes: "What are some other things you thought about when designing the schoolyard that

were not mentioned previously? Feel free to share any extra ideas that helped you design the schoolyard." This question aimed to capture broader design thinking and unanticipated factors that influenced participants' choices. The second question focused on specific design rationales by presenting participants with their selections: "Here is a list of the landscape elements you placed in your schoolyard design: [list of objects]. Briefly, using your own words and complete sentences, tell us why you chose these particular objects." This question allowed participants to reflect directly on their design choices while providing context for their decisions.

We implemented a structured qualitative analysis approach to examine these responses systematically. To minimize analytical bias, we first compiled responses from both groups into separate files for each question and randomized their order. The initial identification of themes employed Claude 3.5 Sonnet, an AI chatbot that can analyze written text, to generate preliminary themes and subthemes from the compiled responses (Appendix B). Following this analysis, our research team reviewed the identified themes and participant responses to verify thematic appropriateness. We then analyzed the distribution of themes and sub-themes between groups alongside word count and completion rates.

2.4.3 Design Choice

The Land.info application captured three distinct types of interaction data: participants' exploration of available objects (object exploration), their implementation of specific objects by placing them on the site (object placement), and their modification decisions (deletion data). This comprehensive data collection allowed us to examine how participants explored design options and ultimately implemented their choices.

We focused our analysis on two fundamental aspects of participant behavior: exploration patterns (object exploration) and design implementation (object placement). To assess overall engagement, we first compared the total number of objects viewed and objects placed on the site between the climate information and control groups using Mann-Whitney U tests, as these data did not meet normality assumptions.

To understand more nuanced patterns in exploration and implementation, we examined participants' interactions across all five design object categories: vegetation, play equipment, furniture, paving, and site props. Using chi-square tests of independence, we evaluated whether exposure to climate information affected participants' exploration and implementation of specific design objects. For the exploration pattern, we analyzed the distribution proportion of object views across categories between the groups. Similarly, for the implementation pattern, we analyzed the distribution proportion of actual objects placed across categories between the groups.

2.4.4 Tool Usability

We assessed participants' interaction with the decision support tool through a post-task questionnaire evaluating multiple user experience dimensions. The questionnaire included three usability metrics rated on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree): enjoyment of use, ease of use, and perceived helpfulness of 3D features.

Chapter 3 Results

3.1 Participant Demographics and Gaming Experience

Our analysis examined the demographic characteristics of the participant sample (Appendix C), consisting of 97 individuals in the climate information group and 90 in the control group. Age distribution showed notable differences between the groups. The climate information group included a larger proportion of mid-career professionals aged 35–49 years (27.8% compared to 20.0% in the control group), whereas the control group had more participants aged 65 or older (25.6% versus 18.6%).

Gender distribution was balanced across both groups; female participants comprised approximately 51%, and male participants accounted for 47–49%. Educational attainment was also similar, with bachelor's degrees being the most common qualification (25.8% in the climate information group and 28.9% in the control group). However, income levels varied more in the control group, which had greater representation at high and low economic extremes. Computing platform use was consistent, with around 52% of participants in both groups reported using laptop PCs.

Gaming background and proficiency were comparable between the groups (Appendix D). Regular gaming engagement was reported by roughly two-thirds of participants in each group (65% in the climate information group and 63% in the control group). Occasional gaming was slightly more common in the climate information group (35% versus 32%), while frequent gaming was marginally higher in the control group (31% versus 29%). Gaming proficiency levels were similar, with casual and intermediate players making up the majority in both groups

(64% in the climate information group and 62% in the control group) and expert gamers representing smaller proportions (14% and 10%, respectively).

3.2 Design Reasoning

3.2.1 Attribute rating

Our analysis of design attributes, which employed Mann-Whitney U tests (Table 1), revealed distinct patterns between the climate information (n=97) and control groups (n=90). The climate information group demonstrated significantly higher consideration of flooding ($W = 5284.0$, $p = 0.009$), with 37.1% reporting they "Often" considered flooding compared to 18.9% in the control group. This difference was further emphasized by the significantly lower proportion of "Never" responses in the climate information group (16.5%) versus the control group (35.6%).

Table 01: Mann-Whitney U test results for design considerations between groups

Attribute	Statistic W	p value	significance
Dry Weather	4360.5	0.9004	ns
Hot Days	4954.5	0.0654	ns
Flooding	5284.0	0.0095	**
Safe for Kids	4708.0	0.3179	ns
Sit and Relax	3724.0	0.0780	ns
Outdoor Learning	4581.0	0.4589	ns
Physical Activities	4201.0	0.6281	ns
Visual Appeal	4384.5	0.9540	ns

While flooding showed the strongest statistically significant difference, other climate-related attributes that did not reach significance revealed interesting patterns. Consideration of extreme heat in their design (i.e., Hot Days) showed a marginally significant trend (W = 4954.5, p = 0.065), though both groups maintained similar median responses of "Often" (median = 3). Dry Weather considerations showed no significant differences between groups (W = 4360.5, p = 0.900).

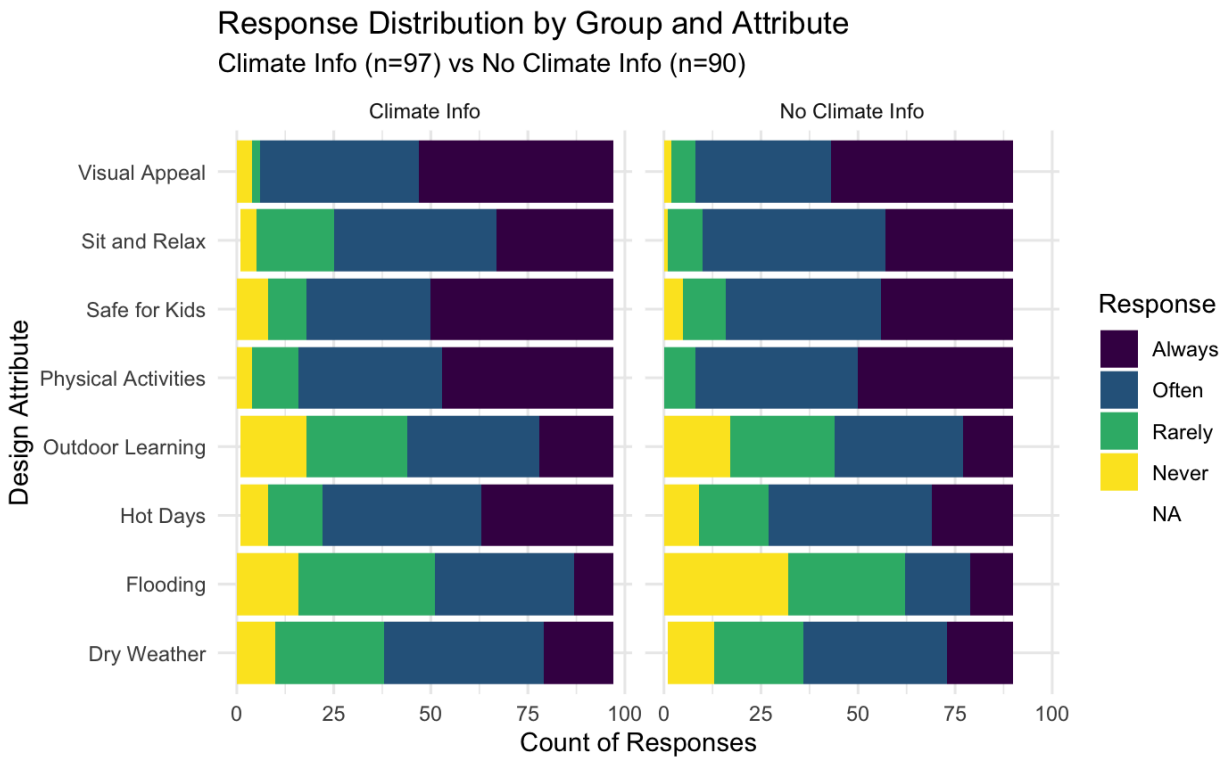


Figure 04: Response distribution by group for different attribute rating

The analysis of non-climate attributes revealed consistent patterns across both groups. Visual Appeal emerged as the most consistently considered design reasoning, with the highest median response (median = 4, "Always") and no significant difference between groups (W = 4384.5, p = 0.954). Other design considerations, including Safe for Kids (W = 4708.0, p =

0.318), Physical Activities (W = 4201.0, p = 0.628), and Outdoor Learning (W = 4581.0, p = 0.459), all showed high consideration levels (median = 3, "Often") across both groups.

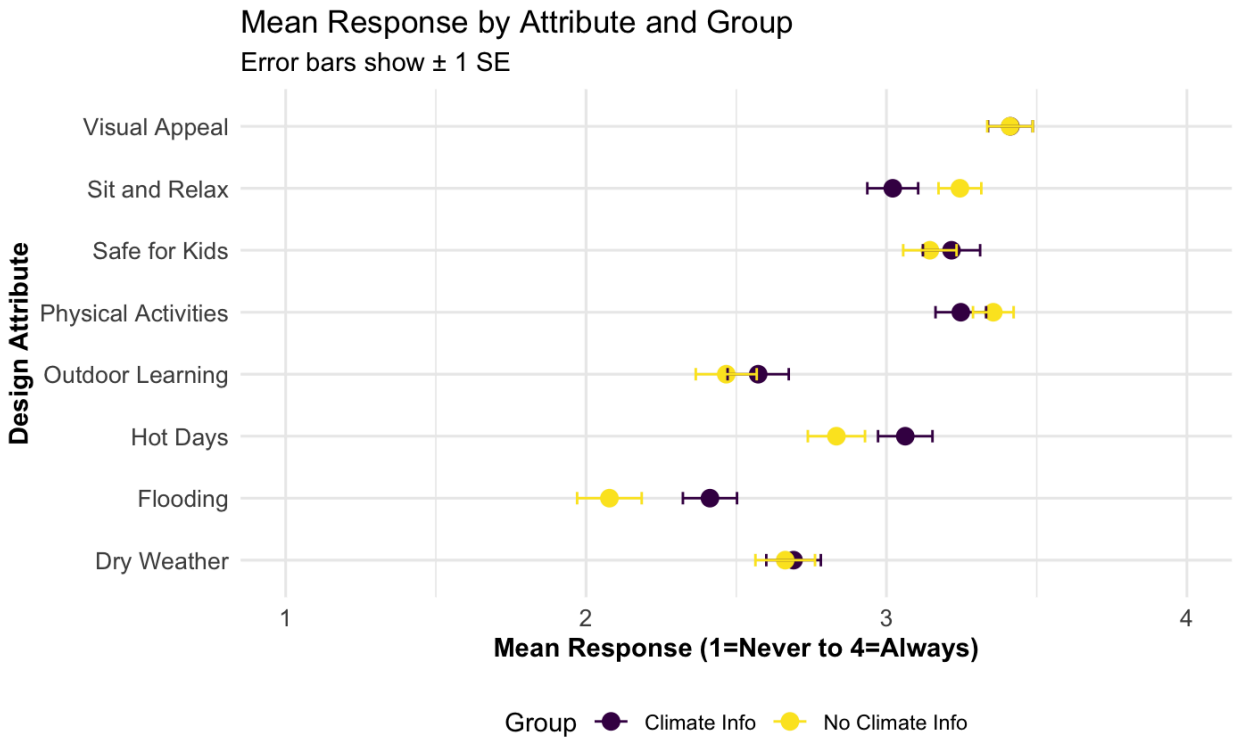


Figure 05: Mean response by group for different attribute rating

3.2.2 Other Design Considerations Analysis

The climate information group provided slightly more concise responses (mean = 10.45 words, median = 8.33, SD = 8.33) compared to the control group (mean = 12.59 words, median = 8.17, SD = 17.57). Both groups showed high engagement, with response rates of 88.7% (86/97) for the climate information group and 92.2% (83/90) for the control group.

The analysis of participants' open-ended responses to other factors that influenced their design revealed interesting similarities and differences in how climate information influenced

design thinking. Both the climate information group and the control group had significant numbers of participants who either had "No Additional Ideas" (climate: 17.4%, control: 19.3%) or mentioned miscellaneous factors categorized as "Other" (climate: 20.9%, control: 22.9%). These categories comprised a large portion of the responses in both groups.

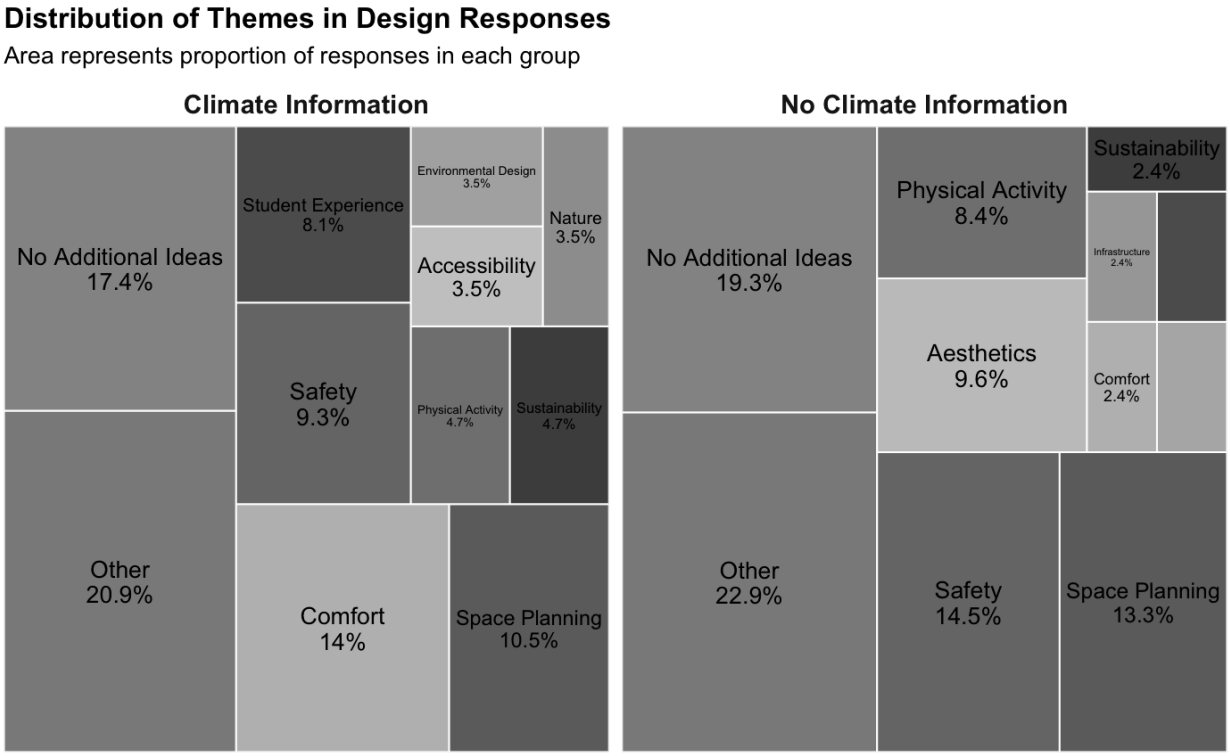


Figure 06: Other consideration themes participants made while designing the schoolyard.

Beyond these commonalities, the thematic analysis (figure 06) revealed notable divergences between groups. The climate information group thought about comfort-related considerations (14.0%), space planning (10.5%), and safety (9.3%), while demonstrating substantial attention to student experience (8.1%) and environmental themes (11.7%). In contrast, the control group emphasized safety (14.5%), space planning (13.3%), and aesthetics as a key theme (9.6%) – notably absent in the climate information group's responses. The control

group placed less emphasis on comfort (2.4%) and showed limited environmental considerations (2.4%) compared to the climate information group. (Subthemes - Appendix E)

3.2.3 Design Choice Reasoning Analysis

The climate information group provided more concise responses (mean = 14.45 words, median = 11, SD = 12.38) compared to the control group (mean = 18.07 words, median = 11, SD = 28.80). Both groups demonstrated strong engagement with the reflection process, achieving high response rates of 95.9% (93/97) and 97.8% (88/90) for the climate information and control groups, respectively.

The thematic analysis highlighted distinct priorities in decision-making (figure XX). The climate information group emphasized user experience (25.8%) and multi-purpose functionality (21.5%) while giving notable attention to environmental factors (15.1%). Their reasoning also incorporated comfort and safety (8.6%) and functionality (4.3%), with aesthetics representing a smaller proportion (6.5%). In contrast, the control group prioritized multi-purpose functionality (36.4%) and gave greater emphasis to aesthetic considerations (10.2%) and functionality (9.1%) compared to the climate information group. While environmental factors (11.4%) were mentioned, they received less focus, and comfort and safety considerations (4.5%) were minimal.

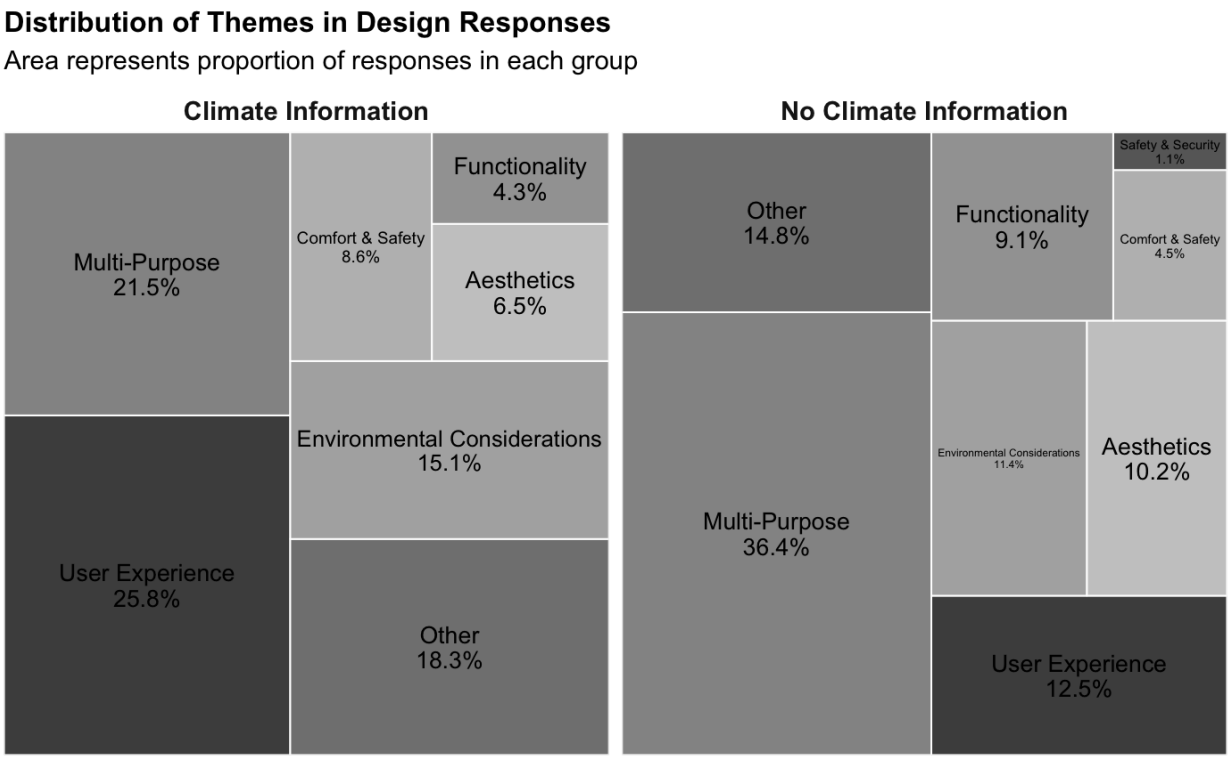


Figure 07: Design reasoning themes for the elements participants placed in the schoolyard

Examining theme-subtheme relationships revealed nuanced differences between the group's rationale(see Figures 2 and 3). The climate information group developed cohesive design rationales by integrating multiple factors, connecting themes like "Natural Elements," "Temperature Management," and "Student Well-being," showcasing environmentally adaptive thinking. In contrast, the control group leaned toward practical and aesthetic considerations, focusing on themes such as "Visual Appeal" and "Activity Zones." Their responses prioritized immediate functionality and aesthetics.

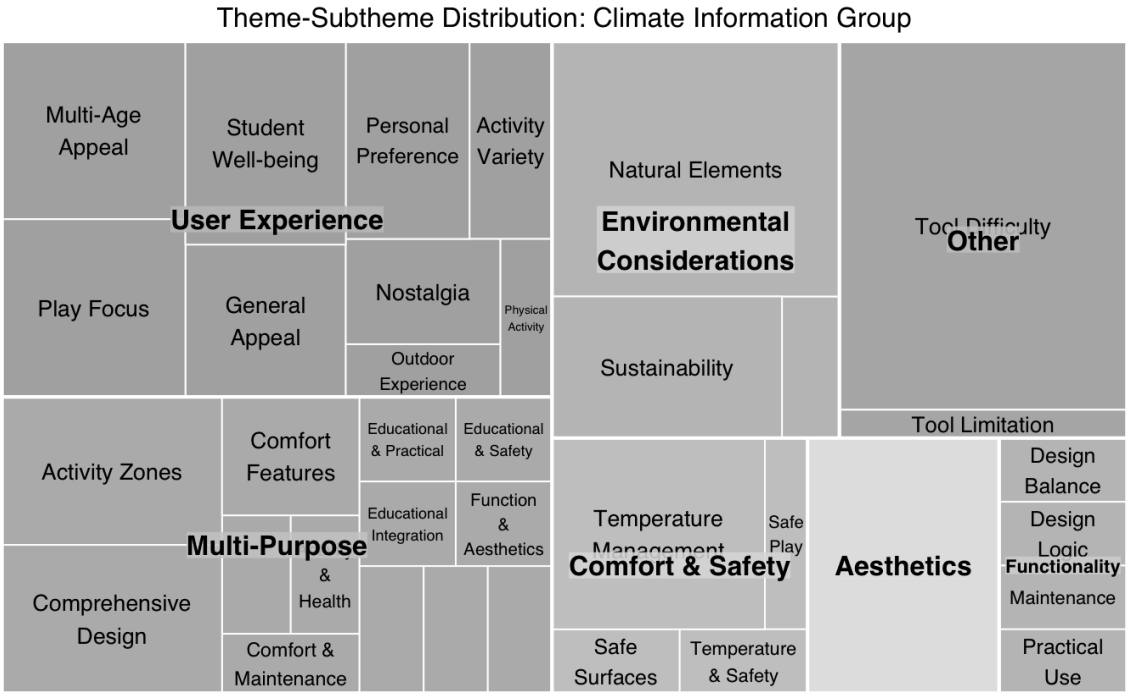


Figure 08: Design reasoning sub-themes for elements placed by climate information group

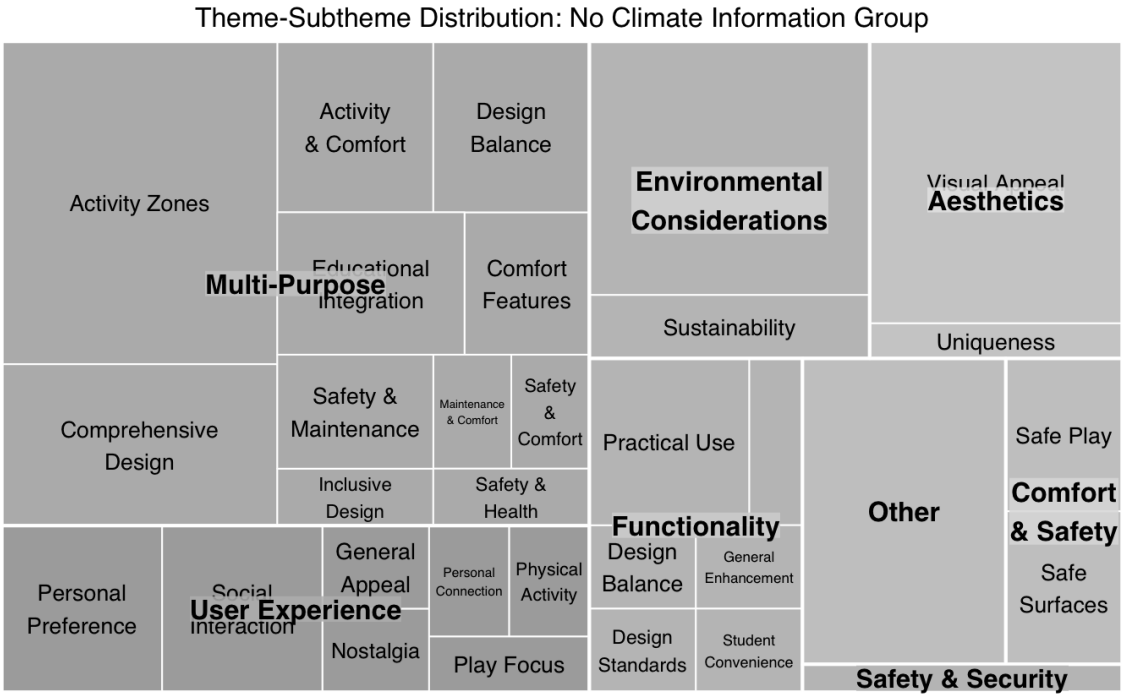


Figure 09: Design reasoning sub-themes for elements placed by no climate information group

3.3 Design Choice

3.3.1 Object Exploration Analysis

Overall engagement levels were similar between the climate information group (n = 97, median object views = 29.0) and the control group (n = 90, median object views = 28.5), with no significant difference confirmed by a Mann-Whitney U test (W = 4221, p = 0.698). However, the climate information group displayed a broader range of engagement (3–346 views) compared to the control group (6–105 views), suggesting more diverse exploration patterns among participants exposed to climate-related context.

When attention to specific object categories was examined, significant differences emerged, confirmed by a chi-square test ($\chi^2(4) = 125.42$, $p < 0.001$), revealing that group assignment influenced viewing patterns across categories. Both groups directed the highest proportion of views toward vegetation elements (climate information: 52.5%, M = 17.51, SD = 17.27; control: 51.1%, M = 16.01, SD = 13.03). However, participants in the climate information group devoted significantly more attention to play equipment (27.9%, M = 9.31, SD = 23.50) compared to the control group (19.1%, M = 6.00, SD = 9.44). In contrast, the control group focused more on furniture (11.6% vs. 7.2%) and paving elements (9.3% vs. 5.0%). Both groups exhibited similar levels of attention to site props (climate information: 7.4%; control: 8.8%).

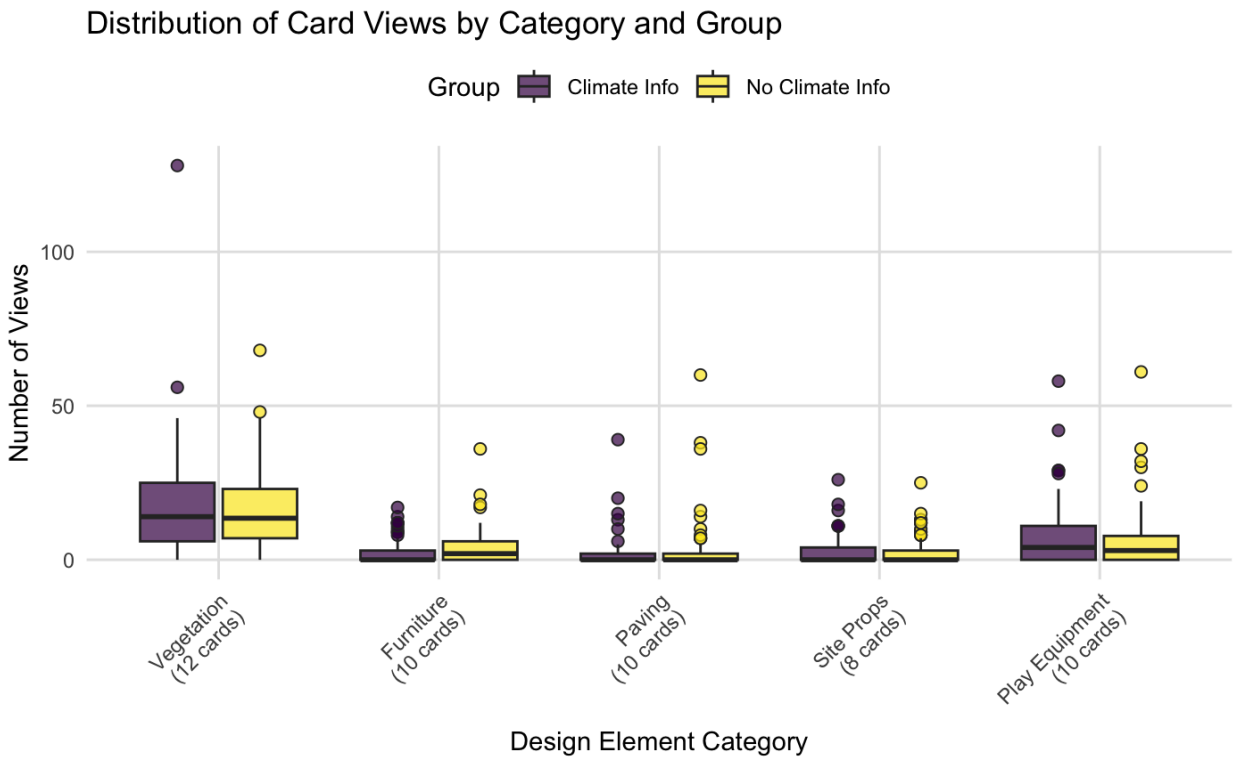


Figure 10: Distribution of objects exploration by category

3.3.2 Object Placement Analysis

For the object placement on the site, Both the climate information group (n = 97) and the control group (n = 90) placed a similar median number of objects on the site (climate information: 13; control: 14; M = 12.32, SD = 6.96, and M = 13.26, SD = 6.53, respectively). A Mann-Whitney U test indicated no significant difference in total objects placed (W = 4039, p = 0.372), suggesting comparable overall engagement in design implementation across groups.

When attention to specific object categories was examined, significant differences emerged, confirmed by a chi-square test ($\chi^2(4) = 26.889$, $p < 0.001$), revealing that group assignment influenced placement patterns across categories. Both groups directed the highest

proportion of placements toward vegetation elements (climate information: 63.85%, M = 7.86, SD = 4.44; control: 58.26%, M = 7.73, SD = 4.27). However, participants in the climate information group devoted more attention to play equipment (19.08%, M = 2.35, SD = 1.65) compared to the control group (16.60%, M = 2.20, SD = 1.44). In contrast, the control group focused more on furniture (12.24% vs. 6.95%) and paving elements (6.20% vs. 4.52%). Both groups exhibited similar levels of attention to site props (climate information: 5.61%; control: 6.71%).

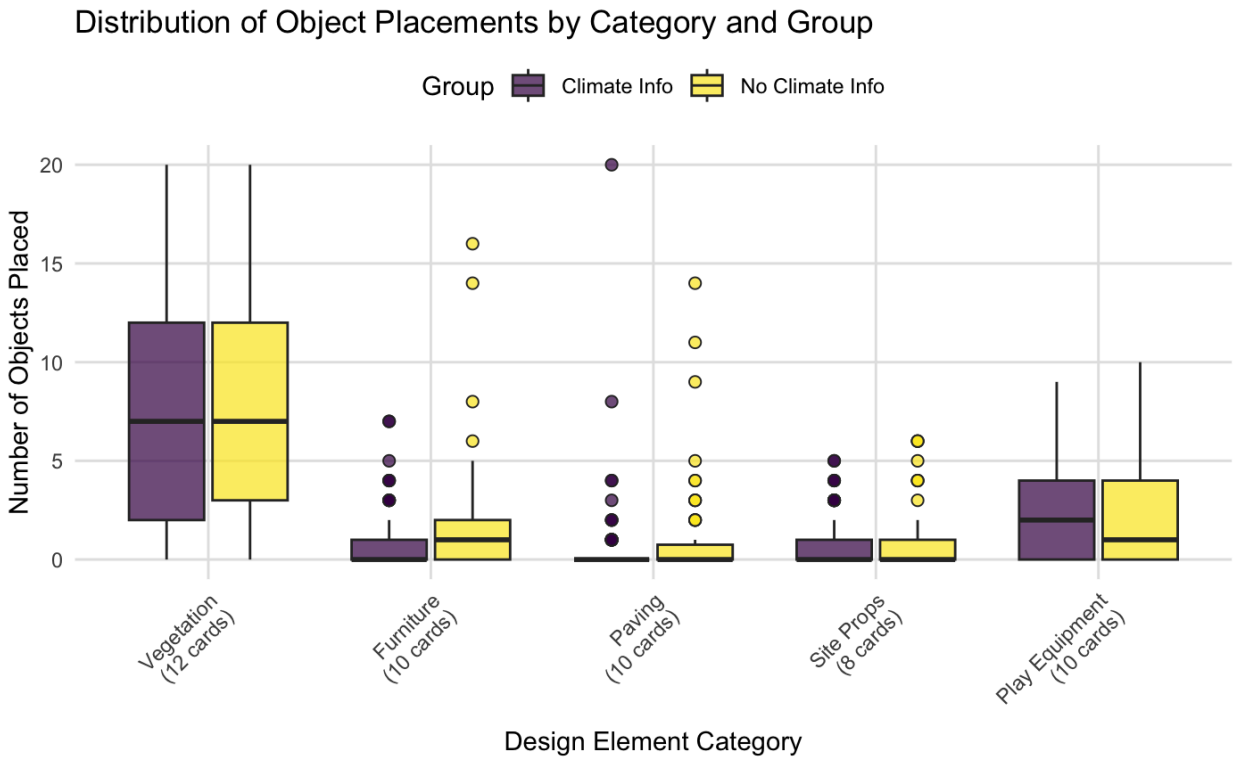


Figure 11: Distribution of objects placement by category

3.4 Tool Evaluation

Participants' assessments (Appendix F) of the design tool were predominantly positive across both groups. The 3D visualization features received particularly strong endorsement, with approximately 70% of participants expressing agreement or strong agreement regarding its helpfulness. General usability ratings were consistent between groups, though the control group indicated a slightly higher strong agreement with ease of use (25% versus 22%). Overall enjoyment ratings were favorable, with more than 60% of participants in both groups affirming that the tool was engaging.

Chapter 4 Discussion

This study investigated how exposure to climate change information might influence design choices and reasoning in a crowdsourced schoolyard design task. Utilizing Land.info DST, we engaged participants in virtually designing a schoolyard in southeast Michigan. Our findings suggest that while overall engagement with the design tool remained consistent across groups, providing climate information influenced the design reasoning and design choices between the groups.

4.1 Impact on Design Reasoning

The results indicate that participants who received climate information reported considering flooding more frequently in their designs than in the control group. Specifically, 37.1% of the climate information group indicated they "Often" considered flooding, compared to 18.9% in the control group. The research findings indicate that providing detailed, context-specific information about environmental risks can effectively enhance awareness and influence decision-making processes, aligning with prior research (Linden et al., 2015; Moser, 2010)

While other climate factors such as "Hot days" and "Dry weather" did not show significant differences between the two groups, this may be attributed to the differential salience of climate impacts. Flooding is a more immediate and visually tangible phenomenon, making it more salient to participants compared to heat and dryness. Research indicates risks that are more vivid and easily imaginable tend to have a greater influence on perception and decision-making processes (O’Neill & Hulme, 2009; O’Neill & Smith, 2014; Whitmarsh, 2008).

Regarding non-climate attributes, both groups maintained high consideration levels for general design attributes such as visual appeal, safety, and physical activities (median ≥ 3 on a 4-point scale). The consistent high prioritization of these relevant attributes across both groups indicates that while climate awareness can enhance design priorities, it does not displace core considerations—a finding consistent with the notion of additive rather than substitutive integration of new information in decision-making (Gregory et al., 2012).

Analysis of open-ended responses revealed distinct differences in design priorities between participants. The experimental group, exposed to climate data, demonstrated a stronger emphasis on environmental considerations, with 14.0% focusing on comfort-related aspects and 11.7% highlighting environmental themes. In contrast, the control group gravitated toward traditional design elements, prioritizing safety (14.5%) and aesthetics (9.6%). When provided with detailed climate information, participants adopted a more comprehensive approach that balanced user experience with environmental resilience (Corner et al., 2015). However, when contextual information is limited, functional and aesthetic considerations tend to dominate design decisions (Gobster et al., 2007; Nassauer, 1995).

4.2 Impact on Design Choices

The exploration and implementation of design objects further illustrate the influence of climate information. Participants exposed to climate information devoted more attention to vegetation and play equipment, incorporating these elements more extensively into their final designs. The increased emphasis on vegetation is noteworthy, as it aligns with nature-based solutions aimed at enhancing resilience to climate impacts such as flooding and heat (Bush & Doyon, 2019; Kabisch et al., 2016; Ordóñez Barona et al., 2022). Furthermore, this focus by both groups reflects the perception of the multifaceted benefits of vegetation, including environmental

mitigation, aesthetic enhancement, and social well-being (Hunter et al., 2019). Such benefits may have been more salient to participants informed about climate impacts, leading them to prioritize vegetation more in their designs.

The heightened attention to play equipment among the climate information group may reflect an integrated approach that balances environmental resilience with user experience. Play areas can be designed to be both climate-resilient and supportive of children's physical and social development (Chawla, 2015). This could indicate that participants did not view environmental considerations as separate from or in opposition to traditional design goals but as complementary elements that enhance overall site functionality.

Conversely, the control group placed greater emphasis on furniture and paving elements, which are associated with traditional schoolyard designs (Danks, 2010), focusing on immediate functional and aesthetic needs rather than long-term environmental resilience. This contrast highlights how climate information can reorient design priorities toward objects that contribute to sustainability while enhancing the overall user experience.

4.3 Tool Usability Discussion

The broadly positive reception of the interactive decision support tool underscores the potential of immersive digital environments to enhance public understanding and engagement in participatory planning contexts. Across both experimental conditions, participants endorsed the ease of use and intuitiveness of the platform and found the three-dimensional visualization features particularly useful. This aligns with prior studies demonstrating that 3D tools can improve the clarity, accessibility, and realism of presented information, thereby making it more comprehensible for non-experts (Herbert & Chen, 2015; Sheppard et al., 2011). Interactive 3D interfaces allow users to navigate more freely, intuitively grasp spatial relationships, and better

envision design outcomes. These findings hold notable implications for crowdsourced environmental decision-making and urban greening initiatives, where participants' backgrounds and degrees of environmental literacy may vary widely.

Furthermore, these observations extend beyond enhancing user experience to fostering more equitable and inclusive participatory processes. By presenting information in visually rich, accessible formats, 3D decision support tools help bridge the technical divide between professional planners and community members, enabling individuals with diverse backgrounds to engage meaningfully with complex design scenarios. As a result, community participants are better equipped to understand critical trade-offs and opportunities, increasing their willingness to trust proposed solutions and support interventions that promote urban greening, an outcome consistently highlighted in the literature on digital citizen engagement (Brown & Kyttä, 2014; Vromen, 2017).

Chapter 5 Implications, Future Research and Limitations

Despite the observed shifts in design reasoning and choices, both groups maintained high consideration levels for design attributes like safety, physical activities, and visual appeal. This suggests that introducing climate information may enhance design priorities without undermining relevant fundamental site design considerations. It supports the idea that climate awareness can be integrated into design thinking without compromising other critical aspects, potentially enabling more comprehensive and resilient design outcomes (Gregory et al., 2012).

This finding contrasts with some earlier studies where the introduction of new information displaced traditional considerations (Ordóñez & Duinker, 2015). Our results indicate an additive effect, where climate information enriches the design process rather than detracting from established priorities. Participants demonstrated the capacity to simultaneously prioritize traditional design goals and incorporate climate-resilient thinking, suggesting that environmental awareness can coexist with and enhance standard design practices.

Our exploratory findings have potential implications for developing participatory and crowdsourcing design tools. Providing context-specific climate information might influence public engagement and enhance design priorities toward more resilient and sustainable outcomes. This aligns with the principles of informed participation, where participants may contribute more effectively when equipped with relevant information (Seltzer & Mahmoudi, 2013). It also highlights the potential of tools like Land.info to serve not just as design platforms but also as educational mediums that promote environmental awareness and stewardship.

Future research could expand on these findings by applying the tool in diverse site settings to enhance generalizability and examine the role of demographic factors in how different user groups interact with climate information and the tool. Additionally, investigating the

connections between participants' reasoning and design choices through rigorous spatial analyses could provide deeper insights into how climate information influences design behaviors.

While our study provides valuable insights, it has limitations that warrant consideration. The experimental setting, conducted online and individually, may not capture the complexities of real-world design processes, which often involve collaborative efforts and iterative feedback. Given the exploratory nature of our study, these findings should be interpreted cautiously, and further research is needed to confirm these trends. The sample size, though sufficient for an initial exploration, may limit the generalizability of the findings. Additionally, reliance on self-reported data may introduce biases or variations in how participants interpret design attributes. We also did not explore demographic and spatial differences, which could provide further insights into how different groups interact with climate information.

Chapter 6 Conclusion

This exploratory study demonstrates that integrating site-specific climate information into crowdsourced virtual schoolyard design tasks can meaningfully influence public reasoning and decision-making in urban greening initiatives. When presented with climate impact projections, participants more frequently considered environmental challenges—particularly flooding —and incorporated adaptive elements such as vegetation and play equipment into their designs. Importantly, this heightened focus on environmental considerations did not compromise other fundamental objectives in schoolyard design, including safety, aesthetic appeal, and opportunities for both physical activity and outdoor education. Instead, climate information enriched participants' decision-making processes, demonstrating that environmental awareness can coexist with and enhance conventional design thinking. Rather than displacing traditional considerations, climate data served as an additive influence, encouraging a more holistic outlook on the built environment. This finding suggests that participants can effectively balance multiple objectives, integrating long-term ecological resilience with immediate functional and aesthetic needs. This study highlights the value of information provision, interactive decision support tools and crowdsourcing methodologies in advancing site scale urban greening initiatives to the broader pursuit of creating urban landscapes that are not only environmentally resilient but also culturally responsive and socially sustainable.

Appendices

Appendix A: List of objects available for the participants to design the schoolyard

S.no	Vegetation	Pavers	Furniture	Site Props	Play Equipment
1	Native Grass	Brick Plaza	Wooden Bench	Bike parking	Basketball
2	White Pine	Brick pavers 1	Recycled Bench	Water fountain	Monkey Bars 1
3	Red Oak	Brick pavers 2	Metal Bench	Trash can	Mini Sand Pit
4	Sweetgum	Brick pavers 3	Composite Bench 1	Curved Planter	Sand Pit
5	Lawn Grass	Brick pavers 4	Composite Bench 2	Square Planter	Small Slide
6	Silver Maple	Stone Plaza	Smart Bench	Rectangle Planter	Large Slide
7	Dogwood	Stepping Stone 1	U Concrete Bench	Street lamp	Seesaw
8	Redbud	Stepping Stone 2	Artisan Bench	Water feature	Monkey Bars 2
9	Cherry	Stepping Stone 3	Mixed Material		Swing
10	Apple	Stepping Stone 4	L Concrete Bench		Ultimate Play
11	Red Maple				
12	Bur Oak				

Appendix B: Prompts used for processing the open ended questions

Prompt for Analysis of the other considerations open ended question:

I'm analyzing responses from participants who designed a schoolyard using a 3D design tool where they could place various objects like vegetation, furniture, play equipment, etc. After completing their design, they were asked the following open ended question: 'What are some other things you thought about when designing the schoolyard that were not mentioned previously? Feel free to share any extra ideas that helped you design the schoolyard.'

Here are their responses in a CSV with ResponseId and response text. Please:

1. Read each response
2. Create a CSV with these columns:
    a. ResponseId (keep original)
    b. response (keep original)
    c. word_count (count the number of words)
    d. main_theme (assign one primary theme that best captures the core consideration)
    e. sub_theme (assign a more specific sub-theme where applicable, can be blank)
3. Return the complete CSV with every response categorized
4. After the CSV, please provide:
    a. Your reasoning for how you determined and assigned the themes
    b. Notable patterns in how participants thought about their designs
    c. Any interesting or unexpected considerations that emerged

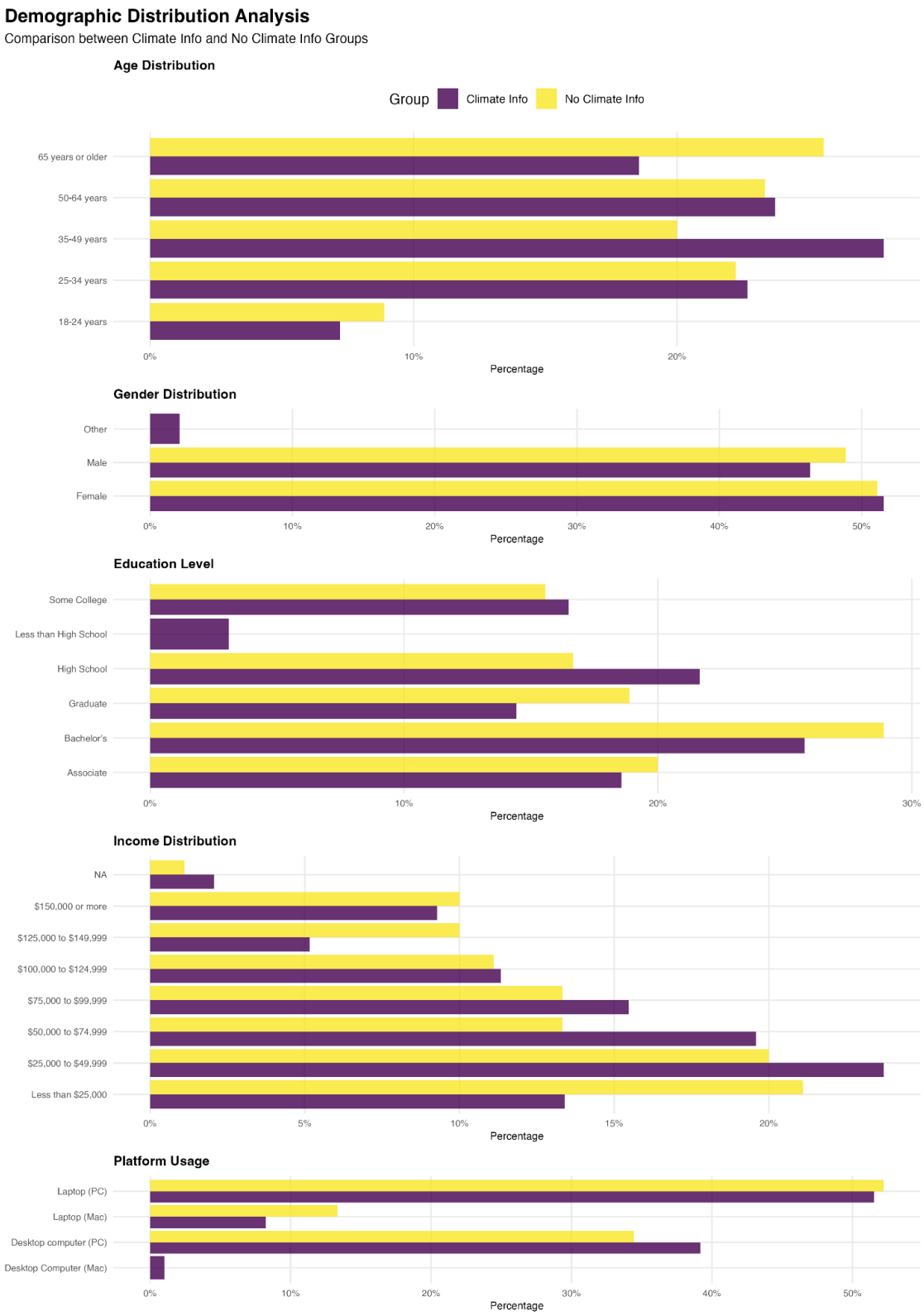
Prompt for analysis of design reasoning open ended question:

list of the landscape elements you placed in your schoolyard design: [list of objects]. Briefly, using your own words and complete sentences, tell us why you chose these particular objects'

Here are their responses in a CSV with ResponseId and response text. Please:

1. Read each response
2. Create a CSV with these columns:
    a. ResponseId (keep original)
    b. response (keep original)
    c. word_count (count the number of words)
    d. main_theme (assign one primary theme that best captures the core consideration)
    e. sub_theme (assign a more specific sub-theme where applicable, can be blank)
3. Return the complete CSV with every response categorized
4. After the CSV, please provide:
    a. Your reasoning for how you determined and assigned the themes
    b. Notable patterns in how participants thought about their designs
    c. Any interesting or unexpected considerations that emerged

Appendix C: Demographic distribution of the participants



Appendix D: Gaming experience and proficiency of the participants

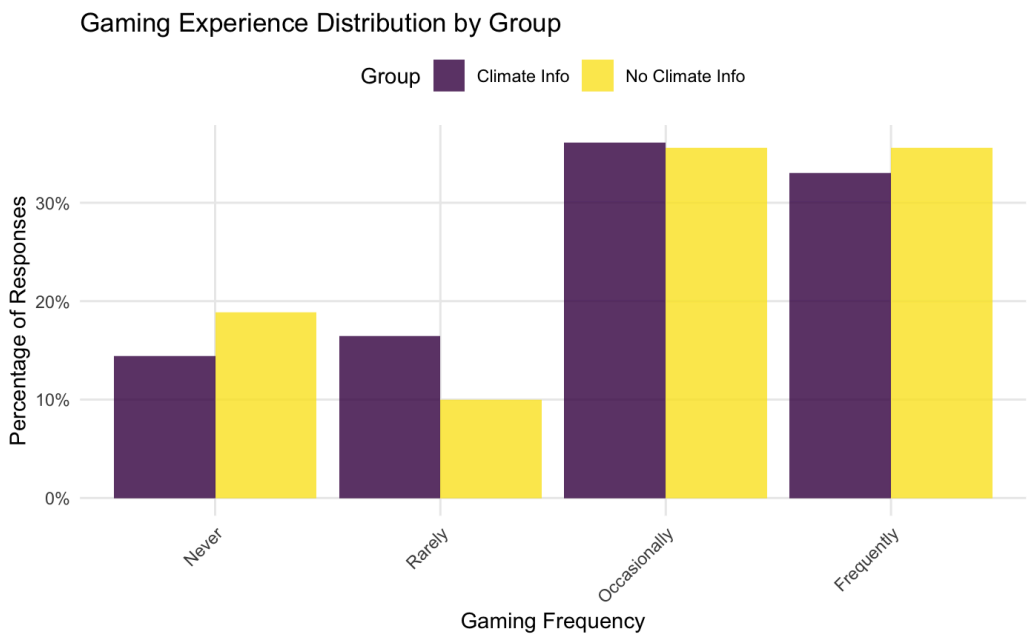


Figure d1: Self reported gaming frequency of the participants

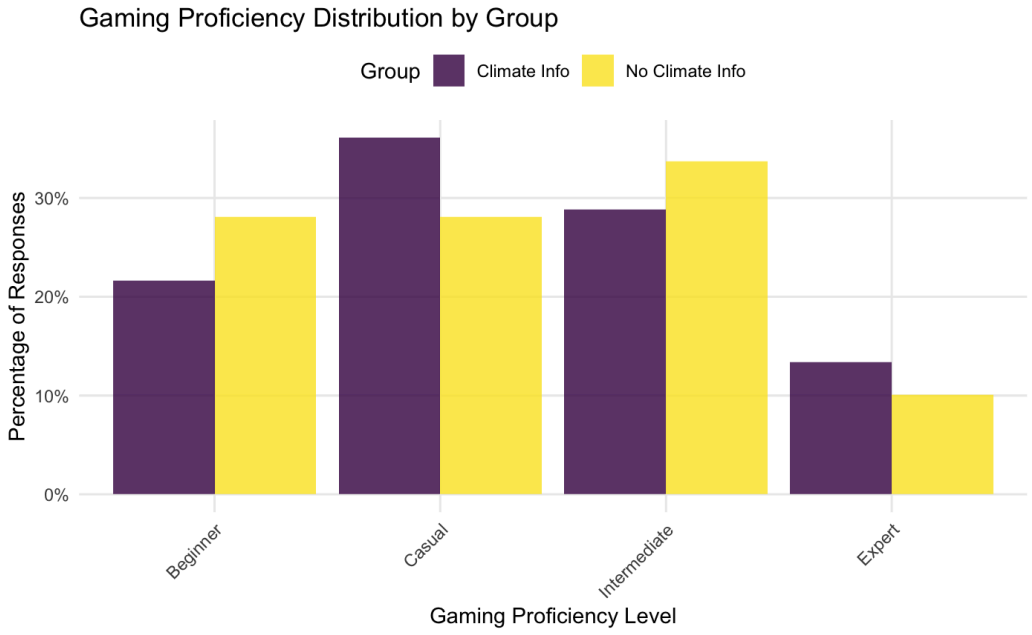
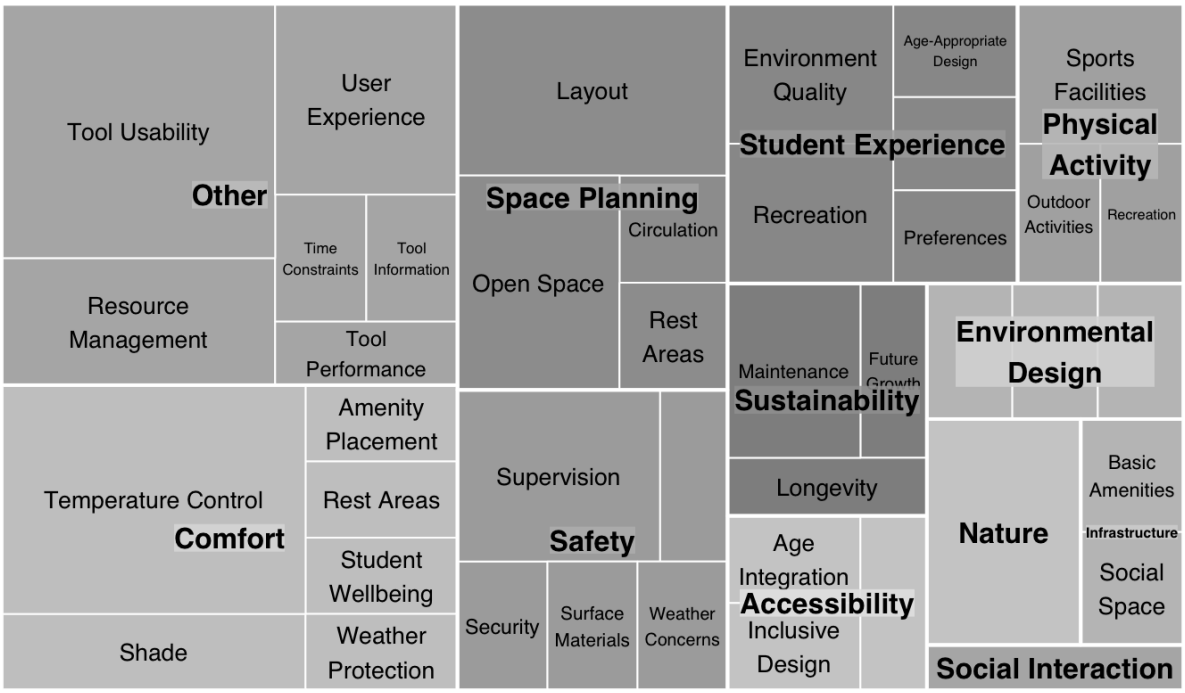


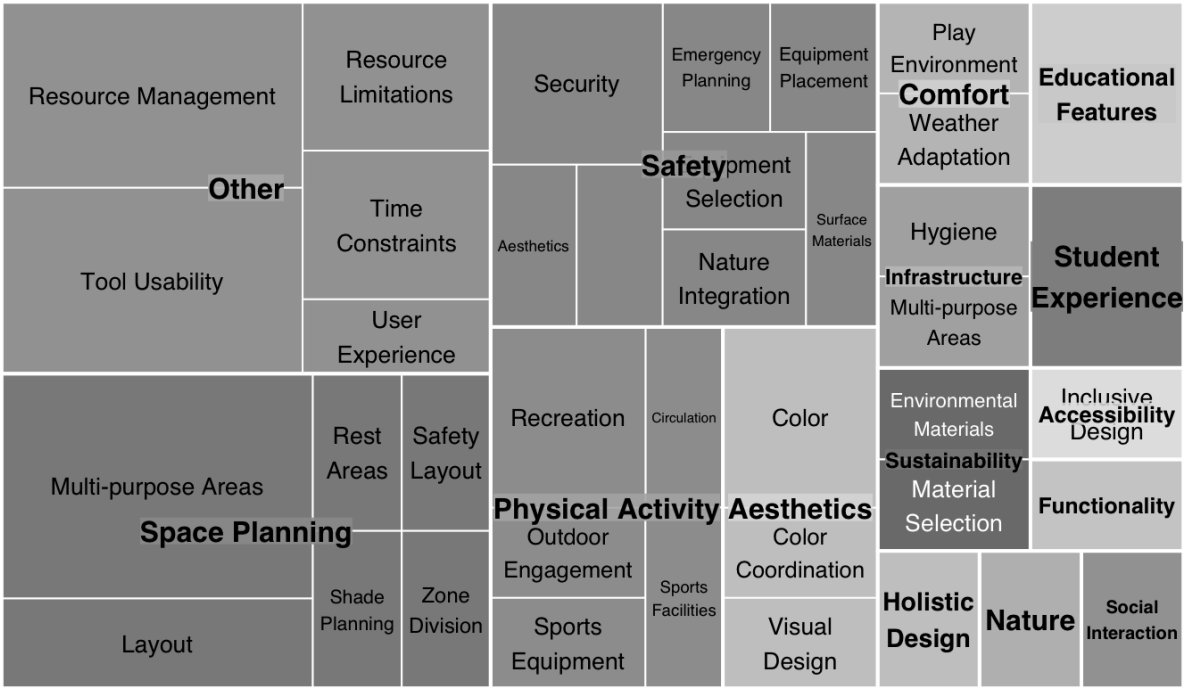
Figure d2: Self reported gaming proficiency of the participants

Appendix E: Theme-Subtheme distribution of other considerations made by participants

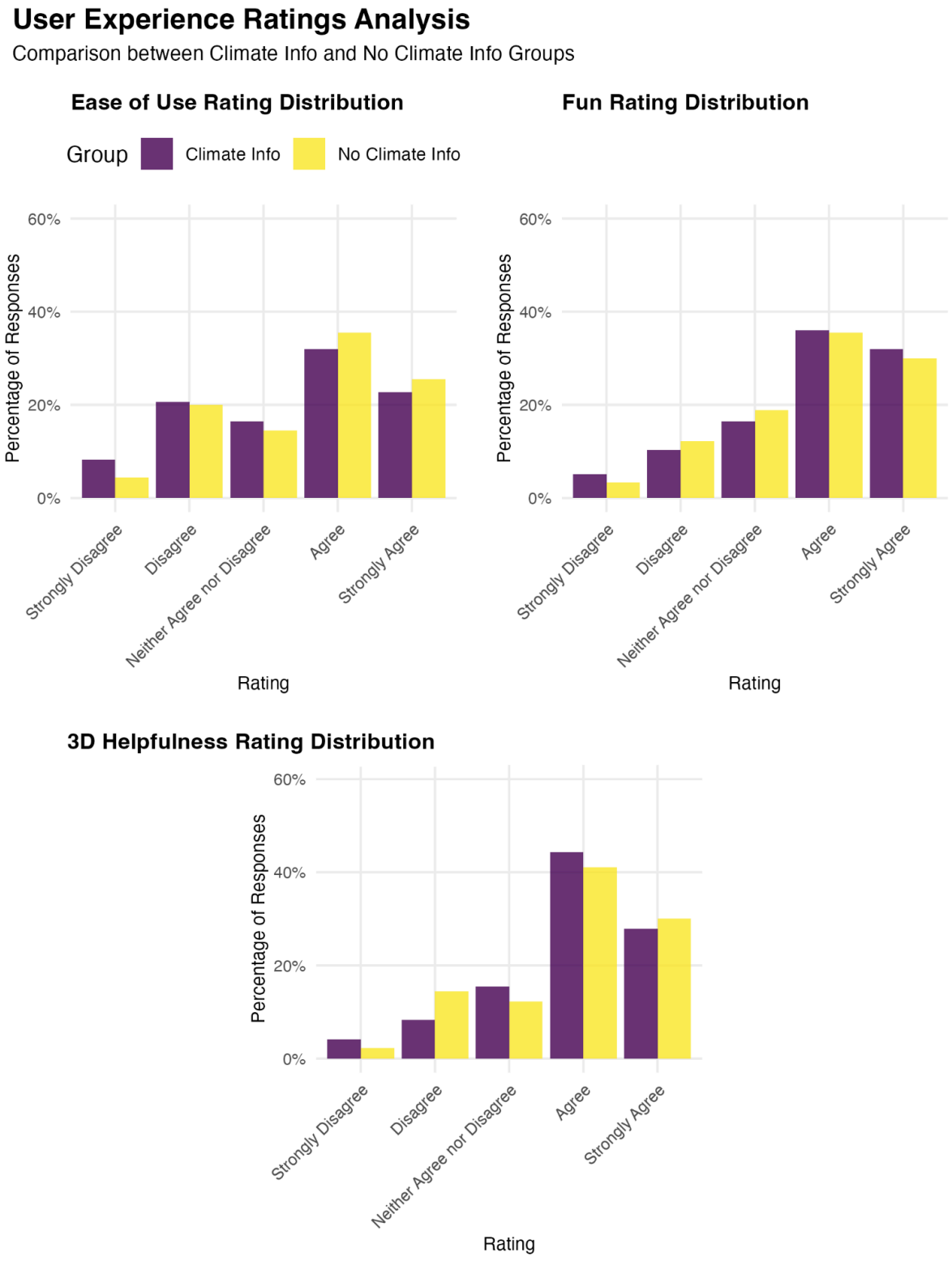
Theme-Subtheme Distribution: Climate Information Group



Theme-Subtheme Distribution: No Climate Information Group



Appendix F: Tool evaluations provided by the participants



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