

Participatory Design in Environmental Contexts: The Influence of Topic-Related Attitudes on Ideation

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Abstract. Participatory design is framed as a democratic approach enabling users to participate in shaping design problems. In sustainability-oriented contexts, however, problems are not immediately recognized, and needs may remain latent. Topic-related attitudes may therefore influence not only engagement but also framing of design problems. While prior research has examined motivation within predesigned frameworks, less attention has been given to attitude variation and co-design in environmental initiatives. This study explores how topic-related attitudes relate to problem framing and how ideation methods interact with these orientations. A workshop series was conducted within a biodiversity awareness project across two universities in Türkiye and Japan. Findings revealed differing epistemic framings of the same environmental design problem around anthropocentric-ecological tensions, and that participation does not inherently decenter anthropocentric priorities. The study demonstrates that prior attitudes are associated with these framings, and identifies key implications for structuring sustainability-oriented participatory design practices that better support ecological-relational framings.

Keywords: Participatory design, Ideation, Environmental attitude, Latent needs, Human-computer-biosphere interaction.

1 Introduction

Participatory design (PD) is widely adopted as an approach that actively involves end users in the development of products and services. Unlike conventional user research that primarily extract insights to inform designer-led decisions, PD emphasizes shared agency, collaborative problem framing, and collective idea generation throughout the design process [1][2]. Through this co-design orientation, participation is understood not only as consultation but as a democratic design practice that redistributes decision-making power and surfaces tacit knowledge [3].

Participatory Design has been widely adopted within Human-Computer Interaction (HCI), where it has predominantly focused on human experiences, user needs, and user-centered design practices [4]. The role of participation, however, becomes more complex when user needs are not immediately perceived or explicitly recognized. In sustainability-oriented contexts, the issues at stake often concern collective and long-term conditions rather than direct personal problems. Moreover, these systems might include the interests of non-human personas which require a more-than-human PD perspective [5].

This perspective is situated within a broader critique of the anthropocentric assumptions underlying human-centered design [6][7][8][9][10]. Rather than rejecting human needs, it calls for understanding humans as part of interconnected ecological and sociotechnical systems, encouraging designers to consider the conditions and agency of non-human actors alongside human ones [11][12]. The growing complexity of networked and IoT-enabled systems further requires moving beyond human-centered perspectives to account for relationships among humans, technologies, and non-human entities [13]. Thus, more-than-human design can be seen as an ongoing expansion of HCI and participatory design, in which participation acknowledges the dynamic relationships through which both human and non-human actors shape shared environments [14]. Particularly in contexts that concern not only human experiences or interests but also broader human-nature relationships, a more holistic understanding of needs—one that considers both human and non-human stakeholders—is needed.

This is particularly evident in initiatives aimed at fostering environmental awareness and literacy, where the design challenge is to cultivate shifts in perception, engagement, and responsibility. In such cases, environmental concerns can be understood as *latent needs*: conditions that affect individuals and ecosystems without being experienced as urgent or personally defined demands.¹

In such contexts, participation cannot be assumed to emerge solely from intrinsic motivation. Differences in topic-related attitudes, such as prior interest or engagement with sustainability-oriented issues may also shape how participants interpret the design task and contribute during early-stage ideation. Thus, studies of environmental and citizen-based initiatives involving non-professional participants frequently report motivation, interest, and pro-environmental values as significant factors influencing engagement and contribution [17][18][19][20][21]. Yet these initiatives take place within predefined scientific or governance frameworks rather than through co-design processes that involve users in problem framing and system development.

¹ The notion of latent needs originates in business-oriented innovation literature, where unarticulated customer demands are often treated as opportunities for innovation and competitive advantage [15][16]. Within design research, however, the concept is open to both critical reflection and pragmatic application. Acknowledging this tension, we consider the concept useful in a sustainability-oriented context. Here it serves not to identify hidden market opportunities, but to recognize environmental concerns that may remain unnoticed at the individual level because they are collective, long-term, or insufficiently articulated.

Consequently, less attention has been paid to how differences in participants' topic-related attitudes may shape idea generation within participatory design settings that address sustainability challenges.

To address this gap, this study investigates (1) how participants' topic-related attitudes relate to early-stage problem framing and ideation in participatory design, and (2) how different ideation methods interact with these attitudes in shaping generated ideas within an environmental awareness context.

The motivation for this study emerged during the early participatory design phase of a broader bioacoustics and sonic interaction design project focused on campus bird biodiversity across two universities in Türkiye and Japan. While the purpose of this project was to foster biodiversity awareness across the broader campus community, we encountered a practical tension during this phase: those who readily engaged in the co-design process were not necessarily representative of the intended audience of the future system. This led us to ask whether the differences in participants' topic-related attitudes should be considered before organizing the workshops.

We conducted a three-week workshop series involving participants with varying levels of interest and employing multiple ideation methods through structured activities. The findings contribute to a more nuanced understanding of how topic-related attitudes and the use of different methods influence participants' contributions, providing practical implications for structuring sustainability-oriented participatory design practices.

2 Background

2.1 Participants' Attitude in Co-design

Previous studies in co-design have already shown that participation is shaped by individuals' perceived relevance of the topic, prior knowledge, expertise, and willingness to contribute. Participants are more likely to engage when they perceive a personal, social, or environmental stake in the issue, while different levels of expertise and interest often lead to different forms and degrees of participation throughout the design process [22]. Similarly, research in urban planning has identified personal interest, social influence, and civic responsibility as important factors influencing citizens' willingness to participate in planning activities [23].

Studies have shown that participants' engagement can be supported through mechanisms such as storytelling, collaboration, identification, and shared ownership of the design process, suggesting that participatory outcomes are influenced not only by workshop methods but also by participants' motives for engaging with the design task [24]. From a broader perspective, co-design has also been conceptualized as a process of joint inquiry and imagination, where participants collectively construct shared understandings rather than merely contribute isolated ideas [25].

These perspectives suggest that the knowledge, interests, and orientations participants bring into a co-design process may influence both how design problems are interpreted and how solutions are developed across co-design contexts, regardless of whether they address environmental or sustainability-related issues.

2.2 Environmental Attitudes

Environmental awareness is a critical component of sustainable transformation, particularly within educational and creative contexts where design practices shape how sustainability is perceived and enacted [26][27]. Within this broad and multidimensional framework, we take environmental attitudes as a central psychological dimension through which individuals' orientations toward environmental issues can be conceptualized and examined. Environmental attitudes, defined as a "psychological tendency to evaluate the natural environment, and factors affecting its quality, with some degree of favor or disfavor", constitute a major focus in the field of environmental psychology [28]. Research consistently shows that environmental attitudes play a crucial role in shaping knowledge acquisition and pro-environmental behavior. For example, Baierl et al. [29] demonstrated that students with stronger environmental attitudes are more willing to engage in learning processes about environmental issues. Similarly, Steg et al. [17] identified normative intrinsic motivation -acting in accordance with social expectations- as the key driver of a sustained pro-environmental behavior. One related group of studies have focused on developing scales and models to assess such attitudes and values toward nature [30][31].

When we review research that are related to environmental attitudes either explicitly or implicitly, it is observed that many involve some form of community engagement at the individual or group level. Within this significant portion of environmental literature that incorporates participatory practices, citizen science stands out as a prominent category of collaborative initiatives in which non-professional participants contribute to research and projects.

2.3 Participatory Practices in Environmental Projects

From the perspective of our research, participatory initiatives in environmental contexts can be broadly grouped into three categories: (1) Data-contributory scientific projects; (2) Environmental management & community governance projects; (3) Educational / awareness-oriented projects.

First group of scientific research are primarily oriented toward the production of scientific data. In these contributory models, non-professional participants collect, classify, or validate environmental observations that support biodiversity monitoring, ecological research, and conservation efforts [32][33]. Platforms such as eBird and iNaturalist enable volunteers to submit geo-referenced species records that are integrated into global databases [34], while systems such as BirdNET rely on large-scale annotated audio recordings that train automated

species recognition models [35]. Participation in such projects is typically driven by intrinsic interest in nature and scientific contribution, and sustained engagement generally presupposes a certain level of prior topic-related motivation.

The second group consists of environmental management and community governance initiatives. These projects address local environmental concerns such as water access, neighborhood conservation, or resource protection, and often operate within policy and civic engagement frameworks. Research in this area also highlights intrinsic interest and pro-environmental values as key drivers in participation. In a water quality monitoring project, Olson and Colston found that participants' motivation significantly influenced engagement, whereas prior experience did not produce a significant effect [18]. Similarly, motivations such as contributing to scientific research [19] or protecting biodiversity [20] are reported drivers. At the same time, participatory policy mechanisms and contextual factors shape engagement [36], as willingness to participate is linked to perceived responsibility, cognitive and socio-demographic characteristics, and local relevance [21].

A third group includes initiatives explicitly designed to foster environmental knowledge, literacy, and attitude change, particularly among students and young participants. In these projects, participation functions primarily as a learning mechanism. Educational modules such as Earthkeeper [37] and FutureForest [38] demonstrated measurable gains in environmental knowledge and behavior. Similarly, Araújo et al. [39] reported positive shifts in students' environmental attitudes in a project addressing microplastic pollution. In these cases, participation is instrumental in supporting awareness and literacy-building goals.

2.4 Research Gap: Participatory Design and Latent Environmental Needs

Across the different orientations of related research, participation consistently involves non-professional participants and community engagement. However, participation typically occurs within predefined scientific or educational frameworks. This structure is coherent with the primary objectives of the initiatives that center on scientific knowledge production or environmental management. In this sense, participants function as contributors or stakeholders within a predefined research or governance agenda rather than as co-designers of the system.

Even in educational models that explicitly aim to foster environmental literacy and awareness, participation primarily operates as a learning mechanism within an established project structure. The design of the system is typically determined prior to participant involvement. From a participatory design perspective, this situation invites a different line of inquiry. Rather than positioning participants within predefined frameworks, a co-design-oriented approach would seek to understand users' needs and motivations through their early involvement in problem framing and ideation. This shift raises a further question: how might

differences in participants' topic-related attitudes influence their contribution in such contexts?

Environmental awareness-oriented systems aim to foster shifts in perception and engagement; yet environmental issues often constitute latent needs. In environmental contexts, latent needs are further complicated by temporal scale. Ecological change often unfolds across seasonal, multi-year, or even generational timescales that exceed immediate human perception. Acoustic biodiversity monitoring infrastructures reveal fluctuations and absences that remain imperceptible in everyday experience. Therefore, participatory design addressing environmental awareness must contend not only with motivational latency, but also with temporal invisibility. Thus, intended users may not initially perceive these issues as personally relevant, and participation cannot be assumed to emerge from intrinsic motivation alone. Moreover, in contexts where ecological systems and non-human actors are also implicated, participatory processes must account for perspectives that extend beyond purely human-centered concerns. In such contexts, differences in topic-related interest may shape how individuals interpret the design task and contribute to early-stage ideation.

Responding to this line of inquiry, our campus-based biodiversity project shares the goal of fostering environmental literacy and awareness but situates participation within the earlier stages of problem framing and system development. The study addresses environmental awareness as a latent design problem. Rather than working with self-selected, highly motivated volunteers, it engages end users recruited from a broader campus population, including individuals who do not initially display environmental interest. Therefore, the study examines how variations in topic-related attitudes may manifest within this participatory design process.

3 Study

3.1 Research Design

This study adopts a qualitative and comparative research design grounded in participatory design. Workshops were used both as a design practice and as a structured data generation strategy. Rather than evaluating the effectiveness of a finalized artefact, the study focuses on early-stage ideation as a site of inquiry. By comparing ideation outcomes across participant groups with differing levels of prior interest in environmental and biodiversity-related topics, the study investigates whether and how topic-oriented attitudes shape the nature and quality of ideas. This approach enables participatory design to be examined not only as a design practice, but also as a lens for understanding engagement in environmental awareness contexts.

3.2 Context of the Study

The study was conducted within the BirdHub Project², a sonic interaction design initiative aimed at raising awareness of campus bird biodiversity through exploratory listening experience. This project connects two university campuses, Yıldız Technical University of Istanbul and the University of Tokyo, through a real-time and interactive soundscape streaming via a web-based edutainment platform.

The project is framed within a Human-Computer-Biosphere Interaction (HCBI) perspective, which extends beyond conventional human-computer interaction to consider animal-animal and animal-computer interaction layers [40][41]. Long-term biospheric interaction research suggests that decentering the human requires not only participatory inclusion but infrastructural exposure to ecological temporalities – such as seasonal variation, migration cycles, and acoustic unpredictability – that challenge immediate user-centered logics. Without such exposure, participatory ideation risks reproducing short-term human engagement models even when ecological themes are introduced. In this sense, the system is not designed solely for human users, but also acknowledges ecological relationships and non-human actors as part of the interaction ecosystem.

The workshops did not aim to design a complete system; instead, they focused on concept development and generating interface and interaction ideas that could inform its future development.

3.3 Participant Recruitment and Grouping

Participants were recruited through convenience sampling within the university context. Fifteen undergraduate and graduate students participated in the study (M = 26 years; 10 women, 5 men). As the proposed system targeted campus users, recruiting participants from this population was considered appropriate. The study was approved by the Social and Human Sciences Research Ethics Committee of YTU (Report No. 20240903322). All participants provided written informed consent prior to participation. Participation was voluntary and unrelated to academic assessment, and participants were informed of the study objectives and their right to withdraw at any time. All data were anonymized prior to analysis.

Prior to the workshops, participants completed a questionnaire designed to assess their self-reported interest and prior engagement with environmental and biodiversity-related topics. The questionnaire was organized from general to context-specific ecological orientations, beginning with broad attitudes toward biodiversity, followed by urban wildlife, bird-related knowledge and experience, and finally campus-specific ecological familiarity. The questionnaire consisted of 23 main items, from 5-point Likert to multiple choice and open-ended questions, covering five complementary dimensions: (1) environmental attitudes toward

² Further information about the BirdHub Project, including the current prototype of the web platform, is available at: <https://birdhub.yildiz.edu.tr>.

urban biodiversity, (2) self-reported knowledge of urban wildlife and bird species, (3) recognition of species, (4) engagement and prior participation in nature-related activities, and (5) motivations and perspectives regarding urban biodiversity and bird conservation (Table 1).

Table 1. Overview of the pre-workshop questionnaire.

Dimension	Example questionnaire items	Purpose
Attitude	"I believe urban wildlife in the city should be protected."; "I see the decline of urban wildlife positively, for reasons such as human safety and health."	Assess participants' attitudes toward biodiversity conservation and human-wildlife coexistence.
Knowledge	"How knowledgeable are you about urban wildlife in your city?"; "How knowledgeable are you about bird biodiversity in your city?"	Assess self-reported knowledge.
Recognition	"Please select the wildlife species below that you recognize."; "What species is the bird shown in the image, and have you observed it on your campus?"	Assess ecological familiarity through species recognition and direct experience.
Engagement	"How would you rate your level of observation and curiosity about the wildlife in your city?"; "Have you participated in any bird spotting and/or educational activities?"	Assess participants' everyday engagement with urban nature.
Motivation	"Which of the following factors negatively affect bird life in cities?"; "What would motivate you to become more curious about urban wildlife?"	Assess participants' motivations and conservation perspectives.

Participants were divided in three groups before the workshops based on their overall response patterns across these dimensions as:

- High-interest group
- Low-interest group
- Mixed-interest group

Each group consisted of five distinct participants allowing for between-group comparison of ideation outputs.

Participants in the high-interest group reported active curiosity toward environmental topics and prior engagement with nature-related activities (e.g., outdoor practices, wildlife observation, or use of biodiversity-related applications).

The low-interest group reported no engagement with environmental issues and did not consider these topics to be of personal interest.

The mixed-interest group included participants with moderate and heterogeneous levels of engagement, serving as a comparative reference group to examine ideation outcomes across varying degrees of topic-related orientation.

3.4 Workshop Structure & Data Collection

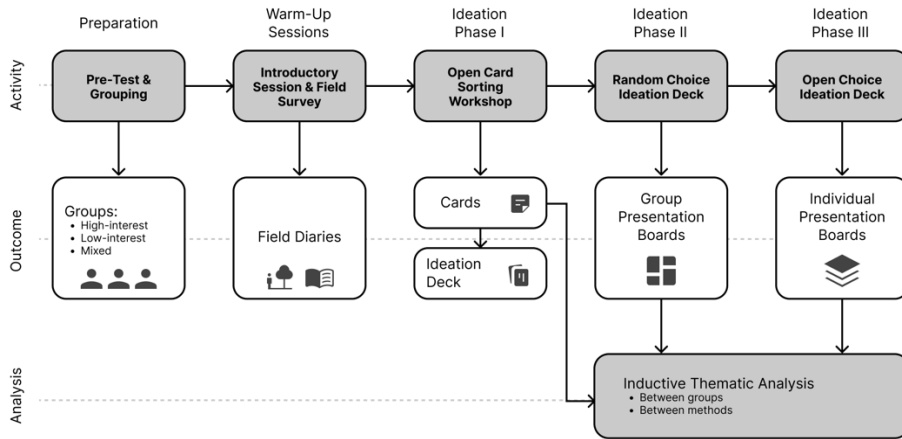


Fig. 1. Methodological flow of the workshop series.

The study was conducted over a three-week period and consisted of three consecutive ideation phases. While prior research suggests that variations in participation models do not necessarily lead to differences in learning outcomes [42], multiple ideation methods were intentionally employed in this study to explore whether methodological variation interacts with participants' topic-related attitudes in shaping idea generation within our context.

3.4.1 Introductory Session

In the introductory session, participants were informed about the scope and objectives of the BirdHub project. The platform was described as a digital system connecting two campuses through real-time soundscapes, aiming to provide interactive and educational experiences focused on bird biodiversity. It was explained that the system would combine physical and digital interaction layers and encourage cross-campus acoustic exploration. Participants were asked to consider multiple interaction design layers in their concept development as in Figure 2.

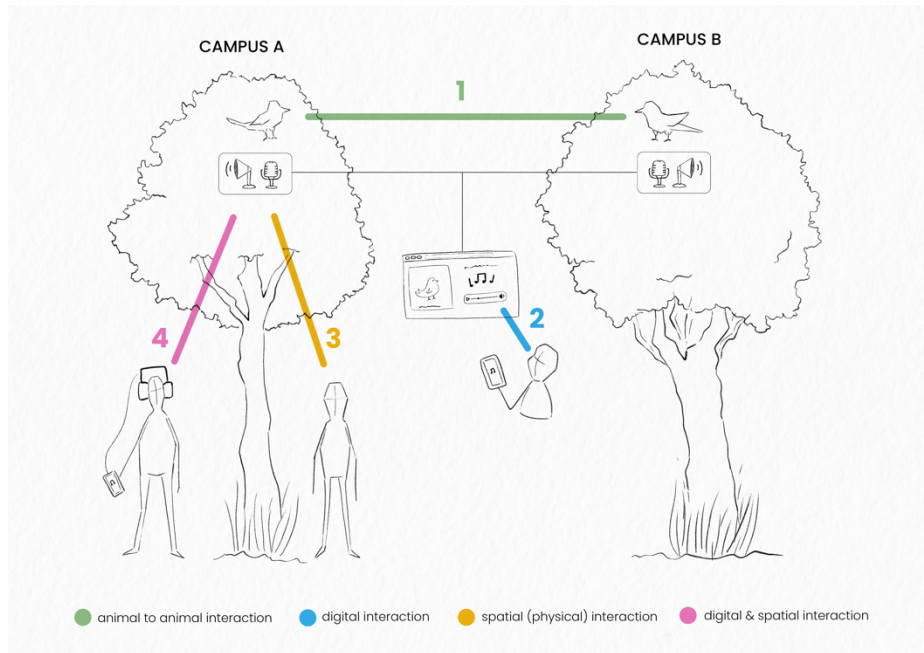


Fig. 2. Concept sketch of the project with its proposed interaction layers, ©Nuran Akarsu

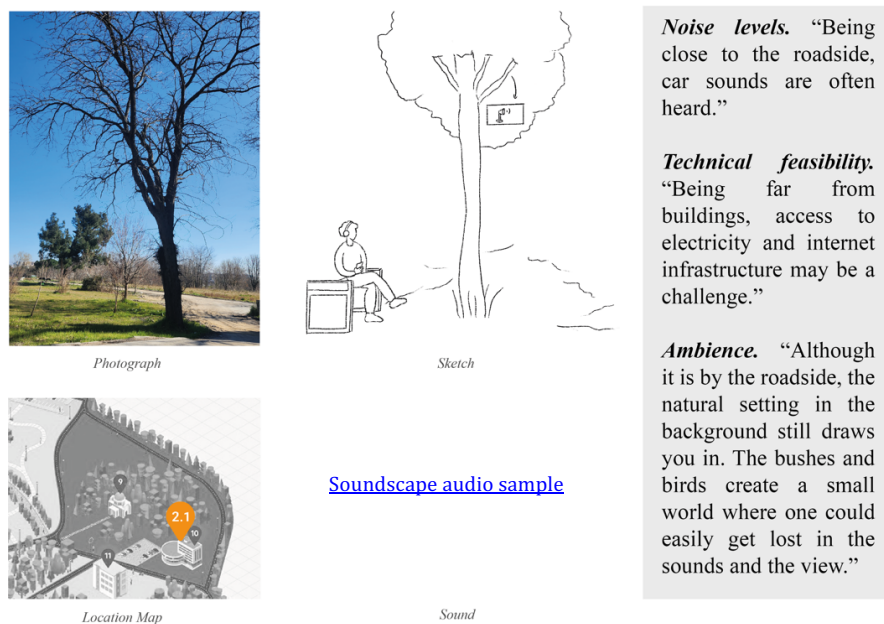


Fig. 3. Multimedia excerpts from participants' field survey diaries

3.4.2 Pre-workshop Activity: Field Survey

Prior to the first ideation session, participants were assigned a short field survey activity intended to sensitize them to the physical and ecological context of the project. They were asked to explore the campus and identify a location they considered suitable for a potential installation.

Participants documented their selected site through a multimedia diary including maps, photographs, sketches, ambient sound recordings, and written field notes (Figure 3). Observations focused on factors as *noise levels*, *crowd density*, *human privacy*, *biodiversity*, *accessibility*, *technical feasibility*, *equipment safety*, and *ambience*. The aim of this activity was not to determine the final installation site, but to encourage situated observation and contextual awareness before the ideation phase.

While the installation sites have been determined at the current phase of the project, at the time of the workshops, the sites had not yet been finalized. This allowed participants to speculate freely about potential locations. The implementation and testing of both the physical installation and the digital platform are beyond the scope of this study.

3.4.3 Workshop I: Open Card Sorting

The first ideation phase employed an open card-sorting method. Participants were asked to write short ideas, concepts, or associations related to the project on colored sticky notes within a limited time frame [43]. In the subsequent session, each group collaboratively clustered and labeled their notes on a shared board. This open structuring process allowed participants to define their own conceptual categories without predefined constraints. At the end of the session, each group produced a clustered board representing their conceptual framing of the system. A brief dot-voting exercise was conducted within groups to identify the most prominent concepts.

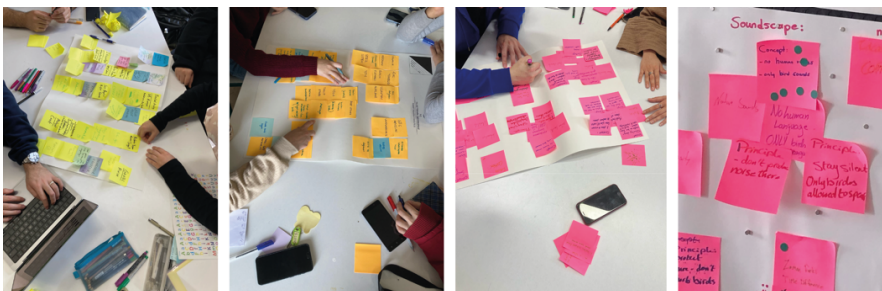


Fig. 4. Open card sorting and dot voting session: High-interest, Low-interest and Mixed groups.

3.4.4 Ideation Card Deck Design

Following the open card-sorting workshop, the research team reviewed and clustered the generated concepts into five categories. Based on these categories, a structured ideation card deck was developed to guide subsequent workshops (Table 2; see Appendix 1 for full card set). Card-based ideation tools are commonly used in design practice to stimulate combinational thinking, support creative reframing, and structure idea generation processes [44][45][46]. The deck translated most common participant-generated concepts into reusable design stimuli for subsequent design sessions.

Table 2. Labels of categories and corresponding cards in ideation card deck.

User Task& Design Ideas	Technology& Communication	Media Elements	Time & Space	Challenges & Opportunities
Matching	Audio Transmission	Narrative	Physical Site	Different Species
Species Identification	Live Broadcast	Maps	Tree / Habitat	Weather Conditions
Exploration	Human-Human Communication	Calendar	Routine	Non-Intrusion
Guessing	Bird-Bird Communication	Language	Seasons	Background Noise
Mimicry	Human-Bird Communication	Audio-Visual	Sunrise	Silent Zone
Customization	Headphones	Bird Songs	Rush Hours	Bird-Only
Gamification	Synchronous/ Asynchronous	Season Colors	Migration	Peace of Mind

3.4.5 Workshop II: Random Choice Ideation Deck

In the second workshop phase, participants used the ideation card deck in a structured combinational format. Each group randomly selected cards and arranged them into a 3×3 grid following the method described by Golembewski and Selby [44]. Based on the resulting combinations, participants developed three design concepts, each presented on boards that included selected cards, sketches, and short explanatory texts. Brief discussion sessions followed each round. After group discussion, one concept per group was selected and further developed into a final concept presentation board.



Fig. 5. Ideation deck session (random choice phase): workshop briefing and session snapshots.

3.4.6 Workshop III: Open Choice Ideation Deck

In the final phase, participants were asked to freely select cards from the ideation deck and develop a personal design concept over a one-week period. This phase allowed participants to intentionally choose elements aligned with their own interests and design priorities. By the end of this stage, each participant submitted an individual presentation board for their design concept. Representative visual samples of the design boards from each participant group are provided in Appendix 2.



Fig. 6. Ideation deck session (open choice phase): workshop briefing and session snapshots.

3.4.7 Data Analysis

An inductive thematic analysis was conducted following the six-phase framework proposed by Braun and Clarke [47]. All design outputs produced across the three workshop phases were collected, transcribed, and systematically documented for analysis. The dataset included notes, sketches, conceptual descriptions, and final concept presentation boards. The unit of analysis was the idea or concept generated within each session, rather than individual participants. Analysis proceeded in three stages:

1. *Inductive Thematic Coding*: All workshop outputs were analyzed collectively across groups and ideation phases to identify recurring codes. These codes were iteratively clustered into first-order themes and subsequently organized into broader thematic framings.

2. *Between-Group Comparison*: The distribution and prominence of identified themes were compared across the high-interest, low-interest, and mixed groups in order to examine how differences in topic-related attitudes related to patterns of idea generation.

3. *Between-Method Comparison*: Themes were further compared across ideation phases (open card sorting, random selection, and open selection) to explore how methodological variation interacted with participant attitudes in shaping ideation outcomes.

This multi-stage approach enabled the study to examine both participant orientation (interest level) and ideation structure (method) as interacting dimensions within a qualitative comparative framework.

4 Results & Discussion

4.1 Thematic Structure of the Workshop Outcomes

Table 3 presents the thematic structure that emerged from the analysis of workshop outputs, including theme descriptions, associated codes, and representative excerpts.

Across the three ideation phases and interest-level groups, eight themes were identified.

- Bonding with nature
- Using nature as escapism
- Knowledge-oriented engagement
- Connecting people
- Nature-centric design
- Ecological integrity
- Engaging user experience
- Situated and practical constraints

Rather than representing fixed categories, these themes indicate recurring orientations in how students articulated the purpose, function, and scope of the proposed system.

Knowledge-oriented engagement was the most consistently present theme across groups. Participants proposed real-time bird identification tools, interactive species cards, personal observation journals, and shared biodiversity databases. In some proposals, these features were presented as stand-alone informational tools as “bird cards”; in others, they were embedded within broader interaction systems such as quizzes and challenges. Knowledge production and access thus appeared as a central entry point into the design problem.

Closely intertwined with this theme was *Engaging user experience*, which included gamification mechanics, reward systems, customization options, narrative layers, and aesthetic interface considerations. For example, some participants proposed point-based systems unlocking avatars or virtual rooms, while others developed collectible sound cards enriched with poetic descriptions inspired by bird vocalizations. Here, the emphasis shifted from knowledge delivery alone to sustaining user involvement.

The theme *Connecting people* introduced a social dimension to the system. Proposals included cross-campus exchanges, social-media-like features, and event-based bird observation activities. Biodiversity functioned as a shared topic around which community interaction could be structured.

In contrast, *Using nature as escapism* framed the system as a restorative environment. Meditation zones, silent listening areas, and stress-reduction features positioned bird soundscapes as tools for psychological relief within campus life.

The theme *Bonding with nature* encompassed proposals emphasizing emotional or experiential closeness between humans and birds. Participants suggested using technology to “bring people closer to nature,” mimicking natural forms in interface design, or creating immersive listening experiences that heighten awareness of bird presence.

More explicitly ecological concerns were articulated under *Nature-centric design and Ecological integrity*. These themes included ideas such as minimizing technological intrusion, removing human-generated noise, acknowledging environmental unpredictability, and in some cases positioning birds as primary users of the system. These proposals did not eliminate human interaction but introduced sensitivity toward non-human actors and ecological processes.

Finally, *Situated and practical constraints* captured pragmatic considerations such as technical feasibility, campus routines, crowd density, and equipment limitations. Particularly in early ideation phases, participants grounded their concepts in everyday campus realities.

These themes demonstrate that the project was not interpreted uniformly. The thematic structure suggests multiple ways of approaching the design challenge.

Table 3. Themes, codes and excerpt samples.

Theme	Associated Codes	Sample
Bonding with nature	Using technology to get closer to nature	<i>“Concept: Technology always makes us far from nature. But we will use it reversely.”</i>
	The system is conceived as a tool to help establish a bond between potential users and nature.	Building connection between humans and nature <i>“In our monotonous city life, to strengthen the bond between humans and nature through the campus ecosystem and the human-bird relationship.”</i>
	Imitating natural elements	<i>“A bond is established with the bird by imitating the bird’s daily routines such as sounds it makes, eating and sleeping habits throughout the day.”</i>
Nature as escapism	Nature as relaxation space	<i>“Relax & Lock: ‘Take a BREAK!’, Lock phone.”</i>
	Ideas positioning nature as a tool/place for relaxation purposes.	Nature as a source of inspiration <i>“Narrative: The emotions surfaced thanks to the bird sounds are uttered through literary writing such as poems as stories.”</i>
		Nature as a meditation tool <i>“Listen to your favorite bird daily in 5-minute relaxation.”</i>
Knowledge-oriented engagement	Raising awareness	<i>“It also functions [...] for sharing bird sightings and connecting across campuses, fostering global awareness, [...], and nature appreciation.”</i>
	Ideas generated with a focus on the knowledge acquisition and/or contribution through the application.	Expert-to-user knowledge sharing <i>“Find hidden ‘professors’ in some areas of the map and ask them questions about species.”</i>
		Informing users about bird species <i>“When the user checks it, they see a 3D image of the bird, listens to its sound, and learn about it.”</i>
		Identifying birds <i>“Identifying species by bird sounds.”</i>
	Real-time info flow	<i>“...a vibrant social hub where real-time sound sharing and audio-based challenges unite both campuses in playful, acoustic rivalry.”</i>
	Contributing to a shared data pool	<i>“The visual archive consists of images taken by the user and is shared publicly on permission.”</i>
	Learning about nature through exploration	<i>“The main purpose of the app is to provide nature education to users while they try to explore the biodiversity of a foreign campus environment...”</i>
	Highlighting the campus ecosystem	<i>“View matched observations from another region: See whether the same species was observed in the other location.”</i>

	Personal observation journal	<i>"While completing tasks, the user can record bird sounds and ambient noise, saving them to their collection."</i>
Connecting people	Human-to-human communication	<i>"Group missions and Social Interaction: Form Groups with other users to complete collaborative tasks and explore together."</i>
Ideas that prioritize human-human interaction.	Cross-cultural communication	<i>"Blending bird sounds with cultural stories..."</i>
	Social media features	<i>"They can share a sound, image, bird sound, messages, audio postcards, or their thoughts [...]"</i>
	Event-based interaction	<i>"Check out recent events in the home page. See event's detail & register to attend."</i>
Nature-centric design	Designing for birds	<i>"Birds can 'claim' these hubs by singing or perching routinely, influencing the audio output."</i>
User experience design is centered around non-human concepts.	Nature-to-nature interaction	<i>"Songs played by perches mimic nearby birds to foster interaction"</i>
	Positioning birds as the users	<i>"User (Bird) Tasks: Perch on the device during routine hours, Sing/emit song near the mic, Become the "main voice" of that hub, hear custom audio reflecting their presence."</i>
	Integrating natural elements	<i>"A different bird is selected from the campus habitat every sunrise, which supports the endless cycle of nature."</i>
Ecological integrity	Removal of human-generated noise	<i>"No human sound, only bird sounds."</i>
Ideas that are aware of natural conditions / concerned with not interfering with nature.	Minimizing human interference	<i>"Principle: protect nature, don't disturb birds."</i>
	Awareness of technological impact	<i>"Challenge: digital stuff isn't good for nature"</i>
	Sensitivity to natural conditions	<i>"Challenges: Season, bad weather, time difference."</i>
	Sensitivity to negative human attitudes	<i>"Unawareness, indifference, carelessness."</i>
Engaging user experience	Acknowledging unpredictability	<i>"Challenges: Birds decided to hang out on another tree."</i>
	Poetic/storytelling features	<i>"Idea of the brand name "Hikatari" comes from the combination of 'hikaye' and 'monogatari' both of which means story."</i>
	Game-like mechanics	<i>"The user plays a visual-auditory matching game at the campus panel (Wingdeck)."</i>
Ideas focused on engaging and motivating	Interface and interaction elements	<i>"Interaction effort -Low"</i>

potential
users.

	Customization options	<i>“Customization: Personal Bird Avatar, special Bird Room of each user”</i>
Situated and practical constraints Ideas that consider real-life and practical conditions.	Campus life and student routines	<i>“Dormitories – Daily life flow, Library environment: Read – listen – dive”</i>
	Technical feasibility	<i>“Challenge: Money, Wi-Fi connection.”</i>
	Tools and equipment	<i>“The system is installed into ten different locations in both campuses.”</i>
	Human-made environmental factors	<i>“Challenge: Human & car noise.”</i>

4.2 Emergent Framings of the Design Problem

While themes emerged inductively from the coded workshop data and describe recurring content areas, a second, interpretive layer of analysis revisited both the coded data and the resulting themes through a different analytical question: *What did participants implicitly understand the design problem to be?*

As environmental awareness constitutes a *wicked* design problem, it does not present a single, fixed problem definition [48]. Rather, participants implicitly reconstructed it into a well-defined problem in different ways before proposing solutions. The second analytical layer examined their underlying conceptions, which we conceptualize as *epistemic framings*. These framings reflect participants' implicit assumptions about what the design problem fundamentally is, how nature and human–nature relationships are conceived, what concerns are considered relevant, and what values should guide potential design responses. Five such primary framings have been identified.

Informational framing defined the project as a matter of acquisition and contribution of ecological knowledge. Here, the central question became how to recognize, categorize, and disseminate information about birds. Knowledge-oriented engagement formed the backbone of this framing.

Motivational framing defined the challenge as engaging user to sustain their interest. In this orientation, informational components were often combined with gamification, customization, or narrative mechanisms. The problem was not only how to provide knowledge, but how to make interaction compelling enough for continued participation.

Social framing interpreted biodiversity as a medium for connection. Through connecting people features, the system was conceptualized as a social infrastructure linking students across campuses or cultural contexts.

Therapeutic framing positioned nature as a source of psychological restoration. Using nature as escapism, participants articulated the system as a refuge within the rhythms of academic life.

Ecological-relational framing shifted attention toward the position of non-human actors. Drawing from themes of Nature-centric design, Bonding with

nature, and Ecological integrity, this framing redefined the challenge as one of establishing respectful, minimally intrusive relationships with birds and their habitats. Rather than centering solely on human-user benefit, it foregrounded ecological sensitivity.

The first four framings are predominantly *anthropocentric*: they interpret the system in terms of human learning, motivation, sociality, or well-being. The ecological-relational framing introduces a *more-than-human* orientation in which birds are not merely content or context but participants within an interaction ecosystem.

Importantly, these framings are not mutually exclusive. Individual proposals often combined elements from multiple orientations. Notably, Bonding with nature does not align exclusively with a single framing. In some proposals, bonding was articulated as psychological closeness to nature, aligning with therapeutic orientations. In others, it implied attentiveness or reciprocity toward non-human actors, aligning more closely with ecological-relational perspectives. In this sense, bonding may operate as a bridge between anthropocentric and ecological-relational orientations. However, the ecological-relational framing was conceptually distinct in that it questioned the assumption that human experience is the sole organizing principle of the system. Table 4 summarizes the relationship between thematic clusters, emergent framings, and their relative prominence across interest-level groups at the final stage of the workshops.

Table 4. Emergent framings of the design problem and their association with themes and groups.

Framing	Associated Themes	Low-Interest	Mixed Group	High-Interest
Informational	<i>Knowledge-oriented engagement</i>	Strong	Very Strong	Very Strong
Motivational	<i>Engaging user experience</i> (+ overlap with <i>Knowledge-oriented engagement</i>)	Strong	Present	Strong
Social	<i>Connecting people</i>	Strong	Limited	Present
Therapeutic	<i>Using nature as escapism</i> (+ selective <i>Bonding with nature</i> when articulated as psychological closeness or restoration)	Limited	Limited	Present
Ecological-Relational	<i>Nature-centric design + Ecological integrity</i> (+ selective <i>Bonding with nature</i> when articulated as reciprocity or ecological sensitivity)	Limited	Strong	Present

Remark. For each epistemic framing, we reviewed the individual design concepts to identify its presence, then converted the resulting frequencies into within-framing percentage distributions per group. Descriptors (*Very Strong, Strong, Present, Limited*) reflect the relative distribution of these percentages across groups and are intended as qualitative summaries rather than statistically defined categories.

4.3 Topic-Related Attitudes and Ideation Methods

4.3.1 Topic-Related Attitudes in Problem Framing (RQ1)

Our first research question examined how participants' topic-related attitudes shape early-stage problem framing and ideation. When thematic distribution and emergent framings are considered together, several patterned tendencies appear.

Participants in the Low-Interest group most frequently articulated informational and motivational framings. Real-time identification systems were commonly paired with reward structures, and engagement mechanics were foregrounded. Ecological sensitivity appeared primarily in relation to feasibility or minimizing disturbance, rather than as a restructuring of the system's core logic.

Participants in the High-Interest group also engaged strongly with informational framing, but often integrated it with social or narrative elements. Moreover, ecological-relational tendencies were visible in certain proposals, particularly where attention was given to soundscape integrity or non-intrusive interaction.

The Mixed-Interest group displayed the widest visible articulation of contrasting framings. Informational and motivational approaches coexisted alongside therapeutic and ecological-relational proposals. While ecological-relational framing, including proposals positioning birds as user, appeared most explicitly articulated in this group, it was not exclusive to it.

The data does not support a linear progression from anthropocentric to ecological-relational framing across interest levels. Instead, heterogeneous group composition appears to have enabled greater visibility of divergent orientations within the same collaborative setting in early stages.

4.3.2 Ideation Methods and Attitude Interaction (RQ2)

Our second research question examined whether different ideation methods interacted with topic-related attitudes in shaping outcomes.

Across all groups, the ideation trajectory moved from broad conceptual associations (open card sorting), to structured collective combinations (random deck), to individualized system proposals (open choice). Later phases intensified detail and coherence, yet dominant framings remained largely stable. Specifically,

informational and motivational orientations persisted and, in many cases, deepened across methods.

However, ideas aligned with a more-than-human framing, did not consistently translate into more fully developed design concepts as the process advanced. Across all groups, ecological-relational framings became less prominent as ideas progressed toward structured and finalized proposals. Ecological-relational perspectives were more visible during early, open-ended stages, particularly in the Mixed and High-Interest groups. However, their subsequent decline was not method-specific. As the process shifted toward selection and formalization, pragmatic concerns and feasibility considerations narrowed the framing of the design problem. While all groups showed this tendency, the Mixed-Interest group maintained ecological-relational framings more visibly than the others, even as their overall prominence decreased.

Structured ideation methods diversified feature combinations and increased conceptual complexity, but they did not substantially alter dominant interpretive orientations. The decreasing visibility of ecological-relational framings appears more closely related to convergence dynamics and practical prioritization than by methodological variation.

4.4 Implications for Structuring Participatory Design in Environmental Context

The findings of this study have several implications for participatory design practices addressing sustainability-oriented challenges.

Participatory processes do not automatically decenter human priorities. Although the project was framed within an ecological and HCBI perspective, anthropocentric framings remained dominant across the dataset. Informational, motivational, social, and therapeutic orientations all centered human experience as the primary organizing principle of the system. From an HCBI perspective, this persistence may not only reflect participants' prior attitudes but also the structural legacy of human-centered design traditions embedded in design education and digital culture.

Long-term biospheric interaction research suggests that decentering the human requires not only participatory inclusion but also infrastructural exposure to ecological temporalities – such as seasonal variation, migration cycles, and acoustic unpredictability – that challenge immediate user-centered logics. Without such exposure, participatory ideation risks reproducing short-term human engagement models even when ecological themes are introduced. Thus, the ecological-relational framing introduced an alternative orientation, but it did not replace human-centered approaches. Anthropocentric reasoning appears to function as a default cognitive baseline in early-stage design, and participatory design alone does not guarantee a shift toward more-than-human orientations. For sustainability-oriented participatory design, this reveals a structural tension: co-design may reproduce anthropocentric assumptions unless ecological perspectives are intentionally scaffolded through facilitation and design materials

that make non-human constraints, rhythms, and dependencies experientially present.

Ideation methods structure ideas, but do not override attitude-driven orientations. Across ideation phases, structured tools diversified combinations of features and increased conceptual complexity. However, underlying framings remained relatively persistent. Informational and motivational orientations deepened rather than disappeared in later phases, and ecological-relational tendencies were elaborated rather than replaced. This suggests that methodological variation shapes the articulation of ideas but does not fundamentally transform participants' interpretive positions toward the design problem. For sustainability-oriented participatory design, this implies that methodological tools alone are insufficient to produce epistemic shifts; facilitation strategies must explicitly engage framing assumptions.

Designing for latent needs require inclusion beyond the already motivated. The study conceptualized environmental awareness as a latent need: an issue that affects ecological systems but is not necessarily experienced as personally urgent by all participants. The variation in framings demonstrates that latent needs do not surface uniformly in participatory settings. Participants with lower prior interest frequently translated ecological awareness into informational or motivational systems, unsurprisingly embedding biodiversity within familiar engagement logics. Rather than interpreting this as a deficit, these translations reveal how broader user populations are likely to make sense of sustainability-oriented systems and what forms of engagement may enable their participation. In this respect, such framings provide critical insight into how latent needs can be translated into accessible entry points. Since this group represents the most challenging and consequential audience for sustainability design, excluding them would risk designing primarily for the already engaged.

Plural and heterogeneous participation expands the design negotiation space. The absence of a linear progression from low-interest to ecological-relational framing indicates that interest level alone does not determine ecological orientation. Instead, heterogeneous group composition appears to enable stronger articulation of contrasting positions within the same collaborative setting. The Mixed-Interest group did not simply represent a midpoint; rather, it provided a space in which informational, motivational, therapeutic, and ecological-relational framings coexisted and became visible. Participants with lower prior engagement surfaced how end users may frame sustainability systems, while more ecologically engaged participants articulated alternative possibilities. Considering these orientations together is crucial: ecological ambition without attention to inclusivity risks exclusion, while purely engagement-driven approaches risk downgrading ecological complexity. Plural participation therefore creates the conditions under which both ecological-relational alternatives and motivational entry points can be negotiated within the same design space.

Sustaining ecological-relational framing requires intentional continuity. Although ecological-relational framings emerged across groups, they did not consistently persist through stages of selection. As ideas moved toward structured

system proposals, pragmatic considerations often narrowed the design focus. However, the Mixed-Interest group demonstrated greater conceptual continuity, carrying early ecological sensitivities more consistently into later design outputs. This suggests that sustaining more-than-human perspectives requires more than initial articulation. The continued presence of participants with stronger topic-related commitment appears necessary, but not sufficient on its own. Heterogeneous participation expands the range of possible orientations and may slow the dominance of purely anthropocentric framings; however, as observed even in the High-Interest group, ecological-relational perspectives remain vulnerable to convergence dynamics. Under pragmatic and feasibility pressures, design processes tend to revert toward familiar anthropocentric logics. In this sense, ecological-relational framings are structurally fragile within participatory settings and require deliberate support if they are to be maintained.

Practically, the findings suggest that sustainability-oriented participatory design may benefit from a dual-layer strategy: (1) motivational and informational entry points that accommodate heterogeneous user orientations, and (2) infrastructural embedding within long-term ecological sensing systems that gradually expose participants to biospheric dynamics beyond immediate human benefit. Such coupling between participatory ideation and ecological monitoring infrastructures may create conditions for more durable epistemic shifts.

5 Conclusion

5.1 Contributions

This study explored how topic-related attitudes and ideation methods shape participatory design processes addressing environmental awareness as a latent design challenge. Firstly, the study contributes a new perspective for interpreting early-stage participatory ideation by introducing *epistemic framing* as an analytical lens for sustainability-oriented participatory design. The findings suggest that participatory design does not operate as an epistemically neutral process: participants enter co-design settings with prior orientations that influence how the issue itself is framed. Informational framing remained prominent across all groups, higher topic interest was associated with greater integration of ecological-relational concerns, and heterogeneous groups made contrasting framings most visible. Rather than indicating a linear progression from anthropocentric to ecological-relational perspectives, these findings suggest that group diversity expands the range of sustainability framings available for negotiation.

Methodological variation diversifies ideas and expressions, yet dominant interpretive orientations, informational framings in particular, remain relatively stable across phases. More-than-human perspectives, however, proved to be vulnerable and difficult to sustain. In this sense, topic-related attitudes operate as

structuring forces within participatory design, influencing how sustainability challenges are framed and negotiated, but their effects are mediated by group composition and convergence dynamics.

The study also highlights a broader ethical tension within participatory design. User-centered approaches historically emerged to represent users' needs within industrial systems; however, this model presupposes that needs are recognizable and articulable. In contexts such as environmental awareness, where concerns may be long-term, collective, or only partially perceived, participatory processes surface differences not only in solutions, but in problem definitions. Designing solely around expressed preferences risks reinforcing dominant orientations, while excluding less engaged participants risks narrowing the negotiation space. Engaging heterogeneous participants proved particularly valuable, as it surfaced tensions between human-centered and more-than-human orientations. Informational and motivational framings emphasized accessibility and user engagement, while ecological-relational proposals questioned the primacy of human benefit. Their coexistence enables a more reflexive and balanced design process.

Taken together, these findings suggest several key implications for better structuring sustainability-oriented participatory design practices:

- *Ecological scaffolding*: Since participatory processes do not automatically decenter human priorities, facilitators can support this shift by introducing materials and activities that make ecological constraints, rhythms, and dependencies explicitly present from the outset.
- *Framing-aware facilitation*: As methodological structure alone does not shift participants' underlying orientations, ideation techniques should be complemented by facilitation that directly engages participants' framing assumptions.
- *Inclusion beyond the already motivated*: Because less-engaged participants represent one of the most consequential audiences for sustainability design, purposefully including them can help avoid designing solutions that only resonate with those already invested.
- *Heterogeneous participation*: Bringing together participants with different levels of interest expands the negotiation space by enabling diverse framings to be articulated and negotiated.
- *Ongoing ecological-relational framing*: Since such framings are vulnerable and tend to fade without reinforcement, sustaining them requires revisiting or re-anchoring them at multiple points in the process.

5.2 Limitations

The findings should be interpreted considering the study's limitations. Conducted with fifteen participants across a series of three-week workshops within a single biodiversity awareness project, the study was designed to generate analytical insights and design implications rather than establish broadly generalizable patterns.

Although the workshops were situated within a biodiversity awareness project centered on bioacoustics, the observed dynamics are not inherently specific to this context. The analytical insights and design implications proposed in this study can be transferable to other sustainability-oriented participatory design settings in which environmental issues function as latent design challenges.

5.3 Future Research

Future research may explore how participatory design can be calibrated in other contexts where latent needs such as environmental sustainability are not uniformly perceived by participants, particularly within creative industries and design education settings. As sustainability becomes central to innovation practices, understanding how design methodologies engage differing epistemic orientations is crucial. Creative sectors, positioned at the intersection of culture, technology, and pedagogy, offer a promising space for developing participatory and educational frameworks that translate latent sustainability concerns into inclusive and transformative design practices. Comparative studies involving diverse sustainability domains like climate adaptation, circular design, or urban resilience, could examine the transferability of the design implications proposed in this study, as their applicability across different sustainability domains remains to be empirically validated. Such work may also investigate how creative practitioners negotiate tensions between user-centered innovation and more-than-human perspectives, and how participatory methods can better support ecological thinking throughout creative processes.

CRedit author statement. **Umut Tasa:** Supervision, Methodology, Writing-Original draft preparation. **Hill Hiroki Kobayashi:** Supervision, Methodology, Writing- Reviewing and Editing. **Nuran Akarsu:** Writing- Original draft preparation, Investigation. **İdil Şenel:** Methodology, Investigation. **Barış Öçal:** Visualization. **Arda Eden:** Software. **Haoran Hong:** Conceptualization. **Yukun Jiang:** Conceptualization.

Funding. This work has been supported by JST FOREST Program, Grant Number: JPMJFR211B, and by Yildiz Technical University Scientific Research Projects Coordination Unit, Project Number: SBI-2025-6127.

Use of Generative AI Statement. During the preparation of this manuscript, the authors used GPT-5.2&5.5 (OpenAI) for translation and language improvement purposes only. The authors have reviewed and edited the output and take full responsibility for the content of this publication.

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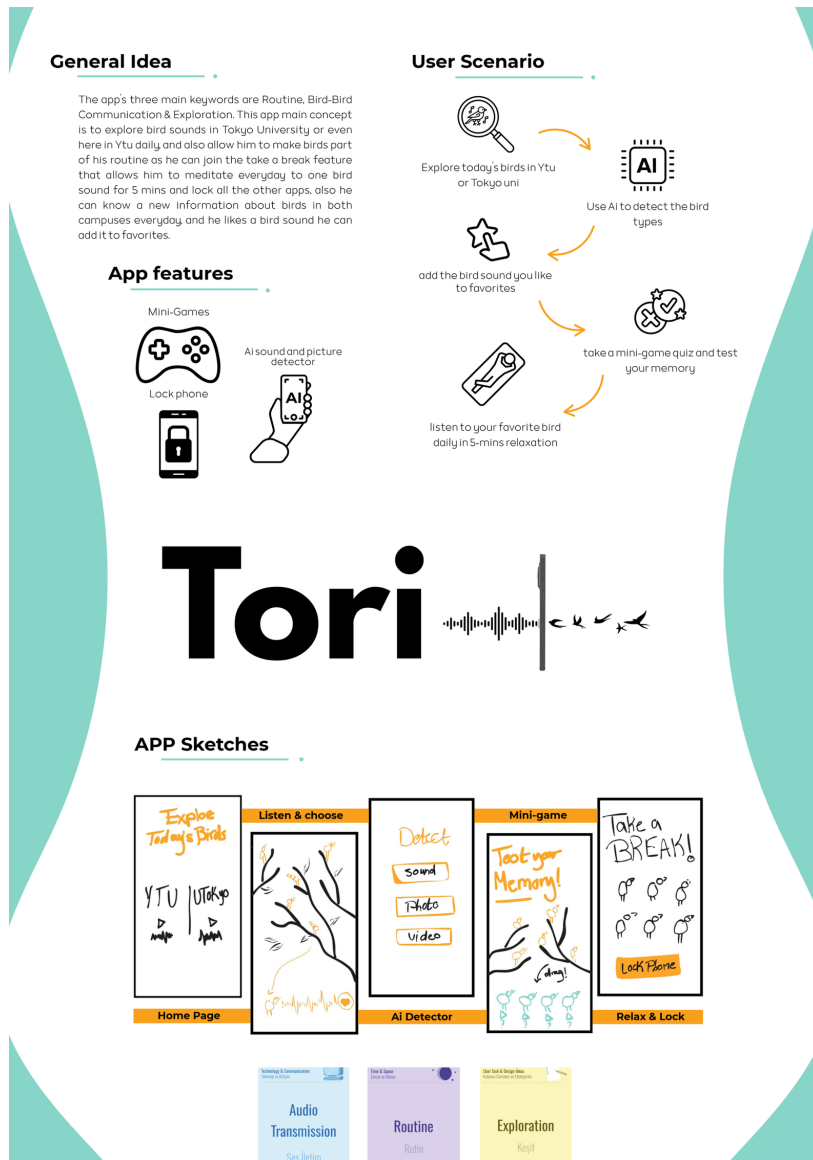
Appendix 1

Full Card Deck Design (English version), each 5x7cm.

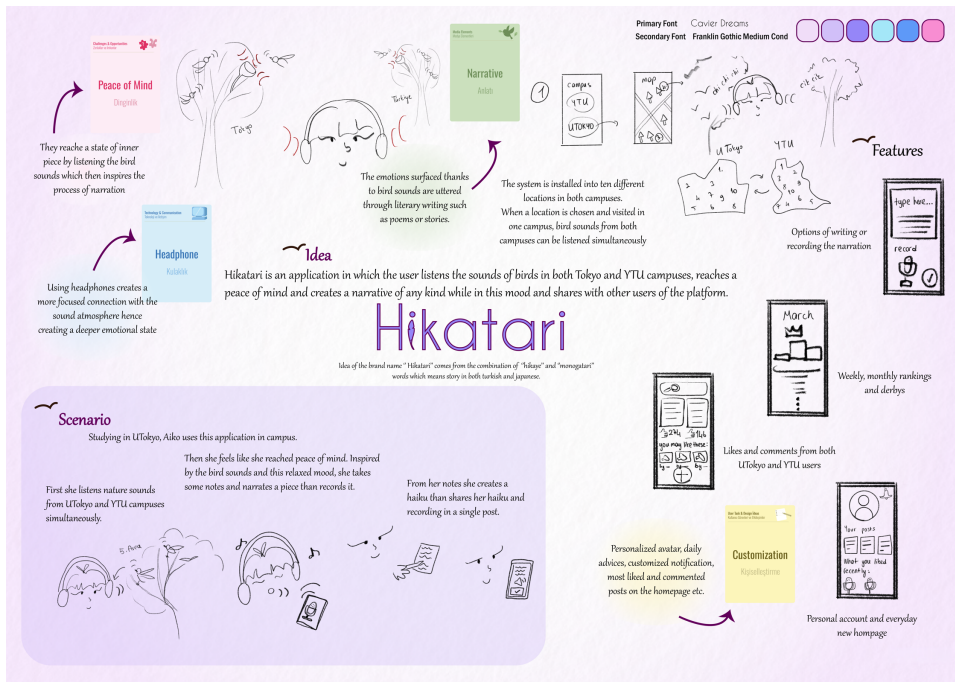
User Task & Design Ideas Matching	User Task & Design Ideas Species Identification	User Task & Design Ideas Exploration	User Task & Design Ideas Guessing	User Task & Design Ideas Mimicry	User Task & Design Ideas Customization
User Task & Design Ideas Gamification	Technology & Communication Audio Transmission	Technology & Communication Live Broadcast	Technology & Communication Human-Human Communication	Technology & Communication Headphone	Technology & Communication Synchronous / Asynchronous
Technology & Communication Bird-Bird Communication	Technology & Communication Human-Bird Communication	Media Elements Language	Media Elements Audio-Visual	Media Elements Narrative	Media Elements Map
Media Elements Calendar	Media Elements Bird Songs	Media Elements Season Colors	Time & Space Physical Site	Time & Space Tree / Habitat	Time & Space Routine
Time & Space Seasons	Time & Space Sunrise	Time & Space Rush Hours	Time & Space Migration	Challenges & Opportunities Different Species	Challenges & Opportunities Weather Conditions
Challenges & Opportunities Non-Intrusion	Challenges & Opportunities Background Noise	Challenges & Opportunities Silent Zone	Challenges & Opportunities Bird-Only	Challenges & Opportunities Peace of Mind	

Appendix 2

Representative Design Boards from Participant Group



(a) Mixed group



(b) High-Interest Group – above & (c) Low-Interest Group - below

