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Master's Thesis
Academic Year 2025

Designing for Sense of Home: Applying Self-Determination Theory in the Creation of Personalized Multisensory Artifacts

Keio University
Graduate School of Media Design

Yuki Iwama

A Master's Thesis
submitted to Keio University Graduate School of Media Design
in partial fulfillment of the requirements for the degree of
Master of Media Design

Yuki Iwama

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Abstract of Master's Thesis of Academic Year 2025

Designing for Sense of Home: Applying Self-Determination Theory in the Creation of Personalized Multisensory Artifacts

Category: Design

Summary

As mobility due to migration, displacement, or education becomes more common, maintaining a sense of home is increasingly important for emotional well-being. This study explores how Self-Determination Theory (SDT), which emphasizes autonomy, competence, and relatedness, can inform the design of multisensory artifacts that evoke a sense of home. International students in Japan participated in a three-stage design process: a cultural probe to reflect on sensory memories, the creation of a personalized artifact using visuals, sounds, and scents, and a group-sharing session. Data from SAM scales, an adapted SDT questionnaire, and thematic analysis showed that the process deepened awareness for the self and the environment, encouraged emotional expression, and fostered social connection. The findings suggest that applying SDT in design can support individuals in creating emotionally resonant experiences of home.

Keywords:

sense of home, multisensory, self determination theory, artifact design, wellbeing

Keio University Graduate School of Media Design

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Lastly to my friends, family, and all the fellow people from Myanmar who are currently residing abroad for refuge, thank you for inspiring me to do this research. I hope one day we can all return back safely to the place we first called home.

Chapter 1
Introduction

1.1. Background

Is home a place, a feeling, or a memory? For some, it is the house they grew up in. For others, it is a scent, a language, or the presence of loved ones. Home, a multidimensional concept that extends beyond physical environments to identities, emotions, and communities, plays an important role in shaping our well-being and everyday experiences (Mallett 2004).

In an era of increasing globalization, migration, and displacement, understanding the sense of home has become more relevant than ever. Millions of people are on the move with some seeking refuge from wars, political unrest, or natural disasters, while others migrate in pursuit of better economic opportunities, education, or personal growth. These movements often disrupt conventional notions of home, forcing individuals to construct and maintain their sense of home in different environments.

1.2. Research Motivation

My personal background and experiences have driven me to conduct this research as well. As someone from Myanmar, a country that has been deeply affected by conflicts and natural disasters, I feel very fortunate to be able to find refuge in other countries and continue to pursue education. However there are many people in worse situations where they have been forced out and don't know when they can or if they can ever return home. Therefore, I would like to use this opportunity and dedicate my research to developing solutions that could ultimately be used to help support communities who are away from home, in hopes of preserving their memories and contributing to their wellbeing.

1.3. Research Objective

The objective of this research is to explore how individuals' sense of home can be evoked through the process of creating a multisensory artifact that is grounded in three principles of the Self Determination Theory (SDT): competence, autonomy, and relatedness. This research not only creates a tangible design outcome but also examines how each phase of the process supports the evocation of a sense of home by qualifying and quantifying the following research questions.

1. How can the Self-Determination Theory be applied to the creation of a multisensory artifact to evoke a sense of home?

2. How does the creation of the multisensory artifact enhance an individual's sense of home?

Through this process, the research seeks to provide insights into how individuals define and experience a sense of home through sensory experiences and psychological needs as well as how this design framework can be used to support mobile populations.

1.4. Research Contributions

The current research makes several key contributions. By aligning psychological needs with the lived, sensory experience of home, the current research theoretically introduces Self-Determination Theory as a framework for creating experiences that evoke a sense of home. In terms of design, this research proposes a design of a multisensory artifact that can be personalized to include visuals, sounds, and scents that resonate with the sense of home of individuals in mobile living situations. Through these approaches, this research aims to examine how each phase of the SDT-based design process and/or the sensory elements of the artifact contributes to the participants' sense of home. Ultimately, the research offers a framework for designing emotionally supportive tools in mobile contexts with potential applications in student life, migration, disaster recovery, and beyond.

1.5. Structure of Thesis

This thesis consists of the following five chapters, explaining the research conducted.

1. **Chapter 1** introduces the background and motivation for this research, outlines its objective and research questions, highlights the key contributions of the research, and provides an overview of the thesis structure.

2. **Chapter 2** provides a review of the literature, explaining the foundational concept of sense of home, introducing the Self Determination Theory (SDT) as the guiding framework, and reviewing related works in multisensory design that influenced the research approach.

3. **Chapter 3** describes the design concept in detail, covering the steps taken as part of the research journey, and the development of the prototype.

4. **Chapter 4** presents the proof of the design concept for this research. This chapter describes the implementation of the design concept as a cultural probe study and workshop, highlighting the methodology, relation to the SDT, data collection and analysis, and outcomes of each process. Lastly, this chapter summarizes the overall findings from these processes.

5. **Chapter 5** provides the discussion of the research through insights gained from the finding as well as describing the challenges and limitations faced.

6. **Chapter 6** concludes the research by summarizing the key findings and contributions as well as proposing considerations for future research.

Chapter 2
Literature Review

2.1. Sense of Home

2.1.1 Defining Sense of Home

Although home has been commonly defined as the place of residence by many dictionaries (Cambridge Dictionary 2025, Merriam-Webster 2025), previous research looking at home from different disciplines, ranging from psychology to architecture, have proposed multiple understandings of home (Mallett 2004, Blunt and Dowling 2006) .

Researchers studying the concept of home from a social aspect have expressed that the home serves as a foundation for socio-cultural life experiences since social interactions within residential environments forms community identity and relationships, reflecting broader cultural values and norms (Oswald and Wahl 2005, Somerville 1997). Additionally, studies focusing on the physical aspects of the home emphasize elements such as structure, functionality, and building form, highlighting their role in shaping the sense of home. For instance, Sixsmith (Sixsmith 1986) and Rijnaard et al.(Rijnaard et al. 2016) explored how the design and layout of a house influence feelings of comfort, security, and belonging. Van Steenwinkel and colleagues (Van Steenwinkel et al. 2012) further examines how architectural features and spatial arrangements contribute to creating a personal connection to the home. Home has also been explored through the psychological aspect, highlighting its role as a reflection of the self including identity, emotions, and behaviours (Gibson et al. 2011). Graham and colleagues' (Graham et al. 2015) study on the psychological importance of home environments have emphasized the impact of home on emotional well-being and interaction. Similarly, Sigmon and colleagues' (Sigmon et al. 2002) study has defined "Psychological Home" as a

space for identity and refuge, where personalization enhances attachment and life satisfaction.

Despite the multifaceted meanings of home, it has been noted by many researchers that home is more than a geographical location in which an individual resides as it encompasses the relationship between the physicality of the space and the psychology of the self. Therefore, to make a clear distinction between home as a physical space and home as a subjective experience and connection that one has with the space, this paper will hereafter refer to the latter concept of home as "sense of home". This paper adopts the meaning of sense of home, which is based on the the qualitative metasynthesis study on the meaning of home by (Molony 2010), as a feeling of connection between a person and place that is shaped by the evolving psychology of the self, social relationships, and the physical elements of one's living environment.

Table 2.1 Disciplines of Sense of Home

Disciplines	**Descriptions**	**Studies**
Social	Socio-cultural experiences, relationships, community	(Oswald and Wahl 2005) (Somerville 1997)
Physical	Structure, functionality, spatial arrangements of homes	(Sixsmith 1986) (Rijnaard et al. 2016)
Psychological	Identity, emotions, behaviours	(Blunt and Dowling 2006) (Gibson et al. 2011)

2.1.2 Importance of Sense of Home

Residential mobility, the act of changing one's residence, has been increasing. According to the 2024 UNHCR's Global Trends report and International Migration Outlook 2024, migration to OECD nations has reached new records and more than 117.3 million people faced forcible displacement in 2023 (United Nations High Commissioner for Refugees 2024, OECD 2024).

Whether it be due to economical factors, lifestyle aspirations, or external crises like wars and natural disasters, residential mobility has profound impacts on

individuals as the process of moving requires individuals to adapt to the routines of life in unfamiliar environments. While it encourages adaptability and openness, this disruption to long established routines, environments, and social ties can lead to emotional stress and a decline in well-being (Oishi and Tsang 2022, Seamon 2015, Silver and Grek-Martin 2015). In these situations, having a sense of home can address these effects by providing continuity of old comforts and connections through familiar objects, senses, and routines as individuals navigate their new environments (Scannell and Gifford 2017).

2.1.3 Constructing and Experiencing Sense of Home

Constructing a sense of home refers to the process of creating a homely atmosphere which elicits feelings such as familiarity, belonging, comfort, and security (McCracken 2005). Since constructing a sense of home is an universal yet subjective experience, many researchers have explored how individuals construct their sense of home in various communities, namely in students (Holton and Riley 2016), older adults (Rijnaard et al. 2016), migrant, (Ralph and Staeheli 2011), and people sleeping rough populations (Parsell 2012). Despite the varying contexts, researchers have come to understand that the construction of home involves psychological, social, and physical processes (Somerville 1997, Rijnaard et al. 2016).

The psychological aspect of constructing a sense of home involves exercising one's autonomy and maintaining one's routines and values. Autonomy is exercised by personalizing the space with familiar items or photos, controlling the access to personal spaces, and making decisions about daily activities. This allows individuals to freely express themselves, supports privacy and emotional security, as well as builds their competence and self-efficacy (Graham et al. 2015). Another psychological construct is the continuation of previous habits and values. Engaging in the same routines as in previous homes offers predictability for individuals in unfamiliar environments. Similarly, upholding personal values allows individuals to maintain their personal identity as well as find like-minded communities with similar habits and values which is another aspect of constructing a sense of home (Rijnaard et al. 2016, Van Hoof et al. 2016).

Social relationships are equally important in the process of constructing a sense of home. As mentioned earlier in this paper, home is not only the physical space

but also the dynamic integration of the place and people. Therefore, the relationships between individuals (i.e. between family, friends, neighbors, communities, and pets) contribute significantly to constructing a sense of home. This is particularly evident in research exploring the sense of home in communities living away from home which highlights that maintaining meaningful relationships and interactions with communities around them and back home help them create a sense of home (Rijnaard et al. 2016, Spangler 2023). These social relationships are also built on social media community groups, community events, and communal spaces (Gomes et al. 2014, Wong 2017). By connecting and maintaining social interactions, individuals can feel supported and togetherness with others.

Sense of home is also constructed through factors in the physical environment. One common way is through materials such as personal belongings and heirlooms which are tangible representations of one's identity, memory, and a continuation of their life stories (Ratnam 2018). Additionally, constructing a sense of home relies heavily on the familiarity of sensescapes in the physical environment. These sensory experiences include not only the sights, sounds, textures, tastes, and smells individuals passively encounter in daily life but also those that they actively create, such as through cooking, hobbies, and routines (Pink and Leder Mackley 2016).

Overall, the process of creating a sense of home is multifaceted as it is influenced by one's psychological needs, social interactions, and physical and sensory surroundings. The combination of these activities shows that home is a lived experience with psychological, social, and physical significance rather than a mere space. This is in line with the Self Determination Theory which emphasizes the significance of competence, autonomy, and relatedness in achieving wellbeing and constructing a sense home. The concept of familiar sensescapes is also crucial since the embodied and sensory elements in the environment shape the way we experience and construct a sense of home.

2.2. Self Determination Theory

The Self-Determination Theory (SDT) is a prominent psychological framework established by Deci and Ryan (Deci and Ryan 2000) which explores factors that contribute to how individuals achieve wellbeing and flourish as a person. This

framework highlights the need for competence, autonomy, and relatedness as the three basic psychological needs of all individuals for psychological growth and fulfillment. By applying this theory to the concept of sense of home, SDT offers a valuable perspective for exploring how individuals experience home as a dynamic integration of the self, community, and environment instead of just a place to live.

2.2.1 Competence

In SDT, the need for competence conveys the need to feel capable and effective in one's environment (Ryan and Deci 2017). This is demonstrated in the context of home by the ability and opportunity to change, preserve, and enhance living environments in accordance with the individual's personal values and goals (Soleimani and Gharehbaglou 2023). Research has also shown that individual's feelings of competence and identity grow stronger when they believe that their houses reflect their values and enable them to carry out their routines and habits (Blunt and Dowling 2006, Streimikiene 2015). This is also evident in settings such as nursing homes where residents adopt coping strategies and maintain old routines which not only promote a sense of continuity but also identity and self-efficacy in creating a sense of home.

2.2.2 Autonomy

Autonomy refers to the need to act independently in a way that aligns with one's own will and beliefs and is free from external influences (Ryan and Deci 2017). In the context of sense of home, autonomy reflects the ability to make decisions about one's environment and daily routines (Soleimani and Gharehbaglou 2023). This involves being able to modify or personalize one's space, establish daily routines, and make choices that have an impact on their daily lives. This can mean having the control over how furniture is arranged, where and who is allowed into one's private space, and when one sleeps or eats. Flexible and customizable living environments can fulfill this need and in turn foster a stronger sense of home and wellbeing, while situations such as in rental houses or shared living spaces which limits autonomy can cause emotional distress (Dunn and Hayes 2000, Clark and Kearns 2012).

2.2.3 Relatedness

The need for relatedness describes the need to feel connected with others, reciprocating care for one another (Ryan and Deci 2017). As mentioned earlier, this is an important aspect of the sense of home and is constructed through social interactions, shared experiences, and emotional connections to both people and places. Studies examining the sense of home in international students have examined how they fulfill their need for relatedness through local social networks and continued connections with their home communities (Gomes et al. 2014). Staying in touch with friends and family via social media while making new connections in the host nation also helps to create a hybrid sense of home (Spangler 2023). This shows how relatedness in the context of home means more than co-presence in a confined space as it also entails the emotional ties and digital connectivity that fosters togetherness even when individuals are far apart.

2.2.4 Summary

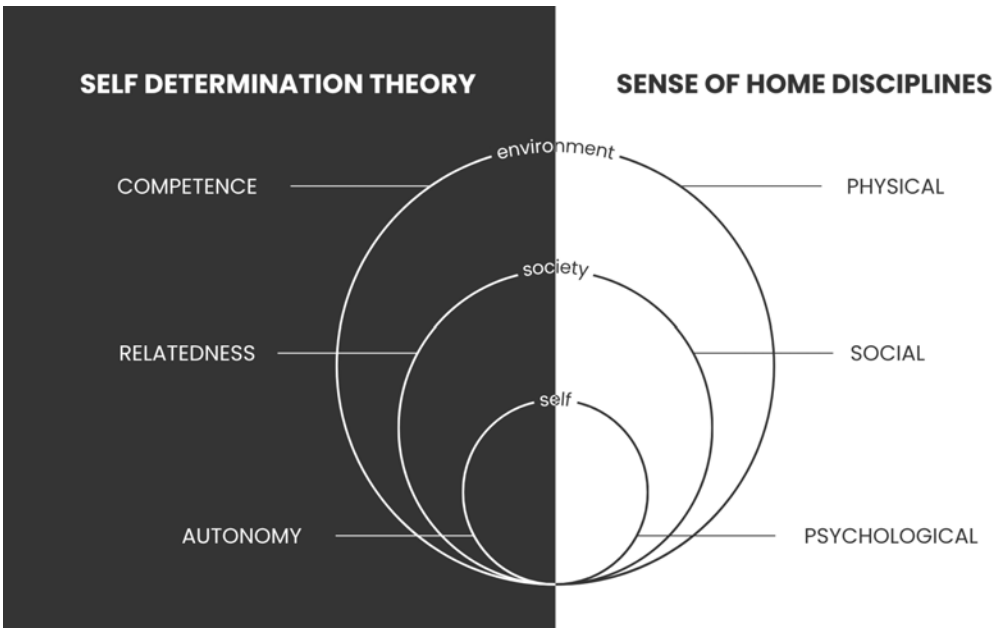

Figure 2.1 SDT and Sense of Home

By looking at sense of home through the lens of SDT, it can be understood how the different emotional, social, and physical components of home are closely related to psychological well-being. Exercising competence, expressing autonomy, and cultivating relatedness all help construct a sense of home, making home a valuable element for well-being (Mallett 2004).

2.2.5 SDT in Design

The SDT has been frequently applied in design research as it is a well-validated theory that influences user experience and wellbeing (Peters et al. 2018). This theory has been applied to different forms of design including those for game design, human-robot interactions, education, and participatory activities (Ballou et al. 2022). As Calvo et al (Calvo et al. 2016) and Peter et al (Peters et al. 2018) have highlighted, the SDT can be applied to different levels of experience ranging from the interface to task, behaviour, and life.

For instance, in the context of human-robot interaction design, it can be understood how the SDT has been applied at an interface and feature level. This is demonstrated through the robot's or conversational agent's ability to provide effective feedback, establish rapport, and allow flexible conversations and interactions (Henkemans et al. 2017, Yang and Aurisicchio 2021). Henkeman and colleagues (Henkemans et al. 2017) have also highlighted how this personalized robot behaviour based on the SDT that engages children with type 1 diabetes through self-management education games has yielded increased pleasure and motivation in children compared to the neutral robot counterparts.

Additionally, the SDT can also be applied to the task level of experience such as in the design of needs support from teachers to enhance students' learnings. The SDT based framework, where teachers encourage students to make choices for projects and tools, provide clear expectations and guidance, and foster interpersonal relationships through group formation and meetings, showed more positive perception of learning and engagement (Xia et al. 2022, Chiu 2022, Ruzek et al. 2016). SDT is also applied in co-design activities where it involves participants in the design processes of products or services. This is reflected in how the activities give participants the control over design decisions, encourage skill development and problem-solving, and emphasize connection to the process and other

contributors (Dent-Spargo 2018). By analyzing existing reports of co-design researches as well as their own co-design project myPAL (My Personalized Adaptive Learning) that contextualizes medical students' learning data to support personal learning (Treasure-Jones et al. 2018), Dent-Spargo (Dent-Spargo 2018) has found that co-design activities that support the three needs of the SDT can promote intrinsic motivation, creativity, and well-being among the participants, resulting in more impactful and valued design outcomes.

2.3. Multisensory Artifact and the Sense of Home

Humans inherently perceive their environments through various senses as these different senses interact to influence how people understand and emotionally respond to their surroundings (Spence 2020). There has been a growing interest among researchers and designers across disciplines to explore how multisensory experience can be used to enhance wellbeing and influence behaviour (Schreuder et al. 2016). The following section will cover several studies in interface design which have used immersive stimulation of multisensory modalities to foster comfort, connection, and memories.

2.3.1 Studies in Multisensory Design

An example of a design that integrates multiple sensory modalities to promote emotional connection and well-being is the Multisensory Interactive Window, introduced by Angelini and colleagues (Angelini et al. 2015). This is a tangible window-like interface that provides an intuitive and immersive experience by combining visual, auditory, olfactory, and tactile components through the use of a mounted window frame, TV screen and web-camera for audio-video stream, scent diffusers, air blower, and ultrasonic vaporizers. The aim of this design was to help elderly users experience distant places and communicate with loved ones through stimulation of being in nature or in a familiar room. This promotes the well-being of the elderly by reducing feelings of isolation and allowing new forms of interactions both remote environments and people.

Multisensory design has also been explored in the context of cultural heritage and urban displacement. The Mapping Memory Routes project, developed by

Terracciano and colleagues, is a multisensory digital interface that aims to document and preserve the intangible cultural memories of Moroccan communities in London (Terracciano et al. 2017). The design consists of a physical map of the Golborne Road which is a neighborhood known as the Little Morocco with physical artifacts such as cinnamon sticks and prayer beads that represent the different aspects of Moroccan culture. Users interact with these objects through a multisensory digital interface that includes a tablet with the Augmented Reality (AR) application and olfactory technologies to play pre-recorded videos and scents that have been sourced from people of Moroccan descent. This study shows how multisensory technology can encourage embodied engagement and cultivate emotional and spatial connections.

Another study by Shakeri and colleagues explored multisensory stimuli in relation to how emerging adults and their parents stay connected after living apart (Shakeri et al. 2023). Through interviews and co-design exercises with 16 pairs of parents and emerging adults, they found how passive sensory cues help families maintain connection. These passive sensory cues included shared visual elements, home scentscapes, ambient sounds of home, and left-behind objects. The co-design session where participants were invited to ideate prototypes of technologies that would help them stay connected also revealed a preference for tangible prototypes with multiple ambient senses that accounts for customization and privacy. Although it is not explicitly stated to be designed for a sense of home, this study offers important insights into how multisensory technology can help address psychological needs considering changes in home environments. The following section continues to explore multisensory design in the context of home.

2.3.2 Multisensory Design in the Context of Home

Visual Artifact

People have relied heavily on visual elements to express and to feel a sense of home. A study by Sabie and colleagues proposed a paper-based home drafting tool called Our Home Sketcher, allowing immigrant participants to sketch their ideal homes which were then made into 3D models (Sabie et al. 2020). This tool demonstrated how visual representations of space allow individuals to express their memories

of home as well as provide a feeling of agency and cultural continuity. Additionally, Kitamura and colleagues study explored how tatami, a traditional Japanese flooring that is not widely used anymore, can be reintroduced into everyday life in the form of ambient displays (Kitamura et al. 2025). Although it is not specifically intended to evoke a sense of home, this study shows how traditional visuals and materials, particularly those associated with domestic spaces, can be used to maintain cultural familiarity and reinforce one's sense of home.

Sound Artifact

In addition to visuals, soundscapes also play an important role in shaping the sense of home. According to Zorea and Kushi's research on how Japanese residents perceive domestic soundscapes, paying attention to sounds like rain, household appliances, or noise from pets encourages caregiving practices and awareness of the surrounding environment (Zorea and Kushi 2024). The authors emphasize the potential of technology and interaction design to encourage residents to notice, interpret, and engage with the subtle ambient sounds of home which would enhance care and connection in home environments. Similarly, a study by Houben and colleagues explored how everyday sounds can contribute to the wellbeing of people with dementia and their caregiving partners at home (Houben et al. 2022). The researchers and the participants co-designed familiar sound player prototypes, inspired by music boxes, radios, and record player, to develop a device that can be used to evoke memories, spark conversations, and support emotional engagement between partners. This study demonstrates how the interactive everyday sound device offers an innovative way to enhance the sense of home as well as social interaction, emotional well-being, and shared experiences.

Olfactory Artifact

Smell is another sensory modality that has a strong link to memory and emotion which makes it an important element in evoking a sense of home. A study by Mei-Kei, aimed to design and integrate interactive olfactory experience into daily family bathing routines by embedding motion sensors and scent diffusers in shampoo containers (Mei-Kei 2021). These olfactory interactions helped reinforce sensory familiarity with different scents while creating playful shared experiences

and meaningful bonding between family members. Another design using olfactory stimuli is the Sensorwake Trio, a scent-based alarm clock (SensorWake Trio (Sensorwake) 2018). This clock allows the users to input familiar scents like coffee and citrus to wake them up, providing comfort, memory, and a positive start to the day. These scent-based projects show how smell can reinforce a feeling of home and evoke nostalgic associations through embodied, interactive experiences.

2.3.3 Summary

Together, these studies convey how artifacts that engage multiple senses can be used to evoke memory, familiary, and connections which all contribute to a sense of home. Especially for individuals in transient or unfamiliar environments, the senses of sight, sound, and smell each offer various ways to recreate a sense of familiarity as well as support emotional well-being which also aligns with the psychological needs outlined in the SDT. Therefore, multisensory design helps individuals feel more connected to what they consider home even when their sense of home may be evolving.

2.4. Research Gap

Although sense of home has been researched extensively from disciplines such as psychology, architecture, and sociology, there is a notable gap in how sense of home is addressed in design studies particularly in relation to both psychological needs and sensory experiences. Especially looking from the psychological perspective and as mentioned above, there are several overlaps between the SDT and how individuals construct or experience their sense of home. However, this area of study has been unexplored and has not been applied in the context of designing for a sense of home. Similarly, existing studies have also highlighted the influence of different sensory elements on evoking memory and comfort. However, there are limited studies exploring how these multisensory elements can be incorporated into artifacts and activities to enhance the sense of home particularly for individuals such as international students in transitional or mobile living environments.

Chapter 3
Design

3.1. Design Concept

To address the research gaps identified in the previous chapter, this research proposes a design process grounded in Self Determination Theory (SDT) (Ryan and Deci 2017)to create a personalized multisensory artifact that evokes a sense of home. This multisensory artifact integrates familiar sounds, scents, and visuals selected by the participants and is designed to recreate emotional and sensory experiences that contribute to the feeling of home.The design process is guided by SDT which emphasizes the importance of fulfilling three basic psychological needs of competence, autonomy, and relatedness. Participants first reflect on and document the sensory elements that make them feel at home through a Cultural Probe Study (competence), choose and personalize these sensory elements to assemble the artifact (autonomy), and lastly share and connect their experiences with others (relatedness). By addressing the three basic psychological needs outlined in the SDT and integrating familiar sensory elements selected by each participant, the artifact and its design process are designed to not only evoke the sensory memory of home but also help participants better understand and express what sense of home is for them.

3.1.1 Why a Multisensory Artifact?

Home is inherently experienced and remembered through a combination of senses. Research in psychology and sensory studies have also shown how these senses interact to influence emotional perception and recall (Spence 2020). Particularly, olfaction has been understood as an effective trigger for autobiographical memories and emotional responses due to its close connection to the limbic system

(Herz et al. 2004). Similarly, familiar visual elements and ambient soundscapes of home influence individuals' feeling of comfort and sense of home (Blunt and Dowling 2006, Sou and Webber 2023). Therefore by appealing to different senses, the artifact can reflect the emotional and embodied experience of home more holistically. This also provides individuals with sensory continuity which supports their emotional well-being as they adapt to unfamiliar environments.

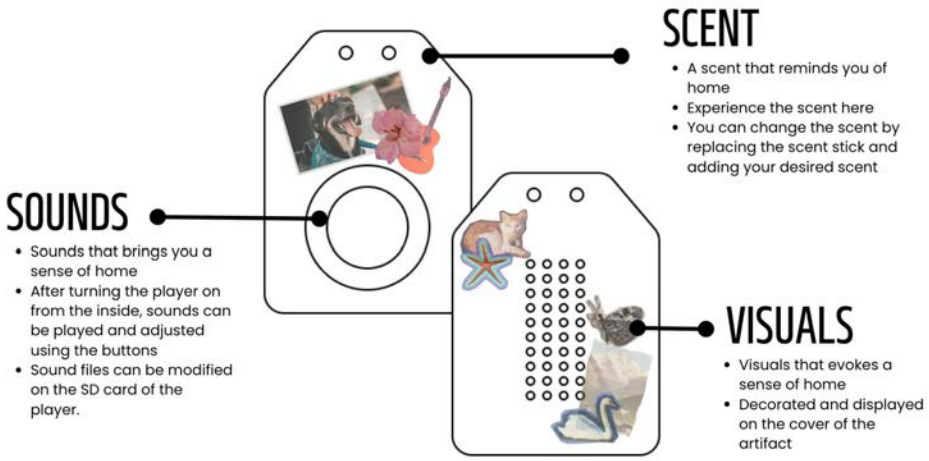

Figure 3.1 Design Concept

3.1.2 Why Apply the SDT to the Design Process?

SDT (Ryan and Deci 2017) serves as the foundation for the design process since its three main psychological needs for autonomy, competence, and relatedness closely align with the key elements that influence an individual's sense of home. These key elements of sense of home include but are not limited to having control over one's environment, establishing effective routines, personalizing space, and maintaining social relationships which reflect the three dimensions of the SDT.

As mentioned above, the three dimensions of SDT are reflected directly in

the design process by having participants experience competence through documenting sensory elements that are effective in evoking a sense of home, exercise autonomy by choosing their own sensory elements that resonates with them, and foster relatedness by sharing their experiences and what sense of home is for them. By implementing the principles of SDT, it ensures that the artifact is not only functional but also offers emotional and psychological support. This is especially important for mobile communities who frequently experience loss of control, changes in routines, and weakened social relationships.

Additionally, since SDT is a well-established theory in psychology, it offers a validated evaluation framework (i.e. Basic Psychological Needs Satisfaction Scale) to evaluate how the design affects participants' sense of home and wellbeing. This makes it possible to systematically assess how each stage of the design process contributes to meeting the SDT needs and the effectiveness of the design process in enhancing the sense of home.

3.2. Design Process Overview

The proposed design process was designed based on the 3 principles of the Self Determination Theory (SDT): competence, autonomy, and relatedness. Therefore, the process is separated into three phases to reflect each principle of the SDT as described below in Figure 3.2. The participants were international students from the Graduate School of Media Design, Keio University (KMD) (please refer to Chapter 3.4.1 for more information on participants).

As for the overall design journey of the research, it consisted of the following processes.

1. Ethnographic Study at two evacuation centers in Nanao City, Ishikawa Prefecture. Decided to change study participants to KMD international students after this ethnographic study.

2. Two Preliminary Surveys were conducted: one online questionnaire and one at the KMD Forum

3. Cultural Probe Study

4. Development and Iterations of the Prototypes

5. Workshop (Artifact Assembling, Interacting, Sharing)

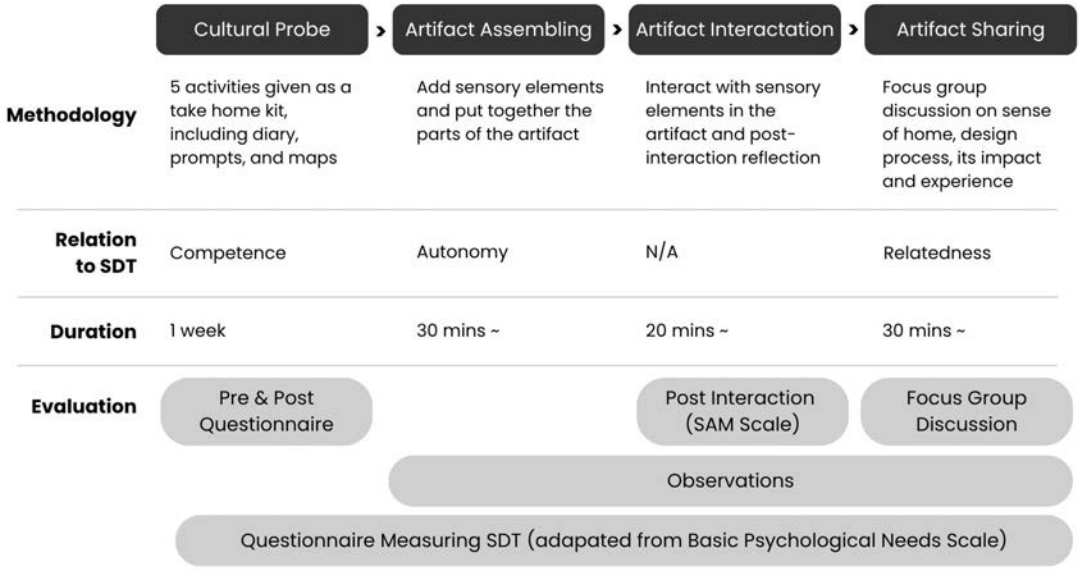

Figure 3.2 User Journey

3.3. Ethnographic Study

The ethnographic study was conducted in two remaining evacuation centers in Nanao City, Ishikawa Prefecture: Nanao Civic Gymnasium Evacuation Center and Yatagou District Community Center Evacuation Center. It was conducted on June 1st, 2024 which was six months after the 2024 Noto Peninsula earthquake that occurred on January 1st, 2024. The aim of the study was to gain insight into the daily lives, spatial arrangements, and needs of the individuals who were still residing in these temporary shelters. The study was carried out by the researcher with support from three students from KMD who assisted with interpretation and documentation. At each evacuation center, the team was guided by a facility

manager who provided detailed explanations of the center's operations and residents conditions. These explanations were transcribed and photographs of the facilities were taken with permission as part of the data collection process.

3.3.1 Nanao Civic Gymnasium Evacuation Center

At the Nanao Civic Gymnasium Evacuation Center, cardboard houses developed by Professor Keisuke Kitagawa (Nagoya Institute of Technology 2024) were utilized to accommodate the 51 remaining evacuee residents at the time of visit. Each modular unit came with a cardboard bed and offered a decent amount of privacy and personal space as well as heat and sound insulation. However, as summer was approaching, the cardboard houses raised concerns about heat stroke so this evacuation center was scheduled to close down on June 16th, 2024. It was mentioned that the residents would be relocated to limited temporary shelters based on the lottery system or the evacuation center at the Yatagou District Community Center.

The cardboard houses were also adjustable, allowing bigger families to connect several units together. The residents also personalized their individual units such as by decorating with flower vases and anime figures, adding doorknobs made with tape, and creating a space outside to hang their clothes. This showed the small yet significant efforts that the individuals make to create familiarity.

In terms of the social aspect, family visits were also allowed under certain conditions, and volunteers supported the residents with health related and recreational services. It was also mentioned that the people in charge also took into account residents' neighborhood backgrounds when assigning spaces which helped them preserve some form of social familiarity. Even though the remaining residents faced challenges such as uncertainty about relocation and job insecurity, many still maintained routines such as commuting for work from the evacuation center or going back to their inhabitable homes to collect belongings.

In one brief exchange with an elderly lady, she spoke about her grandchildren who were living in Tokyo, expressing hopes for the future of seeing them grow up. This showed how memories and relationships continue to influence emotional resilience even in temporary and disrupted environments.

Figure 3.3 Pictures of Nanao Civic Gymnasium Evacuation Center

3.3.2 Yatagou District Community Center Evacuation Center

Unlike the gymnasium evacuation center, the Yatagou Community Center used low cardboard walls instead of enclosed cardboard houses to accommodate the residents as they prioritized visibility over privacy. This choice of partition was to allow personnel to check on residents easily and encourage communal support, which reflected their focus for community and safety. Initially, right after the earthquake their main concern was to accommodate as many people as possible. However, overtime as the space evolved to provide more privacy and with fewer residents, the residents gradually gained control over their surroundings to build makeshift doors, organize personal storage and help maintain shared facilities. These demonstrate actions that contribute to the individuals' sense of autonomy.

This community center not only functioned as an evacuation center but also a space for social and logistical activities to distribute goods to other areas of Ishikawa Prefecture and hosting art and recreational events as space opened up. Both residents and children from the neighborhood contributed to the maintenance of the facility by cleaning and organizing books in the library. Therefore, despite the challenges such as water shortages and overcrowding that it initially faced, the community center promoted shared responsibility, adaptive utilization of space, and community engagement. Through these familiar routines, social structure, and opportunities for contribution, they were able to support emotional stability and collective resilience of the residents which are also important aspects in constructing a sense of home.

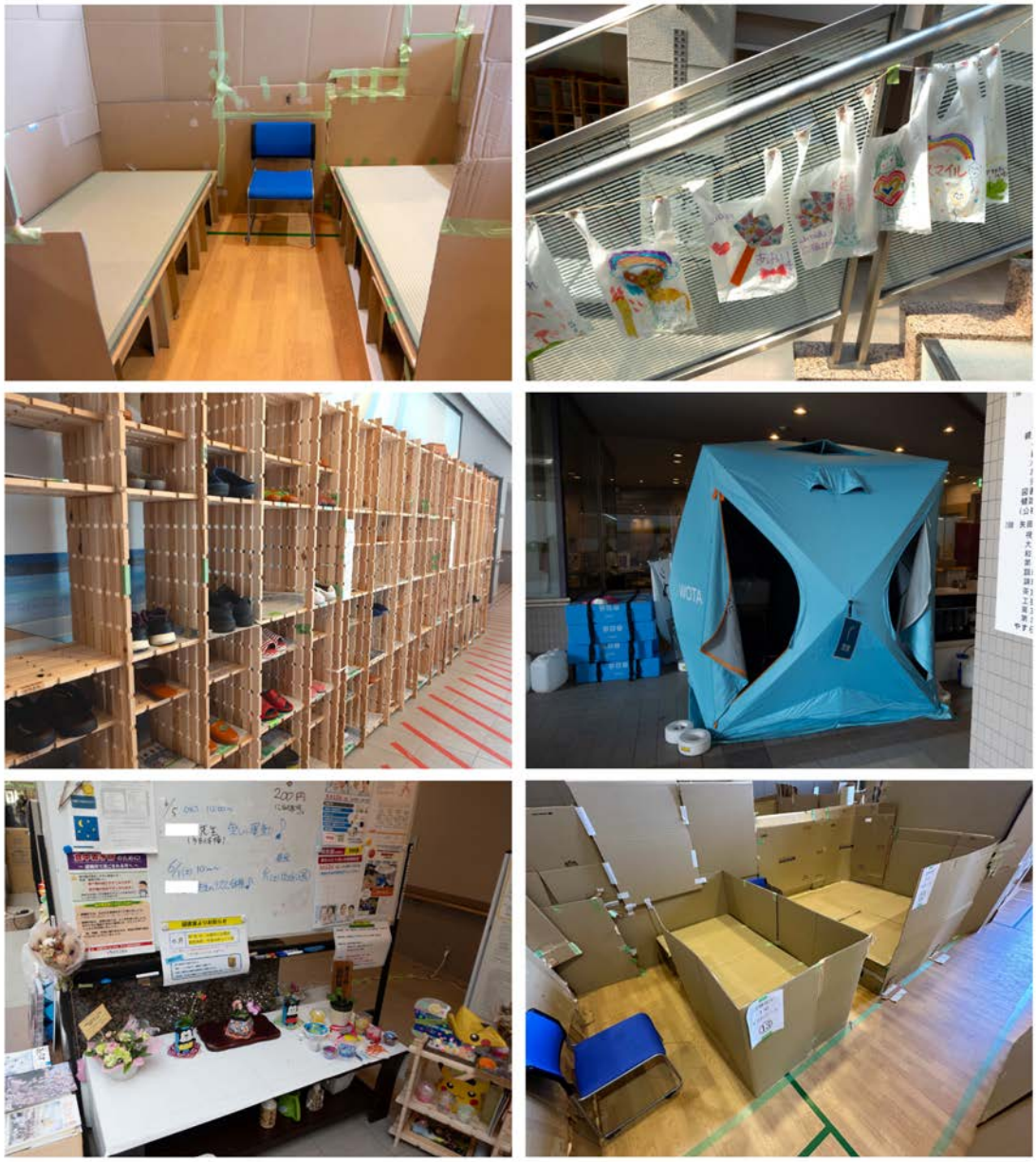

Figure 3.4 Pictures of Yatagou District Community Center Evacuation Center

3.3.3 Summary

In summary, both evacuation centers showed that even within temporary and constrained environments, individuals still looked for ways to reestablish familiar routines, maintain social connections, and modify their personal space which are all key components of a sense of home. These efforts reflect how autonomy, social continuity, and familiarity with the senses and space all contribute to stability during displacement.

While this ethnographic study provided invaluable insights, it also highlighted the challenge to continue the current research to design and conduct usability studies with the residents. By the time of the visit, many residents had moved out and the remaining residents were preparing to relocate. This made it hard to maintain contact throughout the scope of this research. However, the observations provided important insights for understanding how individuals reconstruct their sense of home in uncertain living conditions and offered direction for designing for displaced communities in future work.

3.4. Target Audience

The main target for this research is individuals who are preparing for or experiencing relocation or transitional living. This includes migrant communities, international students, refugees, and individuals impacted by emergencies like natural disasters. These populations often face challenges in constructing or maintaining a sense of home due to detachment from familiar environments and social support systems which can affect their general well-being. By developing a multi sensory artifact that incorporates sensory elements and is based on the framework of the Self Determination Theory, this research aims to support these individuals in enhancing their sense of home.

3.4.1 Participants

The research participants for this study were international students from Keio University Graduate School of Media Design, a population chosen for both practical and theoretical reasons. Although their relocation is often voluntary and for

educational purposes, their emotional, social, and sensory experiences of displacement reflect the social and psychological dynamics encountered by other mobile communities.

The same group of participants went through the entire design process. However, there were initially 13 participants who participated in the cultural probe but due to personal commitments two participants were unable to continue with the later design processes. Therefore, only 11 participants were able to complete the full design process. The age of the participants ranged from their 20s to 30s. The participants were of different nationalities, including China, Korea, Norway, Myanmar, United States, Indonesia, and Pakistan.

3.5. Preliminary Surveys

Following the change in the research participant group after the ethnographic study, a preliminary survey was conducted to explore how international students at KMD understand and experience a sense of home. The responses were initially collected through an online questionnaire and then in person at the 2024 KMD Forum. The purpose of the survey was to gain insight into participants' perceptions of home in relation to memory, identity, well-being, and sensory experiences. The recurring themes and personal reflections identified in this study helped guide the direction of the design phase.

3.5.1 Online Questionnaire

An online survey of multiple choice and open ended questions was conducted. There were 16 respondents who were international students from KMD. The demographics of the respondents were the same as the participants of this study. The findings are as follows.

Definitions and Associations of Home

Participants described home as a place of emotional and physical comfort, safety, and belonging. More than a specific location, home was often defined as a relational and affective space as "where loved ones are" or "where I can be myself

without judgment." This perspective was reinforced by responses to the question "What makes a place feel like home to you?" where participants responded with emotional security, physical comfort and safety, personal memories, and the presence of loved ones as key elements. In addition, when participants were asked "Where is home for you?" participants identified multiple spaces including their current residence, childhood home, and places where their family are. This reflects the relational understanding of home where emotional and social bonds with family are prioritized even when the participants are living abroad away from their family. This also revealed an adaptable understanding of home, suggesting that home is both symbolic and situated which is influenced by time, relationships, and circumstances.

Home and Memory

Participants were also asked whether they associate specific memories with their sense of home, to which 15 out of 16 participants responded affirmatively. These memories often revolved around routines such as shared meals, religious practices, or conversations with family which highlighted home as the grounds of lived experiences. When participants were asked to describe a specific place that felt like home and what made it special, many mentioned intimate or sensory-rich settings such as a childhood bedroom, a particular balcony, or a shared apartment. These places were valued not only for their physical attributes but also for their emotional resonance and significance with the memories created in these places.

Identity and Role of Control

Participants were asked whether their home reflected their identity and personality. The majority of the participants responded affirmatively as their homes contained personal collections (e.g. books, decorations), reflected their lifestyle, or served as spaces of expression. However, several participants pointed out limitations when living in temporary or rented accommodation as they lacked agency over their space which contributes to less expressions of identity. This was further supported by responses about creating a sense of home in new or temporary environments. To this question, participants responded that personalization through

decoration, routines, or cooking served as effective ways of reinforcing identity and experiencing comfort.

Wellbeing and Emotional Aspect of Home

The majority of the participants responded that their sense of home had a positive impact on their wellbeing. Particularly during stressful periods, home was described as a place of emotional refuge and recovery. When asked why their sense of home affects their wellbeing, participants mentioned the calming effects of familiarity and the psychological benefit of having a space where they can be completely themselves. Homesickness was another emotional component that was examined in the study. When the participants were asked whether they feel homesick when they are away from home, the responses were mixed with 62.5% of the participants responding with yes and 37.5% with no. While some indicated they rarely experienced homesickness, others reported feeling emotional longing when they are away from their familiar surroundings. People who experienced homesickness attributed it to missing family, comfort food, personal spaces, and familiar routines which highlighted the emotional and sensory aspects of home. These responses showed how disconnection from emotionally significant environments can influence mental and emotional health emphasizing how home serves as a psychological construct.

Reconstructing Home Away From Home

In a question asking how participants create a sense of home when away from home, participants responded with a range of methods. The most mentioned strategies were building and maintaining relationships with family and friends, establishing and following routines, creating a comfortable and safe environment, and engaging in activities that bring joy and relaxation, maintaining autonomy over their space, and personalizing the space. However, they also reported a number of difficulties in doing so. The most commonly mentioned challenges were lack of control over the space, feelings of loneliness, and financial constraints. In order to establish a sense of home, participants were also asked which senses were important. The top three responses were sight (familiar decor, personal items), sound (music, ambient noise), and smell (cooking aromas, fragrances),

and were followed by touch (comforting textures). These findings highlight the multisensory nature of home and which sensory stimuli contribute to memory recall and experiences of home.

Experiencing Home Beyond Physical Space

When asked whether home can be experienced outside of a physical space, 50% of the participants responded with a yes, 43.8% maybe, and 6.3% no. For those who responded affirmatively, explanations offered included emotional bonds, shared routines, and symbolic or sensory cues like the smell of a home-cooked meal or the presence of a loved one. This shows how they defined home as a movable emotional experience that they carry with them through relationships and routines even in temporary or unfamiliar environments. On the contrary, others had a more spatially fixed view of home as being tied to a specific environment.

3.5.2 KMD Forum

At the KMD Forum, two additional questions were asked assessing one's best advice for making a space feel like home and what makes you feel at home. The questions were displayed at a booth with pens and pieces of paper provided, allowing the participants to write or draw as shown in Figure 3.5. The findings are as follows.

Multisensory Engagement

Several participants highlighted the importance of engaging the five senses, especially smell, touch, and visual elements to create a sense of home. One participant also mentioned a frustration because they were not able to get a specific sense of home, so they are in search for a dedicated smell for their room. Beyond scents, others noted the value of having comfy furniture, art, plants, and other personal items that contribute to the visual aesthetic and textures of home.

Personalization and Familiar Objects

The soft furnishings, art, plants, and other personal items including photos, gifts, and character goods were frequently mentioned as used to create a sense of home.

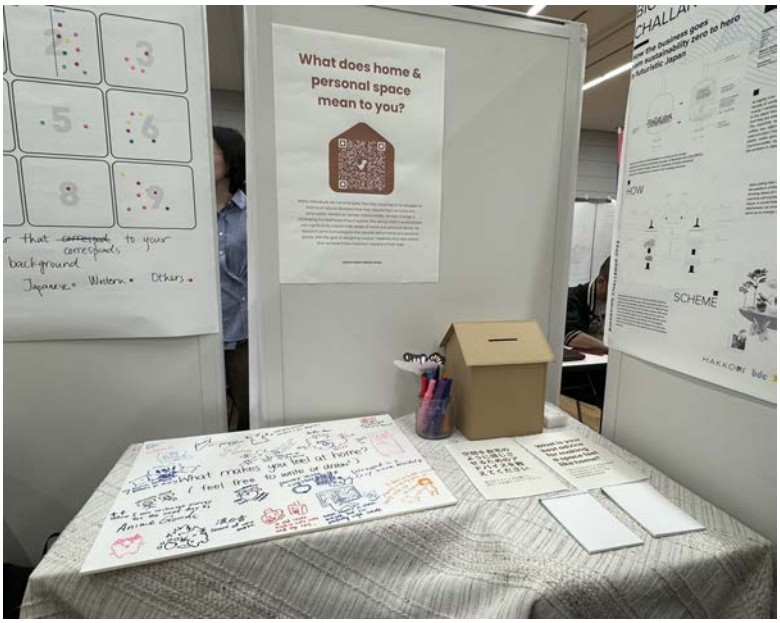

Figure 3.5 KMD Forum Survey

These items serve as emotional representations, which connects individuals to their past and to meaningful relationships. Having familiar objects allows individuals to express their identity in their environment, turning a mere space into a personal and emotionally connected environment.

Comfort

Physical comfort was a recurring theme as participants frequently mentioned having a soft sofa, blankets, and pillows. Additionally comforting activities like reading a book inside while it's raining, sitting in front of an old stove with their cat, and sleeping to recharge themselves helped reinforce a sense of home for them.

Social and Emotional Support

Participants' sense of home was also influenced by the presence of friends, family, and loved ones. According to some, having family members visit them from abroad contributed to their sense of home. Others found comfort in spending time with their partners, pets, and roommates through shared routines such as cooking or

going for a walk. These social interactions contribute to one's sense of home and reinforces home as a place of belonging.

Freedom in Space-Making

Participants also mentioned the importance of having control over the layout and functionality of their environments. The ability to add, rearrange, and throw furniture and decorations as one wish allowed them to exercise control over their environment while contributing to their personal well being and sense of home.

3.5.3 Reflection

From both preliminary surveys, it could be understood that home for the international student community in KMD is an emotional and sensory experience that is influenced by comfort, personal memories, and connection to loved ones, supporting previous literature on the sense of home. Individuals experience and create a sense of home through personalization of the environment, sensory elements especially smell and sound, and social connections. However, they can be challenged by feelings of homesickness and lack of control in their environment.

The findings of the study laid out key design considerations for the creation of the prototype.

1. Integrate multisensory elements to recreate comforting and familiar atmospheres
2. Support for personalization and autonomy by allowing users to customize or adapt aspects of the prototype
3. Consider features to help users feel socially connected
4. Incorporate features that evoke memory and emotional reflection

3.6. Prototypes

3.6.1 Prototype 1: Pillow

Since comfort and familiarity were recurring themes identified in the preliminary surveys, the first prototype was developed in the form of a pillow, a common everyday object that provides comfort. The prototype consisted of a speaker, scent packets, printed pictures on transparent sheets placed inside the pillow. The sensory elements for the sound and visuals were directly extracted from the data collected from the cultural probe study. The scents were recreated or sourced based on the descriptions provided by the participants in the cultural probe study and placed inside scent packets containing perlite, a low-cost material that naturally absorbs and releases scent (Rattanaplome et al. 2015).

To test the concept and usability, two participants were invited to interact with the prototype that was personalized with the sensory elements they inputted in the cultural probe study. Participants expressed positively to the form of the pillow, noting that it was physically comfortable, and appreciated how the pictures displayed resemble the blur of real memories. However, several challenges were identified in how the sensory elements were presented. The participants responded that the sensory elements felt scattered, making it difficult to find where the sounds and scents were coming from and the perlite inside the scent packets were easily crushed which compromised the usability. Additionally, it was noted that the elements were limited as it was solely based on self documented data. Another observation was that although participants have chosen food-related scents like kimchi and coffee that evoke their sense of home, encountering them through in the form of a pillow felt strange and out of place. Some suggestions for improvement included grouping the sensory elements more clearly for ease of interaction and replacing the scent packets with scent diffusers. Participants also recommended offering pre-curated or shared sensory elements, using thin, flexible, and non-invasive LED displays, allowing users to change or update the sensory content, and including a guided process for interacting with the prototype.

Figure 3.6 Pillow Prototype

3.6.2 Prototype 2: Omamori

While keeping the feedback received from the participants in mind and taking the advice from supervisor to explore other forms of artifacts, the second prototype was developed in the form of an omamori, a traditional Japanese amulet that is associated with protection, well-being, and good fortune (Swanger and Takayama 1981). Based on omamori's significance as a symbol of emotional and psychological comfort, the prototype is reconceptualized as a portable and personalized artifact that evokes a sense of home through sensory memories. Similar to how individuals can choose omamori that is dedicated to specific purposes such as health, academic achievement, family safety, this artifact is also designed to be customized with sounds, scents, and visual elements that have personal significance (Rahmah 2020, Mendes 2015). By combining personal elements of home into a familiar cultural form of an omamori, the artifact becomes a symbolic bridge between participants' current environment in Japan and their past homes which creates a continuity in their sense of home.

The structure of the artifact was designed to include a sound player and a small box containing a scent stick. The outer structure and the small box were designed in Tinkercad and printed for each participant using the Bambu Lab 3D Printer with TPU and PLA basic filaments. The artifacts were then assembled and personalized by each participant during the assembling workshop to input the sound files, add the scent source, and decorate the artifact with pictures and stickers provided.

Figure 3.7 Omamori Prototype

Chapter 4
Proof of Concept

4.1. Cultural Probe

Cultural probe study is a qualitative research method developed by Gaver and colleagues (Gaver et al. 1999) to gather subjective, emotive, and context-rich data about participants' lives, values, and experiences. It is conducted by providing participants with kits containing journals, photos, maps, and other creative materials to encourage them to self-document their experiences. These creative, self-explorative means allow researchers to explore and understand deeper emotional and cultural context of participants' daily lives to guide user-centered designs which may be difficult to convey in structured, face to face research.

Because sense of home is a personal and subjective concept that is rooted in everyday experiences, emotions, and sensory experiences, the cultural probe method was particularly suited for this research. By inviting participants to reflect and record their own experiences over time, the method enabled the collection of rich personal insights on their sense of home which would be challenging to obtain in in-person interviews.

For this study, the cultural probe study was adapted into a form of a take-home study kit to explore the sense of home among international students. The kit included five activities with pre- and post-study questionnaires (please refer to A.1 and B.1 in Appendix for more details of the questionnaires) to be completed over the course of seven days. The participants were 13 international students from KMD mentioned earlier in Chapter 3.4.1 who are of various nationalities but they were all residing in the Greater Tokyo region at the time of the study. The aim of the study was to encourage participants to reflect on and document the sensory experiences (visuals, sounds, smells) that are effective in evoking a sense

of home for them. The collected data which includes visuals, audio recordings, and scent description would then contribute to the development of the prototype for the artifact. This cultural probe study ensured that the participants could actively participate in the design process by determining which sensory elements best reflected their personal sense of home.

4.1.1 Methodology

The five activities included in this take-home cultural probe study kit are as follows:

Figure 4.1 Cultural Probe Materials

Activity 1: Sensory Diary

Over the course of seven days, participants were asked to document their everyday sensory experiences, focusing on sights, sounds, and smells that make them feel a sense of home. A journal booklet was provided for them to write or sketch and also included a QR code linked to Google Drive to upload photos or audio recordings, allowing them to choose how they document. This journal entry allowed the participant to reflect on how everyday sensory experiences influence their sense of home.

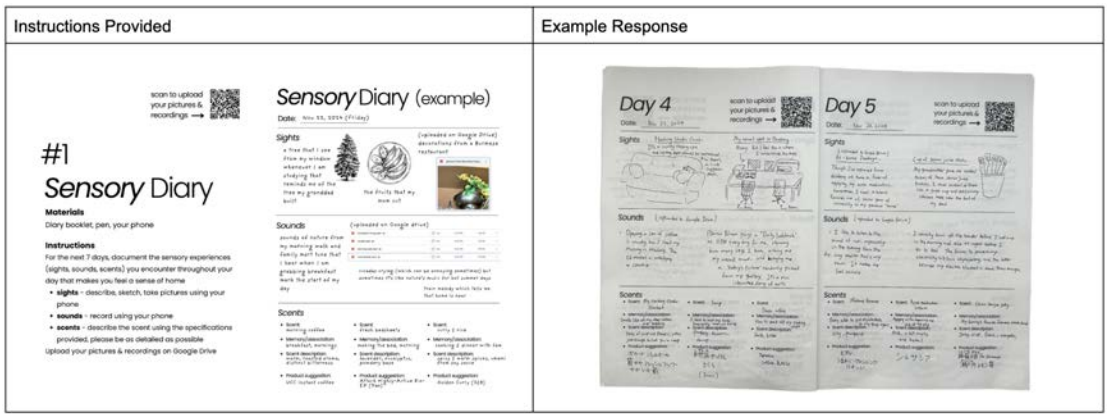

Figure 4.2 Sensory Diary Example

Activity 2: Sensory Map

In this activity, participants created a map of where they call home which could include their living space and neighborhood to mark areas where they encountered specific sensory experiences. Participants were given blank pieces of paper and color-coded stickers: green for visuals, blue for sound, and red for scent. Visually mapping their sensory environments of home allowed participants to reflect on how their spatial surroundings supported or lacked sensory cues associated with their sense of home.

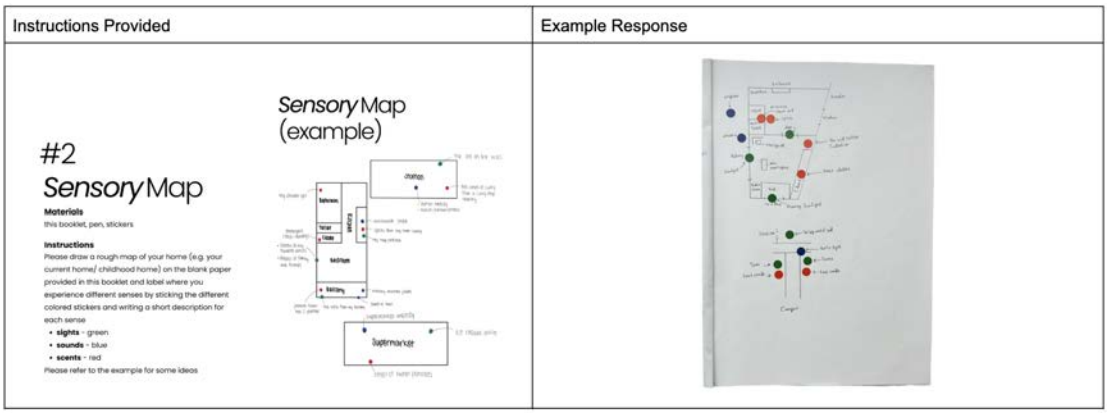

Figure 4.3 Sensory Map Example

Activity 3: Photographic Exploration

Prompt photo frames were provided to encourage participants to take photos of objects, sceneries, or items in their environment that reminded them of home. This activity provided insight into how visual elements support the emotional experience of home in daily life by helping them recognize the visual elements that hold personal meaning of home.

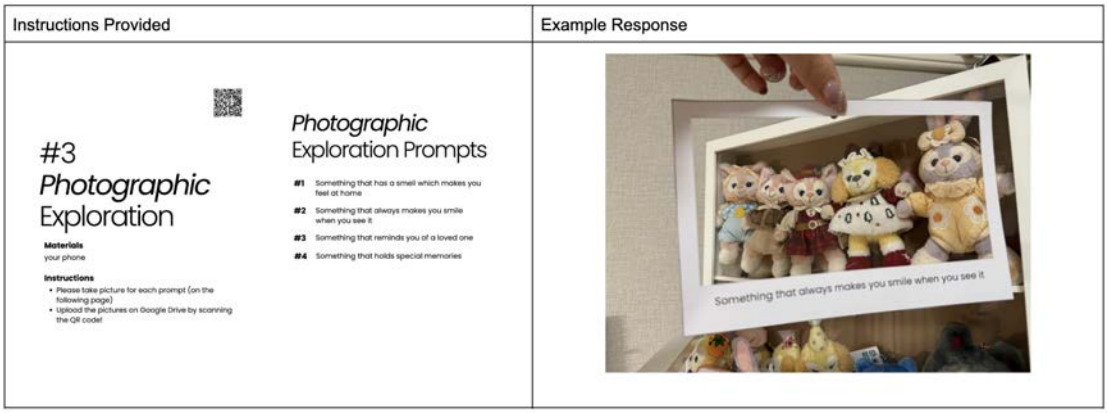

Figure 4.4 Photographic Exploration Example

Activity 4: Sound Exploration

Similarly to the previous activity, prompts cards were given to invite participants to record sounds that represented different parts of their daily routine or brought back memories of home such as ambient sounds and familiar household sounds. The aim was to help them identify sound elements that offer comfort, routine, or emotional resonance to highlight the significance of sound in shaping a sense of home.

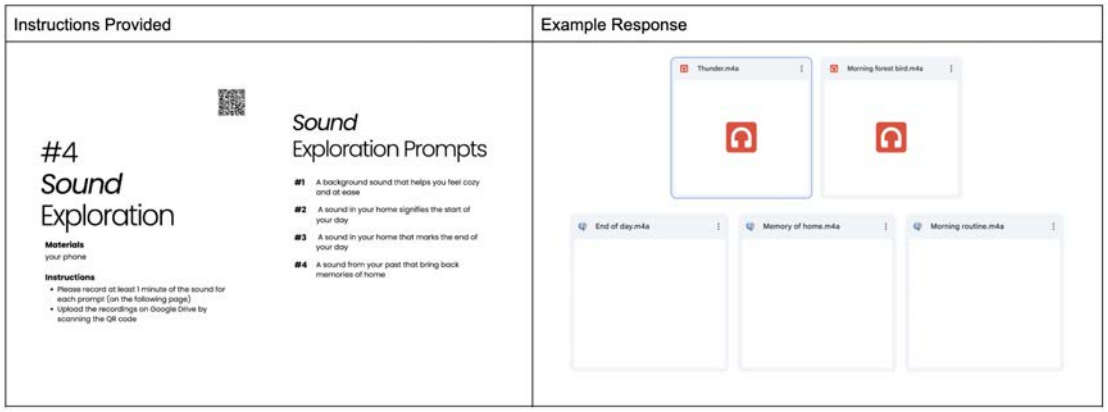

Figure 4.5 Sound Exploration Example

Activity 5: Sense of Home Kit Creation

For the final activity, participants were asked to imagine and create a personalized Sense of Home Kit containing elements that would make them feel at home when away. They selected and described sensory elements for modality (visuals, sounds, and scents) which were then written on post-it notes and placed into a paper box that they decorated to their liking. This activity encouraged them to actively choose and visualize the prototype in a creative and tangible form.

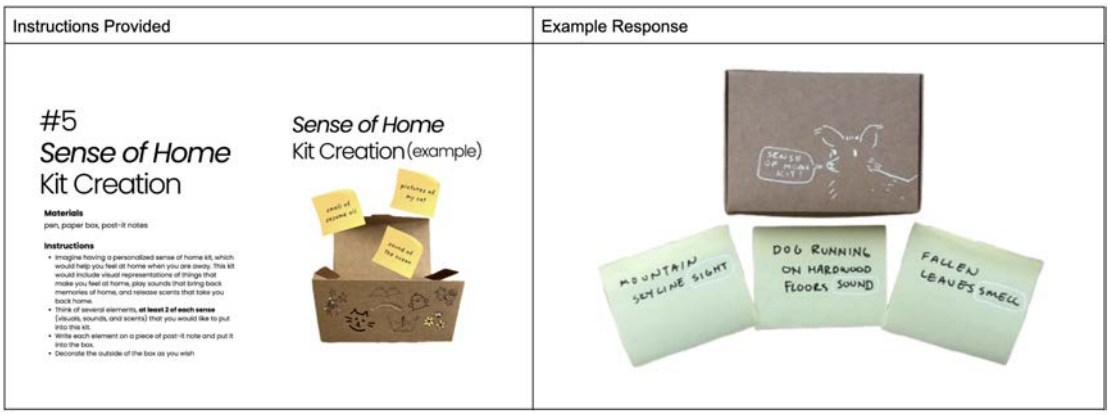

Figure 4.6 Sense of Home Kit Creation Example

4.1.2 Relation to SDT (Competence)

The cultural probe study was designed to align with the competence aspect of the Self Determination Theory (Ryan and Deci 2017) which highlights individuals' need to feel effective and capable in their activities and interactions with the environment. Through the activities outlined above, the participants were given the tools and opportunity to observe, reflect, and express their own sensory experiences and specific elements that make them feel a sense of home. This allowed them to develop a deeper understanding of what sense of home is for them and their sensory experiences and how they interact and contribute to each other.

Participants actively constructed insights about themselves and their lived experiences through creative activities that can be done through common daily actions such as writing, sketching, and taking photos. This is to not only foster self-expression and self-exploration but also to give participants the agency to contribute to the design of the artifact that is tailored to their sense of home. By doing this, the goal is to help participants feel competent in both navigating their current environment and shaping how their sense of home could be represented through design.

4.1.3 Data Collection & Analysis

Data were collected through pre and post cultural probe questionnaires as well as through the five cultural probe activities. The pre and post cultural questionnaires included questions assessing participants' awareness, usage, and perceived effectiveness of sensory experiences in creating a sense of home in order to evaluate change over the course of the cultural probe study. This indicates whether the activities enhanced participants' ability to emotionally engage with their environment through sensory experiences that bring them a sense of home. The data received from the cultural probe activities were in the forms of photographs, sound recordings, journal entries, sketches, and cardboard pretotype of an imagined artifact. As the cultural probe activities were not designed to be scientifically analyzed to prove a point (Gaver et al. 1999), only the amount of sensory elements documented and the questionnaire results were noted and analyzed.

4.1.4 Results

Figure 4.7 shows the number of sensory elements documented across the Sensory Diary, Sensory Map, and Sense of Home Kit Creation activities where participants were able to report all three types of sensory elements.

Pre and Post Questionnaire

After comparing the pre and post questionnaire results, the findings indicated an increase in perception of the importance of sensory experiences (visuals, sounds, and smells) in helping them feel a sense of home. However when asked how much each of these sensory experiences contribute to their sense of home, there was only an increase in sights and scents but not sounds. Additionally there was an increase in reported frequency of using sensory cues to make a space feel more home. As for the perceived influence of sensory experience on emotional states, it was the same for visuals but showed an increase for sounds and decrease for scents. Although these findings do not demonstrate a clear pattern, the decrease in how sounds contribute to a sense of home and how scents influence their emotional states could be attributable to the differences in convenience and accessibility of documenting the different senses.

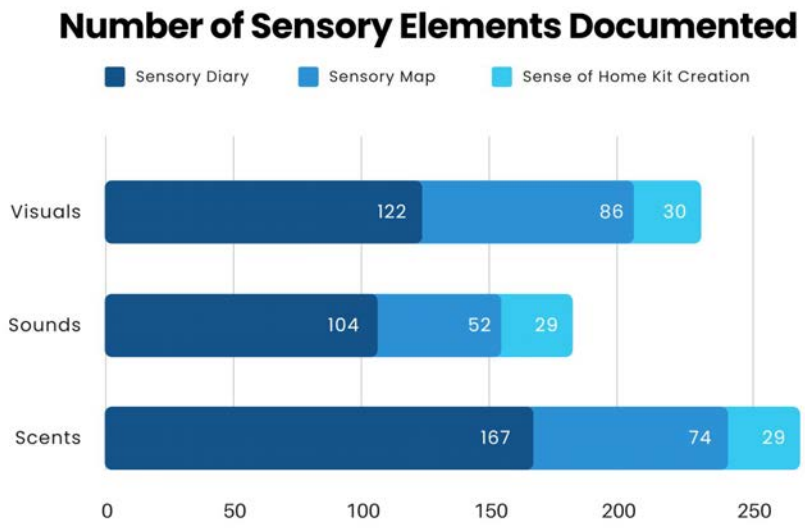

Figure 4.7 Number of Sensory Elements Documented Across Activites 1, 2, 5

According to what some participants wrote in the comment section of the questionnaire, sounds and smells were harder to record and think of compared to visuals so this may have led them to reflect less on sounds and smells. Participants wrote "*Fun activities but a little bit hard to record sounds*" and "*It was very hard some days to think of different smells, new things?*". However, by analyzing the number of sensory elements documented, scents was the most reported followed by visuals. Despite the contrasting findings for scents and sounds, visuals remained consistent.

In addition to these challenges, some difficulties were noted for how the activities were formatted. For example, one participant described "*I don't really have the habit of documenting things on my phone (I didn't grow up with a smartphone) so I thought it was difficult to remember to record or take a picture of something.*" Another participant also mentioned "T*his can feel a bit intense with many things to do, and google drive link can't be saved and accessed without QR so I don't happen to take and upload immediately.*" Although these methods were implemented to adapt to the convenience of using smartphones to record, it rather posed a dif-

ficulty that could be prevented by making the cultural probe more traditional and analog. However, this challenge may have unintended contributions to their need for competence, allowing them to learn something new instead of doing something that is easy and intuitive.

The participants' reflections also highlighted the importance of other senses that were not addressed in the current research, such as the sense of touch and taste. Two participants mentioned the sense of touch by saying "*I think the sense of touch—especially how my skin feels against a soft blanket—makes me feel at home. The warmth plays a big part too*" and "*I feel sometimes touch feelings are also important*" while another participant brought up the importance of taste "*I think I am much more into taste. Because, the one that keeps my heart full with term of home is when you can find, feel, and make something that will fill it up entirely, and now for me it's food.*"

Overall the insights from the cultural probe study and the questionnaire provided an overview of patterns describing participants' experiences of sense of home and considerations to keep in mind for future research.

4.2. Artifact Assembling Workshop

4.2.1 Methodology

The artifact assembling workshop was conducted in person in groups of 2-3 participants and lasted approximately 30 minutes. Prior to the workshop, the participants were contacted to confirm the sensory elements they have chosen in Activity 5 of the Cultural Probe Study and to decide whether they want to select sensory elements from them or bring in additional sound files, images, or personal scent items.

The workshop started with a five-minute introduction of the workshop itinerary which was followed by the main assembly phase of approximately 25 minutes during which participants assembled their personal artifact using the provided or brought in materials. Materials provided include the base structure of the artifact, sound player with SD card, small container with a scent stick inside, a few bottles of essential oil, participants' chosen images printed on sticker paper, extra

sticker papers, art supplies for personal decoration, and strings with omamori inspired knots. Participants were free to apply their printed or hand-drawn visuals to the outer cover of the artifact, insert their chosen scent into the scent container, and upload the audio files onto the SD card. Once the sensory elements are in, the participants put the components together and add the knot to complete their creations. Through this approach, the workshop emphasized hands-on engagement and creative freedom which allowed the participants to personalize the artifact in a way that reflected their own sense of home.

Figure 4.8 Participants Assembling Artifact

4.2.2 Relation to SDT (Autonomy)

The artifact assembling workshop was designed to fulfill the autonomy aspect of the SDT by allowing participants to exercise control and agency throughout the creation process. Participants selected personal sensory elements (sounds, images, and scent) that held individual significance and evoked their sense of home, which

enabled them to create an artifact that reflected their lived experiences and their own sense of home. By making their own creative choices and engaging with the artifact's elements and meaning, participants are offered a sense of ownership over the process and the outcome which reinforces their autonomy.

4.2.3 Data Collection & Analysis

The outcomes of the workshop were the personalized artifacts that participants have created as well as filmed observational data for later analysis of participants' actions and behaviours. Please refer to C in Appendix for more details on the sensory elements the participants chose.

4.2.4 Results

Figure 4.9 Assembled Artifacts

4.3. Artifact Interaction

4.3.1 Methodology

The artifact interaction session was conducted after a short break following the artifact assembling session. The purpose of this session was to allow participants to engage with the sensory elements in their personalized artifact individually and simultaneously and reflect on their emotional and sensory responses. This session lasted approximately 20 minutes and was divided into four interactions. The four interactions were visuals only, sounds only, scent only, and all three sensory elements simultaneously. Each interaction lasted for one minute and was followed by a four minute reflection. The order of the interactions were randomized for each participant to minimize order bias.

4.3.2 Data Collection & Analysis

For the post-interaction reflection, the Self-Assessment Manikin (SAM) scale (Bradley and Lang 1994) was used to evaluate the participants' emotional responses to each sensory interaction. This standardized SAM scale (Bradley and Lang 1994, Morris 1995) measures participants' emotional states across three dimensions of valence (pleasure), arousal, and dominance. During each four minute of reflection, participants completed the SAM scale and were asked to provide a brief explanation for their particular rating on the scale (please refer to D.1 in Appendix for more details). This evaluation helped identify whether there were differences in emotional responses across the different sensory interactions.

4.3.3 Results

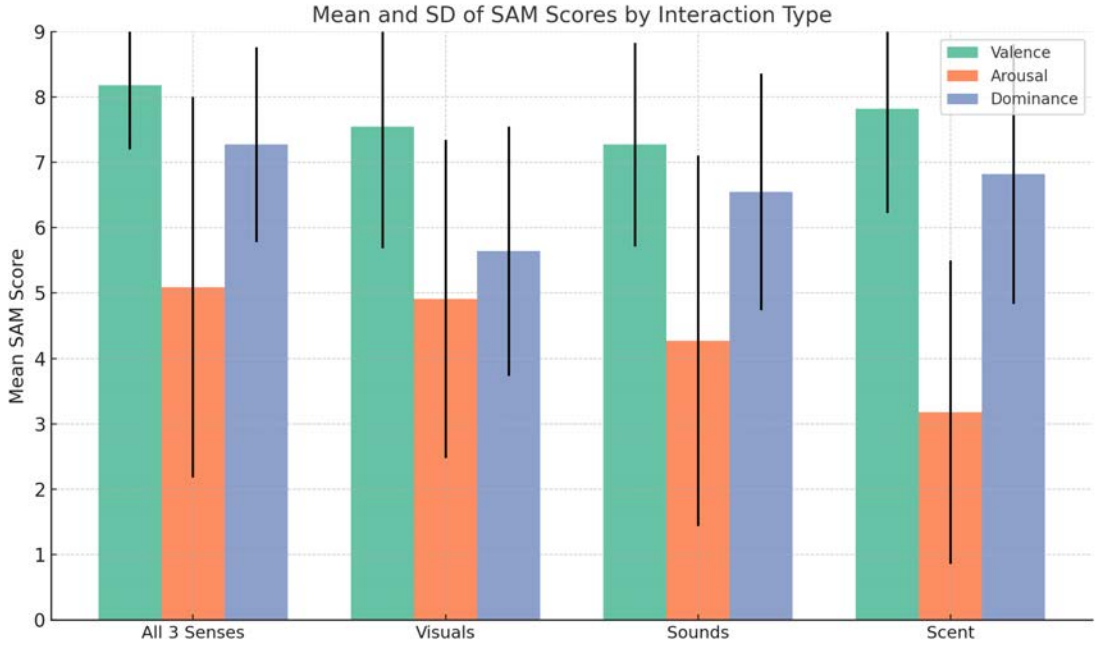

Figure 4.10 SAM Scale Results

Note: Graph generated by ChatGPT

The Friedman test revealed no statistically significant differences across the four interactions for valence (p=0.695), arousal (p=0.203), and dominance (p=0.093) (please refer to E.1 E.2 E.3 in Appendix for complete test values) which indicated that participants' emotional responses were similar regardless of the sensory modality. From this it can be understood that a much larger participant pool is necessary. It could also be that the different sensory modalities may not affect the emotional dimensions measured which may be because the participants were interacting with sensory elements they have chosen for themselves rather than responding to unanticipated elements.

However, notable trends were observed from the descriptive statistics. Interaction with all three senses received the highest mean scores for all three SAM Scale dimensions which suggests that integrating multiple senses can enhance pleasure,

excitement, and controlled emotional responses even if not statistically significant. Scent only interactions were rated lowest in arousal but were associated with high valence, indicating a calming and pleasant effect. Interactions with only visuals had the lowest dominance scores which implies that participants may feel less agency in visual-only experiences. This could also be attributed to the way the visuals were presented since it cannot be turned on and off like the sound elements or are hidden like the scent. The variability in the responses, especially in arousal, highlights the subjective nature of sensory perceptions of home. For instance, while a participant chose an upbeat song that motivates them for their sound element, another participant chose a very calm background piano sound. Another possible attribute is the familiarity with the elements. As some participants have mentioned in their short written reflection, they did not feel the excitement from the stimuli since they are so familiar with them. Overall, despite the statistical insignificance, the findings align with participants' qualitative reflections and supports the potential of multisensory designs to evoke a sense of home and similar affective experiences.

4.4. Artifact Sharing Workshop

4.4.1 Methodology

The artifact sharing activity came after the artifact interaction activity and lasted approximately over 30 minutes. For the first 25 minutes of the workshop, the participants were invited to share what the artifact they have created and what sense of home is to them as well as the sensory elements they have chosen and their relation to their sense of home. This open sharing discussion session created space for participants to express their thoughts, memories, and experiences in a supportive group environment. This session was conducted in a focus group format guided by open-ended questions such as how their sense of home was evoked, whether it had changed through the process, if so how, and which stage of the experience they found the most resonant with their sense of home. This session encouraged collective reflection and connection while providing an opportunity for the participants to learn from each other's diverse experiences and perspectives

of sense of home.

4.4.2 Relation to SDT (Relatedness)

This workshop was designed to support the relatedness element of the SDT by creating a means for participants to interact with each other through shared personal expressions and experiences. By using the artifact as a medium, participants are given the chance to share their thoughts on what home means to them as well as the meaning behind their chosen sounds, scents, and visual elements. In addition to sharing about the artifact, the discussion was facilitated accordingly using some questions prepared beforehand and follow-up questions (please refer to G in Appendix for more details). This gave participants the opportunity to listen to others' stories and experiences from which they are able to find commonalities among their varied experiences and foster emotional connection. Overall, this workshop aimed to encourage participants to not only collectively reflect on their own experiences and thoughts, but also to build meaningful connections with others who are going through similar experiences of being international students.

4.4.3 Data Collection & Analysis

As this is the last stage of the research, the data collected consisted of empirical data of behavior observations of the participants, transcribed audio recording of what the participants shared, and a self-report questionnaire assessing the implementation of SDT which was adapted from the General Basic Psychological Needs Scale (Deci and Ryan 2000) (please refer to F in Appendix for more details on the questionnaire).

Observational analysis and thematic analysis were conducted to evaluate data from the discussion. For the SDT questionnaire, negative worded questions were first reverse scored and descriptive statistics were calculated and analyzed for each dimension of the SDT.

Thematic Analysis

The transcribed audio recordings of the participants' discussion were analyzed using Thematic Analysis approach. Thematic Analysis refers to a widely em-

ployed analysis method in qualitative research that is used to identify, analyze, and interpret patterns in meanings, forming themes of qualitative data (Braun and Clarke 2006). This method involves six steps as shown in Figure 4.11.

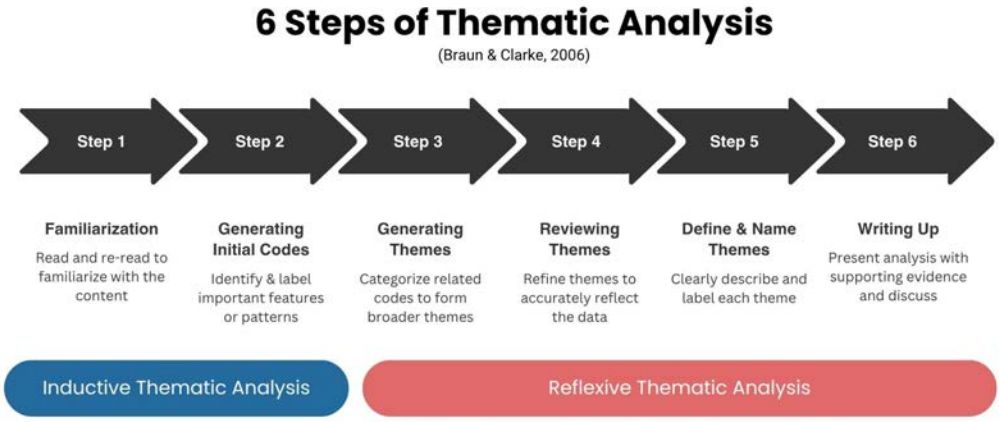

Figure 4.11 Six Steps of Thematic Analysis

During this process, both Inductive Thematic Analysis (ITA) and Reflexive Thematic Analysis (RTA),two specific approaches of thematic analysis, had been applied as shown in Figure 4.12. Although both approaches are rooted in the broader TA framework proposed by Braun and Clark (2006), they are different in the sense that ITA produces themes that are derived directly from the raw data without the influence of pre-existing theories or frameworks, whereas RTA acknowledges the subjectivity of the researcher in interpretation of the themes (Braun and Clarke 2019, Clarke and Braun 2017).

In terms of the application, ITA had been implemented in the first and second phase of the analysis to openly familiarize with the data and generate initial codes that directly quote the data. This was done in a pen and paper format to prevent digital interference and influence of outside information. From this stage onwards, the RTA was applied since the process of categorizing codes and

reviewing potential themes had been influenced by the aforementioned dimensions of sense of home and the theoretical framework of the SDT which were of interest in this research. The researcher's self-reflections were noted and described in the report of the results.

By using both approaches, it ensured that the findings not only convey participants' words and experiences but are also theoretically meaningful and transparent of the researcher's subjective role. This was especially important due to the researcher's positionality which is further explained in Chapter 4.5 on Reflexivity.

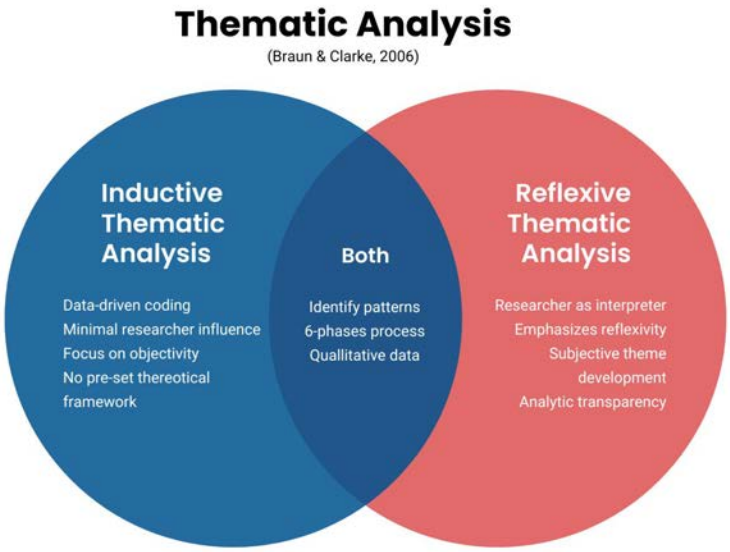

Figure 4.12 Differences Between ITA and RTA

4.4.4 Results

Thematic Analysis of the Discussion

By following the six steps process of thematic analysis, the following initial codes were generated using the ITA approach and were subsequently refined into categories and themes using the RTA approach (please refer to Figure 4.11). The themes identified from the participants' discussion were summarized as follows.

Themes	Categories	Codes	Quotations	Reflexivity
Home in the acts of caring	Care	Social (Family, friends, pets)	"There're like parks that she [P's dog] likes to go. So I take time to go to those ones" "We used to have our own activities and you know we used to watch our shows and stuff. But now we feel more happy when he's happy watching." "My apartment is important but also like people. I always think like I'll stay in Japan. I like being here because all my friends are here."	Since I had done the literature reviews and focused on the three dimensions (i.e. social, psychological, and physical) of sense of home before doing this thematic analysis, I was drawn to categorizing the codes into these three categories. However, during the discussion, there were no framing questions from me as a facilitator that shaped them into sharing these narratives.
		Self	"I've also written that like when I finally put him to sleep, I'm just trying to get my me time, you know, to feel myself." "So now I can talk something more like me instead of like pretending like I'm going to be like Asian kid at home"	
		Responsibiliites	"Sometimes when something smells bad, I'll feel like.. That's my home but it smells so bad. But I'll start to say like wait, I'll throw something cause I have to throw things on that day."	
Rediscovering home through attention	From subconscious experiences to awareness	Subconscious	"I knew what home is deep unconsciously back in your mind but never really then express it enough" "I live everyday life without thinking about the noises and sounds like the smells that we put in" "When I lived with my parents, I don't think I was social with them but I always heard them. In [place they lived before], I always have my roommates, maybe a bunch of noise or people downstairs. And now it's a karaoke downstairs. So I'm like okay there's someone there, you know." "The sound of the dishwasher is like a super big part of my sense of home when I was in [country they lived before]. so like my dad sleeps really early about like 10. And then my mom is always like looking at her phone at night on the sofa. So 9 o'clock is the time when we set up, like put all the dishes into the dishwasher and start. So whenever I hear the dishwashers I can imagine like there's only like a lamp light, so it's very dark. And then it's only the dishwasher sound and my mom's like on the sofa."	After moving to Japan, I have also noticed myself being more aware of the sensory stimuli in my surrounding since there are a lot of repeated stimuli such as the 5pm bell and train station melody that we experience regularly. Therefore, my personal experience made me relate to the participants more and emphasized these points.

Figure 4.13 Thematic Analysis

Themes	Categories	Codes	Quotations	Reflexivity
		Awareness of Self	"I associated myself as being chaotic and that I didn't really have a routine but through the diary I realized I do have some like rituals, especially surrounding the dog." "like going through or having to like look at what I have and like why I do what I do, why I like my photos on my wall" "It's like being made aware of like the type of things you do around your house to create that sense of home is really interesting."	
		Awareness of Surrounding	"There's a sound near my apartment and like every 5pm. But before I never notice this. Like this is at like 5pm. But after doing this, I kind of want to know when it is and all. I kind of start to be aware of those things."	
Finding comfort from the discomforts	Comfort	Vulnerability	"I feel since it's like so personalized maybe I should include elements that really make me happy. Some elements that don't because it reminds me of things that are around me are out of my control sometimes" "But when I come to Japan, my parents were like keep this photo in your wallet. So I just like, okay, this is for me.. Why do I feel like I want to cry right now?"	Although the design process was structured to promote connection among participants as based on the Relatedness aspect of the Self Determination Theory, I personally did not expect the participants would share stories that are too close to home for them. However, hearing this made me realize the role home plays in emotional resilience and being able to voice these challenges.
		Seeing the positives	"It's very emotional. It was very difficult for me because I came in COVID actually. And also when we came after 10 days, my dad passed away....But I think KMD really helped me, emotionally because I'm a very passionate person in terms of work as well. So it came as a very good time." "At that time we were living in a very very small house. A tiny studio. We really enjoyed it. It was really small and tiny like a doll house. And now we are actually trying to settle down and making a home." "This song means a lot to me because after my graduation it was a really hard time. So I decided to take a gap year and tried a lot of things and made a lot of different challenges. So this song actually like saved me from like the very high pressure life and gave me more motivations to like frankly talk to my parents."	

Figure 4.14 Thematic Analysis

Themes	Categories	Codes	Quotations	Reflexivity
Differences in aency over the senses	Differences in senses	Visuals as easily recognized	"I usually pay attention to the visuals, but I never paid attention to the sounds and the scents before" "Maybe in here the easiest thing is the visual because some scent is totally in a different presence because with the difference of culture as well." "For me things I carry with me or animals I could have with me are that I associate more strongly with home, which is why I think the visuals and the sounds that were associated with those particular things were the most striking for me"	Having analyzed the results from the initial parts of the study (i.e. preliminary questionnaires, Cultural Probe study), I was aware of how there are differences in the way people perceive senses in their environments. Although similar comments were made during the discussion, the pre-existing awareness might have emphasized the extent of this theme.
		Active Vs. Passive Senses	"Recently I smelled something strange in front of the Hiyoshi station where I smelled something like a pandan but I don't know what kind of plant" "whenever I wake up, normally in my house, I have like two sisters so it's very noisy. Right now it's very very quiet and whenever I wake up. I keep searching for a noise"	
		Evaluation of senses	"In the second part, it is that I know you have a lot of options to choose from that you pick the best one. So I think assembling is pretty important." "The smell was mostly the vanilla cake smells. It smells like what I want to smell like. You know, it's so sugary. Like I put some Lemon too and this is what I want my perfumes to smell like" "And then to match, I show like the pink red theme and added the strawberries around." "But I think because they're kind of like general scents, it's like oh I like the smell. I don't necessarily associate it with home. Possibly because I don't usually use like any sort of like incense." "For the smell, I have difficulties to find something that 100% reminds me of my hometown"	
Sensory connections bridging individual experiences	Responsive remembering	Associations	"I have it as well in my childhood and I always had fights with my brother. I want to sit there, I want to sit there." "You guys would love my cabin. It smells like wood" P6 was talking about the scent he put in (Coffee) because they would drink coffee when they're working late at night and P11 asks "Wait, you can still sleep?". P13 also joins in by agreeing with P6 on how they can sleep after drinking coffee but not with milk tea.	Since sensory cues and connectons were of interest in the current study, I was naturally drawn to see how they were expressed during the discussion and saw more significance in them over other types of interactions such as compliments and laughs.

Figure 4.15 Thematic Analysis

1. Home in the Acts of Caring

This theme expresses how participants experience and construct a sense of home not just as a physical space but as something that is continually formed through everyday practices of care. These acts of caring are shown across social relationships, personal well being, and responsibilities towards their built environment. For all participants, care for others whether it is family, friends, or even pets were mentioned throughout the discussions. One participant described how their daily routine was shaped around their dog's preferences. *"There're like parks that she [Participant's dog] likes to go to. So I take time to go to those ones."* - P7 This implies how attending to the needs of a loved one is what brings them a sense of home. Prior to this remark, the participant also mentioned how their sense of home is evoked through interactions with things they can bring with them rather than through photos. This further explains how this act of care not only serves as a form of interaction with what is important to them but also a way of bringing a sense of home around with them.

Similarly, another participant reflected on their shared happiness within the family. *"We used to have our own activities and you know we used to watch our shows and stuff. But now we feel more happy when he's happy watching."* (P1). P1's reflection highlights a form of care where personal preferences are set aside in favor of supporting another person's joy, indicating that caregiving can shape what family and home feel like.

Caring for those that one has close relationships with extends beyond family. This can be seen in what P4 had expressed. *"My apartment is important but also like people. I always think I'll stay in Japan. I like being here because all my friends are here."* (P4). Here the value of friendships and their emotional support becomes a key reason for staying in a particular place which shows that home is not just where one lives but where one feels connected and supported. This feeling of connection and support does not happen instantly as it is something that is built through care for one another.

In addition to caring for loved ones, participants also spoke about the importance of caring for themselves. One participant described how their sense of home is also found through giving time alone to themselves after caring for others. *"I have also written that like when I finally put him to sleep, I'm just trying to get*

my me time, you know, to feel myself." (P1). This shows that care can sometimes be exhausting, and in that case self-care becomes necessary to restore energy and to have the time and space to be oneself. Another participant also expressed their care for themselves through a song that they used to listen to when they were going through a difficult time in life during their gap year. This song has motivated them to be more confident and stand up for themselves. *They said "So now I can talk about something more like me instead of pretending I'm going to be like a typical Asian kid at home."* (P13). In this case, home is where they can express themselves without having to hide their feelings and pretend to be someone else which makes it a reminder to care for oneself. These examples showed how sense of home is strengthened when people look after their own well-being in addition to others'.

Finally, care is also expressed in their day to day responsibilities of their environment. This is seen in how they mention *"I still need to do my chores"* (P2) which can be referred to as something that is not always enjoyable but a form of care that is necessary. Another participant also said *"Sometimes when something smells bad, I'll feel like that's my home but it smells so bad. But I'll start to say like wait, I'll throw something because I have to throw things on that day."* (P3). This shows how even small tasks of keeping track of the trash days and remembering to throw them away become part of how we keep the physical home livable and functioning. It also highlights how smells even though it is unpleasant can serve as sensory reminders to care for the home.

Across these examples, participants had framed home as something that is formed and maintained through everyday acts of care. Whether it is caring for loved ones, prioritizing oneself, or being responsible for what is around, these actions play an important role in how people understand and experience home.

Since literature reviews were done prior to this thematic analysis where the focus was placed a lot on the three dimensions of sense of home (i.e. social, psychological, and physical), the researcher was particularly drawn to categorizing the codes into these three categories. However, during the discussion, there were no framing questions from the researcher as the facilitator that shaped the participants into sharing these narratives.

2. Rediscovering Home Through Attention

The second theme is in relation to the experience and impact of the design process. This theme covers the impact of the entire design process of creating the multisensory artifact in helping the participants shift from a passive, subconscious experience of home to a more active and reflective understanding of what makes their environment feel like home.

Several participants reflected on how aspects of home were previously only understood at a subconscious level. For instance, one participant shared this. *"I knew what home is deep unconsciously at the back of my mind but never really expressed it enough"* (P1). This indicates that even though the feeling of home was present, it had not been reflected upon. Other participants also noted how sensory elements like sounds and smells that they associate with home were part of their everyday lives but typically they go unnoticed. *"I live everyday life without thinking about the noises and sounds like the smells that we put in."* (P5). These remarks show that before beginning the design process, the participants were often unaware of how the different elements in their environments contributed to their feeling of home. However, these unnoticed cues such as ambient sounds, routines, and background presence of others played a role in shaping their experience.

Participants also described how sounds from their past home influenced their appreciation for coexistence with others. *"When I lived with my parents, I didn't think I was social with them but I always heard them.. Now it's karaoke downstairs. So I'm like okay there's someone there, you know."* (P4). Although this participant had moved places, being able to hear people in the distance seemed to be a consistency across their environments. Another sound of coexistence was also described in detail, coming not directly as a sound from people but from the sound of a mere dishwasher. *"The sound of the dishwasher is like a super big part of my sense of home when I was in [country they lived before]. so like my dad sleeps really early about like 10. And then my mom is always like looking at her phone at night on the sofa. So 9 o'clock is the time when we set up, like put all the dishes into the dishwasher and start. So whenever I hear the dishwashers I can imagine like there's only like a lamp light, so it's very dark. And then it's only the dishwasher sound and my mom's like on the sofa."* (P11). This detailed memory of coexistence, sensing the presence of parents from the sound of the dishwasher,

had been constructed through years of routine. Though these things may once feel like a small part of the day, now that the participant is living away from home, they become more meaningful through the process of reflection.

The diary and artifact creation process also increased participants' awareness of themselves and their surroundings. One participant noted, *"I associated myself as being chaotic and that I didn't really have a routine but through the diary I realized I do have some like rituals, especially surrounding the dog."* (P7). This change in self perception from seeing oneself as disorganized to recognizing personal rituals suggests that participants are becoming more aware of how their habits contribute to the feeling of home. Another participant shared *"It made me think of, go through, and look at what I have and what I like, why I do what I do, I guess like, why I like my photos on my wall."* (P4). This shows how the design process prompted self-reflection about the meaning behind everyday objects and practices. This kind of reflection allows individuals to guide their own thoughts, define for themselves what contributes to their sense of home based on their values and preferences. This experience was also described by another participant *"being made aware of the type of things you do around your house to create that sene of home is really interesting"* (P5) which highlights the value of simply noticing what had previously been subconscious.

The design process also influenced the awareness of the surrounding environment. *"There's a sound near my apartment everyday at like 5pm. Before I never noticed this. But after doing this, I kind of want to know when it is and all. I kind of started to be aware of those things."* (P3). This remark shows how the process helped the participants pay more attention to their environments which reveals the subtle cues that contribute to their emotional connection to place. This increased attention can support relatedness not only to oneself but also to the people around and their environment, enhancing one's sense of home by making the invisible visible.

The way the researcher came to emphasize these points may have been influenced by her personal experience of living in Japan. After moving to Japan, the researcher found herself being more aware of the sensory stimuli in the environment since there are a lot of repeated stimuli such as the 5pm bell and train station melody, compared to places she had resided before. Therefore, the frequent

exposure could have led her to relate more to what the participants described.

3. Differences in Agency Over the Senses

The theme Differences in Agency Over the Senses covers the varying degrees of familiarity, control, and personal connection participants had with the sensory modalities during the workshop as well as in their daily lives. The differences influenced how the participants engaged during the design process and how effectively each sense contributed to evoking a sense of home.

Across the discussions, many participants described the visuals as the most easily accessible and recognizable sense. As one participant had mentioned, *"I usually pay attention to the visuals,but I never paid attention to the sounds and scents before."* (P13). This indicates that visual elements are more consciously noticed and processed in daily lives where other senses, smell and sounds are perceived in the background. Another participant also noted, *"Maybe in here the easiest thing is the visual because some scent is totally in a different presence because of the difference of culture as well."* (P8). The reason for this might be because the visuals can be replicated exactly through photos or stickers while the sounds and scents are hard to recreate depending on the availability of the sources.

On a similar note, another participant linked visuals and sounds to the meaningful objects or beings they associate with home. *"For me, things I carry with me or animals I could bring with me are what I associate more strongly with home, which is why I think the visuals and the sounds that were associated with those particular things were the most striking for me."* (P7). This suggests that being able to physically bring or recreate these visual elements give them a stronger role in creating a personal connection.

Similar instances had been noted in other participants, whether it be their collections of artwork or plushies. *"When I was in college, I went to New York, so New York was totally different to my hometown. Here, Tokyo is closer to my home than New York. So I was more familiar. And I always bring, like, some of my collections, like here this is my work."* (P9). The way the participants described their sensory experiences also revealed differences in passive versus active perception.

One participant shared their unexpected experience of encountering a smell that

reminded them of their hometown but could not figure out where it was coming from. *"Recently I smelled something strange in front of the Hiyoshi station where I smelled something like a pandan but I don't know what kind of plant."* (P8). This highlights how one can unexpectedly experience a sense of home through smells from the environment but it is difficult to find the source of the scent.

Similarly, sounds are also commonly experienced passively from the environment. This is described by a participant who said *"Whenever I wake up, normally in my house, I have like two sisters so it's very noisy. Right now it's very very quiet... I keep searching for a noise."* (P6). From this, it can be understood how certain experiences are very associated with one's sense of home that the absence of it can feel disoriented and trigger a more active search. This also emphasizes the importance of the waking-up period when people might not be fully conscious of where they are so they draw on familiar environmental cues to locate themselves.

Additionally, through the design process the participants were also active agents in evaluating the sensory elements to put into the artifact. One participant described the decision-making process they went through while they were assembling the artifact. *"In the second part, we have a lot of options to choose from so you have to pick the best one. So I think assembling is pretty important."* (P6). Other participants described selecting the scents that were linked to their own preferences or aesthetics, showing how the artifact became a platform for exercising their creative agency. *"The smell was mostly the vanilla cake smells. It smells like what I want to smell like. You know, it's so sugary. Like I put some Lemon too and this is what I want my perfumes to smell like."* (P4) *"And then to match, I showed the pink red theme and added the strawberries around."* (P5)

Participants also noted the challenge of associating some sensory elements, particularly scent, to specific memories or feelings of home. Participants said, *"But I think because they're kind of like general scents, it's like oh I like the smell. I don't necessarily associate it with home. Possibly because I don't usually use any sort of incense."* (P7) *"For the smell, I have difficulties finding something that 100% reminds me of my hometown."* (P8). These quotes suggest that even though the design process encouraged agency over the senses, it was not possible to ensure equal agency across the different senses due to limited access and the particularity of the senses.

Having analyzed the results from the initial parts of the study such as the preliminary questionnaires and the Cultural Probe study, the researcher was aware of how there are differences in the way people perceive senses in their environments. Although similar comments were made during the discussion, the pre-existing awareness might have emphasized the extent of this theme.

4. Finding Comforts From the Discomforts

This theme covers how the design process was more than just creating a multisensory artifact that evokes pleasant memories of home as it also created a safe space to acknowledge the complexities and challenges experienced. This was seen in how the participants were comfortable to share moments of emotional vulnerabilities.

One participant expressed, *"I feel since it's so personalized, maybe I should include elements that really make me happy. Some elements that don't because it reminds me of things that are around me are out of my control sometimes."* (P2). This shows an awareness that home is not always associated with stability or comfort and that acknowledging these not so perfect moments are also a way of constructing a sense of home. Therefore, instead of excluding these realities, participants had embraced them through the artifact or even through their narratives which shows that home is also where one learns to live with discomfort.

It can be seen how the participants were also aware of their emotions and were able to express that through words as seen in the following remark. *"But when I came to Japan, my parents were like, "Keep this photo in your wallet. So I just like, okay, this is for me.. Why do I feel like I want to cry right now?"* (P8).

In addition to these reflections of difficult feelings, participants also shared how they were able to cope with their past challenges. One participant said, *"It was very emotional. It was very difficult for me because I actually came in COVID. And also when we came after 10 days, my dad passed away....But I think KMD really helped me, emotionally because I'm a very passionate person in terms of work as well. So it came at a very good time."* (P1). Here, despite the pain and loss that the participant went through, they were able to see the positives and what was there for them and recognized it as a turning point for growth and emotional support.

Similarly, another participant explained the emotional significance of a partic-

ular song during their difficult point in life. *"This song means a lot to me because after my graduation it was a really hard time. So I decided to take a gap year and tried a lot of things and made a lot of different challenges. So this song actually saved me from a very high pressure life and gave me more motivation to talk frankly to my parents."* (P13). This shows the depth of the emotional memory as well as the appreciation for how the song had made an impact on their life.

Overall this theme revealed that instead of avoiding uncomfortable memories, participants actively chose to include them, using the artifact as a way to process and reflect on those experiences.

Although the design process was intentionally structured to promote connection among participants as based on the Relatedness aspect of the Self Determination Theory, it was not expected for participants to share narratives that are close to home for them. However, observing how participants were comfortable to share these experiences made the researcher realize the role home plays in emotional resilience and being able to express these challenges.

5. Sensory connections bridging individual experiences

This theme expresses how the design process not only supported individual reflection but also fostered responsive remembering and connection between the participants. This was seen in the artifact sharing part of the workshop where individuals responded to each other's narratives of home and made associations to their own experiences and memories through sensory cues. These exchanges of dialogue show how sensory elements served as a common ground between different individual experiences while fostering associations and empathy.

Through the discussion, it can be seen how the participants were recalling their own memories in response to others' stories. For instance, when a participant shared a story of a beach bench that they have back at home, another participant responded with the following. *"I had it as well in my childhood and I always had fights with my brother. I want to sit there, I want to sit there."* (P8). This way of reactive remembering shows how hearing someone else's sensory memory can activate one's own.

Similarly, in response to the other participants' choice of the Hinoki scent for their smell, a participant commented, *"You guys would love my cabin. It smells*

like wood." (P4). This comment not only conveyed a personal association with the scent but also allowed others to imagine and relate to the cabin environment that they mentioned which further encourages mutual engagement.

Another interesting interaction occurred when P6 was explaining their choice of scent as coffee since it reminded them of late-night working sessions. In response, P11 asks *"Wait, you can still sleep?"* and then P13 joins in by agreeing with P6 on how they can sleep after drinking coffee but not with milk tea. These moments highlight how the shared reflection process opened up the space for the participants to connect through their senses not just with their own past experiences but to each other.

Since sensory cues and connections were of interest in the current study, the researcher was naturally drawn to see how they were expressed during the discussion and may have seen more significance in them over other types of interactions such as compliments and laughs.

SDT Questionnaire

The results from the adapted SDT questionnaire revealed that the design process effectively supported the participants' basic psychological needs of competence, autonomy, and relatedness. On a 7-point scale, all three needs scored above 6 on average, with the highest score for relatedness (M = 6.24), followed by autonomy (M = 6.11), and competence (M = 6.09) with relatively low standard deviation values as shown in table 4.1. These findings suggest that participants felt capable of identifying and expressing their sense of home, experienced freedom in making creative choices, and felt connected to others in the group setting, indicating effective implementation of the SDT in the design process.

Table 4.1 Mean & Standard Deviation of SDT Questionnaire

Psychological Needs - Design Process	**Mean**	**Standard Deviation**
Competence - Cultural Probe	6.09	0.62
Autonomy - Artifact Assembling	6.11	0.85
Relatedness - Artifact Sharing/Discussion	6.24	0.78

Note: 7-point Likert Scale: 1 (Not true at all) to 7 (Very true)

Additionally, participants were asked to rank the three stages of the design process (i.e. Cultural Probe, Artifact Assembling, and Artifact Sharing/Discussion) in the order of most to least evoking a sense of home. For this question, participants most frequently ranked the Cultural Probe as the design stage that most strongly evoked a sense of home, instead of the Artifact Sharing/Discussion stage which reflects the results of the SDT questionnaire. This suggests that feelings of relatedness may have been built not only through interpersonal sharing but also through the introspective process of reflecting and documenting their personal sensory experiences of home. This further conveyed how relatedness may not just be about social connection but also from reconnecting with oneself and one's own memories which highlights the value of self-reflection in design processes for emotion engaging concepts.

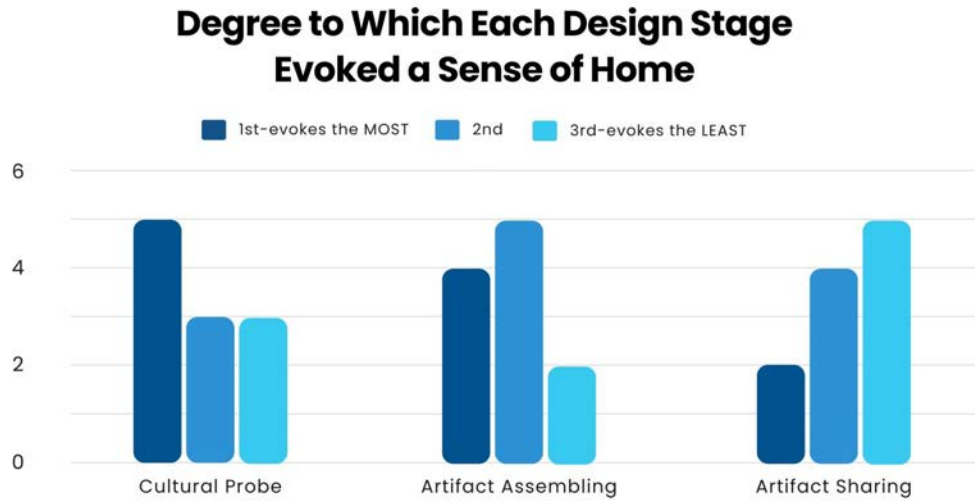

Figure 4.16 Design Stage Ranking

4.5. Reflexivity

The researcher would like to acknowledge that her background and experiences have influenced how this research was conducted and how the results were analyzed (Holmes 2020). Despite having familial relations in Japan, the researcher was

brought up and had studied abroad in different countries and finally moved to Japan in 2023 for her higher education, marking this as her first long-term stay in the country. Her experiences of living in and moving to new places influenced her motivation to research this topic. In addition, her status as a student and pre-existing relationship with the participants may have influenced the interpretation of the results. However, this shared experience also allowed the researcher to build rapport with the participants and allow them to feel comfortable sharing their thoughts, feelings, and personal experiences.

Chapter 5
Discussion

5.1. Finding Sense of Home in the Process & the Outcome

The findings of this study suggested that the sense of home was not only evoked in the final artifact but also throughout the design process. By applying the principles of the Self Determination Theory to the design process, the participants were able to explore and express their personal experiences and relationships with home.

The process began with the cultural probe phase, based on the competence principle, which revealed a change in participants' awareness of their surroundings and themselves. Many participants expressed that they had never thought deeply about sense of home, especially in regards to the senses in their everyday lives that influence it. Therefore, the act of intentionally observing and documenting these moments allowed them to re-experience the overlooked senses with an awareness of their emotions and associations with home. For instance, discovering how the sound of a dishwasher or the smell of a sun-dried laundry can trigger memories of home, was less about mastering a skill but more about interacting effectively with the environment to appreciate what is around. This supports the importance of multisensory everyday experiences and objects, particularly for those in mobile living environments as highlighted by (Sou and Webber 2023) and (Kale et al. 2019).

During the second phase of artifact assembling, giving autonomy to the participants showed different ways of expressing their sense of home. It was interesting to see not only the variety of the elements but also the different factors that they considered for choosing the elements, whether it was to make it aesthetically pleasing,

reflect their personal preferences, or resonate with their emotions and realities of home. Although some participants noted some limitations in customization especially with the availability of the scents, the presence of other elements balanced it out and were able to find ways it related with their sense of home. Despite the constraints, this process showed choosing the sensory elements for their artifacts allowed participants to express their identity through their memories and associations of home.

Lastly, the artifact sharing/ discussion phase which was based on relatedness provided space for participants to connect by seeing and hearing how others construct their own meanings of home. Participants reflected on how hearing other's stories also brought back their own memories which revealed unexpected commonalities through shared sensory memories. This process supported the understanding of home that is not only based on the concept of self but also social interactions (Somerville 1997). This sense of social connectedness was also observed when some participants shared experiences that were close to home, such as when they lost a family member or when they were going through a difficult period in life. Even though some participants already knew each other to some extent, it was also observed in participants who just met each other so it shows how this activity helped create a feeling of comfort and connectedness between participants.

In terms of the outcome, the multisensory artifact served as a tangible representation of their sense of home. Although there were no statistical significant differences across each sensory modality, the SAM scale results reflected overall high pleasure and dominance scores which suggests that participants found the artifact was an enjoyable way to recall with their sensory memories of home in a controlled manner. However, the variability across the scores for the arousal dimension indicates how things that bring a sense of home can be both calming and exciting for individuals which supports the subjective nature of home (Mallett 2004).

Overall the current findings highlight a broader point in design research of how the value of a design often lies not just in the final outcome but in the process of making. The reflective, participatory design process of this study is consistent with work in co-design and participatory design by (Gauntlett 2011)

which emphasizes that making is a way of engaging and connecting with the environment, oneself, and each other. In the current study, the process was not only about creating an artifact that evokes a sense of home but it also became a way for participants to engage with and construct their sense of home through thoughtful attention, self expression, and shared interaction.

5.2. SDT & Design in General

The study contributes to the growing interest in applying SDT and supports Peter and colleagues' study (Peters et al. 2018) that emphasized the importance of addressing users' psychological needs to design effective experiences. Although their focus was on digital design, this study shows that the same principles apply in physical, multisensory design by using the SDT not only as an evaluation tool but also as a framework for structuring the design process.

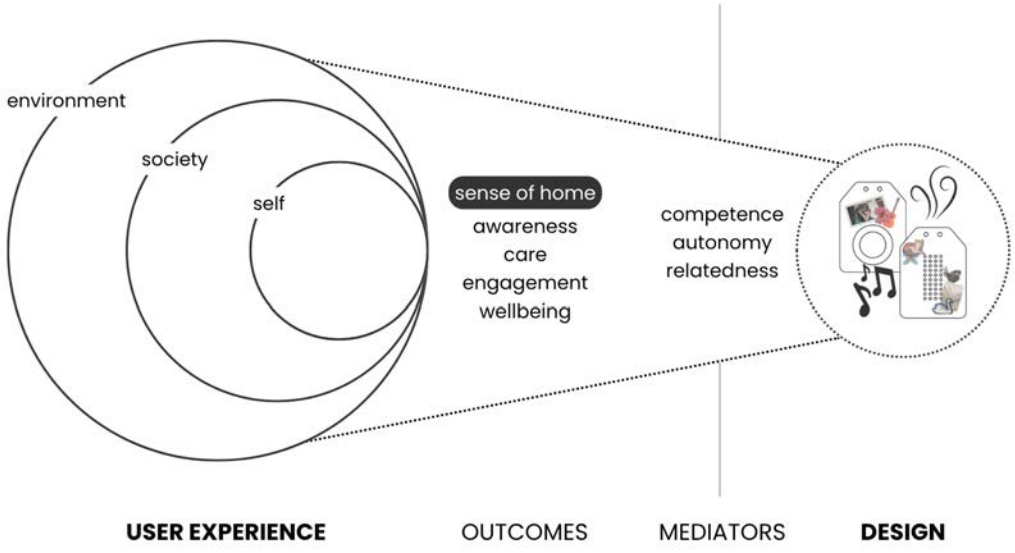

Figure 5.1 Design Outcome

The findings of this study revealed that competence can be fulfilled through activities that guide participants to feel more aware and interact more with the

sensory cues in their environment. This shows how design processes can be an opportunity for individuals to learn more about themselves and the environment. Autonomy was supported not only by giving participants options, but by allowing them to decide what and how they wanted to express their sense of home through the artifact assembling phase. Relatedness was also shown through dialogue between participants where they connected through shared memories and sensory associations, indicating how relatedness in design is about creating a space where people feel heard and comfortable to share.

Therefore, by addressing these psychological needs, the design becomes more than just an artifact that evokes a sense of home. It becomes a means of connecting with oneself through self reflection and expression as well as to connect with the world through care and understanding for others and the physical environment.

5.3. Challenges

Several challenges were faced during this research. One of them arose during the ethnographic phase which initially focused on individuals living in evacuation centers following the Noto Peninsula earthquake. However, at the time of visit the residents were preparing to relocate to different places which became unfeasible to maintain contact and involve them in the full design process. Therefore, this led to a change in participant demographics to international students which required revision to the research plan. Additionally, as it is a high participant engagement research, participant availability remained a challenge even after the demographic shift with a few individuals unable to participate in the workshop due to personal commitments. These factors highlight the complexity of conducting participatory, multisensory design research which can be taken into consideration in future research with similar demographics.

It was also a challenge to digitalize the artifact due to convenience of use and resource constraints. The possibility of digitalizing the artifact was explored using Arduino, DF sound player, and micro humidifier module. Although each component worked, it required the participant to connect with their laptop everytime they interacted which impeded the convenience of use. Since the artifact was personalized with the visuals, sounds, and scents chosen by each participant, it also

required the artifact to be produced for each participant which was not feasible with limited availability of resources. Although it was a challenge, it also revealed a potential advantage. Keeping the artifact analog enhanced its accessibility, affordability, and feasibility for wider use especially in contexts where technology is limited. Therefore, this challenge could in turn support the future applications of this artifact in diverse settings among populations with varying needs.

Another challenge was the lack of appropriate standardized measurement to evaluate whether a sense of home has been evoked after interacting with the prototype. Although there are standardized scales measuring different aspects of home such as attachment to home (Nartova-Bochaver et al. 2022), meaning of home (Oswald et al. 2006), and the emotional impact of homesickness (Stroebe et al. 2002), these scales are developed to measure the attributes that are associated with the general, established relationships with home instead of the evaluating the interaction and effects of the using the artifact. Therefore, in the context of this research, the SAM scale (Bradley and Lang 1994) combined with qualitative interviews was adopted. This approach was more appropriate since the SAM scale is widely used to measure participants' emotional response to specific events or objects and the qualitative interviews provided more subjective meaning of home as well as how the sense of home was evoked.

5.4. Limitations

The current study contained several limitations. As mentioned above, the high-engagement nature of the participatory design process limited the sample size. Although the small sample size undermined the extent to which the quantitative data can be generalized to other populations, the subjective qualitative data from the cultural probe study and focus group discussions provided deeper insights into the sense of home of international design students in Japan.

Additionally, the shared background between the participants posed limitations. The participants were all international students from one university pursuing higher education in the field of Design and have been in Japan for over a year. This shared background and pre-existing relationships between the participants may have influenced the outcomes of the research, especially the focus

group discussion section of the workshop, making it subject to social desirability bias.

Another factor that could have led to social desirability bias is the use of self reported measures. Even though the potential to measure biophysiological data was considered, due to the small sample size and minimal intervention more focus was placed on the qualitative measures to assess the subjective impact of the design on the participants. However, efforts were made to minimize the bias by using mixed methods with anonymous surveys, reassuring confidentiality, and building rapport with the participants.

As mentioned in earlier chapters of this research, there are different kinds of transitional living and relocations. Since the participants were international students, the context of the study is based on individuals who have relocated to pursue education and personal goals and are past the initial stages of relocation. Therefore, the methodology and the outcomes of the current study may not be applicable in different contexts.

Chapter 6
Conclusion

6.1. Conclusion

In conclusion, the research demonstrated how the SDT can be applied to the design process of a multisensory artifact that evokes a sense of home. Through this approach, it aimed to understand how this creation process might influence individuals' emotional connection to home particularly in the context of international students in navigating life in Japan.

Though the sample size was small to be able to generalize to a wider population, using both quantitative and qualitative methods revealed interesting insights. The findings from the questionnaire reflected that the three psychological needs were supported in the design process. This was supported by participants' qualitative reflections which revealed how the Cultural Probe activities encouraged introspection and helped them identify the sensory elements that represent home for them. Assembling the artifact provided a sense of agency, allowing them to express not only what home looks, sounds, and smells like but also how they want to remember and carry it with them. The group sharing session allowed them to connect with each other through shared reflection on their sense of home.

In terms of the artifact itself, participants reported positive emotional experiences after interaction, especially when all three senses were combined. This supports the understanding of home as a multisensory experience therefore the presence of multiple sensory modalities are important when evoking a sense of home. The findings also showed how the artifact was a controllable way to interact with the varying sensory elements that one associates with home. This highlights the subjective nature of sense of home and the different levels of agency one has of those senses. Therefore, this artifact serves as a representation of their sense of home that they want to remember despite the absence of some elements in their

current environment.

At a time when many people are experiencing displacement, relocation, or cultural shifts, this research offers a way to support identity, belonging, and wellbeing through small yet impactful designs that are based on established theoretical frameworks. Ultimately, the current findings can inform the designs of everyday objects, services, and environments for more diverse mobile populations that are not only usable but also provide deeper psychological support.

6.2. Future Considerations

Even though this study has demonstrated the potential of using a multisensory and SDT based design process to help individuals reflect and express their sense of home, there are several areas that can be further explored and improved for future research.

One key consideration for future research is the need for more standardized ways to evaluate the sense of home. Although a mixture of standardized and adapted self-report questionnaires as well as qualitative reflections were used in the current study, having a more consistent framework for evaluation that also considers the sensory and emotional aspects of home would allow for more robust comparisons across studies and participant groups.

Another point that can be addressed is the design of the artifact. Even though the analog nature of the artifact, a limitation due to resource constraints, could make the experience more accessible and affordable, future work could explore digital versions to provide more flexibility and enhance usability of the artifact. With an enhanced design of the artifact, it would be interesting to explore more sensory modalities such as taste and touch which were mentioned by participants in the pre and post questionnaires of the cultural probe study.

Additionally, increasing the sample size and diversity of the participant is another important consideration. Although the study's focus on a small group of international students in one graduate school provided insightful information, it limited the sample power and demographic diversity to evaluate the statistical significance and generalizability of the results. Therefore, future studies should include a larger and more diverse pool of samples to explore how varying circum-

stances shape the meaning and experience of home. By doing this, future research could also eliminate the bias resulting from the familiarity between the participants themselves and with the researcher. Future research could also benefit from including more anonymous reflection activities to reduce potential bias.

Moreover, although the current artifact is in the form of an omamori which has cultural significance in Japan, the structural form can adapted to be applied to different cultures and contexts. By keeping the basic design features, the multisensory elements, the artifact offers flexibility to be recreated in many different structural forms that reflect the culture of the users. This provides a way for the research to be replicated for different populations as well as a way for users to further personalize their own artifact.

As mentioned earlier in Chapter 5.4 on Limitations, measuring biophysiological data such as heart rate variability and skin response in future studies could strengthen the impact of the design. In addition, this study was also limited in the way that it only explored the immediate emotional response and impact of the design process and artifact. Therefore, future research could also explore the long term effects to evaluate whether the design has continued influences on other parts of life as well.

Overall, these considerations highlight the potential and importance of expanding this research. By deepening the research across different populations, methodologies, and contexts, future research can build on the contributions of this study.

References

Angelini, Leonardo, Maurizio Caon, Nadine Couture, Omar Abou Khaled, and Elena Mugellini (2015) "The multisensory interactive window: immersive experiences for the elderly," in *Adjunct Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2015 ACM International Symposium on Wearable Computers*, pp. 963–968.

Ballou, Nick, Sebastian Deterding, April Tyack, Elisa D Mekler, Rafael A Calvo, Dorian Peters, Gabriela Villalobos-Zúñiga, and Selen Turkay (2022) "Self-determination theory in HCI: shaping a research agenda," in *CHI conference on human factors in computing systems extended abstracts*, pp. 1–6.

Blunt, Alison and Robyn Dowling (2006) *Home*: Routledge, 1st edition.

Bradley, Margaret M and Peter J Lang (1994) "Measuring emotion: the self-assessment manikin and the semantic differential," *Journal of behavior therapy and experimental psychiatry*, Vol. 25, No. 1, pp. 49–59.

Braun, Virginia and Victoria Clarke (2006) "Using thematic analysis in psychology," *Qualitative research in psychology*, Vol. 3, No. 2, pp. 77–101.

Braun, Virginia and Victoria Clarke (2019) "Reflecting on reflexive thematic analysis," *Qualitative research in sport, exercise and health*, Vol. 11, No. 4, pp. 589–597.

Calvo, Rafael A, Dianne Vella-Brodrick, Pieter Desmet, and Richard M. Ryan (2016) "Editorial for "Positive computing: A new partnership between psychology, social sciences and technologists"," *Psychology of Well-being*, Vol. 6, No. 1, p. 10.

Cambridge Dictionary (2025) "Home," URL: `https://dictionary.cambridge.org/dictionary/english/home`, Accessed: 2025-06-18.

Chiu, Thomas KF (2022) "Applying the self-determination theory (SDT) to explain student engagement in online learning during the COVID-19 pandemic," *Journal of research on Technology in Education*, Vol. 54, No. sup1, pp. S14–S30.

Clark, Julie and Ade Kearns (2012) "Housing improvements, perceived housing quality and psychosocial benefits from the home," *Housing Studies*, Vol. 27, No. 7, pp. 915–939.

Clarke, Victoria and Virginia Braun (2017) "Thematic analysis," *The journal of positive psychology*, Vol. 12, No. 3, pp. 297–298.

Deci, Edward L and Richard M Ryan (2000) "The" what" and" why" of goal pursuits: Human needs and the self-determination of behavior," *Psychological inquiry*, Vol. 11, No. 4, pp. 227–268.

Dent-Spargo, Rosie (2018) "Using self-determination theory to support co-design activities," in *CEUR Workshop Proceedings*, Vol. 2190, CEUR Workshop Proceedings.

Dunn, James R and Michael V Hayes (2000) "Social inequality, population health, and housing: a study of two Vancouver neighborhoods," *Social science & medicine*, Vol. 51, No. 4, pp. 563–587.

Gagné, Marylène (2003) "The role of autonomy support and autonomy orientation in prosocial behavior engagement," *Motivation and emotion*, Vol. 27, pp. 199–223.

Gauntlett, David (2011) *Making is connecting*: Polity.

Gaver, Bill, Tony Dunne, and Elena Pacenti (1999) "Design: cultural probes," *interactions*, Vol. 6, No. 1, pp. 21–29.

Gibson, Marcia, Hilary Thomson, Ade Kearns, and Mark Petticrew (2011) "Understanding the psychosocial impacts of housing type: qualitative evidence

from a housing and regeneration intervention," *Housing studies*, Vol. 26, No. 04, pp. 555–573.

Gomes, Catherine, Marsha Berry, Basil Alzougool, and Shanton Chang (2014) "Home away from home: International students and their identity-based social networks in Australia," *Journal of International Students*, Vol. 4, No. 1, pp. 2–15.

Graham, Lindsay T, Samuel D Gosling, and Christopher K Travis (2015) "The psychology of home environments: A call for research on residential space," *Perspectives on Psychological Science*, Vol. 10, No. 3, pp. 346–356.

Henkemans, Olivier A Blanson, Bert PB Bierman, Joris Janssen, Rosemarijn Looije, Mark A Neerincx, Marierose MM van Dooren, Jitske LE de Vries, Gert Jan van der Burg, and Sasja D Huisman (2017) "Design and evaluation of a personal robot playing a self-management education game with children with diabetes type 1," *International Journal of Human-Computer Studies*, Vol. 106, pp. 63–76.

Herz, Rachel S, Corrente Schankler, and Sophia Beland (2004) "Olfaction, emotion and associative learning: effects on motivated behavior," *Motivation and emotion*, Vol. 28, pp. 363–383.

Holmes, Andrew Gary Darwin (2020) "Researcher Positionality–A Consideration of Its Influence and Place in Qualitative Research–A New Researcher Guide," *Shanlax International Journal of Education*, Vol. 8, No. 4, pp. 1–10.

Holton, Mark and Mark Riley (2016) "Student geographies and homemaking: Personal belonging (s) and identities," *Social & Cultural Geography*, Vol. 17, No. 5, pp. 623–645.

Houben, Maarten, Rens Brankaert, Gail Kenning, Inge Bongers, and Berry Eggen (2022) "Designing for everyday sounds at home with people with dementia and their partners," in *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, pp. 1–15.

Kale, Amber, Polly Stupples, and Sara Kindon (2019) "Feeling at home: A multisensory analysis of former refugee and host society residents' integration in Wellington, Aotearoa New Zealand," *Emotion, Space and Society*, Vol. 33, p. 100615.

Kitamura, Riku, Kenji Yamada, Takumi Yamamoto, and Yuta Sugiura (2025) "Ambient Display Utilizing Anisotropy of Tatami," in *Proceedings of the Nineteenth International Conference on Tangible, Embedded, and Embodied Interaction*, pp. 1–15.

Mallett, Shelley (2004) "Understanding home: A critical review of the literature," *The sociological review*, Vol. 52, No. 1, pp. 62–89.

McCracken, Grant David (2005) *Culture and consumption II: Markets, meaning, and brand management*, Vol. 2: Indiana University Press.

Mei-Kei, LAI (2021) "Ludic Odor: Designing Interactive Olfactory Experience for Daily Family Routines," *Special Proceedings of 2021 Asian CHI Symposium*.

Mendes, Eric (2015) "Ancient Magic and Modern Accessories: A Re-Examination of the Omamori Phenomenon," *The Hilltop Review*, Vol. 7, No. 2, p. 19.

Merriam-Webster (2025) "Home," URL: `https://www.merriam-webster.com/dictionary/home`, Accessed: 2025-06-18.

Molony, Sheila L (2010) "The meaning of home: A qualitative metasynthesis," *Research in gerontological nursing*, Vol. 3, No. 4, pp. 291–307.

Morris, Jon D (1995) "Observations: SAM: the Self-Assessment Manikin; an efficient cross-cultural measurement of emotional response," *Journal of advertising research*, Vol. 35, No. 6, pp. 63–68.

Nagoya Institute of Technology (2024) "Professor KITAGAWA Keisuke delivers Instant Houses for indoor use to the area affected by the Noto Peninsula Earthquake," March, URL: `https://www.nitech.ac.jp/eng/news/2024/11052.html`, Accessed: 2025-06-19.

Nartova-Bochaver, Sofya, Sofia Reznichenko, Vasily Bardadymov, Milana Khachaturova, Victoria Yerofeyeva, Narine Khachatryan, Iryna Kryazh, Shanmukh Kamble, and Zulkarnain Zulkarnain (2022) "Measurement invariance of the Short Home Attachment Scale: A cross-cultural study," *Frontiers in psychology*, Vol. 13, p. 834421.

OECD (2024) *International Migration Outlook 2024*, Paris: OECD Publishing.

Oishi, Shigehiro and Shelly Tsang (2022) "The socio-ecological psychology of residential mobility," *Journal of Consumer Psychology*, Vol. 32, No. 3, pp. 519–536.

Oswald, Frank, Oliver Schilling, Hans-Werner Wahl, Agneta Fänge, Judith Sixsmith, and Susanne Iwarsson (2006) "Homeward bound: Introducing a four-domain model of perceived housing in very old age," *Journal of environmental psychology*, Vol. 26, No. 3, pp. 187–201.

Oswald, Frank and Hans-Werner Wahl (2005) "Dimensions of the meaning of home in later life," *Home and identity in late life: International perspectives*, pp. 21–45.

Parsell, Cameron (2012) "Home is where the house is: The meaning of home for people sleeping rough," *Housing studies*, Vol. 27, No. 2, pp. 159–173.

Peters, Dorian, Rafael A Calvo, and Richard M Ryan (2018) "Designing for motivation, engagement and wellbeing in digital experience," *Frontiers in psychology*, Vol. 9, p. 300159.

Pink, Sarah and Kerstin Leder Mackley (2016) "Moving, making and atmosphere: Routines of home as sites for mundane improvisation," *Mobilities*, Vol. 11, No. 2, pp. 171–187.

Rahmah, Yuliani (2020) "Omamori: Harmonization of humans and their environment in cultural symbols," in *E3S Web of Conferences*, Vol. 202, p. 07073, EDP Sciences.

Ralph, David and Lynn A Staeheli (2011) "Home and migration: Mobilities, belongings and identities," *Geography compass*, Vol. 5, No. 7, pp. 517–530.

Ratnam, Charishma (2018) "Creating home: Intersections of memory and identity," *Geography Compass*, Vol. 12, No. 4, p. e12363.

Rattanaplome, Tithinun, Philaiwan Pornprasit, and Napat Chantaramee (2015) "The Potential of Perlite as an Odour-Adsorbing Fillers in Natural Rubber Vulcanizates," in *Macromolecular Symposia*, Vol. 354, pp. 197–206, Wiley Online Library.

Rijnaard, Maurice D, Joost Van Hoof, BM Janssen, Hilde Verbeek, Wouter Pocornie, A Eijkelenboom, HC Beerens, SL Molony, and EJM Wouters (2016) "The factors influencing the sense of home in nursing homes: A systematic review from the perspective of residents," *Journal of Aging Research*, Vol. 2016, No. 1, p. 6143645.

Ruzek, Erik A, Christopher A Hafen, Joseph P Allen, Anne Gregory, Amori Yee Mikami, and Robert C Pianta (2016) "How teacher emotional support motivates students: The mediating roles of perceived peer relatedness, autonomy support, and competence," *Learning and instruction*, Vol. 42, pp. 95–103.

Ryan, Richard M and Edward L Deci (2017) *Self-determination theory: Basic psychological needs in motivation, development, and wellness*: Guilford publications.

Sabie, Dina, Samar Sabie, and Syed Ishtiaque Ahmed (2020) "Memory through design: supporting cultural identity for immigrants through a paper-based home drafting tool," in *Proceedings of the 2020 CHI conference on human factors in computing systems*, pp. 1–16.

Scannell, Leila and Robert Gifford (2017) "The experienced psychological benefits of place attachment," *Journal of environmental psychology*, Vol. 51, pp. 256–269.

Schreuder, Eliane, Jan Van Erp, Alexander Toet, and Victor L Kallen (2016) "Emotional responses to multisensory environmental stimuli: A conceptual framework and literature review," *Sage Open*, Vol. 6, No. 1, p. 2158244016630591.

Seamon, David (2015) *A Geography of the Lifeworld (Routledge Revivals): Movement, Rest and Encounter*: Routledge.

SensorWake Trio (Sensorwake) (2018) "SensorWake Trio: Smell-Based Alarm Clock to Improve Your Day," `https://www.kickstarter.com/projects/sensorwaketrio/sensorwake-trio-smell-based-alarm-clock-to-improve`, June, Accessed 2025-06-09.

Shakeri, Hanieh, Denise Y Geiskkovitch, Radhika Garg, and Carman Neustaedter (2023) "Sensing their presence: How emerging adults and their parents connect after moving apart," in *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, pp. 1–18.

Sigmon, Sandra T, Stacy R Whitcomb, and Charles R Snyder (2002) "Psychological home," in *Psychological sense of community: Research, applications, and implications*: Springer, pp. 25–41.

Silver, Amber and Jason Grek-Martin (2015) ""Now we understand what community really means": Reconceptualizing the role of sense of place in the disaster recovery process," *Journal of Environmental Psychology*, Vol. 42, pp. 32–41.

Sixsmith, Judith (1986) "The meaning of home: An exploratory study of environmental experience," *Journal of environmental psychology*, Vol. 6, No. 4, pp. 281–298.

Soleimani, Maryam and Minou Gharehbaglou (2023) "The role of self-determination needs and sense of home," *Journal of Housing and the Built Environment*, Vol. 38, No. 1, pp. 347–370.

Somerville, Peter (1997) "The social construction of home," *Journal of architectural and planning research*, pp. 226–245.

Sou, Gemma and Ruth Webber (2023) "Un/making the 'sensory home': tastes, smells and sounds during disasters," *Social & Cultural Geography*, Vol. 24, No. 6, pp. 949–967.

Spangler, Vera (2023) "Home here and there: a spatial perspective on mobile experiences of 'home'among international students," *Social & Cultural Geography*, Vol. 24, No. 8, pp. 1440–1457.

Spence, Charles (2020) "Senses of place: architectural design for the multisensory mind," *Cognitive research: principles and implications*, Vol. 5, No. 1, p. 46.

Streimikiene, Dalia (2015) "Quality of life and housing," *International Journal of Information and Education Technology*, Vol. 5, No. 2, p. 140.

Stroebe, Margaret, Tony Van Vliet, Miles Hewstone, and Hazel Willis (2002) "Homesickness among students in two cultures: Antecedents and consequences," *British Journal of Psychology*, Vol. 93, No. 2, pp. 147–168.

Swanger, Eugene R and K Peter Takayama (1981) "A Preliminary examination of the" Omamori" phenomenon," *Asian Folklore Studies*, pp. 237–252.

Terracciano, Alda, Mariza Dima, Marina Carulli, and Monica Bordegoni (2017) "Mapping Memory Routes: A multisensory interface for sensorial urbanism and critical heritage studies," in *Proceedings of the 2017 CHI conference extended abstracts on human factors in computing systems*, pp. 353–356.

Treasure-Jones, Tamsin, Rosie Dent-Spargo, and Sisira Dharmaratne (2018) "How do students want their workplace-based feedback visualized in order to support self-regulated learning? Initial results & reflections from a co-design study in medical education," in *CEUR workshop proceedings*, Vol. 2193, CEUR Workshop Proceedings.

United Nations High Commissioner for Refugees (2024) "Global Trends: Forced Displacement in 2023,"Technical report, UNHCR.

Van Hoof, J, H Verbeek, BM Janssen, A Eijkelenboom, SL Molony, Esther Felix, KA Nieboer, ELM Zwerts-Verhelst, JJWM Sijstermans, and EJM Wouters (2016) "A three perspective study of the sense of home of nursing home residents: the views of residents, care professionals and relatives," *BMC geriatrics*, Vol. 16, pp. 1–15.

Van Steenwinkel, Iris, Stijn Baumers, and Ann Heylighen (2012) "Home in later life: a framework for the architecture of home environments," *Home Cultures*, Vol. 9, No. 2, pp. 195–217.

Wong, Joshua WE (2017) "'So that she feels a part of my life': how international students connect to home through digital media technologies," *International Student Connectedness and Identity: Transnational Perspectives*, pp. 115–135.

Xia, Qi, Thomas KF Chiu, Min Lee, Ismaila Temitayo Sanusi, Yun Dai, and Ching Sing Chai (2022) "A self-determination theory (SDT) design approach for inclusive and diverse artificial intelligence (AI) education," *Computers & education*, Vol. 189, p. 104582.

Yang, Xi and Marco Aurisicchio (2021) "Designing conversational agents: A self-determination theory approach," in *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pp. 1–16.

Zorea, Marine and Katsuhiko Kushi (2024) "All Is Heard: Reimagining The Sounds of Home With Care," in *Proceedings of the 2024 ACM Designing Interactive Systems Conference*, pp. 2708–2718.

Appendices

A. Pre-Cultural Probe Questionnaire

Table A.1: Pre-Cultural Probe Questionnaire Items

Questionnaire Item	**5-point Measure Values**
How important do you think sensory experiences (sights, sounds, smells) are in helping you feel "at home"?	Not important at all – Extremely Important
How much do the following sensory experiences contribute to your sense of home? (Sights)	Not at all – Very much
How much do the following sensory experiences contribute to your sense of home? (Sounds)	Not at all – Very much
How much do the following sensory experiences contribute to your sense of home? (Smells)	Not at all – Very much
How often do you use sensory cues (sights, sounds, smells, etc.) to make a space feel more like home?	Never – Always
How effective do you think sensory experiences (sights, sounds, smells) are in making a space feel like home?	Not effective at all – Extremely effective
How much do the following sensory experiences influence your mood or emotional state? (Sights)	Not at all – Very strongly

Questionnaire Item	**5-point Measure Values**
How much do the following sensory experiences influence your mood or emotional state? (Sounds)	Not at all – Very strongly
How much do the following sensory experiences influence your mood or emotional state? (Smells)	Not at all – Very strongly
Is there anything else you would like to share about your sense of home or sensory experiences?	

B. Post-Cultural Probe Questionnaire

Table B.1: Post-Cultural Probe Questionnaire Items

Questionnaire Item	**5-point Measure Values**
How important do you think sensory experiences (sights, sounds, smells) are in helping you feel "at home"?	Not important at all – Extremely Important
How much do the following sensory experiences contribute to your sense of home? (Sights)	Not at all – Very much
How much do the following sensory experiences contribute to your sense of home? (Sounds)	Not at all – Very much
How much do the following sensory experiences contribute to your sense of home? (Smells)	Not at all – Very much
How often do you use sensory cues (sights, sounds, smells, etc.) to make a space feel more like home?	Never – Always

Questionnaire Item	**5-point Measure Values**
How effective do you think sensory experiences (sights, sounds, smells) are in making a space feel like home?	Not effective at all – Extremely effective
How much do the following sensory experiences influence your mood or emotional state? (Sights)	Not at all – Very strongly
How much do the following sensory experiences influence your mood or emotional state? (Sounds)	Not at all – Very strongly
How much do the following sensory experiences influence your mood or emotional state? (Smells)	Not at all – Very strongly
What was the most surprising or unexpected sensory experience you documented during the study?	
How did these activities impact your perception of sense of home?	
Is there anything else you'd like to share about your experience in this study, or any thoughts or questions that came up during the activities?	

C. Sensory Elements of Participants

Participant	**Visuals**	**Sounds**	**Scent**
P1	family, animals (birds, bears, duck, cat), flower, trees	Elmo songs	Vanilla

Participant	**Visuals**	**Sounds**	**Scent**
P2	favorite plushie, flowers, food, supermarket tags, receipt, bath ball, medicine	"Cover Girl", "Love Like You"	Anna Sui's Sundae Mellow Yellow perfume, Body Fantasies' Wedding Day body mist
P3	shark plushie, beach shore, sticker of a person walking, rabbit, strawberries, flowers, Duffy plushies, picture from friend's wedding	Mahjong ASMR, OST from TV Series	Hinoki, rosemary
P4	Photobooth pictures of friends, favorite tea, small figures, supermarket tags, strawberries, dog plushie from childhood	Sound of people talking, Sound of videos/music playing in the background	Vanilla, lemon
P5	Picture of parents, grandma's cat, black cats, strawberries, monstera plant, flowers (tulip)	Piano sounds, White noise of cooler sounds	Hinoki

Participant	**Visuals**	**Sounds**	**Scent**
P6	Picture of university campus (sky, road), game from childhood, craft tape, picture of city from home country, yogurt	Sound of rain, Sound of birds	Coffee, vanilla
P7	Postcard from friend, picture of dog, hand drill, flowers, lemon	Sound of falling leaves, Sound of dog walking	Hinoki, vanilla
P8	Flowers, deer, nature, stars in the sky, mountains, picture of sky	Sound of cicadas in the forest, Sound of children reciting	Hinoki
P9	Desk at home, kotatsu, onsen, steak, milk, beach bench	Sound of rain, Sound of humidifier	Hinoki
P11	Polaroid pictures of family, book collection, incense stick collection, ceramics cup from dad	Piano sounds	Incense stick

Participant	Visuals	Sounds	Scent
P13	Plushie collection, artwork of cat, picture of gift from friend, fox, flowers, birds, nature, camera	”Jinsei wa Saikou no Himatsubushi” by HoneyWorks feat. Hanon	Lemon

D. Post Interaction Reflection: SAM Scale

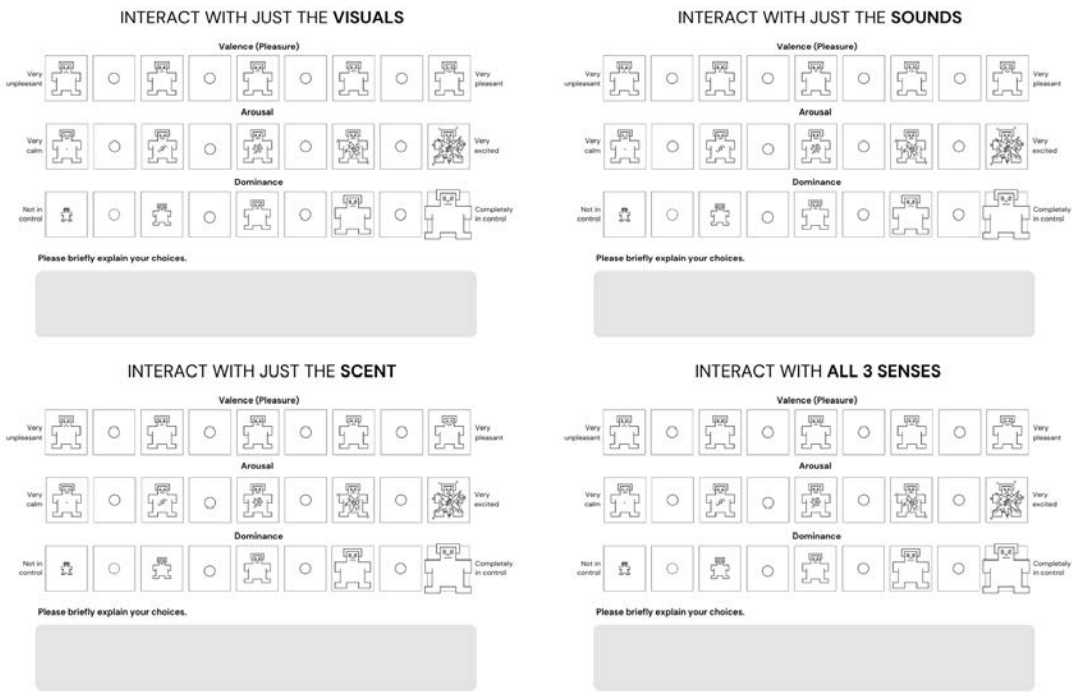

Figure D.1 SAM Scale

E. SAM Scale Friedman Test

Valence (Pleasure)

A Friedman test showed that there was no significant difference between the dependent variables, p = .695.

Descriptive Statistics

	N	Mean	Median	Standard deviation
All 3 Senses	11	8.18	8	0.98
Visuals	11	7.55	8	1.86
Sounds	11	7.27	8	1.56
Scent	11	7.82	8	1.6

Ranks

	Mean Rank
All 3 Senses	2.86
Visuals	2.27
Sounds	2.32
Scent	2.55

Statistics

Chi 2	df	p
1.45	3	0.695

Pairwise compairson (Dunn-Bonferroni Test)

	Test statistics	Standard error	Std. test statistics	p	Adj. p
All 3 Senses - Visuals	0.59	0.55	1.07	0.283	1
All 3 Senses - Sounds	0.55	0.55	0.99	0.322	1
All 3 Senses - Scent	0.32	0.55	0.58	0.563	1
Visuals - Sounds	-0.05	0.55	-0.08	0.934	1
Visuals - Scent	-0.27	0.55	-0.5	0.62	1
Sounds - Scent	-0.23	0.55	-0.41	0.68	1

In each row, the null hypothesis is tested if both samples are the same, the "Adj. p-value" is obtained by multiplying the p-value by the number of tests.

Figure E.1 Friedman Test: Valence (Pleasure)

Arousal

A Friedman test showed that there was no significant difference between the dependent variables, p = .203.

Descriptive Statistics

	N	Mean	Median	Standard deviation
All 3 Senses	11	5.09	6	2.91
Visuals	11	4.91	5	2.43
Sounds	11	4.27	4	2.83
Scent	11	3.18	2	2.32

Ranks

	Mean Rank
All 3 Senses	2.82
Visuals	2.86
Sounds	2.5
Scent	1.82

Statistics

Chi 2	df	p
4.61	3	0.203

Pairwise comparison (Dunn-Bonferroni test)

	Test statistics	Standard error	Std. test statistics	p	Adj. p
All 3 Senses - Visuals	-0.05	0.55	-0.08	0.934	1
All 3 Senses - Sounds	0.32	0.55	0.58	0.563	1
All 3 Senses - Scent	1	0.55	1.82	0.069	0.277
Visuals - Sounds	0.36	0.55	0.66	0.509	1
Visuals - Scent	1.05	0.55	1.9	0.058	0.23
Sounds - Scent	0.68	0.55	1.24	0.215	0.862

In each row, the null hypothesis is tested if both samples are the same, the "Adj. p-value" is obtained by multiplying the p-value by the number of tests.

Figure E.2 Friedman Test: Arousal

Dominance

A Friedman test showed that there was no significant difference between the dependent variables, p = .093.

Descriptive Statistics

	N	Mean	Median	Standard deviation
All 3 Senses	11	7.27	8	1.49
Visuals	11	5.64	6	1.91
Sounds	11	6.55	6	1.81
Scent	11	6.82	7	1.99

Ranks

	Mean Rank
All 3 Senses	3.05
Visuals	1.73
Sounds	2.45
Scent	2.77

Statistics

Chi 2	df	p
6.41	3	0.093

Pairwise comparison (Dunn-Bonferroni test)

	Test statistics	Standard error	Std. test statistics	p	Adj. p
All 3 Senses - Visuals	1.32	0.55	2.39	0.017	0.067
All 3 Senses - Sounds	0.59	0.55	1.07	0.283	1
All 3 Senses - Scent	0.27	0.55	0.5	0.62	1
Visuals - Sounds	-0.73	0.55	-1.32	0.186	0.746
Visuals - Scent	-1.05	0.55	-1.9	0.058	0.23
Sounds - Scent	-0.32	0.55	-0.58	0.563	1

In each row, the null hypothesis is tested if both samples are the same, the "Adj. p-value" is obtained by multiplying the p-value by the number of tests.

Figure E.3 Friedman Test: Dominance

F. SDT Questionnaire

This questionnaire was adapted from the Basic Psychological Needs Satisfaction Scale to measure whether the need for competence, autonomy, and relatedness has been addressed in the design process (Deci and Ryan 2000, Gagné 2003). This scale uses a 7-point Likert scale from 1 (not at all true) to 7 (very true).

F.1 Competence - Cultural Probe

1. Documenting sensory elements for the cultural probe activities made me feel capable of identifying what represents "home" to me.

2. I was able to express my feelings and experiences about my sense of home clearly through the cultural probe activities.
3. I felt uncertain about how sensory elements reflect my sense of home. *(Reverse-coded)*
4. I discovered new things about how I experience a sense of home through the cultural probe activities.
5. I felt effective in completing the cultural probe activities.

F.2 Autonomy - Artifact Assembling

1. I felt free to decide which sensory elements to include in my artifact.
2. I felt restricted in how I could combine the sensory elements in the artifact. *(Reverse-coded)*
3. I was able to express my sense of home through the way I designed and assembled my artifact.
4. I was able to create the artifact in a way that aligned with my personal definition of sense of home.
5. I felt that I had control over how my artifact would look, sound, and smell.

F.3 Relatedness - Artifact Sharing/Discussion

1. I felt comfortable expressing personal thoughts about sense of home in the group setting.
2. I found it meaningful to hear others' stories and experiences related to their sense of home.
3. I felt that others in the group cared about what I shared.
4. I felt that others didn't really understand or relate to what I shared. *(Reverse-coded)*

5. Sharing my artifact and feelings about sense of home helped me connect with others on a deeper level.

G. Artifact Sharing/ Discussion Questions

The following questions were asked accordingly to facilitate the discussion.

- What is sense of home for you?
- Could you please share the sensory elements you've chosen?
- What impact, if any, did the design process have on your sense of home?
- In terms of the entire design process (Cultural Probe, Assembling the Artifact, Sharing with others) what stages contributed the most in evoking a sense of home for you? Why
- and follow-up questions...