The Nature Experience

Augmenting a Path to Healthier Lifestyles

Eryn Pierce

Department of Graphic Design
College of Design
North Carolina State University

April 29th, 2021

Submitted in partial fulfillment for
the degree of Master of Graphic Design

Deborah Littlejohn, PhD, Committee Chair
Associate Professor of Graphic Design

Kermit Bailey, Committee Member
Associate Professor of Graphic Design

Matthew Peterson, PhD, Committee Member
Assistant Professor of Graphic Design

This document details a final project, which in design is commonly referred to as a graduate "thesis," at North Carolina State University. The work was defined in a 3-credit course in a fall semester, and executed in a 6-credit course in the following spring semester. The Master of Graphic Design is a terminal professional degree with a research orientation, but like the MFA and MDes, it is not a primary research degree. This is a discovery-based investigation. Cash (2018) describes the process of building scientific knowledge as a cycle between theory building and theory testing. The theory-building model includes (1) discovery and description, (2) definition of variables and limitation of domain, and (3) relationship building (pp. 88–89). This investigation is restricted to the theory building mode. The theory testing model includes (4) prediction, testing, and validation, and (5) extension and refinement (p. 89). While experts may have been consulted, this investigation does not entail any testing with human subjects, and it does not endeavor to prove anything; all assertions are tentative and speculative.

See: Cash, P. J. (2018). Developing theory-driven design research. *Design Studies*, 56, 84–119.

Experiences in nature coupled with positive encounters with nature have significant psychological health benefits. However, for many urban citizens, especially adolescents, there is a disconnect between the natural world and one's place within it. This project examines how the design of immersive learning technologies like augmented reality (AR) combined with social engagement-based motivation tactics can inform the achievement of healthier lifestyles outdoors. Findings from this study suggest that designing AR supported and adaptive learning experiences, which include moments for technology disconnection and opportunities for personal and shared encounters within and outside of the nature experience, contribute to the formation of healthy habits and can improve the effectiveness of restorative nature-based prescriptions.

THANK YOU.

I would like to extend my deepest gratitude to those who have supported me along this journey.

To John Burrows who was always a phone call away, for the constant reminders to stay balanced and enjoy the process.

To Alyssa Hardbower and the marketing team at Southern Energy Management for all their kindness and overwhelming support.

To my beyond creative roommate Jack Ratterree and his wonderful mother, Meribeth Dinwiddie, for giving me energy through friendship, creativity, laughter, and love.

To Ab Feldman and Marcie Laird for being my biggest cheerleaders and constant source of inspiration. I am in awe of your accomplishments.

To Deborah Littlejohn for your wise words and thoughtfulness and for giving me the confidence to push the boundaries of my design abilities.

To my committee members, Kermit Bailey and Matt Peterson, for your time and thoughtfulness.

To Denise Gonzales Crisp for giving me the opportunity to pursue my passions and for teaching me how to create the unexpected.

To all my friends, family, faculty, and MGD cohort. Know that I could not have done this without you.

Finally, to Mom and Dad for instilling in me a love for nature and learning. I'm so lucky to have you in my life.

TABLE OF CONTENTS

01. INTRODUCTION **09**

02. PROBLEM SPACE **10**

2.1 Problem Statement 10

2.2 Justification 11

2.3 Annotated Bibliography 12

2.4 Definition of Terms 14

2.5 Assumptions and Limitations 16

2.6 Precedents 16

03. INVESTIGATION PLAN **21**

3.1. Conceptual Framework 21

3.2. Research Questions 26

3.3. Investigation Model 27

3.4. Scenario 28

04. STUDIES **31**

4.1. Strengthening Connections and Increasing Awareness 31

4.2. Increasing Feelings of Comfort and Belonging 47

4.3. Encouraging Engagement 59

4.4. Increasing Perception of Mastery 71

05. DISCUSSION **87**

5.1. Design Principles 87

5.2. Future Work 89

5.3. Conclusion 91

06. REFERENCES **93**

"All the time I was getting closer to animals and nature, and as a result, closer to myself and more and more in tune with the spiritual power that I felt all around. For those who have experienced the joy of being alone with nature there is really little need for me to say much more; for those who have not, no words of mine can even describe the powerful, almost mystical knowledge of beauty and eternity that come, suddenly, and all unexpected. The beauty was always there, but moments of true awareness were rare. They would come, unannounced; perhaps when I was watching the pale flush preceding dawn; or looking up through the rustling leaves of some giant forest tree into the greens and browns and the black shadows and the occasionally ensured bright fleck of blue sky; or when I stood, as darkness fell, with one hand on the still warm trunk of a tree and looked at the sparkling of an early moon on the never still, softly sighing water of Lake Tanganyika."

—JANE GOODALL

01. INTRODUCTION

In early March of 2020, stay-at-home orders were initiated statewide as a strategy to reduce the spread of COVID-19 in the United States. Citizens were forced to transition from a highly social way of living and working to the more restrictive confines of their homes (Moreland et al., 2020). We saw how quickly a virus could dismantle our way of life and undermine the support systems that contribute positively to our mental health. With mounting stress due to the global trauma created by the pandemic, taking time to attend to our mental health has never been more important. In this unprecedented time, we have witnessed a surge in the number of people taking to local parks and gardens in search of non-stress inducing environments (Fisher & Grima, 2020).

Nature
Encompasses the plants, animals, and landscapes that make up the planet.

Still, even amidst a revitalization of outdoor recreation and nature-based activities, not everyone is participating. The rise in park visitors correlates more closely with rural residents and an increase in the number of repeat visits by those who, like outdoor enthusiasts, already prescribe to outdoor activities (Rice et al., 2020). With this in mind, questions emerge around why people are still unable or unwilling to participate in these activities despite the crucial psychological health benefits.

Urban Areas
Highly developed and densely populated regions where people live and work. They are often characterized as built environments.

Nature/Outdoor Experiences
A period of time spent directly or indirectly interacting with and/or within nature.

Factors that have long been associated with a decrease in outdoor participation have ranged from general access to recreational amenities, fear of crime, and overcrowding (Sreetheran et al., 2014). The pandemic, for better or worse, has brought to light and exacerbated these factors that disproportionately impact urban citizens and have decreased their likelihood to seek outdoor experiences (Rice et al., 2020). Thus, as we continue to face an uncertain future and as the urgency to address these realities intensifies, designers and health providers play a unique role. The design of interventions and experiences that foster connections between nature and people could mean the difference between the maintenance of a participant's mental and emotional well-being and its unraveling to a state of disrepair.

02. PROBLEM SPACE

2.1. PROBLEM STATEMENT

Urban Populations/Residents
People living in cities or inhabiting areas that have a greater population density than rural areas and are overall more compact than rural areas.

Adolescents
Individuals transitioning from formative years to adulthood that fall between the ages of 15–19.

Even as the mental strain caused by the global pandemic intensifies, urban residency has long been considered a strong predictor of the development of mental disorders such as depression and anxiety (Leavell, 2019). According to Peen et al. (2010), physical factors (e.g. air pollution, small housing, population density) and social factors (stress, life events, perinatal conditions, social isolation) are thought to be responsible for illness in city environments. Thus, questions around the way we live and interact in these environments become front and center, especially for our most mentally vulnerable populations.

The World Health Organization (WHO) warns that suicide has now become the third leading cause of death among adolescents between the ages of 15 to 19 (WHO, 2020). Young people in their formative years of life are more at risk for developing mental health disorders than any other population (Hoare et al., 2016). The use of mobile technologies and social media not only keeps this group from engaging in physical activities, but platforms like Facebook and Instagram perpetuate social and self-comparison behaviors that compromise mental health (Torre et al., 2020). Unfortunately, COVID-19 restrictions on top of city living, have only perpetuated unhealthy, stagnant, and screen-dependent lifestyles (Montag & Elhai, 2020). Thus, any efforts to motivate individuals to seek healthier lifestyles that contribute to overall physical and emotional well-being must be prioritized (WHO, 2020).

Nature Prescriptions
Written instructions provided by a doctor that encourage a patient to seek time outdoors in nature as a treatment method for various health conditions.

Nature Therapy
A range of techniques or treatments used within nature to help improve an individual's mental or physical health.

Attention Restoration Theory (ART)
The idea that people are better able to concentrate after looking at or spending time with nature.

One popular solution that is gaining traction, is a nature-based health intervention called Park Rx. This approach, championed by the healthcare industry, is a way of elevating one's health through participation in the natural environment. According to Van Tubergen, this type of intervention can be traced back to the "Hippocratic era (460–370 BC), when changing environments and lifestyle practices were advised by the physicians of the time" (as cited in Robinson et al., 2020). Today studies reveal that activity and behavior focused prescriptions alongside nature-based therapy tactics can improve mental well-being by mitigating feelings of stress, anxiety, and depression simply by encouraging individuals to spend time in nature (Sefcik et al., 2019). Drawing from attention restoration theory (ART), these methods have been proven to alleviate the stress associated with inner city living and technology immersed lifestyles (Berman, 2008).

Today there is even more motivation for healthcare providers to adopt these nature and practice embedded prescriptions as they not only promote more sustainable health outcomes but additionally supply patients with important co-benefits within social, environmental, and economic domains (Robinson et al., 2020). However, research by Bragg and Leck (2017) shows that although effective, these current unorthodox types of nature-based therapies are not typically prescribed to patients who express apathetic feelings towards outdoor experiences. For urban residents, these feelings are especially common as lack of interest is often tied to their ignorance around the nature experience and its associated benefits such as attention restoration, stress reduction, and positive emotional recall (Abraham et al., 2009). Furthermore, the idea that these residents, who have been steeped in digital technology, will develop a subjective sense of connectedness with nature with a prescription alone is unrealistic (Nisbet et al., 2010). Thus, tools that support patient understanding of and exposure to nature will be key in the initial prescription filling process and the long-term health of the patient.

2.2. JUSTIFICATION

Augmented Reality (AR)
An interactive experience where the real world environment is overlaid with digital content.

Fortunately, within the larger Park Rx movement, there is evidence that as nature-based prescribing programs gain popularity, technological interventions may help with the adoption of these prescriptions (Leavell et al., 2019). Studies performed by Ruchter (2009) indicate that using technology can facilitate experiences in and encounters with nature rather than distract from it. In fact, adolescents are far more likely to engage in outdoor learning environments when the learning is combined with novel, computer-mediated forms of interpretation. Technology that incorporates augmented reality (AR) for example, shows promise for creating closer connections between users and their physical surroundings (Kiryakova, 2020). By overlaying virtual objects on top of the physical world there is the opportunity to increase one's ability to make sense of an activity and therefore improve the overall experience.

This AR driven strategy has proven successful with significant potential in several instances of use. Gabbiadini et al. (2018) presented supporting research in the article, "Does Pokémon Go Lead to a More Physically Active Life Style?". Here, they discuss the benefits of mobile AR games, like Pokémon Go, which mixes virtual elements with real world physical activities. Their research shows how this game has been causally linked to an increase in social interaction and time outdoors. However, they emphasize that despite an increase in connection and attention to an outdoor setting, the positive long-term effects of this game in promoting a healthy lifestyle are limited to game driven activities and does not translate to more active behavior in general. Thus, there is opportunity within AR and outdoor-based facilitated experiences to incorporate learning and motivation tactics that continue to engage the user following the outdoor experience. For example, social sharing of tracked results is one strategy that could increase motivation and foster positive behavioral reinforcement. Yet, games like Pokémon Go have not fully explored how social engagement features might encourage direct outdoor participation and interaction. In addition, information delivery tactics that assist with skill development and attention directing mechanisms that leverage the benefits of being outdoors are missed opportunities that are worth exploring.

Healthier Habits/Lifestyles
Building a culture of engagement around nature, increasing activity outdoors, and immersing oneself in nature for *at least* 120 minutes a week.

Immersive
The perception of physical presence.

Social Engagement
Social involvement or social participation within a community of users.

So, to improve the effectiveness of nature-based prescriptions, particularly for patients being prescribed attention restorative therapy, this investigation will look at how the design of immersive learning technology combined with social engagement-based motivation tactics can assist adolescents in achieving a healthier lifestyle outdoors.

2.3. ANNOTATED BIBLIOGRAPHY

Parks
Manicured or semi-natural green spaces inside towns and cities reserved for human recreation and enjoyment as well as for wildlife and habitat preservation.

Park Rx & Time in Nature. There is an emerging national health movement that aims to prevent chronic disease and improve feelings of well-being through the prescription of physical activity combined with time in parks (Stone & Roberts, 2020). Public parks, in particular, are uniquely positioned to promote physical activity, positive social interactions, and overall well-being (Rock et al., 2016). According to Park Rx America, the use of parks as "a low-cost intervention that utilizes a known, generally trusted, and accessible resource—parks—to influence positive health outcomes" is a worthwhile endeavor to bridge the healing benefits of nature therapy with public health initiatives (Park Rx America, 2020, unpaginated url).

Barriers to Access. There are several barriers to the access of urban parks. Safety concerns, the dislike of things associated with natural environments, financial hardship, medical conditions affecting physical function, outdoor conditions, and physical conditions of spaces have all been top reasons that have discouraged individuals from spending time in nature (Sefcik et al., 2019). However, despite these barriers, the presence of organized programs and activities was a strong predictor of park use (Sefcik et al., 2019). Thus, when barriers to access are addressed within organized prescription programs, there is a higher likelihood that these programs will be successful in adherence and effectiveness (Sefcik et al., 2019).

Nature Relatedness & Pro-Environmentalism. Nature relatedness describes an individual's sense of belonging to the natural world (Colléony et al., 2019). Appreciative activities or experiences in nature, like hiking, birding, and walking, are common ways for humans to stay connected to nature and they have been linked to pro-environmental attitudes and behaviors (Rosa & Collado, 2019). However, research suggests that increasing access to nature is not enough to create meaningful interactions with nature that influence environmental attitudes and behaviors (Colléony et al., 2019). Thus, designing experiences that foster the human and nature relationship and mitigate insecurity will be critical for the development of an individual's pro-environmentalism (Rosa & Collado, 2019).

Experiential & Embodied Learning. Several theories are widely used in outdoor education to facilitate a connection between the student and the natural world. Experiential learning is a process where knowledge creation occurs through a transformative experience and the learner is actively engaged with the place or thing being studied (Kolb, 1984, as cited in Lai et al., 2007). Similarly, within embodied learning theory we see how "interactions between the body, mind, and place become foregrounded in the outdoor education experiences" (Dunne, 2018, p. 289). By exposing students to bodily and sensory experiences within a place, they become more connected to and draw meaning from a place (Dunne, 2018).

Immersive Learning Technologies. Virtual reality (VR) and augmented reality (AR), provide a more immersive learning experience by mixing "the real-world physical environments with computer-generated virtual objects" (Kiryakova, 2020, p. 1). Customizable learning environments; direct interactions with real people, places, and locations; temporal manipulation and identity formation; and alignment are all affordances of this technology (Beck, 2019). The advances in processing power, image recognition, object tracking, display and sensor measurement for location and orientation capabilities have made immersive learning a more viable and integratable solution in education (Irshad and Rambli, 2014). A variety of devices, such as smartphones, tablets, and wearables can now be used to successfully display AR technology to create an immersive learning experience (Kiryakova, 2020).

TOPIC	TITLE	CITATION
Park Rx	Park Spaces and the User Experience	Stone & Roberts, 2020
	Public Engagement and Community Participation in Governing Urban Parks: A Case Study in Changing and Implementing a Policy Addressing Off-Leash Dogs	Rock et al., 2016
	Nature-Based Social Prescribing in Urban Settings to Improve Social Connectedness and Mental Well-being: A Review	Leavell, 2019
	What is Park Rx America?	Park Rx America, 2020
Barriers to Access	Perceptions of Nature and Access to Green Space in Four Urban Neighborhoods	Sefcik et al., 2019
Nature Relatedness & Pro-Environmentalism	Experiences in Nature and Environmental Attitudes and Behaviors: Setting the Ground for Future Research	Rosa & Collado, 2019
	The Influence of Spending Time Outside on Experience of Nature and Environmental Attitudes	Colléony, White, & Shwartz, 2019
Experiential & Embodied Learning	Affordances of Mobile Technologies for Experiential learning: The Interplay of Technology and Pedagogical Practices	Lai et al., 2007
	Experiencing the Outdoors: Embodied Encounters in the Outward Bound Trust	Dunne, 2018
Immersive Learning Technologies	The Immersive Power of Augmented Reality	Kiryakova, 2020
	Special Issue: Augmented and Virtual Reality in Education: Immersive Learning Research	Beck, 2019
	User Experience of Mobile Augmented Reality: A Review of Studies	Irshad & Rambli, 2014

Table 2.3.0 ▲
References organized by topic.

2.4. DEFINITION OF TERMS

To help further the understanding and clarification of the various topics and ideas presented in this document, a list of commonly used terms and their corresponding definitions have been included (see Table 2.4.0).

Table 2.4.0 ▸
Definition of terms.

Adolescents	Individuals transitioning from formative years to adulthood that fall between the ages of 15–19.
Annotation	A note or comment that is added to a text or image that helps highlight key words, records reactions to certain concepts, or draws meaning and connection between ideas.
Attention Restoration Theory (ART)	The idea that people are better able to concentrate after looking at or spending time with nature.
Augmented Reality (AR)	An interactive experience where the real world environment is overlaid with digital content.
Embodied	To give tangible or visible form to an idea, quality, or feeling.
Explicit Learning	Learning that requires focused mental attention where learners are aware that they have learned something and can verbalize what they have learned (Ellis et al., 2009).
Focused Attention	Also called central attention, where attention is oriented towards particular visual, auditory, or tactile stimuli.
Implicit Learning	Where the learner obtains tacit knowledge that does not place any demands on central attention resources. The learning here is intuitive and unconscious (Ellis et al., 2009).
In-Situ	The literal translation is on site or in place. In the context of AR, *in-situ* is where information is registered to the 3D position of the object.
In-View	Information is represented in a two-dimensional rendering on the screen of the user's display.
Integration	The act of combining elements into a whole.
Nature	Encompasses the plants, animals, and landscapes that make up the planet.
Nature/Outdoor Experiences	A period of time spent directly or indirectly interacting with and/or within nature.

Nature Prescriptions	Written instructions provided by a doctor that encourage a patient to seek time outdoors in nature as a treatment method for various health conditions.
Nature Therapy	A range of techniques or treatments used within nature to help improve an individual's mental or physical health.
Parks	Manicured or semi-natural green spaces inside towns and cities reserved for human recreation and enjoyment and for wildlife and habitat preservation.
Realism	The level of realistic qualities an experience has that is consistent with those in the real world.
Sustained attention	The ability to hold one's attention for a continuous period of time.
Presence	The feeling of being situated in a place.
Healthier Habits/ Lifestyles	Building a culture of engagement around nature, increasing activity outdoors, and immersing oneself in nature for at least 120 minutes a week.
Immersive	The perception of physical presence.
Quality Nature Experiences	According to the article Attention Restoration Therapy and Stress by CAREpath, there are four characteristics a natural space needs to be effective. These are: being away, soft fascination, extension, and compatibility (2019).
Responsive Interactions	The response of an augmented environment to a user's direct interaction.
Social Engagement	Social involvement or social participation within a community of users.
Urban Areas	Highly developed and densely populated regions where people live and work. They are often characterized as built environments.
Urban Populations/ Residents	People living in cities or inhabiting areas that have a greater population density than rural areas and are overall more compact than rural areas.
Visual Metaphor	A visual representation of a person, place, thing, or idea that points to particular similarities between them. A visual metaphor uses an image rather than words to make the comparison.

2.5. ASSUMPTIONS AND LIMITATIONS

Assumptions. For this investigation, I assume that the subjects of my study are urban residing adolescents who have been prescribed nature as a treatment to improve their mental health and are mentally well enough to partake in activities outside of their home. In addition, I assume that these individuals have worked with their doctor to select an appropriate park location that offers facilities and services that will keep them safe during their nature experience. Finally, I assume that these individuals are able to participate in the park-situated nature-learning experience without the direct accompaniment of a caregiver(s) and have access to wifi and/or data and a mobile device that supports AR technology.

Limitations. I recognize that there are many external factors related to race and socioeconomic status that impact an individual's relationship with nature which need to be addressed before design can truly shift one's behavior with nature. However, my design intervention will address only universal factors, such as fear of the unknown and lack of awareness or knowledge of a place, that limit a person's relatedness to nature within the park setting. Immersive learning technology has the most promise for teaching someone how to interact and build connections within the nature experience and is the basis of my investigation. This investigation is only addressing adolescents ages 15 to 19. In general this age group has garnered independence from their legal guardians, but they still need a system of support necessary for a nature prescription to be successful. Due to scope and time, I will not be exploring directions that involve interactions between doctors, legal guardians, and organizations although they all play a unique role in the nature prescription process. Finally, the investigation will rely on current mobile technology as it is the most affordable and readily available technology that supports AR and offers a sufficiently sized visual display.

2.6. PRECEDENTS

As a part of my design investigation, I sought out examples of nature immersive applications that incorporate features leveraging connection to place and AR technology and highlighted some key takeaways below (see Table 2.6.0 and Figures 2.6.0–2.6.11).

Table 2.6.0 ▸
Key takeaways from nature immersive applications that act as stepping-stones for further exploration.

KEY TAKEAWAYS
+ The combination of play and AR fosters a relationship between people and place and improves the user's feeling of enjoyment in that place (Oleksy & Wnuk, 2017).
+ Identification applications help pique students' interest in nature (Unger, Rollins, Tietz, & Dumais, 2020).
+ Building a connection to the land can be facilitated through the integration of personal narrative, video, spatial awareness, and before-and-after overlays.

+ AR, animated and interactive 3D models, and graphics can help people understand aspects of nature that might have gone unnoticed in daily living.

+ Levels of engagement can encourage people to dive deeper into areas that interest them.

+ GPS and AR can be used in combination to create a more immersive and less distracting navigational experience.

+ Informative peripheral AR experiences can help users feel more connected to a place.

+ Distracting buttons and superfluous interactions can take users out of a nature experience.

+ Geo-triggering allows for site-specific activity.

+ AR combined with physical activity allows more retention of information about a place.

+ AR can provide a more intimate and immersive experience with physical objects in the environment.

+ AR combined with heart rate technology can allow users to manipulate their environment in real-time.

+ Slow design principles (e.g. reveal, expand, reflect, engage, participate, and evolve) and unobtrusive considerations are secondary in AR mobile application experiences.

Pokémon Go (Figure 2.6.0) is a single-player mobile AR gaming experience that encourages users to engage with and play in their physical environments. Virtual Pokémon characters are displayed on a user's smartphone overlaying the user's direct environment. By pointing the smartphone camera at the Pokémon characters, users can experience the act of "catching" the Pokémon. This combination of play and AR fosters a relationship between people and places and improves the user's feeling of enjoyment in that place (Oleksy & Wnuk, 2017).

iNaturalist (Figure 2.6.1) is a science education based application that "aid[s] in identifying a variety of organisms while concomitantly piquing students' interest in nature" (Unger, Rollins, Tietz, & Dumais, 2020, p. 9). Features within this app allow users to view observations of others and navigate suggestions based on image recognition technology, community crowdsourcing, and a GPS database.

Integration
The act of combining elements into a whole.

Appalachian Voices' Google Earth and Google Maps Platform (Figure 2.6.2) seeks to inform the public about the local impacts of mountaintop removal in Appalachia. The tool provides users with the ability to experience the destruction first-hand and build a connection to the land through the integration of personal narratives, video, spatial awareness, and before-and-after overlays.

Agents of Discovery (Figure 2.6.3) is an application that implements AR, animated and interactive 3D models, and graphics to help users discover new insights into the forest ecosystem. This application provides various levels of engagement and allows the user to dive deeper into their learning experience and notice nature at a smaller scale.

Wikitude Drive (Figure 2.6.4) is a navigation system that superimposes driving directions on top of live footage of the surrounding area. GPS and AR combine to create a more immersive and less distracting experience for drivers.

GeoCam (Figure 2.6.5) is an application that implements AR as a peripheral experience to one's mobile video and photo capturing device. This AR experience allows users to connect more intimately to space by overlaying information about the surrounding environment, including the distances from objects and names of outdoor features.

Leaf++ (Figure 2.6.6) is an application that gives users the ability to gather information about the natural environment around them. The interface provides a seamless experience between the view of nature on the user's phone and the information provided. Distracting buttons and additional interactions are removed while a "point and shoot" functionality is adopted.

ARaction Forest Trail (Figure 2.6.7) gamifies the nature experience for children by incorporating AR and geo-triggered activities. The activities promote physical engagement and learning while the AR ties these activities to the area of exploration.

Astoria Park Augmented Reality Tree Ecology (Figure 2.6.8) combines AR and QR technology to promote learning in a local park. AR helps users retain information about the local ecology up to 90% while promoting physical interaction in the space.

Graveyards as a Design Concept for Unobtrusive Interaction (Figure 2.6.9) is an AR application that helps families connect more intimately with gravesites. This is an unobtrusive and discrete technology that provides users with local history and genealogy associated with the gravesite they are visiting.

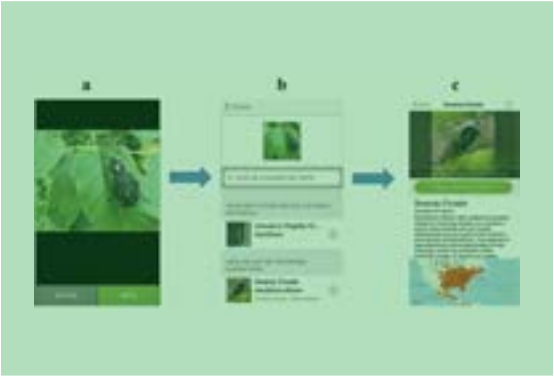
Helium (Figure 2.6.10) offers an AR experience combined with heart rate monitoring technology to give users the power to combat stress and anxiety in their immediate environment. This application allows for a different level of engagement in the physical world by modifying the user's experience in response to their biometric data.

Crunchfish Augmented Reality (Figure 2.6.11) is an immersive AR smartphone experience that gives the user the freedom to control overlaid objects without touching the screen. Interactions focused on gesture in place of touch, offer the user a more immersive experience, and allow for a wider visual field dedicated to the AR experience.

Figure 2.6.0 ▾

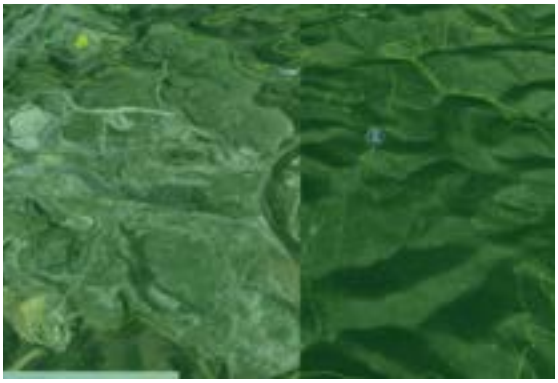
A photo of a user interacting with Pokémon Go in a park setting.

Figure 2.6.1 ▾



Screen grabs from the iNaturalist species identification application showcasing the identification process of an insect.

Figure 2.6.2 ▾



Desktop image of Google Earth's interactive satellite imagery combined with Appalachian Voices mining awareness project.

Figure 2.6.3 ▾

A screenshot showcasing several screen views within the Agent of Discovery application.

Figure 2.6.4 ▾

A photo of the mobile navigation tool from Wikitude Drive mounted on a driver's dashboard.

Figure 2.6.5 ▾

A Screenshot of GeoCam in action.

Figure 2.6.6 ▾

A photo of Leaf++ in a nature environment.

Figure 2.6.7 ▾

A photo of ARaction's Forest Trail educational app.

Figure 2.6.8 ▾

A photo of Astoria Park's mobile augmented reality experience app.

Figure 2.6.9 ▾

A conceptual mockup from the University of Lapland that experiments with augmented reality in a graveyard context.

Figure 2.6.10 ▾

A mobile screenshot from Helium's augmented butterfly experience within their stress monitoring application.

Figure 2.6.11 ▾

A screenshot of a video demonstrating Crunchfish's Mobile AR gesture interaction experience.

03. INVESTIGATION PLAN

3.1. CONCEPTUAL FRAMEWORK

Realism
The level of realistic qualities an experience has that is consistent with those in the real world.

Presence
The feeling of being situated in a place.

The conceptual framework sets the stage for thinking about how immersive technology-facilitated learning experiences in nature can motivate learners towards healthier habits or lifestyles. This investigation utilizes the following theories and models (see Figure 3.1.0): (a) Experiential Learning Theory or Kolb's Learning Cycle (1984), (b) Deci and Ryan's (2000) Self-Determination Theory (SDT), and (c) Hung's (2017) Immersive Learning—Presence, Realism, Autonomy, Subject (PRAS) Model.

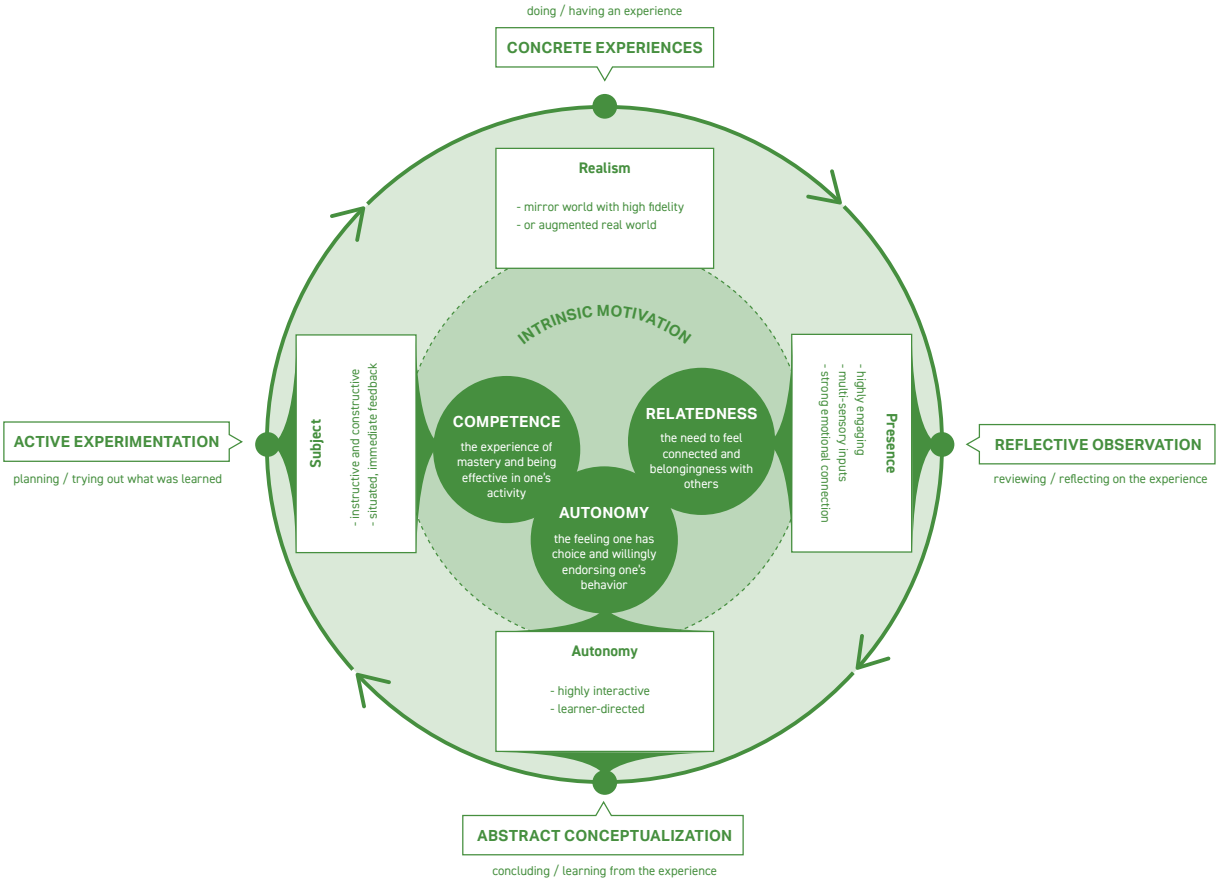


Figure 3.1.0 ▲
A conceptual framework synthesizing Kolb, Deci, Ryan, and Hung's frameworks. The Kolb's Learning Cycle encompasses the framework. The Presence, Realism, Autonomy, Subject Model then highlights the dimensions of an immersive learning environment, as a means for achieving the three Self-Determination Theory principles necessary for reaching an intrinsically motivated state in an outdoor environment.

Experiential Learning Theory (Kolb's Learning Cycle). The experiential learning theory is the idea that learning should occur in a real world context where the learner is an active participant. When learners are able to reflect on an experience and assimilate those new experiences into their previously held beliefs, learning can occur (Kolb, 1984, as cited in Jose, Patrick, & Moseley, 2017). Kolb (1984) breaks down learning into a cycle and identifies the following areas of engagement (outlined in Figure 3.1.1 and defined in Table 3.1.0): concrete experiences, reflective observation, abstract conceptualization, and active experimentation (Jose, Patrick, & Moseley, 2017). Understanding how outdoor, nature-based learning experiences support habit formation is important for delivering positive outdoor experiences that build connections between the learner and nature (Sandoval, 2005, as cited in Jose, Patrick, & Moseley, 2017). Through this lens and as a reference for comparison, I've described how current outdoor experience based applications hold up alongside the four areas of the Kolb's Learning Cycle (findings recorded in Table 3.1.1 on p. 23).

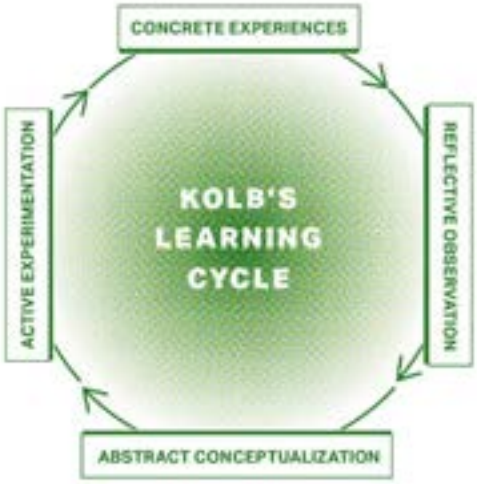


Figure 3.1.1 Components of Kolb's Experiential Learning Cycle (1984).

Table 3.1.0 Components of Kolb's Experiential Learning Cycle defined (1984).

CONCRETE EXPERIENCES	Concrete experiences are new experiences or situations where the learner is presented with abstract concepts or ideas. For example, a learner new to an outdoor environment might be given the names of plant species they come in contact with that they have never heard of before.
REFLECTIVE OBSERVATION	Reflective observation is the phase in the cycle where the learner reflects on the new experience. For example, a learner might review the names and photos of the new plant species they came in contact with.
ABSTRACT CONCEPTUALIZATION	Abstract conceptualization is a comparison activity where the learner is asked to think about the concept and relate it to past understanding about the concept. For example, a learner might think about the new plant species in other outdoor environments they have been to before.
ACTIVE EXPERIMENTATION	Active experimentation is when the learner takes time to investigate the concept and then uses the findings to make decisions. For example, a learner might memorize the plant species names and then quiz themselves by attempting to identify the plants in another outdoor environment.

	CONCRETE EXPERIENCES	REFLECTIVE OBSERVATION	ACTIVE CONCEPTUALIZATION	ACTIVE EXPERIMENTATION
Pokémon Go	+ Explore new places to catch different Pokémon characters. + Discover characters based on the weather. + Take and save photos of Pokémon.	+ Play in the comfort of your home. + Share and view photos within a community of players.	+ Learn location specific information over time through storytelling and game play. + Send gifts and personalized stickers to friends.	+ Battle with friends from anywhere. + Level up in the game by applying new skills.
iNaturalist	+ Record observations in the moment.		+ Keep track of observations and compare those findings with new findings. + Share and discuss findings with other naturalists.	+ Build knowledge by talking with other naturalists and helping others identify species. + Create events and work with others to find as many species as possible.
Appalachian Voices		+ Access to before and after overlays for hundreds of mountains destroyed by mountaintop removal.		+ Enter zip code to see direct or indirect connections with mountaintop removal.
Agents of Discovery	+ Explore the community to win prizes. + Audio search sounds to discover new species. + Opportunity for place based learning.	+ Continue play at home or in the backyard. + Answer pre-challenge and post-challenge questions.		+ Continue to level-up in the game by completing more challenges. + Test new knowledge during gameplay.

Table 3.1.1 ▲
Examining select precedents against the four components of Kolb's Experiential Learning Cycle (1984).

Quality Nature Experiences
According to the article *Attention Restoration Therapy and Stress by CAREpath*, there are four characteristics a natural space needs to be effective. These are: being away, soft fascination, extension, and compatibility (2019).

Self-Determination Theory (SDT). SDT is a human motivation theory that looks at how we derive intrinsic motivation. According to Edward L. Deci and Richard Ryan, to achieve this state, "three universal psychological needs must be met: the principles of autonomy, perceived competence, and relatedness to others" (see Figure 3.1.2 and Table 3.1.2) (Leavell et al., 2019, p. 301). Since, people are more likely to participate in behaviors, such as healthy behavior that supports life satisfaction, I have included these three principles as requirements for creating a quality nature experience (Deci & Ryan, 2000).

◂ **Figure 3.1.2**
Components of the SDT principles (Deci & Ryan, 2000, pp. 233–235).

Table 3.1.2 ▾
SDT principles defined (Deci & Ryan, 2000, pp. 233–235).

AUTONOMY	Autonomy is the power to make choices or decisions around engagement in activities that follow one's inner interests and is important for encouraging natural and spontaneous engagement.
COMPETENCE	Competence is one's perceived mastery of skills or effectiveness in doing a particular activity. Positive feedback is helpful in promoting this sense of competency.
RELATEDNESS	Relatedness refers to how connected one feels to others. A sense of relatedness is necessary for feeling comfortable in an environment.

Immersion Learning—PRAS Model. The model was developed by Alex Hung from the Australian Immersive Education Academy as a way to identify the four key components–autonomy, presence, realism, and learning subject—that are needed to create an immersive learning environment from a learner and learning environment perspective (2017). According to the authors, an immersive learning environment is defined as an interactive learning environment, either physically or virtually, where individuals are able to replicate possible scenarios or teach particular skills or techniques. Autonomy and presence focus on how the learner interacts with and experiences a learning

environment, while realism and learning subject are two necessary dimensions to consider for creating the learning environment (see Figure 3.1.3 and Table 3.1.3). I have incorporated these four components into the final conceptual framework as a means of achieving the three universal psychological needs within the nature experience.

◂ **Figure 3.1.3**
Components of the Immersion Learning—PRAS Model (Hung, 2017).

Table 3.1.3 ▾
Immersion Learning—PRAS Model components defined (Hung, 2017).

AUTONOMY	Autonomy is the ability for the learner to make decisions and have control over their experience in a space that is in line with their interests and goals.
PRESENCE	Presence is a subjective feeling of the learner. The more presence someone feels in a space the more immersed they will be in that learning environment or context (Johnson-Glenberg, 2018). Presence can be achieved through: + highly engaging and meaningful interactions with an environment, + multi-sensory inputs: haptic, visual, and audio, and + strong personal and emotional connections with the learning subject.
REALISM	Realism is referencing the levels (low-, mid-, real world-level) of visual or sensory detail and interactions that are consistent with experiences in the real world.
LEARNING SUBJECT	Learning subject is the area that is being studied by the learner. Situated, immediate feedback that is constructive and instructive is necessary for a learner to achieve complete mastery of the subject matter.

3.2. RESEARCH QUESTIONS

The goal of the investigation is framed by a central research question, while four subquestions add additional guidance as to how the problem might be specifically addressed through design.

Table 3.2.0 ▾
Main research question and four subquestions.

MAIN RESEARCH QUESTION		How can an AR mobile-based information delivery system combined with social engagement strategies support park-situated nature-therapy experiences that foster healthier lifestyles for urban residing adolescents?
SUBQUESTIONS	**01**	***Direct attention and strengthen connections.*** How can an attention-directing AR *in-situ* and in-view overlay information delivery system during a first time encounter with nature draw focused and sustained attention to landscape features to strengthen connections and awareness of nature?
	02	***Increase feelings of comfort and belonging.*** How can an immersive AR *in-situ* and in-view information delivery system following a nature experience create reflective moments outside of place to increase feelings of comfort and belonging?
	03	***Encourage autonomous engagement.*** How can an interactive AR *in-situ* and in-view information delivery system following the nature experience create contemplative moments outside of place to encourage autonomous engagement?
	04	***Increase perception of mastery.*** How can a responsive AR *in-situ* and in-view overlay information delivery system during the nature experience facilitate embodied and instructive encounters to increase perceptions of mastery?

3.3. INVESTIGATION MODEL

The four subquestions adhere to the stages of the Kolb's Learning Cycle as mapped in Figure 3.3.0. Each stage within this investigation is examined at different intervals during the adolescent's journey towards adherence to a healthier lifestyle. Specifically, levels of familiarity and motivation are defined in accordance with the adolescent's assumed state at that point of time. Throughout all these studies, various motivation tactics using AR and social engagement will be explored. Figure 3.3.1 provides context for where the user in this study is in terms of their receptivity to learning about nature and the skills necessary to realize its benefits.

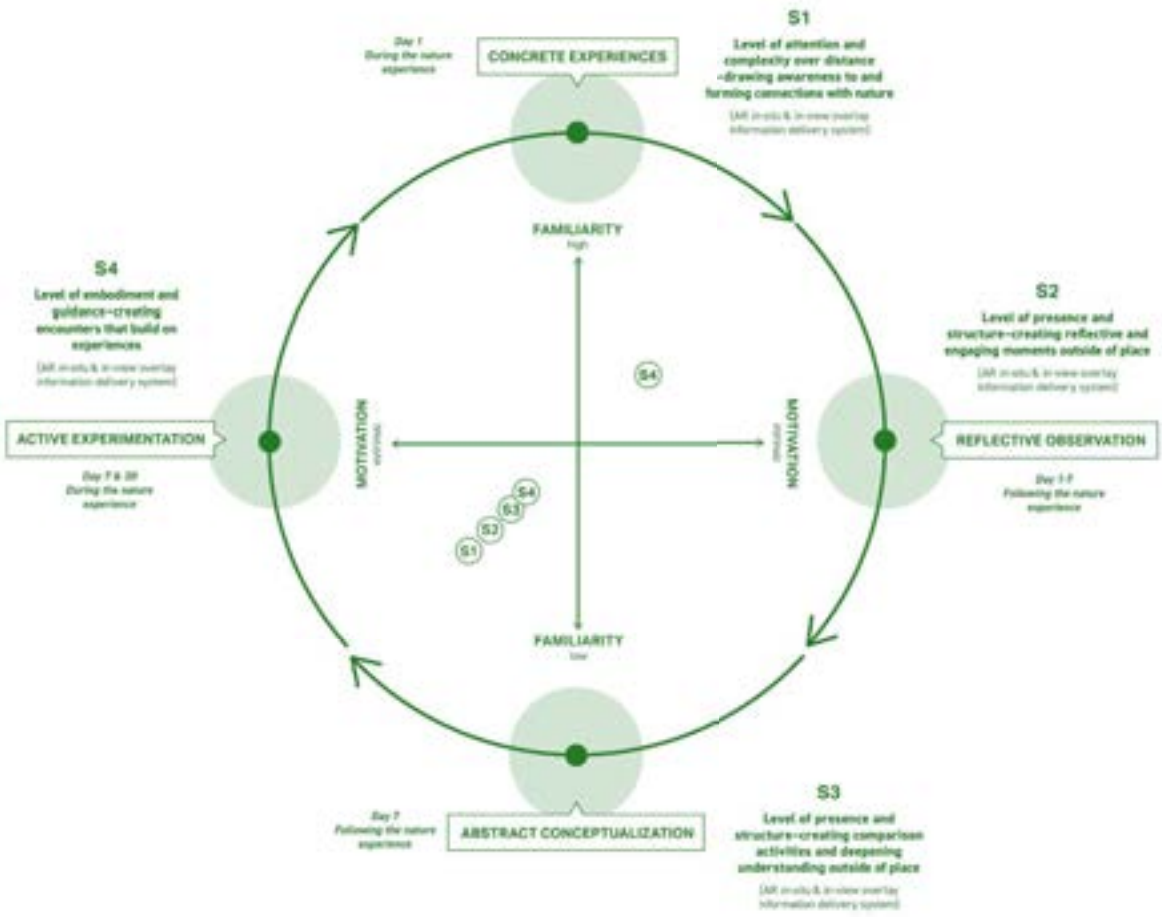


Figure 3.3.0 ▲
Investigation model adapted from the conceptual framework (Figure 3.1.0).

Figure 3.3.1 ►
David Rose's Idea Receptivity Gradient.

3.4. SCENARIO

I facilitated several informal interviews with experts in the field of Park Rx and outdoor programing for children and adults. These interviews helped inform the persona and scenario referenced throughout this investigation. The persona and scenario set the stage for understanding how design can best serve the patient, 17-year-old Ann, at the center of this investigation (see Figure 3.4.0 and Figure 3.4.1 on p. 29).

Persona. Ann is a 17-year-old high school junior. She has lived in the city of Raleigh, North Carolina for most of her life and she and her family do not normally associate themselves with nature or make decisions around protecting and conserving nature. The need for quality and direct experiences in nature is foreign to her. A typical day for Ann is spent traveling back and forth from school via the public transit system, trying to meet the high academic standards set by her parents, staying connected with her friends, and balancing her time between extracurricular activities like piano lessons and band practice.

Ann's achiever type personality and a history of anxiety and depression is exacerbated by her isolated and sedentary lifestyle. She does well in school but spends most of her free time either studying or interacting with friends online, which often leaves her feeling overwhelmed and mentally fatigued. Ann's ability to make commitments to a healthier lifestyle is challenging due to the social and relationship dynamics with friends and family. Ann has a desire to address her anxiety and depression by establishing healthier behaviors; she just wishes she had more guidance and time to do it.

Figure 3.4.0 ▾
This persona overview defines the user's behaviors, experiences, needs, and goals prior to using the nAtuRe app. Information outlined below is based on supporting research from informal interviews and literature reviews.

NAME Ann

AGE 17

GRADE 11th

LOCATION City of Raleigh, NC

BEHAVIOR

Ann has an achiever type personality and a history of anxiety and depression, exacerbated by her isolated and sedentary lifestyle. She does well in school but spends most of her free time either studying or interacting with friends online, which often leaves her feeling overwhelmed and mentally fatigued.

CHALLENGES

+ Unsure where to start an interaction with nature in a park environment
+ Distracted easily by her phone and prefers to engage with technology over nature
+ Slow to make any behavioral changes
+ Unaware of how nature can benefit her health
+ Stress contributes to attention fatigue

NEEDS & GOALS

+ Establish a heathier lifestyle outdoors
+ Reduce anxiety around school & social media
+ Fill the prescription the family practitioner has prescribed her
+ Learn and master the nature therapy skills that contribute to overall well-being

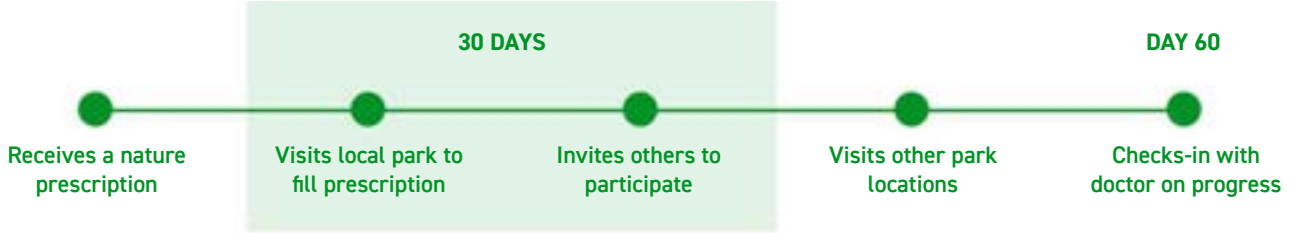


Figure 3.4.1 ▲
Ann's scenario overview. The green highlighted area is where the studies will take place.

Scenario. As a strategy to alleviate Ann's anxiety and stress around school, Ann's family practitioner has prescribed a holistic approach. In addition to medication for depression, Ann's doctor writes Ann a nature-based prescription with the goal that Ann achieves *at least* 20 minutes of nature exposure each day for the next 60 days. Ann's doctor believes that a medication and nature-based approach to her psychological health will give Ann the tools to combat her chronic depression and anxiety.

In response to her doctor's plan, Ann mentions her apprehension about going outdoors since she has not spent much time in nature before. She also expresses concern about where and how she will find a place that meets the criteria of the prescription. Ann's doctor reassures Ann that this therapy tactic is within her ability and asks Ann to download the nAtuRe app, knowing that this tool will address most of her initial concerns. Together, Ann works with her doctor to set up the app and locate an approved park within walking distance from her home in downtown Raleigh. She is familiar with the park but has never noticed the natural aspects nor thought much about how nature could contribute to her overall well-being. Ann is not sure how helpful her doctor's recommendation to spend time outdoors is, but since she has previously been to the park, has felt safe there in the past, and has some guidance from this new app, she is willing to try.

After leaving the doctor's office, Ann expresses some concern to her parents about adjusting to the daily goal outlined in the prescription now visible on her phone. Ann is hoping the nAtuRe app will help make her experience in nature a bit easier to navigate and lessen her fears about going outside and experiencing dark places, spiders, and dirt.

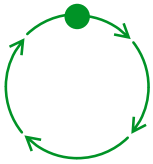
On the first day of actively filling her prescription, Ann turns on the app and immediately shares it with her contacts and creates a secure profile that is public to a community of nAtuRe app users. Ann hopes that her friends will join in and help her be accountable to her new routine. Ann then scrolls through the app and arrives at a feature that allows her to select the type of nature experience she would like to have. Ann selects the attention restoration experience. Upon starting the app guided experience, Ann is prompted by the AR overlay navigation system to select a path to explore. Once Ann selects a path, she is presented with additional visual, auditory, and haptic directional and prompting cues that help bring her awareness to the natural features in the area. Throughout Ann's experience, the app suggests areas for further exploration and observation. As Ann approaches areas of interest additional features and tools are activated via geo-triggering to help bring additional awareness to the surrounding environment.

As Ann becomes more comfortable interacting with nature and exploring her local park, she seeks out other park locations that offer more wilderness-like settings. Eventually, Ann is only using the app to share her nature discoveries with her friends or to get suggestions on new areas to explore. Her anxiety has lessened and her appreciation for the outdoors has improved immensely. She is excited to introduce her friends and family to her daily discoveries and now feels more confident in her ability to tackle school and extracurricular activities.

04. STUDIES

4.1. STRENGTHENING CONNECTIONS AND INCREASING AWARENESS IN THE CONCRETE EXPERIENCES PHASE DURING THE NATURE EXPERIENCE

SQ 01



CONCRETE EXPERIENCES PHASE

How can an attention-directing AR *in-situ* and in-view overlay information delivery system during a first time encounter with nature draw focused and sustained attention to landscape features to strengthen connections and awareness of nature?

Figure 4.1.0 ▲
Study 1 takes place on day one of the 60 day prescription during the concrete experience phase.

In-Situ
The literal translation is on site or in place. In the context of AR, *in-situ* is where information is registered to the 3D position of the object.

In-View
Information is represented in a two-dimensional rendering on the screen of the user's display.

As novice nature therapy patients begin their journey towards a healthier lifestyle, they will need additional guidance to help strengthen their connections with and awareness of nature. These are connections with features that make up a landscape such as mountains, hills, plains, plateaus, lakes, streams, soils, and vegetation. This study will look at different attention-directing tactics within an AR *in-situ* and in-view overlay information delivery system that can be used to assist patient participation in nature attention restoration practices that align with teachings by the Association of Nature and Forest Therapy Guides and Programs (see Table 4.1.0). To further narrow the focus of this study, each of these explorations borrows findings from research on best practices to hold the attention of students interested in plant life and the most common techniques for focusing or directing attention using AR technology.

FOREST THERAPY PRINCIPLES

+ Relax, be mindful, and enjoy a sensory nature-based experience.
+ Simply be in nature.
+ Connect using one's senses of sight, hearing, taste, smell, and touch.
+ Slow down. Stop, stand, or sit.

Table 4.1.0 ▲
Forest Therapy principles defined (Association of Nature and Forest Therapy Guides and Programs).

According to Nyberg and Sanders (2014), it is through personal encounters, observations, and guided explorations that students' attention can be directed towards plants and plant science. In addition, these venues offer specific strategies for creating the emotional and aesthetic experiences necessary to build connections between humans and plants (see Table 4.1.1). Likewise, studies done in the last five years demonstrate the most effective approaches for using AR guiding technology in complex environments where the target of focus is positioned off-screen (see Table 4.1.2–4.1.4 on pp. 32–33). By improving the guided visual experience for users, visual search errors and cognitive load needed to locate the target of interest can be reduced (Renner & Pfeiffer, 2017). This point is especially salient when combined with the idea of attention restoration theory. In order to use AR technology for nature therapy, solutions will need to be examined that not only support nature engagement, but also combat direct attention fatigue. Together, these resources have informed the investigation matrix used to guide this study (see Figure 4.1.1 on p. 34).

Focused Attention
Also called central attention, where attention is oriented towards particular visual, auditory, or tactile stimuli.

Sustained Attention
The ability to hold one's attention for a continuous period of time.

Specifically, my interest is exploring how certain attention guiding techniques might translate over distance—the distance between the patient and the "target" plant(s) of interest—while balancing attention between the real world and the mobile device. As cited in attention studies conducted by Tamber-Rosenau & Marois (2016), there are two broad categories that describe the cognitive process of attention (Badre, 2008). The first being vigilance/arousal and the second being selective attention. I focus on the latter. Selective attention encompasses two extremes: central and peripheral selective attention (Broadbent, 1958, as cited in Tamber-Rosenau & Marois, 2016). Central attention is cognitively more demanding as it is involved in selective information processing where information is interpreted through the senses and tasks are executed. Peripheral selective attention, however, engages with the external world and representations closely associated with the external world. Unlike central attention, peripheral selective attention does not directly rely on cognitive processes and is indirectly controlled by central attention.

With the overarching goal of strengthening connection and increasing awareness, this study will look at how the design of the *in-situ* and in-view overlay information system interface might subtly shift or oscillate between a patient's central attention and peripheral selective attention at different stages of their nature experience to support a more restored cognitive state. To help organize this study, the patient's attention guided exercises and activities are broken down into six key moments in relation to distance from a target of interest (see Figure 4.1.2 on p 34). Meaning from the moment they enter the park to the moment they reach their target. In this study I identify and map out the points in the user journey that have the most potential for AR intervention and support. Additionally, I look for points to leverage social engagement features as a motivational tactic to encourage novice participation.

Table 4.1.1 ▾
Ways to enhance student's attention towards plants (Nyberg & Sanders, 2014).

CREATE POSITIVE ASSOCIATIONS	Create positive associations with plants within a particular location and counteract negative perceptions of undervalued locations like wetlands and swamps. Pointing out marquee plants—a recognizable and popular plant species—in an area is particularly effective in creating new and positive associations with the space.

HIGHLIGHT INTERESTING RELATIONSHIPS	Bring awareness to relationships between plants, animals and fruit production. Highlight the role of plants in the ecosystem.
ATTEND TO 'PLANTNESS'	Display the rich array of plant behaviors within a species, across communities, and in association with other taxa. Show the living or 'moving' aspects of plants.
OBSERVE CLOSELY	Encourage personal encounters with plants by guiding attention to plants in the area.
AMPLIFY PLANT CHARACTERISTICS	Smell, adaptive features, color and pattern, scale, and floristic features are five key characteristics that draw a learner's attention.

Table 4.1.2 ▾
Approaches for peripheral attention guiding mechanisms using AR technology for "off-screen gaze" conditions (Renner & Pfeiffer, 2017).

2D ARROWS	Direct the user towards a target by prompting the user with arrows. Commonly used in pedestrian navigation to help guide an individual to a particular point of interest.
ATTENTION FUNNEL	The attention funnel is an animated visual guiding system, in which a flexible tunnel of frames is drawn from the current head position and orientation to the intended position and orientation when facing the target.
3D HIGHLIGHT	3D highlights help disambiguate between objects at different depths and unlike arrows can be used to direct attention subtly by presenting it as a nearly transparent overlay.
HALO TECHNIQUE	The halo technique is used to guide attention to targets located outside a 2D screen. It surrounds off-screen targets with rings of a radius that reach into the border region of the screen. This way, not only is the location indicated, but also the distance can be approximated based on the size of the visible arc.

Table 4.1.3 ▾
An attention guiding strategy for AR in complex environments (Renner & Pfeiffer, 2018).

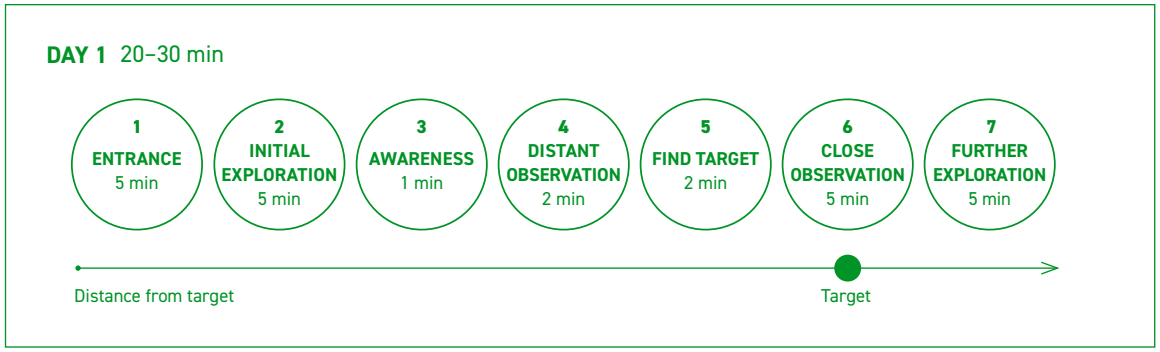
3D PATH TO TARGET	A simple 3D path that guides the user towards a target.

Table 4.1.4 ▾
A visualization technique that supports the comprehension of spatial relationships between virtual and real-world objects for AR applications (Kalkofen et al., 2009).

FOCUS & CONTEXT	The act of rendering objects in visually distinctive styles to draw the user's attention to the focus. Techniques employed to catch the observer's attention include: 3D scenes that rely on opacity modification, use of color, depth of field, or hybrid rendering.

Figure 4.1.1 ▲
Study 1 investigation matrix with explorations (A–N). Cells shaded in green are areas where social engagement features were explored.

Figure 4.1.2 ▼
A broad view of the nature experience journey map on day one broken down into seven stages based on one's distance from the target of interest.



SEVEN STAGES OF THE NATURE EXPERIENCE

Entrance. Ann sets out to fill her nature prescription at a local park. As she enters the perimeter of the park, a notification appears on her mobile device asking her if she'd like to start her nature experience. She selects 'yes' and adjusts her settings to permit the attention-directing and guiding overlay system to become visible on her screen (seen in Figure 4.1.4 on p. 38).

Initial Exploration. At this stage in the process, Ann is looking for support from her social network of family and friends. In this section of mini studies, I've focused on the form different AR guiding strategies and social sharing features could take and which combinations would be effective in encouraging a novice user to begin exploration in a new nature setting with a minimum of cognitive interference (explorations A1–5 seen in Figure 4.1.5 on p. 39).

Awareness. To spark Ann's attention towards interesting areas of exploration the system uses video, audio, and haptic cues to guide her to areas of interest. Explorations occur during the transition from stage 2 to stage 4 of the nature experience (Figure 4.1.6 on p. 40).

Distant Observation. During this stage we see Ann noticing points of interest that are in the distance. These explorations use various attention grabbing techniques that help bring objects at various distances closer to view so that Ann can begin to make navigational decisions (Figure 4.1.7 on p. 41).

Find Target. As Ann approaches the targets of interest, characteristics of the plants become amplified. Various overlay techniques help her maintain focus on the natural world and peak her interest (Figure 4.1.8 on p. 42).

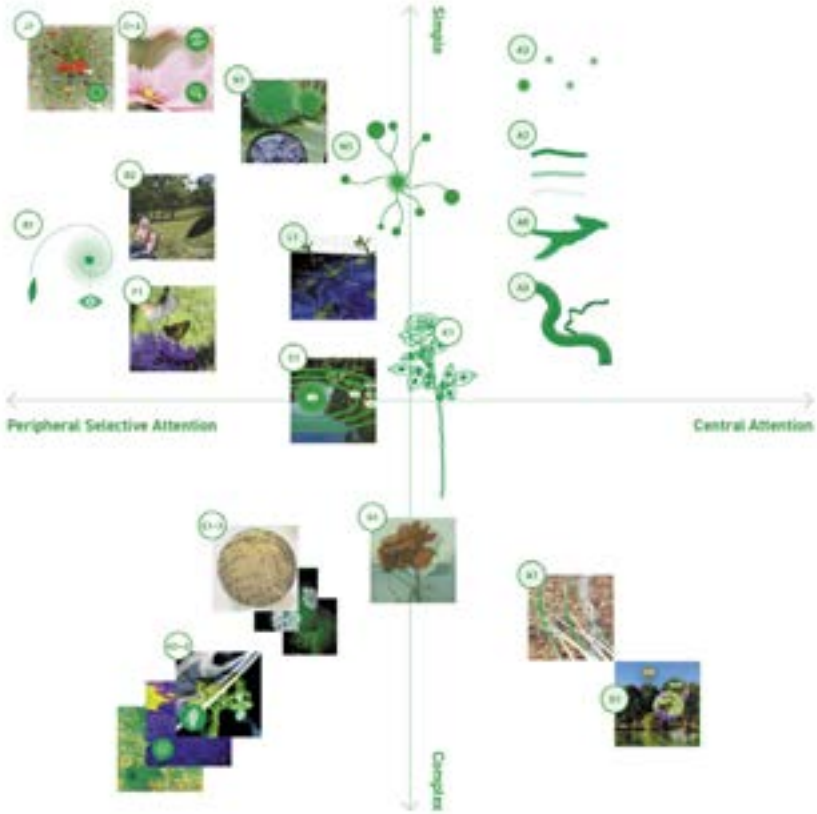
Close Observation. Ann has now reached the target and close observational features appear *in-situ* and in-view on her phone. She is encouraged to engage more directly with the plant as she shuffles through the different filters. Each filter provides Ann with a different perspective and reveals hidden elements of the plant and it's life (Figure 4.1.9 on p. 43).

Further Exploration. After thoroughly exploring the features on her phone, Ann is able to save or pin her favorite plants and see other plants of interest in the area tagged by her contacts. This feature not only shows Ann where she might like to explore next but also the relationship between the target plant and the surrounding vegetation (Figure 4.1.10 on p. 44).

ASSESSMENT

To gauge the success of my explorations in meeting the attention restoration goals of a novice user at different stages in their journey, I have mapped and organized each exploration onto a coordinate plane whose axes are defined as follows: "peripheral selective attention" to "central attention" (left to right) and "simple" to "complex" (top to bottom) (see Figure 4.1.3). "Simple" in this case can be defined as a system with few interface interactions and visual styling, while "complex" refers to a more multi-sensory and task oriented interaction combined with detailed visual cueing or styling. As the user moves towards the target of interest, knowing what combination of these design considerations will help the user best will be reflected upon further in the observation section.

Figure 4.1.3 ►
Study 1 exploration assessment coordinate plane.



OBSERVATIONS

Overall, I drew several conclusions about how an AR delivery system might utilize different attention drawing tactics to strengthen one's connection with nature during the nature experience (see Figures 4.1.4 and 4.1.10 on pp. 36–42). By visually emulating various natural forms within the AR overlay information delivery system (e.g., B1 and H1) I was able to seamlessly integrate the interface with the physical environment. The thought is that the more "natural" and simple the overlay, the less effort will be required to direct one's attention toward or away from the device/interface. Supporting these transitions from the screen to the environment is key to the success of any kind of nature attention restoration therapy.

Similarly, by visually mimicking familiar movement, sounds, or forms found in nature (e.g., shapes, textures, colors) the AR system helps reinforce one's recognition of and connection with natural elements in their physical environment. Thus, stronger relationships or connections between the interface, individual, and the physical world begin to form. This relationship is especially important as humans are more likely to protect the thing, we are familiar with. The ideal scenario would be that as an individual increases in their relatedness to nature they will also adopt more pro-environmentalist behavior. On a community level this strategy could be very impactful as it would lead to an increase in the amount of green space available and distribute it more equitably.

Another conclusion I drew from this study was the need for disconnection. A successful nature experience will need to create moments without the direct use of the phone in order to build long-lasting and meaningful experiences in nature. Thus, the timing and use of any AR intervention should be considered so not to over stimulate the user. Leveraging these necessary technology gaps within the AR system is an area I will explore more in study 2.

As previously stated, social engagement features can be a powerful motivational tactic to foster engagement in guided tasks or activities. From my analysis I believe that these features might serve the novice user best in moments where focused attention and uncertainty is already at its highest. In explorations A1–5 for example, the user must choose a direction of travel. In an unfamiliar environment this can be especially stress inducing. Thus, a successful AR overlay system would need to be simple in design while simultaneously drawing upon a community of users for support to relieve the stress and cognitive burden involved in any decision making process.

Conversely, more complex encounters that require close and direct attention, could also be improved with community engagement. Exploration D1 for example, facilitates curiosity and interest in nature by exposing the user to possibilities for further exploration. As a user previews content generated by the community of users, they can form a better picture of their surroundings without fully drawing their attention away from the nature environment. Finally, L1–N1 gives light to a broader view of targets and the community of users who created them. This perspective helps give context to the target of interest and situates the user in the park space. Other social engagement incorporating opportunities will be further developed in study 2 as I look at various ways the AR system could increase feelings of belonging through moments of reflection following the nature experience.

1
ENTRANCE
5 min

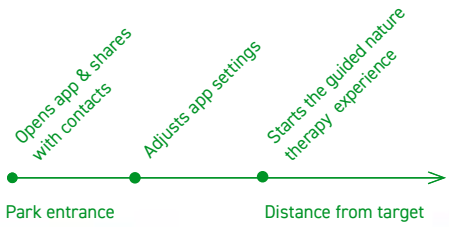


Figure 4.1.4 ▲
The nature experience begins when the user, Ann, opens the nAtuRe app and quickly adjusts the settings to meet their goals.

2
INITIAL EXPLORATION
5 min

Starts walking down a path based on popularity

Observes surroundings generally while navigating

Distance from target

3D Path to Target

Create Positive Associations

A1–5

*Green highlight = social engagement

*The AR system utilizes:
- **Visual Cues**
- **Audio Cues**
- **Haptic Cues**

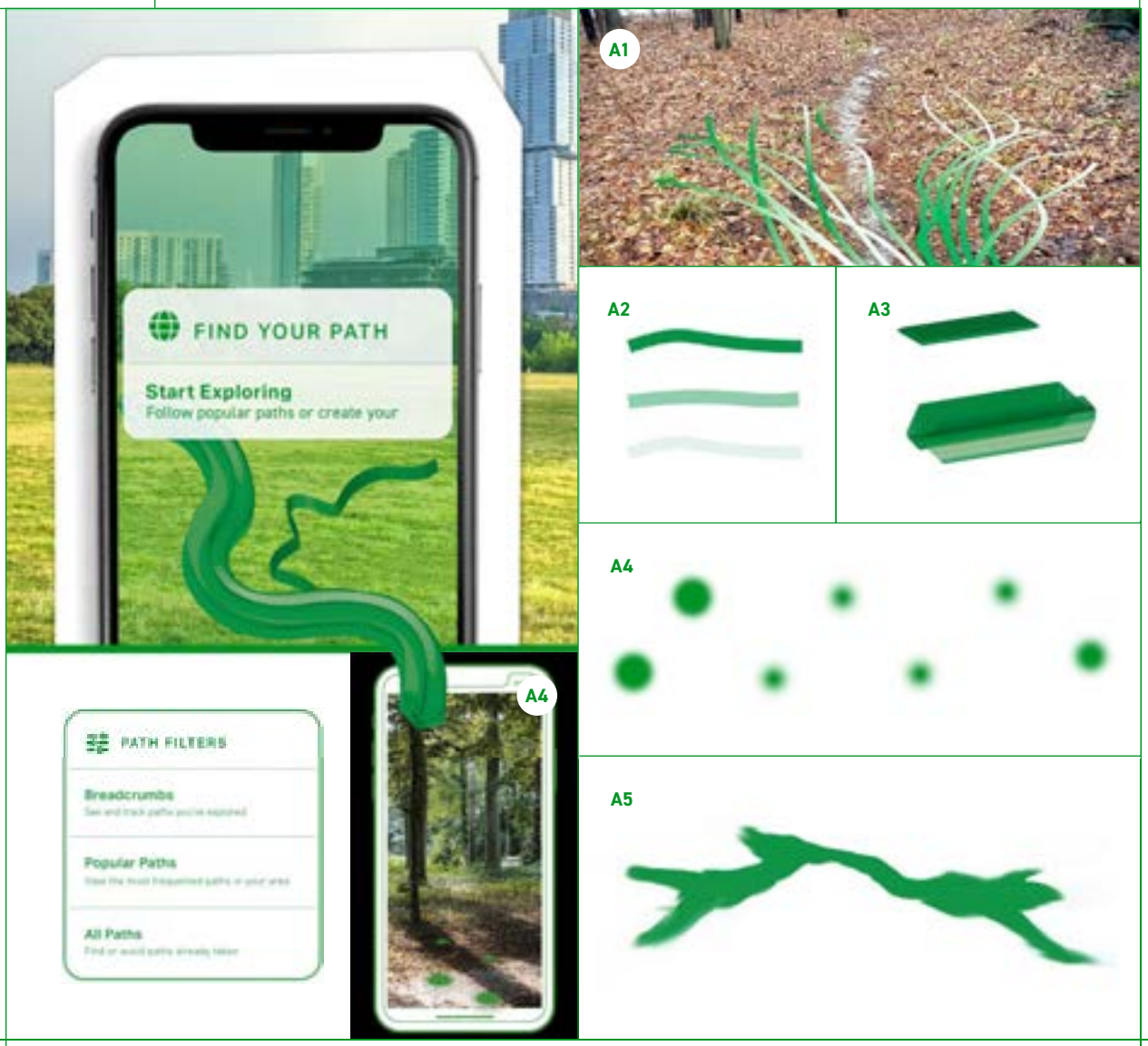


Figure 4.1.5 ▲
Exploration A1–5 looks at a variety of forms a path finding social sharing system could take. The social sharing feature is implemented here to help spark that interest and the visual and audio cues help guide users along a desired route without distracting them from the nature experience.

A1 shows all paths taken by the users' contacts as an *in-situ* overlay. As users walk toward their desired path, the other paths fade and the path selected becomes front and center on the screen. *college.design.ncsu.edu/thenfinally/pierce/study1-a1.mp4*

A2 plays with opacity of the path *in-situ* overlay to show more or less engagement or the popularity of a path.

A3 plays with depth of the path *in-situ* overlay to show more or less engagement or the popularity of a path.

A4 plays with movement and less prominent *in-situ* visual cues to help guide users in a space. The circumference of the circles correlates with the amount of time someone might have stood in a particular location.

A5 looks at how a digital "trail" might simulate a real trail found in the physical environment.

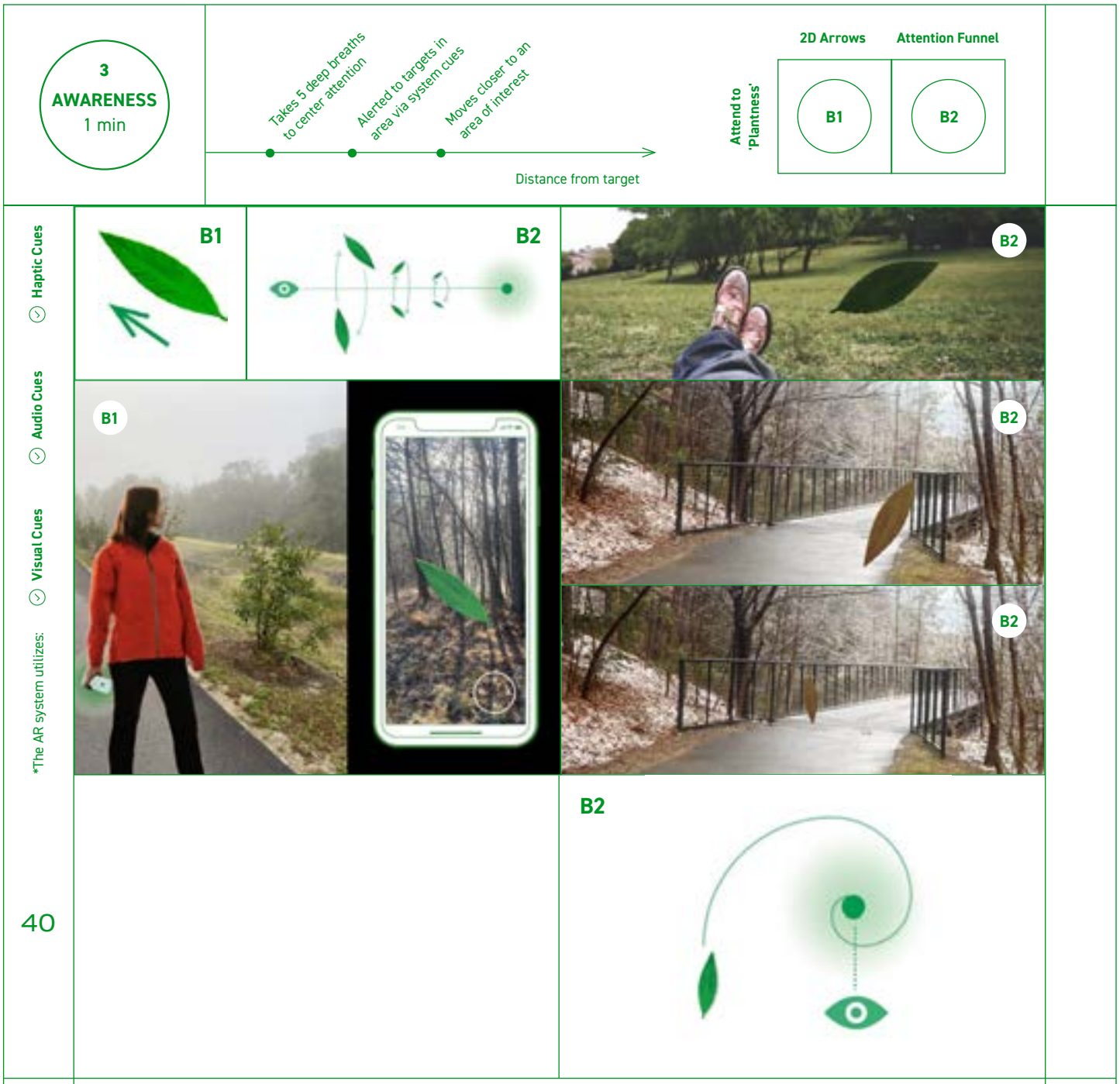
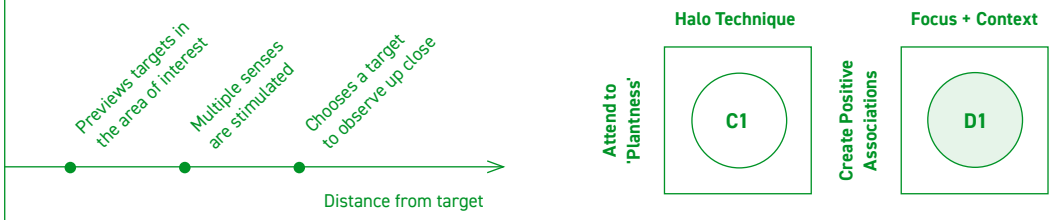


Figure 4.1.6 ▲
These explorations look at attention drawing tactics that allow for a bit more fluidity and freedom in one's attention by encouraging a loose visual exploration of space.

B1 takes the effective attention directing arrow technique and applies formal qualities found in nature, in this case a leaf now represents an arrow. The visual styling of the leaf will adjust based on the time of year. During Fall months, the leaf will show reds and yellows and during the Winter months will be dry and brown. *college.design.ncsu.edu/thenfinally/pierce/study1-b1.mp4*

B2 combines the attention funnel and arrow *in-situ* technique to encourage users to explore and move towards an area of interest. *college.design.ncsu.edu/thenfinally/pierce/study1-b2.mp4*

4
DISTANT OBSERVATION
5 min



*Green highlight = social engagement

*The AR system utilizes:
- Visual Cues
- Audio Cues
- Haptic Cues

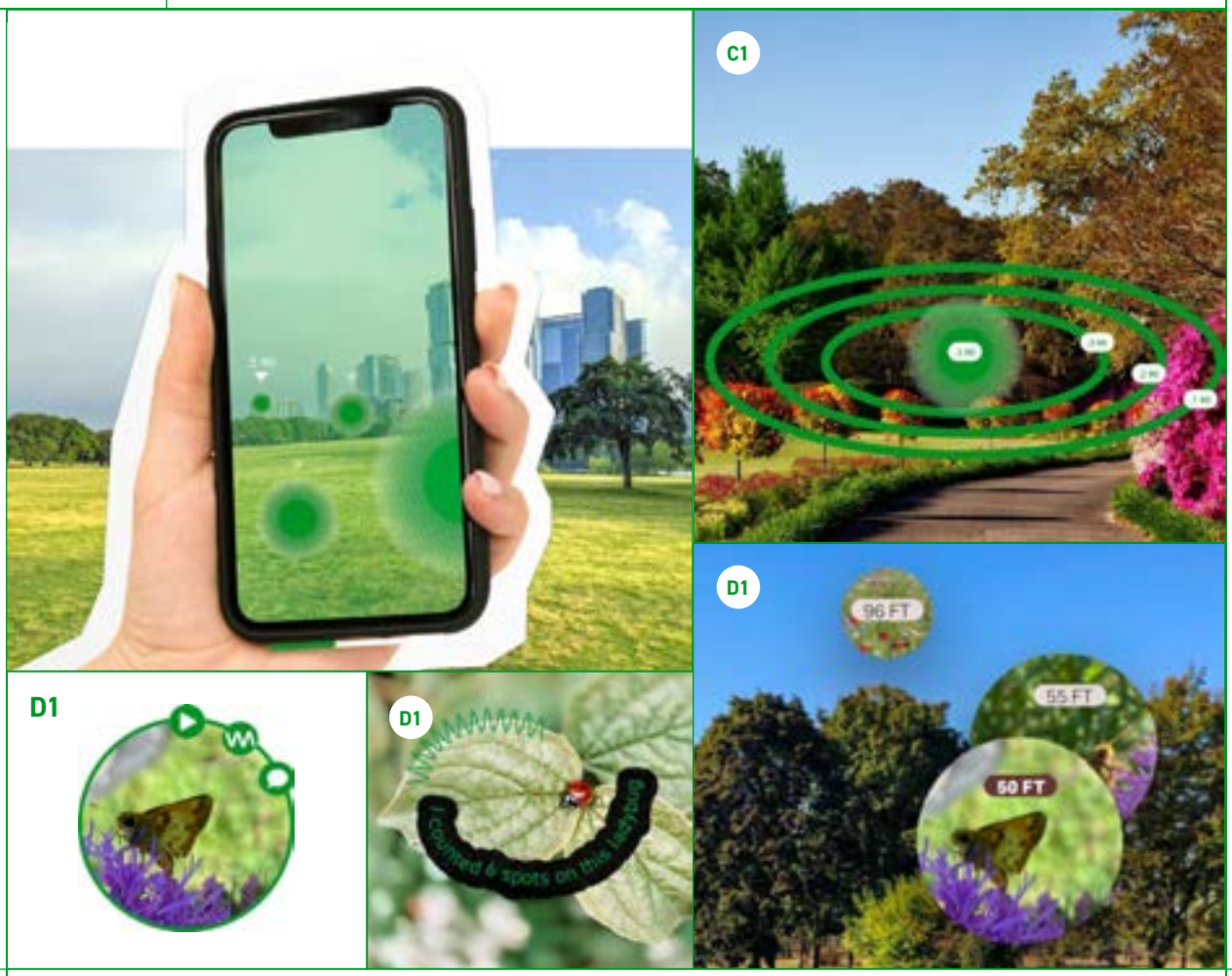


Figure 4.1.7 ▲
Exploration C1–D1 focus on various previewing mechanisms to grab the user's attention and help them navigate to an area of interest.

C1 makes the distance between the individual and the object of interest visible through a halo technique.

D1 allows users to visually preview targets of interest and experience video, auditory, and text based observations recorded by social contacts. By pressing and holding down on the target of interest the AR transitions from *in-situ* to in-view and more investigative options are slowly revealed.

college.design.ncsu.edu/thenfinally/pierce/study1-c1-d1.mp4

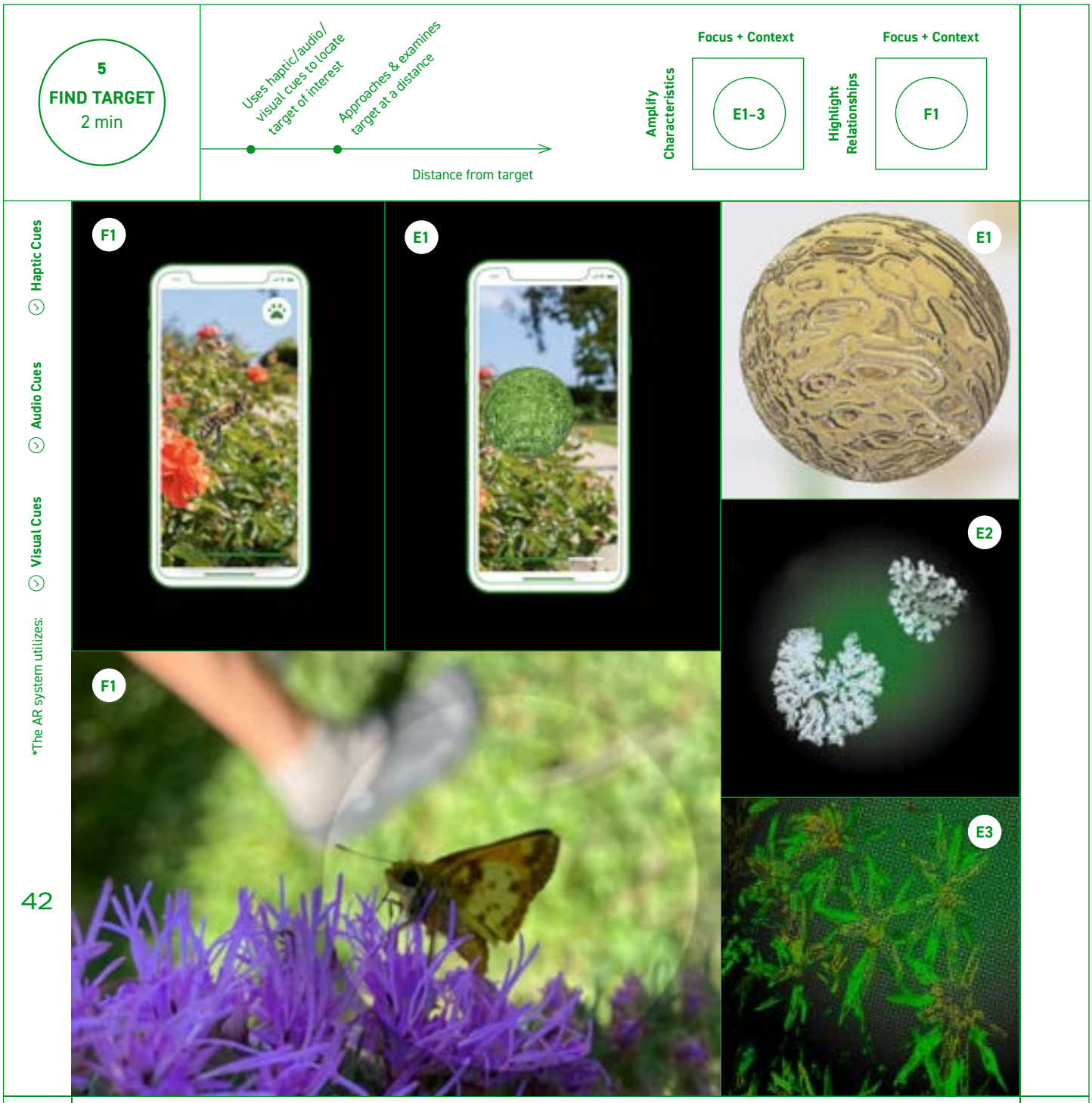


Figure 4.1.8 ▲
These explorations (E1–3, F1) both implement a focus and context AR guiding strategy to help users understand the plant on a relationship and feature level.

E1–3 amplifies sense of touch by creating a textured 3D highlight/overlay. *college.design.ncsu.edu/thenfinally/pierce/study1-e1.mp4*

F1 looks at highlighting the relationships between plants and animals. *college.design.ncsu.edu/thenfinally/pierce/study1-f1.mp4*

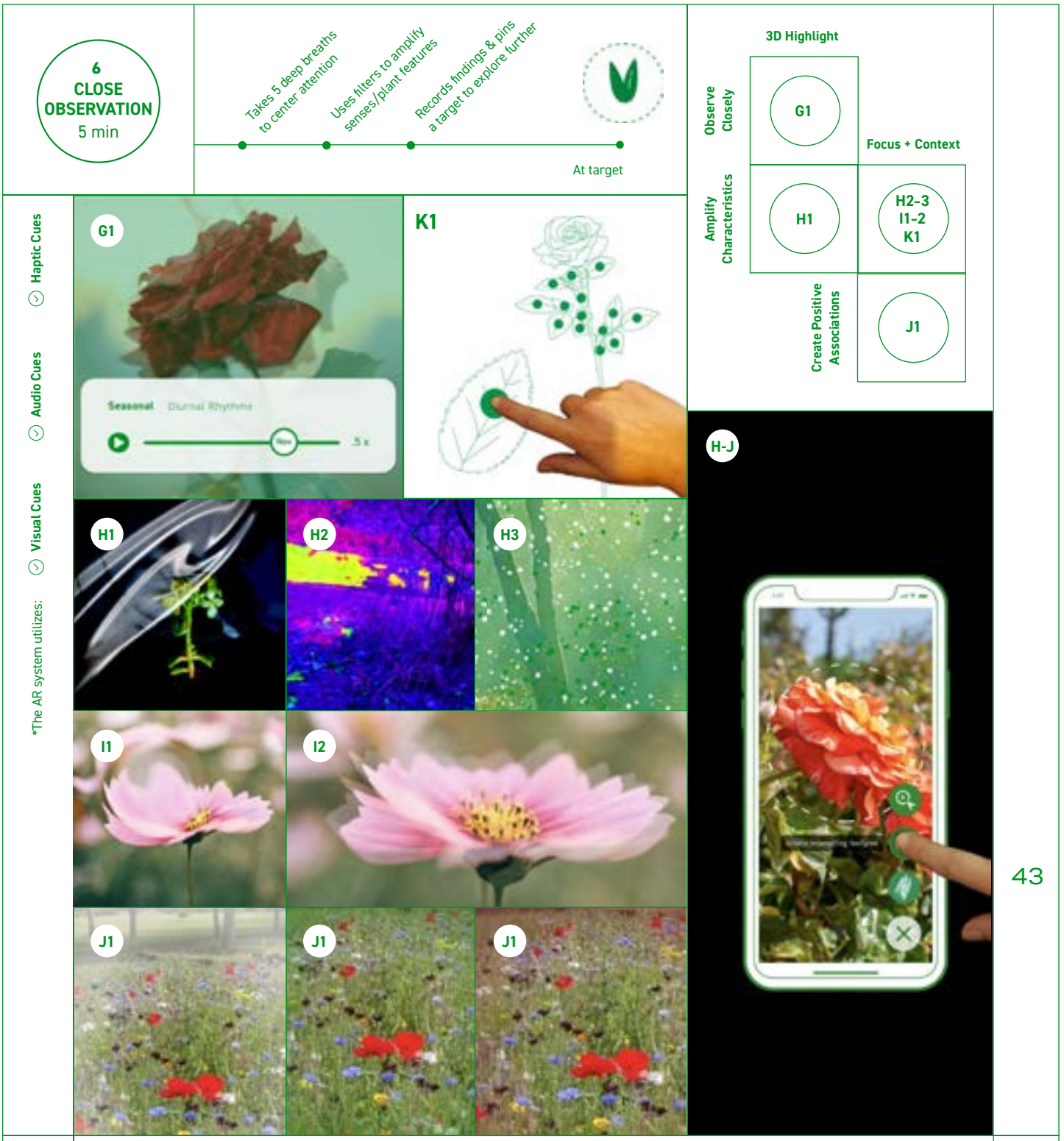


Figure 4.1.9 ▲
Explorations (G1, H1–3, I1–2, J1) at this stage make use of the AR attention guiding system to kick start a deep understanding and awareness of the subject matter.

G1 allows the user to view a plant's life cycle over time. *college.design.ncsu.edu/thenfinally/pierce/study1-g1.mp4*

H1–3 creates an experience that draws a user's attention to plant characteristics invisible to the naked eye. H1 visualizes smell, H2 highlights temperature, and H3 shows pollen particles. *college.design.ncsu.edu/thenfinally/pierce/study1-h1.mp4*

I1–2 encourages closer observation through movement and visual enhancement. *college.design.ncsu.edu/thenfinally/pierce/study1-i1.mp4*

J1 obscures distracting objects in the area so that the user can focus on the plants of interest or specific features of a plant.

H–J is a compilation of these explorations working together to create a more immersive experience during close observation. *college.design.ncsu.edu/thenfinally/pierce/study1-h-i-j.mp4*

7
FURTHER EXPLORATION
5 min

Highlight Relationships	3D Highlight	Halo Technique	3D Path to Target
	N1	L1	M1

*Green highlight = social engagement

*The AR system utilizes:
- Haptic Cues
- Audio Cues
- Visual Cues

N1

M1

L1 Side view

L1 Top view

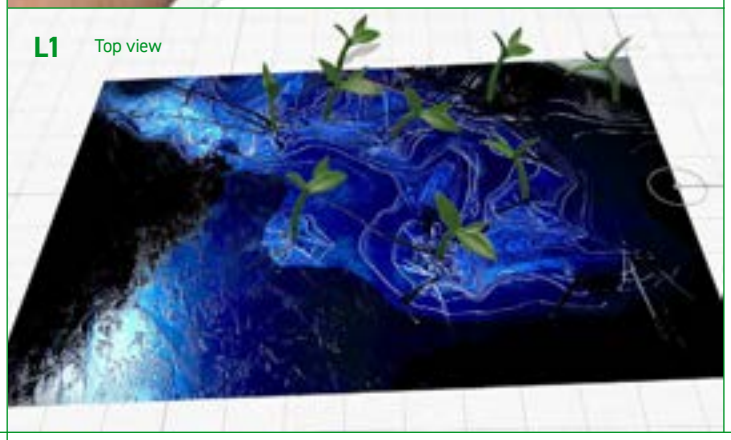


Figure 4.1.10 ▲
Explorations L1–N1 utilize tagged and shared content to help users form connections between the plant of focus and other plants in the area.

L1 reveals the underground communication system between plants using a 3D highlight.

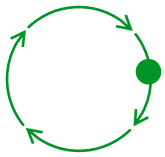
M1 is an in-view overlay that provides the user with a bird's eye view of similar plants in the area.

N1 allows the user to pin a plant or feature of interest and brings attention to similar plants in the area using motion and 3D highlights. *college.design.ncsu.edu/thenfinally/pierce/study1-n1.mp4*

4.2. INCREASING FEELINGS OF COMFORT AND BELONGING IN THE REFLECTIVE OBSERVATION PHASE FOLLOWING THE NATURE EXPERIENCE

SQ 02

How can an immersive AR *in-situ* and in-view information delivery system following a nature experience create reflective moments outside of place to increase feelings of comfort and belonging?



REFLECTIVE OBSERVATION PHASE

Figure 4.2.0 ▲
Study 2 takes place on day one to day seven of the 60 day prescription during the reflective observation phase.

To foster a positive relationship with nature, the AR system will need to provide moments of reflection outside of the park environment that build on and encourage future nature-therapy based experiences. This study examines design potentialities for a reflective AR *in-situ* and in-view overlay information delivery system within the user's home that promotes feelings of belonging with nature. Opportunities to add social engagement through messaging, liking, and sharing within the AR supported moments of reflection, while focusing on design directions that can achieve a sense of presence (see Table 4.2.2 on p. 52), addressed to establish a deeper connection with the natural environment and improve future nature attention restoring encounters.

As defined by Gibbs (1988), reflection can be thought of as an act of contemplation or an active and careful process in which the experience is recaptured and evaluated. Following a learning experience, in this case an experience intended to improve one's connection and attention to features found in nature, participants must reflect on their experience to retain learning. During the act of reflection, feelings and thoughts emerge and generalizations or concepts are formed. More specifically, Gibbs gives structure to this process in the form of six stages (see Table 4.2.0 and Figure 4.2.1 on p. 48) and presents practical methods to assist an individual or a group in the action of reflection (see Table 4.2.1 on p. 49). For this study, only Gibbs' first two stages of reflection—description and feelings/reactions—are addressed as they constitute the process of reflective observation.

Gibbs' research on reflection and strategies for quality reflection act as a guide for identifying areas where AR overlays combined with social engagement features can be successfully implemented to encourage feelings of comfort and belonging (investigation matrix seen in Figure 4.2.2 on p. 50).

Table 4.2.0 ▾
The stages of reflection defined (Gibbs, 1988).

1. DESCRIPTION	To simply describe what happened during the experience.
2. FEELINGS/REACTIONS	To explore feelings or reactions as a result of an experience and how they impacted the experience.
3. EVALUATION	To make value judgments about the experience (good or bad) and integrate new knowledge into one's conceptual framework.
4. ANALYSIS	To make sense of the situation and connect the experience with outside ideas and people who have had similar or different experiences.
5a. CONCLUSIONS (GENERAL)	To draw general conclusions from the experience and the analysis.
5b. CONCLUSIONS (SPECIFIC)	To make specific conclusions that are unique and personal to the situation or ways of operating (behavior) during the experience.
6. PERSONAL ACTION PLANS	To plan or outline next steps based on what was learned.

Figure 4.2.1 ▸
The stages of reflection with a focus on the description and feeling stages (Gibbs, 1988).

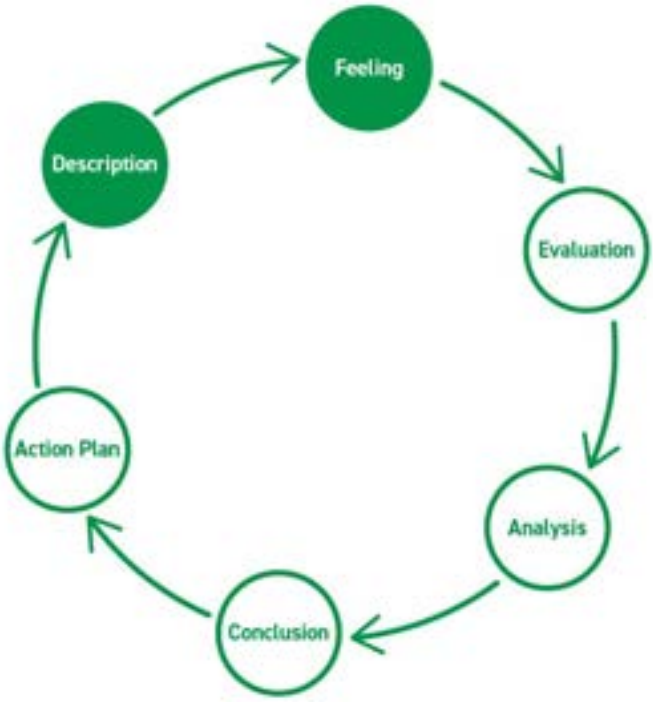


Table 4.2.1 ▾
Strategies for meaningful and substantive reflecting (Gibbs, 1988; Chang, 2012).

VIDEO & AUDIO RECORDINGS	Video and audio recording can be a powerful tool to aid reflection by reminding individuals of key points during their experience or cue detailed recall of exactly how they were feeling at a particular moment in time.
DIARIES/JOURNALING	Keeping a diary or journal allows individuals to record immediate experiences and their reactions to those experiences. They can expand on their thoughts by analyzing or drawing conclusions from them.
DRAWING	Drawing helps individuals sort through different thought processes one might not be able to articulate verbally or in written form (Chang, 2012).
PEER APPRAISAL	When a peer provides feedback on an individual's performance or behavior during an experience it should be positive and forward looking.
STRUCTURED DISCUSSIONS	Guided discussions within a group setting that take place during 4 stages in a snowballing fashion: + Stage 1–individual reflection. + Stage 2–paired reflection. + Stage 3–small group reflection. + Stage 5–whole group reflection.
SELF-ASSESSMENT	Individuals' self-assessment based on their behavior during the experience.
CHECKLISTS & QUESTIONNAIRES	Checklists and questionnaires are useful for starting the conversation. Lists are often generated to which the individual must respond.
SHARED TIME & MUTUAL INTERVIEWING	Where time is shared equally among participants and each learner is given space to reflect within the group.
MODELING	Modeling is where a more experienced learner demonstrates or models the process of reflecting, thus, shaping the learners' behavior towards this model.

	Describe	Record Feelings	Evaluate	Analyze	Draw Conclusions	Create a Plan
Reviewing Video & Audio	B1-15					
Journaling	A1, B13					
Drawing	B11					
Peer Appraisal						
Structured Discussions						
Self-Assessment		C1-2				
Checklists & Questionnaires						
Shared Time & Mutual Interviewing						
Modeling						

Figure 4.2.2 ▲
Study 2 investigation matrix with explorations (A–C) mapped out. Cells shaded in green are areas where social engagement features were explored.

Figure 4.2.3 ▲
Over of stages from day one to day seven following the nature experience. Study 2 only looks at the first two stages of reflection (Gibbs, 1988).

FIRST TWO STAGES OF REFLECTION

Ann has arrived home following her daily walk in the park. For the past seven days of her prescription, Ann has been receiving geo-triggered prompts that ask Ann to reflect on her experience and the content collected during the experience. Here, the system guides Ann through the first two stages of reflection. When Ann thoughtfully describes the events and records her feelings, the system records the data and stores it on her device. The more Ann uses the system the more socially invested and comfortable she becomes with nature and the supporting technology.

Annotation
A note or comment that is added to a text or image that helps highlight key words, records reactions to certain concepts, or draws meaning and connection between ideas.

Description. At this stage in the process, Ann has found a quiet place in her room to sit and reflect on her experience in nature. She is able to record her thoughts at different levels of the experience—describing her overall experience and annotating specific interactions and captured moments. In the following explorations, I've focused on different ways the recorded content could be accessed and presented for reflection using AR overlays to increase user engagement and presence (Figures 4.2.5–4.2.7 on pp. 54–56).

Feeling/Reactions. At this stage in the process, Ann has reviewed and replayed her experience outdoors and has recalled and recorded various details about the experience. Now, Ann will need to reflect on how the experience made her feel. This exploration looks at how AR overlays can help navigate and record users' feelings (Figure 4.2.8 on p. 57).

ASSESSMENT

I have constructed a coordinate plane to help judge the impact of the design solutions in relation to content organization and immersion. When used in combination, these design considerations can assist in one's overall feeling of presence while simultaneously increasing feelings of belonging in nature at different stages of the reflection process. The axes of the plane are as follows: "structured" to "unstructured" (left to right) and "realism" to "abstraction" (top to bottom) (see Figure 4.2.4). "Structured" and "unstructured" define how one might organize observations and feelings using the AR system, while "realism" and "abstraction" touch on the visible qualities of the AR system and how accurately the interface design mimics features found in the physical world.

PRESENCE

Presence is the learner's subjective feeling. The more presence someone feels in a space the more immersed they will be in that learning environment or context (Johnson-Glenberg, 2018). Presence can be achieved through:

+ highly engaging and meaningful interactions with an environment
+ multi-sensory inputs: haptic, visual, and audio
+ strong personal and emotional connections with the learning subject.

Table 4.2.1 ▲
Extracted from the Immersion Learning—PRAS Model (Hung, 2017).

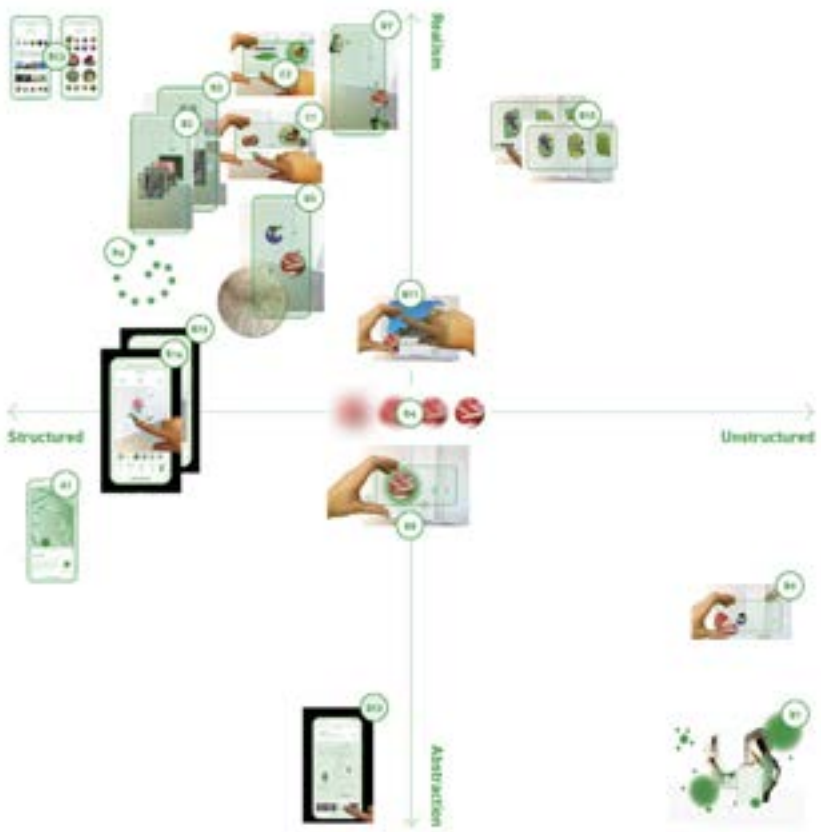


Figure 4.2.4 ►
Study 2 exploration assessment coordinate plane with labeled axes.

OBSERVATIONS

After exploring the visual strategies for the application of AR during the reflective observation phase, I've come to several conclusions. Upon initial assessment, the AR system appears to function best for reflective purposes when visual solutions apply strong "structure" and "realism" qualities. Highlighting realistic elements in the AR space provides a clear picture of the events that have transpired and triggers a more accurate recall of the experience as a whole. In addition, explorations that apply AR *in-situ* technology allow users to examine and reflect on their collected content from broad, specific, or multi-view perspectives. When visual realism is combined with a more structured system in an AR space (e.g., B2), users are more likely to spend time with the images and interpret the details in depth. Thus, as exposure to these natural elements increases, so too does familiarity, leading to an expanded sense of belonging.

Conversely, AR solutions that take a more abstract approach seem to inspire more imaginative realizations. When less detail is presented (e.g., B9), there is more room for new and playful interpretations of the content, helping users focus their thoughts toward feelings during a moment rather than the more logistic and descriptive details of the experience. As certain visual details are diluted, features like sound, movement, and texture are inadvertently amplified and become central to the act of reflection. This dampening of some senses and heightening of others, provides users with a more holistic and sensory focused recall of their experience. The benefit of using more organic and fluid visual styling is that it acts as a visual transition between the states of reflection. As users transition between recall activities, the system can supply them with moments of cognitive rest.

As for social engagement, the option to view, use, borrow, and integrate shared content in the description stage starts to form unexpected relationships between self and others early in the nature prescription process. Merging and sharing one's experience at the beginning of this process not only helps dismantle boundaries and negative perceptions about an experience, but more importantly, provides novice users with a jumping off point for participation (e.g., B12). Essentially, the indoor AR supported environment can be built with shared content until new users have enough self-generated content to analyze on their own. Social engagement at this stage in the learning cycle is effective because it can immediately bring awareness to self and others within the nature experience. This sense of being "known" within a community, whether inside or outside of the physical space, can start to build on one's feelings of belonging and relatedness.

Finally, the implementation of sound and touch are key aspects of a multisensory experience as they contribute to an overall sense of presence but are only briefly mentioned in this study. In the final study, I will discuss how sound and somatic interactions might function with the AR system more directly to help motivate users to engage in nature.

Figure 4.2.5 ▲
A1 allows users to see an overview of their experience overlaid with points of AR interaction where they've recorded content on their phone. Users can then journal a general description of their experience and add specific details.

B1 shows potentialities for placement and organization of captured media in the AR space. The presentation of the AR content is ambiguous visually, sparking curiosity as to what lies beneath. *college.design.ncsu.edu/thenfinally/pierce/study2-b1.mp4*

B2 shows potentialities for placement and organization of captured media in the AR space. This AR content is seen in a stacked pattern, allowing users to shuffle through and focus attention on one key interaction at a time. Distance between the AR content represents the distance between the recorded encounters during the experience in nature. Space in between content visually represents the gaps in the record keeping of the experience. *college.design.ncsu.edu/thenfinally/pierce/study2-b2.mp4*

Figure 4.2.6 ▲
B3 shows potentialities for placement and Exploration B4 illustrates how AR *in-situ* overlays might gradually come into view as users journal about their interaction.

B5 looks at obscuring information by only focusing on key parts of the encounter, heightening the senses around texture and details observed at close range. *college.design.ncsu.edu/thenfinally/pierce/study2-b5.mp4*

B6 tries to incorporate movement into the act of reflection by placing AR *in-situ* content overlays in a spiral formation around the room. To reflect, users must walk along the path of overlays that begins centrally and expands outward until they view the last interaction point.

B7 takes the images collected and masks them in the AR space giving them a more realistic representation of how they might be seen in the physical environment. *college.design.ncsu.edu/thenfinally/pierce/study2-b7.mp4*

B8 shows how you might view and interact with the scattered and abstracted interaction touch points to reveal detailed content. *college.design.ncsu.edu/thenfinally/pierce/study2-b8.mp4*

B9 abstracts the AR overlays and adds an undulating movement to stimulate users visually and give the sense that the collected images of nature are living specimens. *college.design.ncsu.edu/thenfinally/pierce/study2-b9.mp4*

B10 projects AR images on the room walls like windows looking out into nature combined with an annotation feature that has a "graphic view" and a "natural view" setting. *college.design.ncsu.edu/thenfinally/pierce/study2-b10.mp4*

1
DESCRIPTION
5 min

Asked to reflect on experience → Replays experience & key AR encounters → Sorts content collected from experience → Records a general description of experience → Fills in missing information not recorded → Adds detailed descriptions

Home

	Describe
Reviewing Video & Audio	B1-15
Journaling	A1, B13
Drawing	B11

*Green highlight = social engagement

*The AR system utilizes: Haptic Cues, Audio Cues, Visual Cues

B11

B12

B13

B14

B15

STUDIES

Figure 4.2.7 ▲
B11 gives users control over the space and affords the ability to "set the scene" so to speak and reflect organically on their experience recreated in their own space. *college.design.ncsu.edu/thenfinally/pierce/study2-b11.mp4*

B12 allows users to add content not recorded by the AR system and gives them an opportunity for deeper reflection within the home. Users can replay their experiences like a movie, add content collected by others, and recreate or manipulate their own scenes with shared drawings, graphics, and overlays. *college.design.ncsu.edu/thenfinally/pierce/study2-b12.mp4*

B13 looks at how users might view their content as a collection of specimens that they can share or view in their physical space.

B14 incorporates the sense of touch. Texturing effects and overlays can be added to AR specimens as a means of reflection.

B15 uses point specific annotation at the specimen level to help describe intimate and sense stimulating experiences within nature.

2
FEELING
5 min

Answers questions about feelings

Records feelings on nature encounters

Record Feelings

Self-Assessment

C1-2

*The AR system utilizes:
- Visual Cues
- Audio Cues
- Haptic Cues

C1

C2

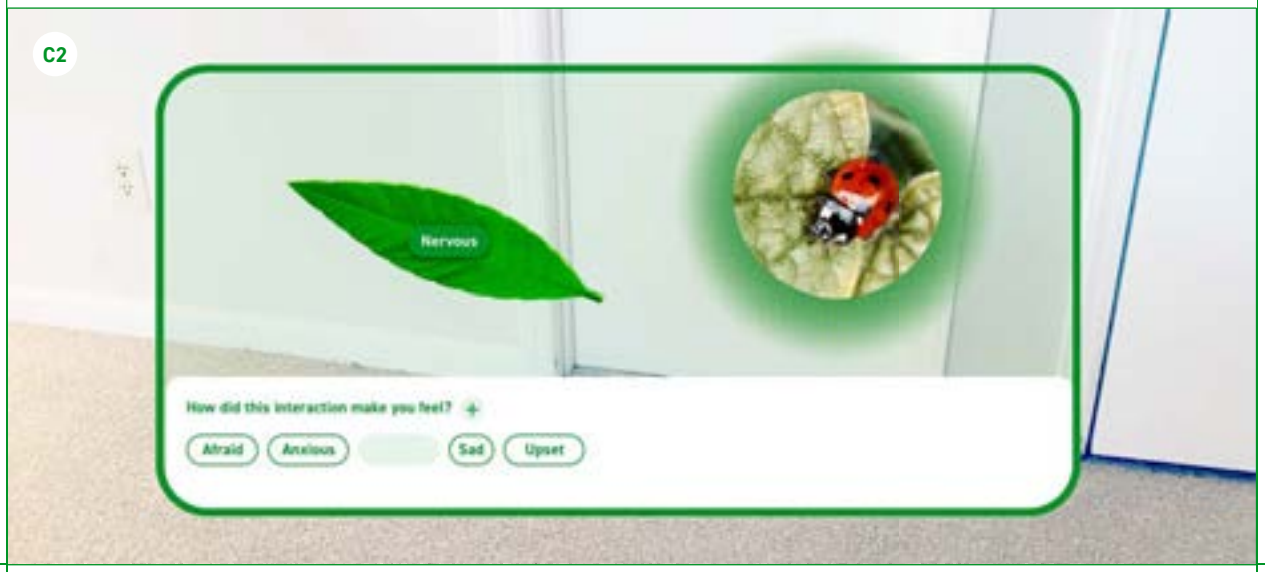


Figure 4.2.8 ▲
C1 allows users to quickly select from a list of words to help them describe their feelings and attach them directly to the event or specimen in question. This activity helps build a visual relationship between the experience and the users' feelings associated with the experience.

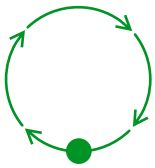
C2 gives the user direct control over their feelings within a highly visual and interactive environment. Negative feelings can be identified and attached to an object *in-situ* as a way to recognize and dissociate oneself from negative feelings surrounding an experience.

58

4.3. ENCOURAGING ENGAGEMENT IN THE ABSTRACT CONCEPTUALIZATION PHASE DURING THE NATURE EXPERIENCE

SQ 03

How can an interactive AR *in-situ* and in-view information delivery system following the nature experience create contemplative moments outside of place to encourage autonomous engagement?



ABSTRACT CONCEPTUALIZATION PHASE

Figure 4.3.0 ▲
Study 3 takes place on day seven of the 60 day prescription during the abstract conceptualization phase.

As a user's familiarity with nature increases along with motivation to fill one's nature prescription, the AR system will need to enhance learning through comparison activities. On day seven, users will be asked to think about the concept(s), such as attention restorative moments with plants, and relate them to their past understanding of the concept(s). This study will explore how an interactive AR *in-situ* and in-view overlay information delivery system in one's home, can create contemplative moments outside of place that encourage autonomous engagement. Gibbs' reflection stages and strategies will again be used as a guide for exploration as I delve through diverse ways the AR system might encourage specific behaviors that give users a sense of autonomy (see Table 4.2.0 on p. 48 , Table 4.2.1 on p. 49, and Figure 4.3.1). The same investigation matrix used in study 2 is applied to help organize explorations that assist users with abstract conceptualization and inspire autonomous engagement (see Figure 4.3.2 p. 60). Finally, social engagement features are explored as potential perception shifting and motivating strategies during the evaluation, analysis, conclusion, and action plan development stages.

Figure 4.3.1 ▸
The stages of reflection with a focus on the evaluation, analysis, conclusion, and action plan stages (Gibbs, 1988).

	Describe	Record Feelings	Evaluate	Analyze	Draw Conclusions	Create a Plan
Reviewing Video & Audio	B1–15		E1	F1	K1–4	
Journaling	A1, B13					
Drawing	B11				J1, I1	
Peer Appraisal				F2		
Structured Discussions				F3		
Self-Assessment		C1	D1–2	G1	K1–4	
Checklists & Questionnaires				F4		L1–3
Shared Time & Mutual Interviewing				F5		
Modeling				H1		

Figure 4.3.2 ▲
Study 3 investigation matrix with explorations (D–L) mapped out. Cells shaded in green are areas where social engagement features were explored.

Figure 4.3.3 ▲
Overview of stages on day seven following the nature experience. This study only looks at the last four stages of reflection (Gibbs, 1988).

LAST FOUR STAGES OF REFLECTION

Ann is returning home from a 25 minute nature experience at her local park when a notification appears on her phone asking her if she has time to reflect on her week as a whole. Ann selects "yes" and sits down in her usual spot indoors to reflect on her progress and learning thus far.

Evaluation. After Ann finishes recording her feelings and details from her most recent experience, she transitions to interpreting those feelings in relation to the goals of forest therapy. These explorations look at how the AR system might allow Ann to visually and spatially sort captured moments to evaluate her feelings (see Figure 4.3.5 on p. 64).

Analysis. With details about her experience thoroughly explored, Ann is asked to draw meaning from those details collected through a targeted analysis. This set of explorations looks at how a more structured interaction with the AR overlays might help facilitate understanding while supporting connections or associations with others (see Figure 4.3.6 on p. 65).

Conclusion. As Ann wraps up her reflection of the nature experience, she takes a few moments to summarize what she has learned and highlights what changes to her actions could improve her experience in the future. In this case it is employing more restored attention and connection to nature. These explorations look at ways the AR system can present the data in a non-confrontational way that encourages curiosity and meaningful engagement with nature (see Figure 4.3.7 on p. 66, Figure 4.3.8 on p. 67, and Figure 4.3.9 on p. 68).

Action Plan. Before Ann closes the app, she is instructed to create a plan to continue her progress with meeting the goals of her nature prescription. This exploration visualizes the features that might be helpful in creating a plan and sticking to that plan (see Figures 4.3.10 on p. 69).

ASSESSMENT

I have applied the same a coordinate plane used in study 2 to help judge the impact of the design solutions in relation to content organization and immersion (see Figure 4.3.2).

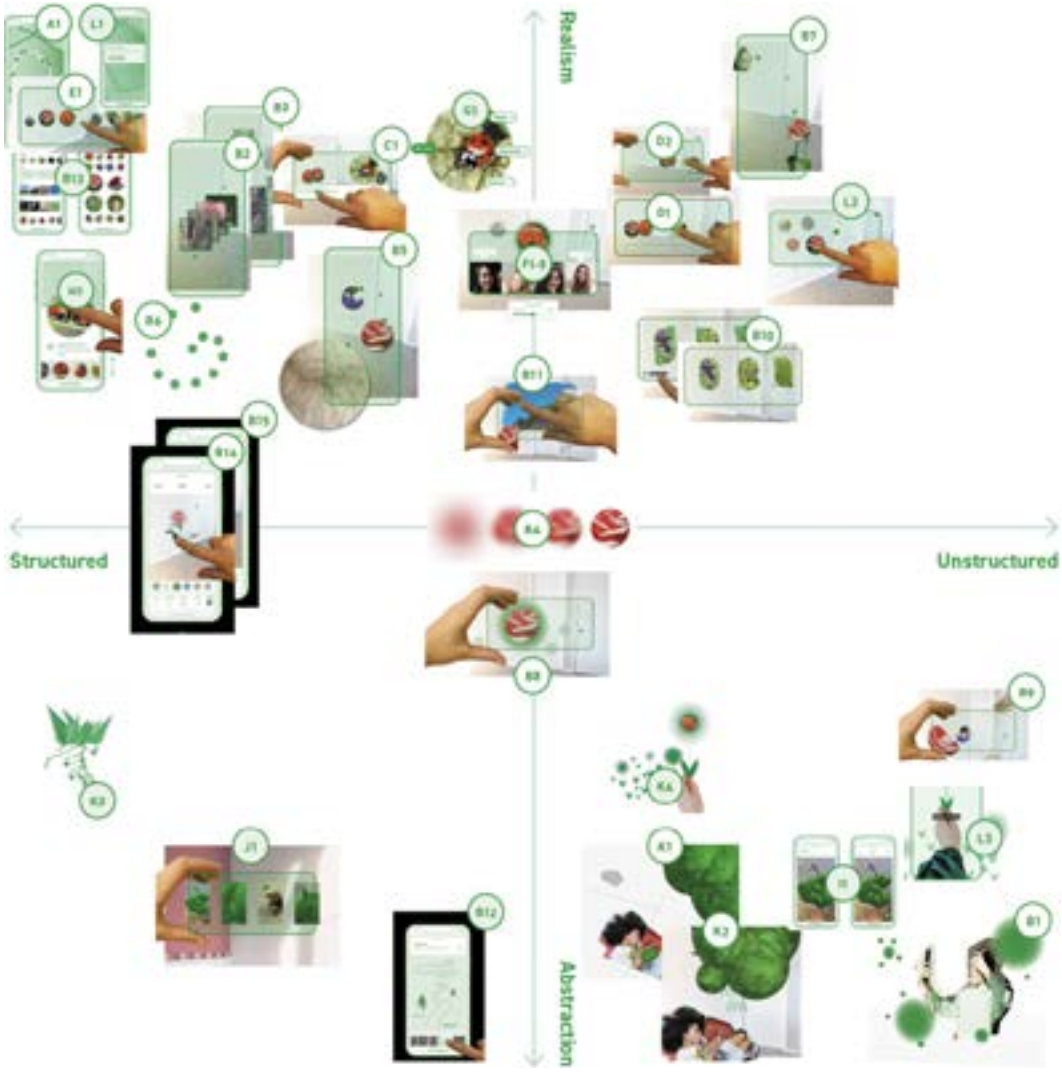


Figure 4.3.4 ▲
Study 3 exploration assessment coordinate plane with explorations (D–L) mapped out alongside explorations from study 2. Circles shaded in green are areas where social engagement features were explored.

OBSERVATIONS

When mapping explorations onto the coordinate plane for assessment (see Figure 4.3.4 on p. 62), I discovered that in the absence of structure, the explorations that presented visual data more organically proved helpful for re-igniting interest in a user's overall experience. The unstructured layout of the collection in the user's space proved beneficial for navigating complex feelings and thoughts that can be initially more fluid and inexact. This freedom to place content anywhere in one's space and to organize thoughts along a spectrum, signifies that the process of understanding one's self, and an individual's relationship with nature, is ever changing and malleable. An unstructured system can also provide users with a greater sense of control. By giving them the power to manipulate their environment using AR elements, users are free to customize their space to their liking.

This strategy aligns well with common guided imagery utilized for relaxation and stress management practices. Participating individuals are asked to imagine a place where they feel most safe as a way to calm their thoughts and to connect more intentionally with their mind and body (Nunez, 2020). The visualization of space can be manifested through an AR information delivery system and can promote the merging of outdoor and indoor spaces. Here, in the safety and comfort of one's home, users are able to select the most positive aspects of their nature experience and choose how they might build upon their own learning in comparison to other users in their community. This self-governance is especially important for novice users who ultimately seek autonomy in unfamiliar and highly stimulating environments.

When examining the last four stages of reflection within the context of the AR system, user experiences during the analysis stage were most positively impacted by the inclusion of social engagement strategies. Here, the AR system can support a space conducive for conversation and function as an informal reflection and association building tool between nature and self. For example, if a user expresses a negative feeling towards a specific encounter with nature, social-based comparison tools can be implemented by friends and family to positively shift one's perspective (e.g., F2–5, G1, H1). The analysis stage is not the only stage that benefited from a social engagement component. The conclusion and action stages were well suited for data sharing capabilities. This cross pollination of ideas and experiences encourages new or repeat visits to a location, provides moments of awe, and assists users in planning future park encounters. Ultimately, simple social considerations, such as the ability to view multiple viewpoints and receive real-time feedback from friends and family, and the promotion of community based comparisons within the AR system, all contribute towards one's confidence in nature and support a sense of autonomy in one's journey towards a healthier lifestyle.

In study 4, I focus on the abstract experimentation phase where I have the opportunity to compare novice and expert user interactions within the AR system as they work towards perceived competency of the skills associated with a positive nature therapy experience. In addition, AR overlays that build on one's nature attention restoration skills and health at key moments of the user's journey are more thoroughly explored.

3
EVALUATION
5 min

Makes judgements about the experience

Focuses on positive & negative aspects

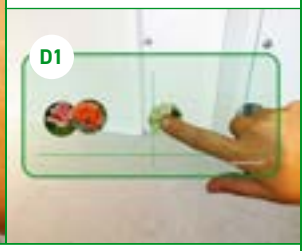
Evaluate

Reviewing Video & Audio — **E1**

Self-Assessment — **D1-2**

*The AR system utilizes:

- **Haptic Cues**
- **Audio Cues**
- **Visual Cues**



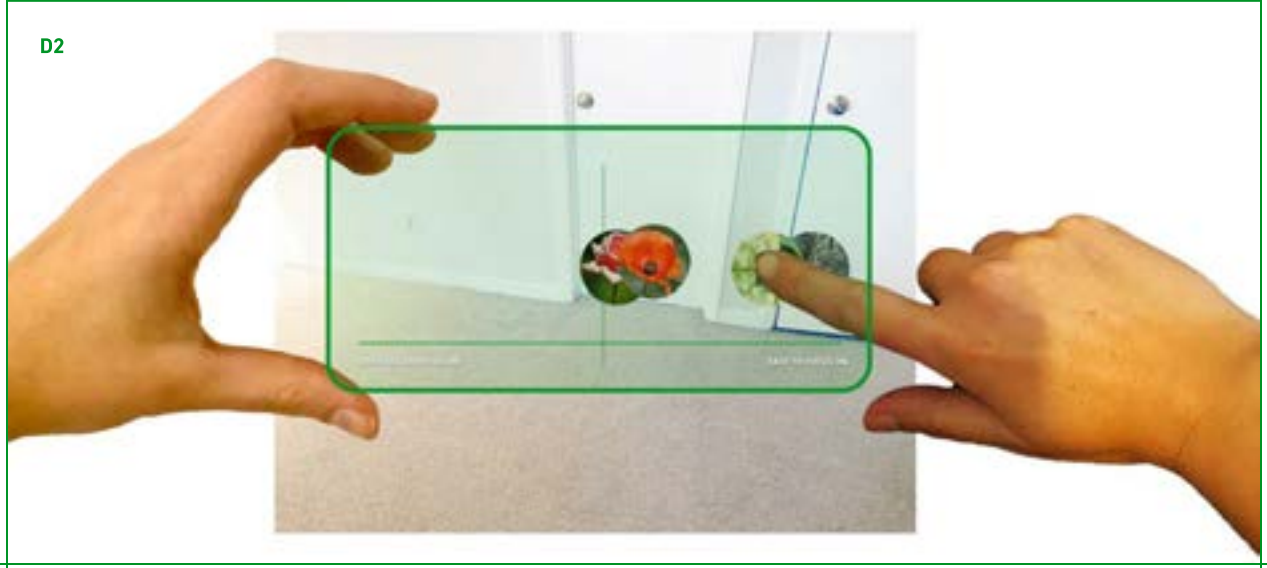


Figure 4.3.5 ▲
D1 encourages users to sort specimens representative of a specific interaction on a spectrum from "relaxing" to "uncomfortable" and compare the events across the spectrum.

D2 prompts users to sort specimens representative of a specific interaction on a spectrum from "difficult to focus on" to "easy to focus on" and compare the events across the spectrum.

E1 asks users to sort specimens in space based on a variety of comparable categories like size, shape, color, smell, and texture and make judgments about their feelings and relationships visualized in front of the screen.

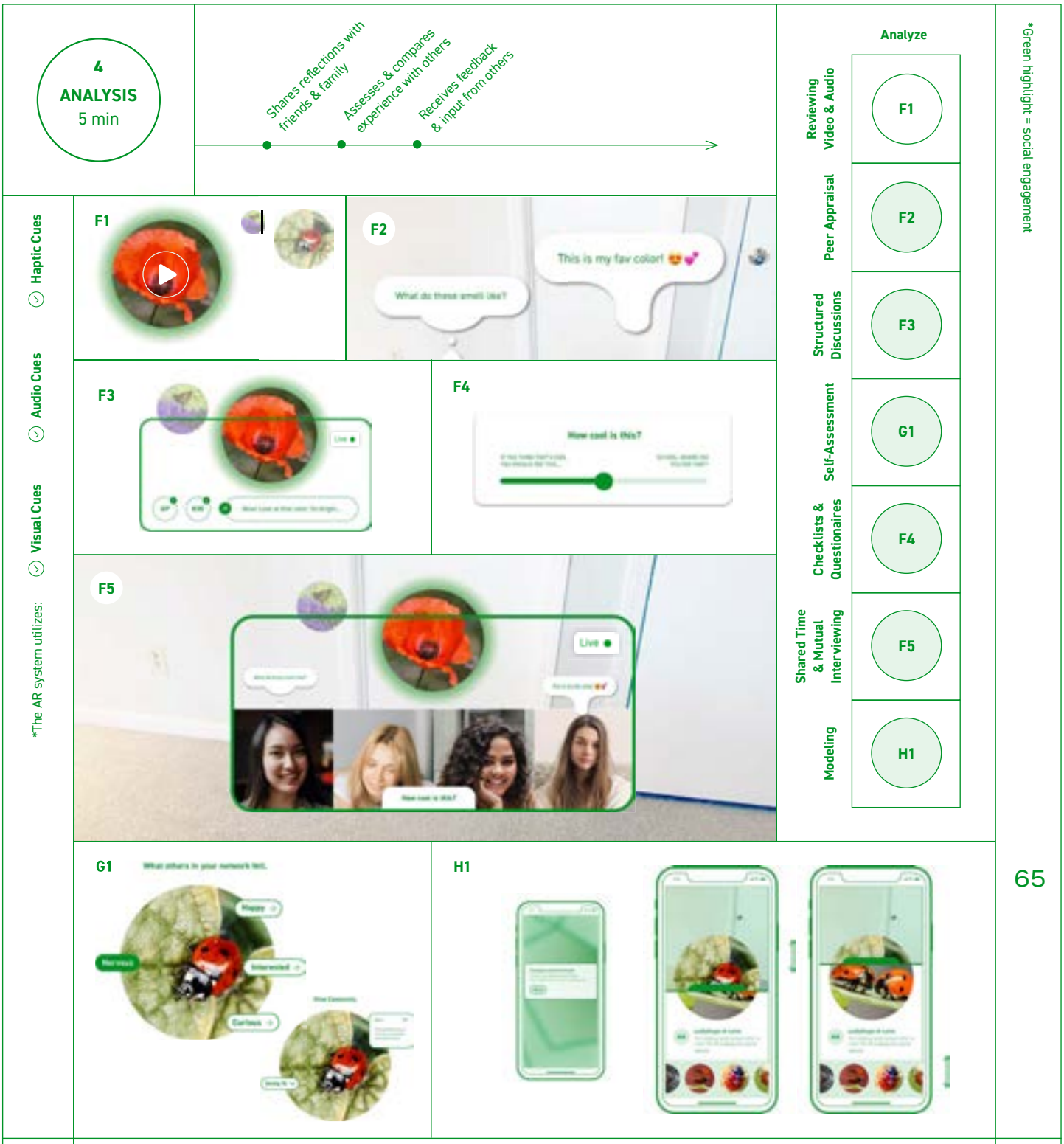


Figure 4.3.6 ▲
F1 is a live video conferencing experience. The AR image or video of interest is highlighted for viewers to interact with and comment on.

F2 is an organic way to experience comments and peer appraisal. Messages appear from an in-view position and gradually transition to an *in-situ* one, connecting the 2D with the 3D environment.

F3 is a more personalized and structured way to receive feedback. For novice users, this social sharing feature will not be available until day seven of the prescription.

F4 adds another level of dynamic social expression. A simple voting mechanism encourages more in-depth conversations around shared content.

F5 looks at how the conversation can be visibly shared by all members of the group.

G1 is a self-assessment tool giving users the ability to compare and contrast parts of their experience to those within their own network.

H1 facilitates visual comparison between AR overlay details and images captured by other users. Through this comparison activity users learn and begin to model similar and more positive reactions to nature.

5
CONCLUSION
5 min

Summarizes learning outcomes

Creates/captures images of learning outcomes

Shares learning outcomes with friends & family

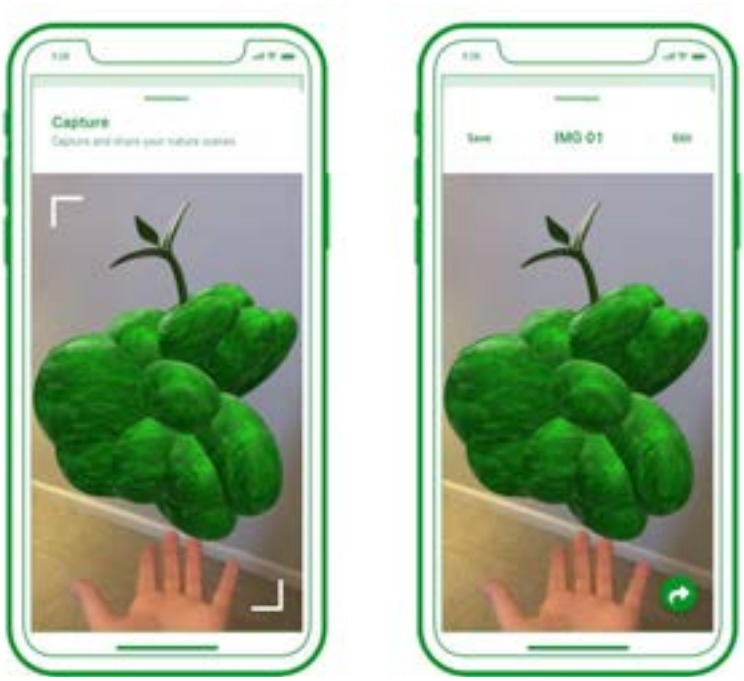
Draw Conclusions

Reviewing Video & Audio	K1-4
Drawing	J1, I1
Self-Assessment	K1-4

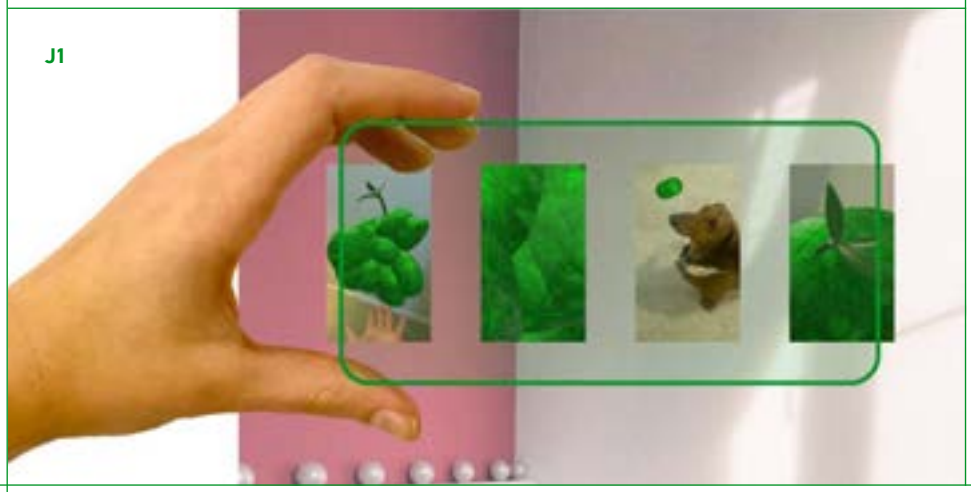
*Green highlight = social engagement

*The AR system utilizes: Visual Cues, Audio Cues, Haptic Cues

I1



J1



STUDIES

Figure 4.3.7 ▲
I1 adds a creative element by giving users the ability to create and manipulate an AR nature scene that helps summarize what has been learned. They can then capture good and bad elements of their experience to share with friends.

J1 records learning in a poster series users can virtually store, share, and collect on their wall for motivation.

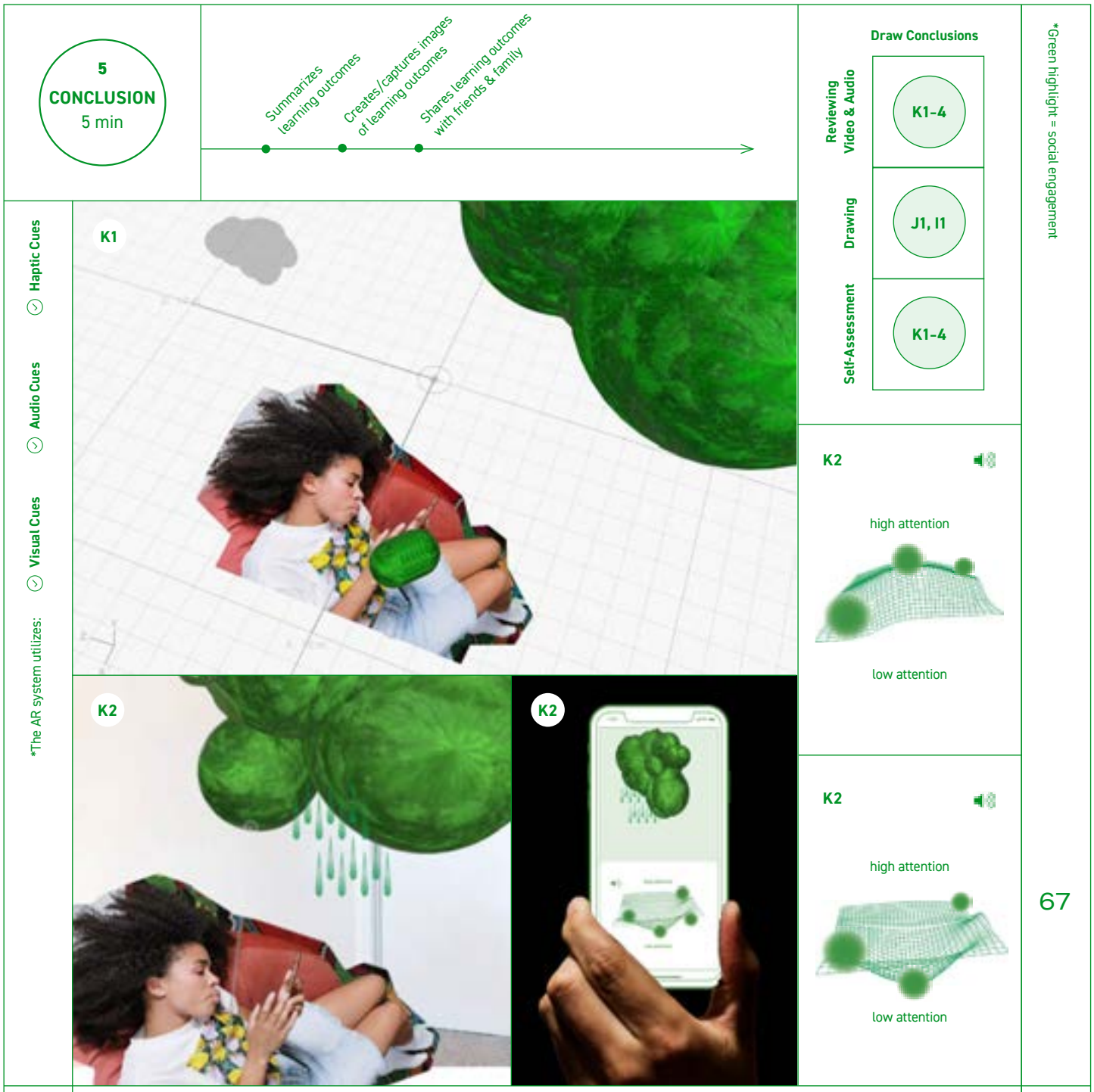


Figure 4.3.8 ▲
Explorations K1–K4 implement the strategy of visual metaphor as a way to present, review, compare, and assess complex data.

K1 gives users an overview of their captured data so far in the form of a malleable and responsive thought bubble. *college.design.ncsu.edu/thenfinally/pierce/study3-k1.mp4*

K2 looks at how users might access their data (imagery, feelings, sound etc.) and manipulate it through a "thought bubble" in real-time. The more experiences users have in a single place, the larger and more visually complex their bubbles become. If the user chooses to visit a new destination, a new "thought bubble" will form and can be cultivated with new insight and encounters. *college.design.ncsu.edu/thenfinally/pierce/study3-k2-1.mp4*

college.design.ncsu.edu/thenfinally/pierce/study3-k2-2.mp4

5
CONCLUSION
5 min

Summarizes learning outcomes

Creates/captures images of learning outcomes

Shares learning outcomes with friends & family

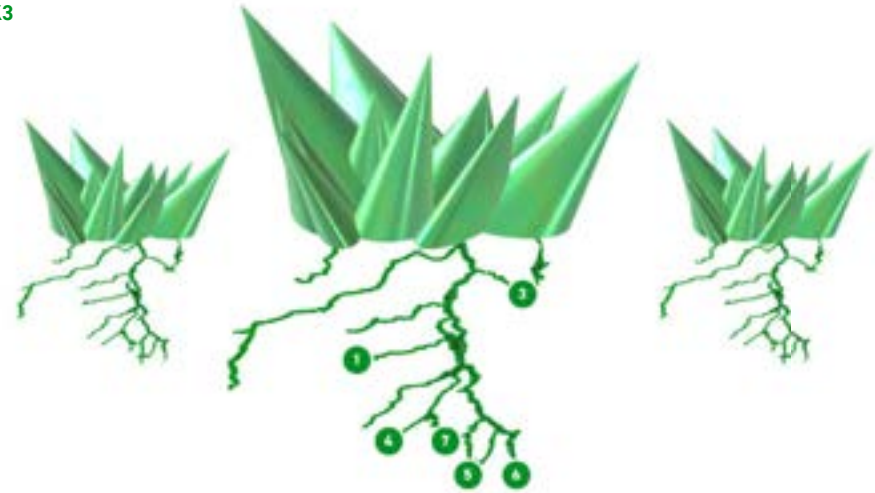
Draw Conclusions

Reviewing Video & Audio	K1-4
Drawing	J1, I1
Self-Assessment	K1-4

*Green highlight = social engagement

*The AR system utilizes:
- Visual Cues
- Audio Cues
- Haptic Cues

K3



K4

K4

Figure 4.3.9 ▲
K3 takes a direct approach and relates users' developing relationship with and experiences in the natural world to the growth of a plant. The more positive and meaningful encounters users have with nature, the larger and taller the AR plant becomes. Users can trace this growth in real-time to the root system visualized below where experiences and details of the experience are stored in a branched pattern. Each experience is shown in relation to the next, allowing for further reflection. Finally, the tracking of experiences in this form helps users visualize opportunities for further exploration.

K4 encapsulates this idea of the garden as a metaphor for life and when creating a garden one needs to consider the aspects that help make it grow. Here each flower represents an experience at a particular location from the surrounding community of users. This visualization and tracking of progress helps users review their own nature experiences, compare their experiences with others, and collect and build on those experiences. To dive deeper into the events, users are able to interact directly with the AR flowers and preview the visual specimens and thoughts captured at that particular location. *college.design.ncsu.edu/thenfinally/pierce/study3-k4.gif*

Visual Metaphor
A visual representation of a person, place, thing, or idea that points to particular similarities between them. A visual metaphor uses an image rather than words to make the comparison.

6
ACTION PLAN
5 min

Reviews the map & plans next park visit

Adds reminders & picks new locations to explore

Invites friends & family to join

Next nature experience

Create a Plan

Checklists & Questionaires

L1-3

*The AR system utilizes:

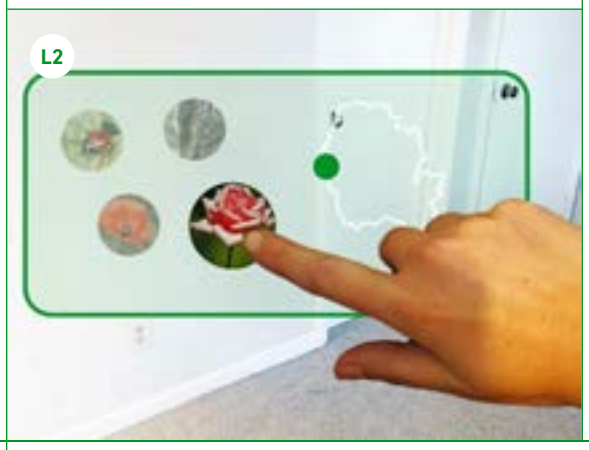
Visual Cues

Audio Cues

Haptic Cues

L1

L2



L3

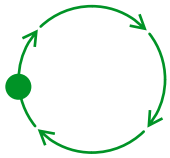
Figure 4.3.10 ▲
L1 gives users the option to quickly preview a path, preselect areas to explore, add reminders, and invite friends and family to join virtually. In addition, based on the individual's collected data and the data gathered from other users' experiences, the app will also recommend routes and site specific encounters for their next outing.

L2 shows how users might quickly preview and build a new path inside the home utilizing the AR overlay feature. It is as if users are planting the seeds for their next attention restoration nature-based experience.

L3 comes back to the idea of the garden as a way to compare and reflect on one's experiences within a community of users. By physically picking and choosing a flower, the AR system becomes a tool for planning their next experience. There is less emphasis placed on the details of planning and more placed on the moments and encounters users want to explore further.

4.4. INCREASING PERCEPTION OF MASTERY IN THE ACTIVE EXPERIMENTATION PHASE DURING THE NATURE EXPERIENCE

SQ 04



ACTIVE EXPERIMENTATION PHASE

How can a responsive AR *in-situ* and in-view overlay information delivery system during the nature experience facilitate embodied and instructive encounters to increase perceptions of mastery?

Figure 4.4.0 ▲
Study 4 takes place on day seven and day 30 of the 60 day prescription during the active experimentation phase.

Responsive Interactions
The response of an augmented environment to a user's direct interaction.

Embodied
To give tangible or visible form to an idea, quality, or feeling.

As Ann sets out to achieve the goals of her prescription towards a healthier lifestyle, she will need to build upon her nature therapy skills and be reassured of her progress throughout her outdoor experience. In this final study I look at how a responsive AR *in-situ* and in-view overlay information delivery system—during the nature experience—might facilitate embodied and instructive encounters that increase perception of mastery in nature therapy practices. More specifically, I continue to explore different AR and social engagement strategies that in addition to guiding the user, help test new skills, deliver positive feedback, and display progress to illustrate one's competence over time. As learning progresses and the user transitions from novice to expert (see Table 4.4.0 for specific characteristics on p. 72), considerations around the level of visual instruction and guidance necessary throughout become central to this study. Thus, explorations are compared across day seven and day 30 of the user's journey (see investigation matrix–Figure 4.4.1 on p. 72).

Finally, to narrow the scope of my study, I decided to address only the moments during the nature experience that allow sufficient time and attention to be spent on one's device. Thus, AR facilitated moments will occur during the previously identified stages at various distances from the target of interest: distant observation, find target, and close observation (see Figure 4.4.2 on p. 73). To assess the effectiveness of these explorations, I again draw on nature therapy practices and what has been gleaned from past studies. In general, any design solution should promote both a somatic and sensory learning environment while providing opportunities for users to practice their learning and progress in their skills.

NOVICE USER	+ Unfamiliar with learning environment + Needs more hand holding, guidance, and explicit instruction + Extrinsically motivated + Follows and attempts to conform to rules + Needs appropriate feedback + Likes information to be presented in a straightforward manner + Likes learning in context + Needs help to discriminate among features of situations
EXPERT USER	+ Familiar with learning environment + Likes covert and implicit instruction + Seeks spontaneous and serendipitous learning opportunities + No longer needs rules, guidelines, or principles. + Enjoys novel situations + Has responsibility for self, others, and the environment + Likes learning centered around discovery of new knowledge + Improvement comes from sharing, seeking deep understanding, and being challenged by others + Intrinsically motivated

Table 4.4.0 ▲
Adapted from the article *Moving from Novice to Expertise and Its Implications for Instruction* by Persky and Robinson (2017).

Figure 4.4.1 ▲
Study 4 investigation matrix. Areas shaded in green explore social engagement strategies.

Figure 4.4.2 ▾
A broad view of the nature experience journey map on day seven and 30 with a focus on stages four through six.

THREE STAGES OF THE NATURE EXPERIENCE

Distant Observation. During this stage of the nature experience we can begin to see how the AR system might function differently depending on one's level of familiarity and motivation—more directly, if the user identifies as novice versus expert. Explorations at this stage will continue to build on the successful attention grabbing techniques and nature therapy activities partially developed in study 1 (see Figures 4.1.4–4.1.10 on pp. 38–44). At this stage I only consider design solutions that leverage social engagement strategies associated with feelings of improved competence over time (see Figures 4.4.3–4.4.8 on pp. 75–80).

Explicit Learning
Learning that requires focused mental attention where the learners are aware that they have learned something and can verbalize what they have learned (Ellis et al., 2009).

Implicit Learning
Where the learner obtains tacit knowledge that does not place any demands on central attention resources. The learning here is intuitive and unconscious (Ellis et al., 2009).

Find Target. In the Find Target stage, two types of users approach the target of interest with the help of the AR overlay system. The novice user will need additional guidance and instruction to locate a target and interpret or respond to findings. Vise versa, the expert user will require more implicit instruction that fosters curiosity and spontaneity. In the following explorations, these considerations along with social engagement strategies will be examined as users progress in their nature therapy practices (see Figures 4.4.9–4.4.11 on pp. 81–83).

Close Observation. Here, in the most attention-directing stage of the nature experience, slight differences can be defined. As novice users seek to apply their learning to the target of interest, expert users will look for more ways to contribute to the larger community of users (see Figures 4.4.12–4.4.13 on pp. 84–85).

OBSERVATIONS

In this study I put an emphasis on fleshing out design possibilities isolated in the previous three studies and compared them across the skill acquisition process of novice and expert learners. As a result, this refinement and comparison activity brought about several revelations. When *in-situ* overlays map emotions, skill assessment, or progress onto natural elements or landscapes, users form a deeper relationship and connection with place. Users not only pay more attention to nature but also begin to tie their own "story" or what they have learned to the land (e.g., E1, E2, G1, G2, H2). Additionally, comparison across user types reveals the importance of cross pollination within the community of users. As novice users build confidence and learn from experts, experts have the opportunity to practice and apply their skills directly—contributing to the broader community of learning.

Again, creating moments and opportunities for reflection during the nature experience is a beneficial process when working towards a healthier lifestyle. In this case, In-action reflection allows users to progress at their own pace and simultaneously increase their time in nature. Both behaviors are important for prescription adherence and success.

Finally, displaying progress *in-situ*, as seen in explorations F1–F2 can create interesting and unexpected discoveries. As users travel along the timeline of images, separations between the real-and digital-world become less defined and aspects of the natural environment become more pronounced. Explorations G1–G2 show the history of interactions in the space and can help bring to light natural rhythms of the park environment and expose one's own relationship to that growth.

Ideally, the social features presented in this study highlight the benefits of sharing, feedback, and comparison with respect to learning skills. Explorations overall that utilized these tactics were most beneficial for novice users becoming familiar with a space and the skills of nature therapy. Experts on the other hand were assisted most when social engagement was implemented as a way to share or reflect on their learning over time. Lastly, overlays that utilized layering and distance to create visual depth, sparked further exploration and curiosity, making each nature experience potentially more engaging than the last.

Figure 4.4.3 ▲
A1 walks novice users through a target preview feature. Tooltips help guide them, and real-time distance reporting helps situate them in place. The overlay display and swiping feature organizes the community captured content from the target area and maps community engagement with the content *in-situ*. The ability to comment on the community content requires users to participate directly with the target, thus motivating them to explore further. *college.design.ncsu.edu/thenfinally/pierce/study4-a1.mp4*

In contrast to A1, exploration A2 gives expert users freedom to comment on any threads at any time. At this point in the journey, expert users have explored the space thoroughly and are now integrated into the larger community of users.

4
DISTANT OBSERVATION
5 min

*Green highlight = social engagement

*The AR system utilizes:
- Visual Cues
- Audio Cues
- Haptic Cues

B1

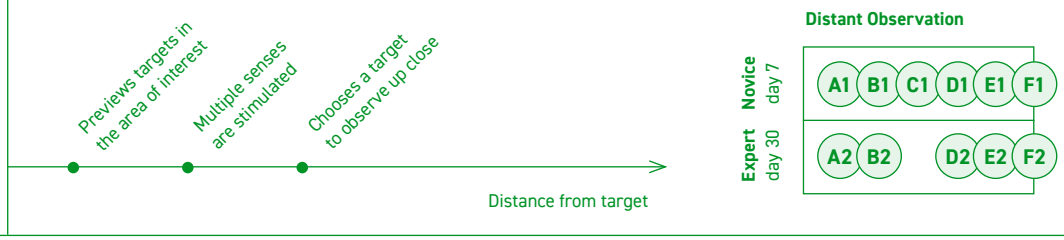
B2

Figure 4.4.4 ▲
This visual illustrates the cross-pollination that occurs between the expert and novice users during their nature prescription process. Exploration B1 and B2 bring the expert and novice users together, allowing their collective knowledge and skills to influence one another.

B2 gives the expert users the power to share their experience with connections and receive real-time feedback from their social network.

B1 builds novice learners' confidence through observation. Expert users demonstrate interactions during the nature experience, while the novice users sit and learn in the comfort of their homes. *college.design.ncsu.edu/thenfinally/pierce/study4-b1.mp4*

4
DISTANT OBSERVATION
5 min



*Green highlight = social engagement

*The AR system utilizes:
- Visual Cues
- Audio Cues
- Haptic Cues

C1

Figure 4.4.5 ▲
C1 gives the user the ability to pick up and collect targets of interest to review later. Novice users are able to examine saved targets more thoroughly on their own time and at their own pace.

4
DISTANT OBSERVATION
5 min

*Green highlight = social engagement

*The AR system utilizes: Visual Cues Audio Cues Haptic Cues

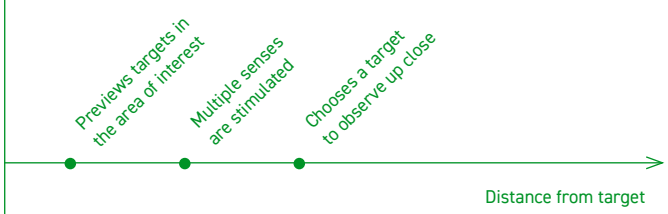
D1

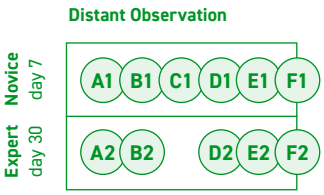
D2

Figure 4.4.6 ▲
D1 looks at navigational support as users narrow in on their target of interest. This progress and guiding feature acts as a handrail for new users who might need more assistance when traveling through a new location. *college.design.ncsu.edu/thenfinally/pierce/study4-d1.mp4*

D2 recognizes expert users might not need navigational assistance, but rather an overview of where they might explore next. *In-situ* and in-view overlays show areas left to be discovered.

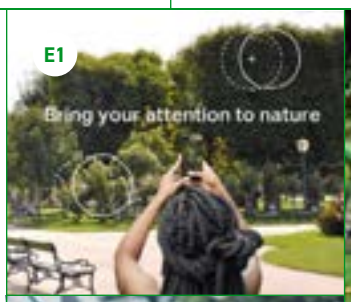
4
DISTANT OBSERVATION
5 min

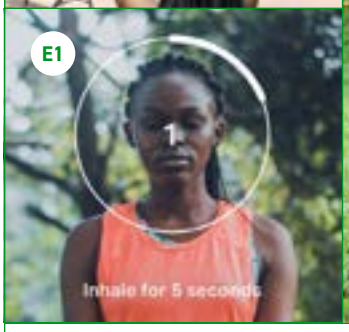




*Green highlight = social engagement

*The AR system utilizes:
- Haptic Cues
- Audio Cues
- Visual Cues





E1

Figure 4.4.7 ▲
E1 looks at skill specific support from the system and how overlays interact with the natural surroundings more directly. During the inhale the user's screen zooms in on the point of attention and zooms out on the exhale.

E1 also looks at a skill specific AR support system that utilizes overlays and prompts to connect users' skill assessment directly to their physical environment. Users are prompted to scan their surroundings and practice noticing areas of interest at different distances and directions along the x, y, and z axis.

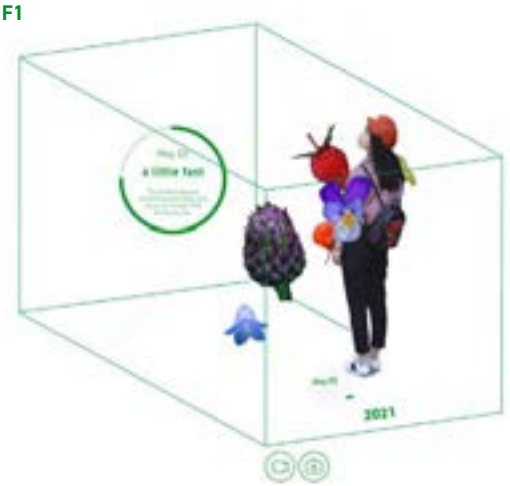
E2 visualizes an expert user's breathing data and maps it to the environment or landscape.

4
DISTANT OBSERVATION
5 min

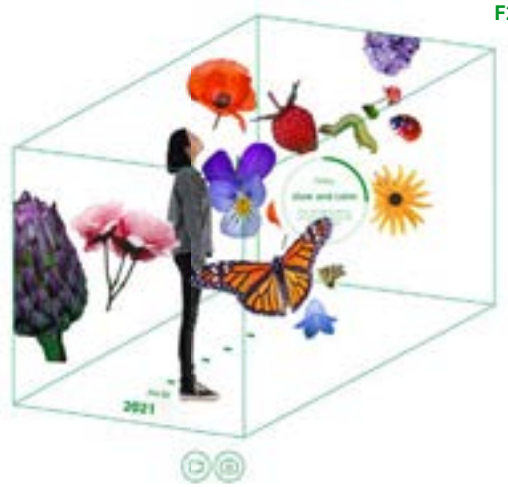
*Green highlight = social engagement

*The AR system utilizes:
- Haptic Cues
- Audio Cues
- Visual Cues

F1



F2



F1

F2

Figure 4.4.8 ▲
This visual illustrates the accumulation of experiences over time. The system prompts users with new insights to help remind them of what they need to work on. This nonlinear approach to data access within the nature environment supports opportunities for serendipitous encounters or unexpected discoveries that users can then capture and share with their friends.

F1 looks at the novice's path towards a healthier lifestyle and provides in the moment insights to help direct user behavior.

F2 shows how experts might view their progress at any time. *college.design.ncsu.edu/thenfinally/pierce/study4-f2-1.mp4*

college.design.ncsu.edu/thenfinally/pierce/study4-f2-2.mp4

college.design.ncsu.edu/thenfinally/pierce/study4-f2-3.mp4

F1

5
FIND TARGET
5 min

*Green highlight = social engagement

*The AR system utilizes:
- Visual Cues
- Audio Cues
- Haptic Cues

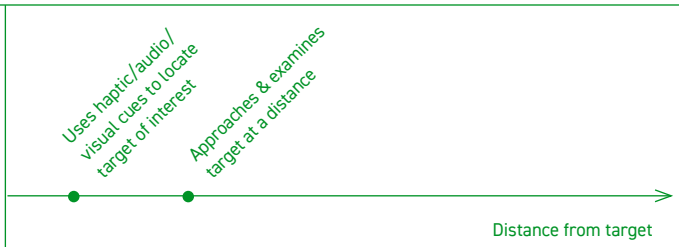
G1

G2

Figure 4.4.9 ▲
G1 visualizes a novice's proximity to a specific target of interest. The blanket like overlay illustrates the spread of interaction at varying distances and exposes areas of interest identified by the community of users.

G2 visualizes the spread of interactions by the expert user in relation to the plant and the community of users in an area over time. This feature is helpful for encouraging return visits to a location and tracking progress against a plant's own unique growth cycle.

5
FIND TARGET
5 min



Find Target

Novice day 7	G1	H1
Expert day 30	G2	H2

*Green highlight = social engagement

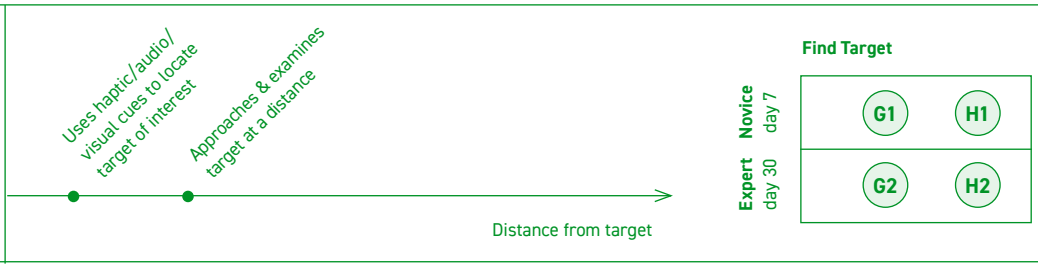
*The AR system utilizes:
- Haptic Cues
- Audio Cues
- Visual Cues

H1

H1

Figure 4.4.10 ▲
H1 helps novice users form more intimate relationships with animals and plants by observing AR supported simulations and community provided observations. *college.design.ncsu.edu/thenfinally/pierce/study4-h1.mp4*

5
FIND TARGET
5 min



*Green highlight = social engagement

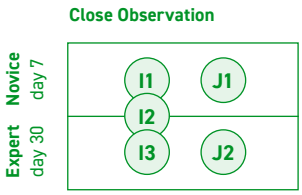
*The AR system utilizes:
- Visual Cues
- Audio Cues
- Haptic Cues

H2

H2

Figure 4.4.11 ▲
H2 gives expert users the ability to create spaces that expand the boundaries of the park. These private or public portals encourage repeat visits and engagement in the area and provide a safe place for open reflection. Here we see how users might use the space like a diary to map and store their feelings directly on nature. Expert users have the ability to share or make private any content they create in the space.

6
CLOSE OBSERVATION
5 min



*Green highlight = social engagement

*The AR system utilizes:
Haptic Cues
Audio Cues
Visual Cues

I1

I2

I2

I3

STUDIES

Figure 4.4.12 ▲
Where the design explorations I1-3 are situated in relation to the close observation stage of the nature experience.

I1-I2 looks at how novices might be first introduced to close observation and allows them to practice their observation skills in real-time. As novices progress in their observational skills, the system introduces more and more tools to assist them in observation. *college.design.ncsu.edu/thenfinally/pierce/study4-i1.mp4*

I2 shows what the toolbar might look like on day one. *college.design.ncsu.edu/thenfinally/pierce/study4-i2.mp4*

I3 shows what an expert toolbar might look like after the user has visited a significant number of targets in the area. *college.design.ncsu.edu/thenfinally/pierce/study4-i3.mp4*

6
CLOSE OBSERVATION
5 min

Takes 5 deep breaths to center attention

Uses filters to amplify senses/plant features

Records findings & pins a target to explore further

At target

Close Observation

Novice day 7	I1	J1
	I2	
Expert day 30	I3	J2

*Green highlight = social engagement

*The AR system utilizes:
- **Visual Cues**
- **Audio Cues**
- **Haptic Cues**

J1

J2

Figure 4.4.13 ▲
J1 allows novice users to track the amount of time they've spent observing a specific plant or object. As time passes the overlayed spiral will slowly move up the plant and is an indicator of progress in meeting observation goals set by the doctor. Social sharing at this level is reserved solely for patients and their doctor(s) and legal guardian(s).

J2 shows what expert users see when they've exceeded their observation time goal recommended by their doctor. The overtime is represented here in green.

05. DISCUSSION

5.1. DESIGN PRINCIPLES

Through extensive exploration and analysis several design principles have surfaced that have potential for further investigation within and outside the field of design.

Consider adaptable and personalized systems.

Build in flexibility to address user limitations related to free time, comfort level, location, and privacy concerns.

An AR system should be flexible when guiding a user through an unfamiliar space. Responsive technology that adapts to user needs and goals in the moment are critical for creating a solid foundation between user and place. As users gain confidence in a learning space, the system should adjust accordingly. The volatile nature of outdoor environments can be tricky to navigate when paired with external requirements or health goals. Thus a system that considers many variables—weather, comfort, familiarity, time, and health—is more likely to sustain consistent user engagement and interest in the subject matter to be learned. There is also more potential to extend one's access to nature therapy when tools continue to stimulate learning inside and outside of the nature environment. Adaptable technology in learning scenarios can thus increase awareness of a space, foster deeper connections, and provide consistent access and openness to learning on the part of the user.

(Studies 1, 2, 3, & 4)

Create emotionally grounded connections

Anchor progress, emotions, thoughts, and stories to the features that make up a landscape.

When providing opportunities for reflection and analysis, consider how the content might be delivered in relation to the subject matter to be learned. In this case it is the elements that make up a landscape. By mapping one's progress, emotions, thoughts, or stories onto the landscape, connections between the person and place begin to form. Users slow down their engagement with the content and begin to see themselves reflected in the landscape, creating a deeper sense of belonging in an unfamiliar environment.

(Studies 1, 2, 3, & 4)

Support expansive and nonlinear paths for exploration

Open the door to possibilities for content exploration and reflection.

A nature centered learning experience should be self-directed. This means learners should be able to make decisions about what content they want to interact with, for how long, and at what distance. Thus AR supported nature therapy solutions that provide deep and broad content visualization and exploration opportunities should be utilized. Not only

will there be an increase in the user's sense of autonomy, but also a spike in curiosity. A nonlinear presentation of information can also remind users that their feelings and progress are not always linear, especially when experienced in an unfamiliar setting.

(Studies 1, 2, 3, & 4)

Transform complex information

In moments of reflection, deliver complex information in abstracted and unstructured forms.

Creativity and curiosity can be enhanced when complex information is presented in an abstract and unstructured form. With more freedom to explore ideas and concepts from different angles, AR that is abstract inspires more imaginative realizations during the reflective phase of the learning process. As a result, users become more comfortable with difficult concepts and ideas related to the learning subject and their feelings associated with it. In general, an unstructured system allows for more autonomous engagement. Users are able to place and organize elements for comparison freely in space and establish a greater sense of control in an unfamiliar environment.

(Studies 1, 2, 3, & 4)

Blur the lines between the digital and physical

Draw visual and interactive inspiration from the physical environment to collapse virtual and physical divides within the learning environment.

Realism and immersion in a space can be greatly enhanced by highlighting and emulating the elements that make up the space. The replication of form, sound, and motion allow for more accurate recall of events, lowers the cognitive load when transitioning from a virtual reality to a physical place, and reinforces one's recognition and connection to elements during periods of observation. The incorporation of these sense-grounding and transitional overlays not only blurs the lines between the digital and physical world but helps ease users into unfamiliar learning environments.

(Studies 1, 2, 3, & 4)

Improve learning and adherence with shared communication

Provide opportunities for collaboration and cross communication to support community learning and growth.

As a user becomes acquainted with a learning environment, social engagement interventions are essential for initiating learning and building upon that learning. The data tracked and the content contributed by the community of users can act as a handrail and encourage engagement and participation in new experiences. Likewise, individuals in reflective or active stages of their learning can discover moments of comparison inside and outside of the learning experience. This open exchange of ideas lowers the barriers to entry and gives the appearance of being "known" in a space. Likewise, when individuals see that their behavior adds value to a social

space, they are more motivated to engage in the larger learning environment for an extended period.

(Studies 1, 2, 3, & 4)

Promote moments of digital disconnection

For users to achieve the full restorative benefits of nature, digital solutions must draw attention away from one's device for extended periods of time.

With the goal of nature therapy programs being primarily to improve one's overall sense of well-being, the more time individuals have away from their mobile devices the better. However, if the choice is between staying inside and going outside with the assistance of technology, the latter is a healthier choice. Thus, in digitally supported nature therapy experiences, designing for moments off screen will be critical to one's health and to reaching one's prescriptive goals of spending more meaningful time outside.

(Study 1 & 2)

5.2. FUTURE WORK

The principles outlined in this investigation seem reliable in the context of a park and nature therapy situated learning environment. However, for principles to be applied more broadly and outside the limitations of this project, more research and testing is required.

User testing. A next step to this research study is user testing. A study with subjects could quickly establish whether certain AR overlay techniques and community engagement applications help or hinder the nature of the learning experience and its associated benefits. The delicate balance between nature and technology is one that must be closely considered as minimal health benefits will be possible from outdoor experiences if users are overly distracted by a digital interface.

Professional Input. Partnering with experts in the education-and social science-based fields could be helpful in validating key findings from this study. For instance, a diverse researcher team could look for answers to the following: If AR and social engagement features are combined appropriately within a supported learning environment, can meaningful relationships with nature form and cement positive behaviors in the outdoors? What is the ideal amount of time for a user to engage in a nature therapy experience when using a mobile device to help guide their experience? In the long-term, do reflective, social, and participatory moments outside of the nature experience contribute to one's overall well-being or diminish it? Are there certain age groups that might respond better to this intervention than others? Do participants develop pro-environmental attitudes as a result of this technology supported intervention?

The Network of Users. Due to the limited scope of this study, I was unable to adequately address the needs and impact of the network of users involved in a Park Rx prescription. In the future it will be helpful to look at each user group individually to understand where and how they might be involved in each adolescent's journey towards a healthier lifestyle.

+ ***Legal Guardians.*** Adolescents present some unique considerations when it comes to their health and families. Because they are not yet adults, they will need support and consent from their parents or legal guardians to participate in any Park Rx program prescribed by the doctor. Understanding where and when parents need to have access to the AR intervention to alleviate any concerns they might have will be essential for establishing healthy behavior inside and outside of the home. In addition, finding ways for parents to participate in their child's progress could be key to motivating some adolescents to achieve their health goals. An outcome worth exploring would be to determine if a family member's motivation to go outside and interact with nature also increases despite their peripheral relationship to the adolescent's nature experience.

+ ***Practitioner.*** A doctor represents an important role in the prescription process. As an advocate for the patient's health, doctors will need to have a way to evaluate and measure patient progress over time and a prescription's overall effectiveness. Thus, understanding what vital signs to measure and how that information should be delivered to the doctor will be an important next step. Other considerations include privacy control and ways for doctors to adjust or respond to the data to help their patients meet desired health outcomes.

+ ***Insurance Companies and Community Organizations.*** Insurance company promotion and community organization support is an important aspect not currently addressed by this study. Although doctors can prescribe a Park Rx prescription, insurance companies and community organizations are the ones that are going to be the change agents within the larger healthcare industry. Giving these groups access to the data associated with this app will be vital for their long term support and funding. Without this data, judgments around the program's effectiveness cannot be determined and will ultimately hinder nationwide integration of these AR nature therapy tools.

Outside of the Park Environment. There is potential within this system to extend beyond the park and home environment. Scenarios that look outside of the comfort of one's own backyard or park could be explored. Understanding how the system might adapt to larger or more remote natural environments could be helpful for maintaining patient interest and participation in the outdoors long after their prescription has been filled.

Prototyping for Augmented Environments. This study has proved challenging when attempting to create and present visual explorations for discussion and analysis. Due to the 3D nature of AR, presenting ideas in a 2D environment requires finesse and creativity. In my final study I was able to mock up a box-like structure to help define the space that my graphics would inhabit in the real world. This visualization strategy helped me better articulate the relationships between the user, device, and augmented overlays and provided me with ideas on how designers might work with AR in the future. Thus, moving forward there is potential here to come up with more concrete guidelines for designers to use when designing with AR to increase the efficiency of the overall design process.

5.3. CONCLUSION

In the face of a global mental health crisis, tools that support connections to nature will be key to one's overall emotional and physical well-being. Alongside the Park Rx movement, immersive technology has the potential to reverse the current trend towards disconnection and instill pro-environmentalist behavior. When used within a community of users, AR technology can facilitate meaningful engagement and relatedness with nature and redefine who restorative nature experiences are for. While only a fraction of possible applications for this technology were explored, findings suggest a promising future where technology, health, and nature intersect—leading to healthier lives for all.

06. REFERENCES

Abraham, A., Sommerhalder, K., & Abel, T. (2009). Landscape and well-being: A scoping study on the health-promoting impact of outdoor environments. *International Journal of Public Health*, 55(1), 59–69.

Arbuthnott, K. D., & Sutter, G. C. (2019). Songwriting for nature: Increasing nature connection and well-being through musical creativity. *Environmental Education Research*, 25(9), 1300–1318.

Attention restoration therapy and stress. Welcome to CAREpath™ Inc. (2019, July 17). https://www.carepath.ca/attention-restoration-therapy-and-stress/.

Ball, K., Bauman, A., Leslie, E. & Owen, N. (2001). Perceived environmental aesthetics and convenience and company are associated with walking for exercise among australian adults. *Preventive Medicine* 33.5: 434–40. Print.

Barreau, D. (1993). Realism vs. abstraction. http://www.hitl.washington.edu/projects/knowledge_base/virtual-worlds/EVE/III.C.2.RealismAbstraction.html.

Barreiros, C., Veas, E., & Pammer, V. (2018). Bringing nature into our lives: Lecture Notes in Computer Science Human-Computer Interaction. *Interaction in Context*, 99–109.

Beate, A., Snep, R., Hauck, T., Ferguson, J., Holy, M., Jakoby, C., Macivor, S., Schär, L., Taylor, M., & Weisser, W. (2020). Designing wildlife-inclusive cities that support human-animal co-existence. *Landscape and Urban Planning 200*: 103817. Print.

Bento, G., & Costa, J. A. (2018). Outdoor play as a mean to achieve educational goals-a case study in a Portuguese day-care group. *Journal of Adventure Education and Outdoor Learning*, 18(4), 289–302.

Berg, S., Bradford, B., Barrett, J., Robinson, D. B., Camara, F., & Perry, T. (2020). Meaning-making of student experiences during outdoor exploration time. *Journal of Adventure Education and Outdoor Learning*, 1–12.

Bragg, R. & Leck, C. (2017). Good practice in social prescribing for mental health: The role of nature-based interventions. *Natural England Commissioned Reports*, 228.

Browning, M. H. E. M., Shipley, N., Mcanirlin, O., Becker, D., Yu, C.-P., Hartig, T., & Dzhambov, A. M. (2020). An actual natural setting improves mood better than its virtual counterpart: A meta-analysis of experimental data. *Frontiers in Psychology*, 11.

Byrne, J., & Wolch, J. (2009). Nature, race, and parks: Past research and future directions for geographic research. *Progress in Human Geography* 33.6: 743–65. Print.

Chang, C.-C., Cheng, G. J. Y., Nghiem, T. P. L., Song, X. P., Oh, R. R. Y., Richards, D. R., & Carrasco, L. R. (2020). Social media, nature, and life satisfaction: Global evidence of the biophilia hypothesis. *Scientific Reports*, 10(1).

Chang, D. (2020). Encounters with suchness: Contemplative wonder in environmental education. *Environmental Education Research*, 26(1), 1–13.

Chang, N. (2012). The role of drawing in young children's construction of science concepts. *Early Childhood Education Journal*, 40(3), 187–193.

Colléony, A., White, R., & Shwartz, A. (2019). The influence of spending time outside on experience of nature and environmental attitudes. *Landscape and Urban Planning*, 187, 96–104.

Cudworth, D. (2020). Promoting an emotional connection to nature and other animals via forest school: Disrupting the spaces of neoliberal performativity. *International Journal of Sociology and Social Policy*, ahead-of-print.

Delavari-Edalat, F., & Abdi, M. R. (2010). Human-environment interactions based on biophilia values in an urban context: Case study. *Journal of Urban Planning and Development*, 136(2), 162–168.

Dinand, E., & Vries, S. (2017). Nearby green space and human health: Evaluating accessibility metrics. *Landscape and Urban Planning 157*. 214–20. Print.

Dunkley, R. A. (2016). Learning at eco-attractions: Exploring the bifurcation of nature and culture through experiential environmental education. *The Journal of Environmental Education*, 47(3), 213–221.

Dunne, J. H. (2018). Experiencing the outdoors: Embodied encounters in the Outward Bound Trust. *The Geographical Journal*, 185(3), 279–291.

Dzhambov, A. M., Hartig, T., Tilov, B., Atanasova, V., Makakova, D. R., & Dimitrova, D. D. (2019). Residential greenspace is associated with mental health via intertwined capacity-building and capacity-restoring pathways. *Environmental Research*, 178, 108708.

Ellis, R., Elder, C., & Loewen, S. (2009). Chapter 1: Implicit and explicit learning, knowledge and instruction. In Implicit and explicit knowledge in second language learning, testing and teaching essay. *Multilingual Matters*, 3–25.

Evans, G., & Ferguson, K. (2011). Built environment and mental health. *Encyclopedia of Environmental Health*. 446–49. Print.

Fisher, B., & Grima, N. (2020). The importance of urban natural areas and urban ecosystem services during the COVID-19 pandemic. *PLOS One*.

Gabbiadini, A., Sagioglou, C., & Greitemeyer, T. (2018). Does Pokémon Go lead to a more physically active life style?. *Computers in Human Behavior*. 84.

Gascon, M., Sánchez-Benavides, G., Dadvand, P., Martínez, D., Gramunt, N., Gotsens, X., ... Nieuwenhuijsen, M. (2018). Long-term exposure to residential green and blue spaces and anxiety and depression in adults: A cross-sectional study. *Environmental Research*, 162, 231–239.

Gibbs, G. (1988). Learning by doing: A guide to teaching and learning methods. *Oxford Centre for Staff and Learning Development*. 134.

Gifford, R., & Nilsson, A. (2014). Personal and social factors that influence pro-environmental concern and behaviour: A review. *International Journal of Psychology*. 141–157.

Gould, K., & Lewis, T. (2017). Green gentrification: Urban sustainability and the struggle for environmental justice. *London: Routledge*, Print.

Hoare, E., Milton, K., Foster, C., & Allender, S. (2016). The associations between sedentary behaviour and mental health among adolescents: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 13(1).

Hutson, G., Peredun, L., & Rochelle, S. (2019). The impact of NOLS Rocky Mountain on the development of a sense of place. J*ournal of Experiential Education*, 42(4), 382–397.

Huynh, T., & Torquati, J. C. (2018). Outdoor adventure instructors' perceptions of nature and their work: A phenomenological study. *Journal of Adventure Education and Outdoor Learning*, 19(3), 269–282.

Jiang, L., & O'Neill, B. C. (2017). Global urbanization projections for the shared socioeconomic pathways. *Global Environmental Change*, 42, 193–199.

Kabisch, N., & Haase, D. (2014). Green justice or just green? Provision of urban green spaces in Berlin, Germany. *Landscape and Urban Planning*, 122, 129–39. Print.

Kalkofen, D., Mendez, E., & Schmalstieg, D. (2009). Comprehensible visualization for augmented reality. *IEEE Transactions on Visualization and Computer Graphics*, 15(2), 193–204.

Kaplan, R., & Kaplan, S. (1995). The experience of nature: A psychological perspective. *Cambridge: Cambridge UP*, Print.

Kaplan, R. (1985). The analysis of perception via preference: A strategy for studying how the environment is experienced. *Landscape Planning,* 12.2, 161–76. Print.

Kellert, S. (2014). Biophilia and biomimicry: Evolutionary adaptation of human versus nonhuman nature. *Intelligent Buildings International,* 8(2), 51–56.

Kimic, K., Maksymiuk, G., & Suchocka, M. (2019). The application of new technologies in promoting a healthy lifestyle: Selected examples. *Bulletin of Geography. Socio-Economic Series*, 43(43), 121–130.

Kondo, M. C., Oyekanmi, K. O., Gibson, A., South, E. C., Bocarro, J., & Hipp, J. A. (2020). nature prescriptions for health: A review of evidence and research opportunities. *International Journal of Environmental Research and Public Health*, 17(12), 4213.

Leavell, M. A., Leiferman, J. A., Gascon, M., Braddick, F., Gonzalez, J. C., & Litt, J. S. (2019). Nature-based social prescribing in urban settings to improve social connectedness and mental well-being: A review. *Current Environmental Health Reports*, 6(4), 297–308.

Li, X., Chuanrong, Z., Li, W., & Kuzovkina, Y. (2016). Environmental inequities in terms of different types of urban greenery in Hartford, Connecticut. *Urban Forestry & Urban Greening,* 18,163–72. Print.

Lin, M., & Stan, J. T. V. (2020). Impacts of urban landscapes on students' academic performance. *Landscape and Urban Planning*, 201, 103840.

Loughran, K. (2016). Imbricated spaces: The High Line, urban parks, and the cultural meaning of city and nature. *Sociological Theory,* 34.4, 311–34. Print.

Loughran, K. (2020). Urban parks and urban problems: An historical perspective on green space development as a cultural fix. *Urban Studies*, 57.11, 2321–338. Print.

Mcgee, B., & Marshall-Baker, A. (2015). Loving nature from the inside out. *HERD: Health Environments Research & Design Journal*, 8(4), 115–130.

Montag, C., & Elhai, J. D. (2020). Discussing digital technology overuse in children and adolescents during the COVID-19 pandemic and beyond: On the importance of considering affective neuroscience theory. *Addictive Behaviors Reports*, 12, 100313.

Moreland, A., Herlihy, C., Tynan, M. A., Sunshine, G., Mccord, R. F., Hilton, C., ... Popoola, A. (2020). Timing of state and territorial COVID-19 stay-at-home orders and changes in population movement: United States, March 1–May 31, 2020. *MMWR. Morbidity and Mortality Weekly Report*, 69(35), 1198–1203.

Nisbet, E. K., Zelenski, J. M., & Murphy, S. A. (2010). Happiness is in our nature: Exploring nature relatedness as a contributor to subjective well-being. *Journal of Happiness Studies*, 12(2), 303–322.

Nunez, K. (2020, September 10). Guided imagery: How to and benefits for sleep, anxiety, more. *Healthline*. https://www.healthline.com/health/guided-imagery.

Nyberg, E., & Sanders, D. (2013). Drawing attention to the 'green side of life.' *Journal of Biological Education*, 48(3), 142–153.

Oleksy, T., & Wnuk, A. (2017). Catch them all and increase your place attachment! The role of location-based augmented reality games in changing people-place relations. *Computers in Human Behavior*, 76, 3–8.

Olivos-Jara, P., Segura-Fernández, R., Rubio-Pérez, C., & Felipe-García, B. (2020). Biophilia and biophobia as emotional attribution to nature in children of 5 years old. *Frontiers in Psychology*, 11.

Park Rx America. (2020). https://parkrxamerica.org/about.php

Park, Y., & Guldmann, J-M. (2020). Understanding disparities in community green accessibility under alternative green measures: A metropolitan-wide analysis of Columbus, Ohio, and Atlanta, Georgia. *Landscape and Urban Planning* 200: 103806. Print.

Peen, J., Schoevers, R.A., Beekman, A.T., & Dekker, J., 2010. The current status of urban rural differences in psychiatric disorders. *Acta Psychiatr. Scand.* 121 (2), 84–93.

Pericak, A. A., Thomas, C. J., Kroodsma, D. A., Wasson, M. F., Ross, M. R., Clinton, N. E., . . . Amos, J. F. (2018). Mapping the yearly extent of surface coal mining in Central Appalachia using Landsat and Google Earth Engine. *PLOS One*, 13(7).

Persky, A. M., & Robinson, J. D. (2017). Moving from novice to expertise and its implications for instruction. *American Journal of Pharmaceutical Education*, 81(9), 6065.

Prabowo, H., & Dewi, M. P. (2017). City face to face with nature.

Razani, N., Hills, N. K., Thompson, D., & Rutherford, G. W. (2020). The association of knowledge, attitudes and access with park use before and after a park-prescription intervention for low-income families. *U.S. International Journal of Environmental Research and Public Health*, 17(3), 701.

Renner, P., & Pfeiffer, T. (2017). Attention guiding techniques using peripheral vision and eye tracking for feedback in augmented-reality-based assistance systems. *2017 IEEE Symposium on 3D User Interfaces (3DUI)*.

Renner, P., & Pfeiffer, T. (2018). Attention guiding using augmented reality in complex environments. *2018 IEEE Conference on Virtual Reality and 3D User Interfaces (VR).*

Rice, W. L., Mateer, T. J., Reigner, N., Newman, P., Lawhon, B., & Taff, B. D. (2020). Changes in recreational behaviors of outdoor enthusiasts during the COVID-19 pandemic: Analysis across urban and rural communities. *Journal of Urban Ecology*, 6(1).

Rigolon, A. (2016). A Complex landscape of inequity in access to urban parks: A literature review. *Landscape and Urban Planning* 153: 160–69.

Robinson, J. M., Jorgensen A., Cameron R., Brindley P. (2020). Let nature be thy medicine: A socioecological exploration of green prescribing in the UK. *Int. J. Environ. Res. Public Health*, 17(10), 3460.

Rock, M. J., Degeling, C., Graham, T. M., Toohey, A. M., Rault, D., & Mccormack, G. R. (2016). Public engagement and community participation in governing urban parks: A case study in changing and implementing a policy addressing off-leash dogs. *Critical Public Health*, 26(5), 588–601.

Rosa, C. D., & Collado, S. (2019). Enhancing nature conservation and health: Changing the focus to active pro-environmental behaviours. *Psychological Studies*, 65(1), 9–15.

Ruchter, M., Klar, B., & Geiger, W. (2010). Comparing the effects of mobile computers and traditional approaches in environmental education. *Computers & Education,* 54(4), 1054–1067.

Russell, R., Guerry, A. D., Balvanera, P., Gould, R. K., Basurto, X., Chan, K. M., ... Tam, J. (2013). Humans and nature: How knowing and experiencing nature affect well-being. *Annual Review of Environment and Resources*, 38(1), 473–502.

Sefcik, J. S., Kondo, M. C., Klusaritz, H., Sarantschin, E., Solomon, S., Roepke, A., ... Jacoby, S. F. (2019). Perceptions of nature and access to green space in four urban neighborhoods. *International Journal of Environmental Research and Public Health,* 16(13), 2313.

Shanahan, D. F., Astell–Burt, T., Barber, E. A., Brymer, E., Cox, D. T., Dean, J., ... Gaston, K. J. (2019). Nature–based interventions for improving health and well-being: The purpose, the people and the outcomes. *Sports*, 7(6), 141.

Sreetheran, Maruthaveeran, & Cecil C. Konijnendijk Van Den Bosch. (2014). A socio-ecological exploration of fear of crime in urban green spaces: A systematic review. *Urban Forestry & Urban Greening,* 13.1, 1–18.

Stairs, D. (1997). Biophilia and technophilia: Examining the nature/culture split in design theory. *Design Issues*, 13(3), 37.

Stone, E. A., & Roberts, J. D. (2020). Park spaces and the user experience. *Nature and Culture*, 15(2), 123–133.

Sussman, A., & Hollander, J. (2015). cognitive architecture: Designing for how we respond to the built environment. *New York: Routledge*, Print.

Tamber-Rosenau, B. J., & Marois, R. (2016). Central attention is serial, but midlevel and peripheral attention are parallel: A hypothesis. *Attention, Perception & Psychophysics*, 78(7), 1874–1888.

The practice of forest therapy. *Nature and Forest Therapy Guides*. https://www.nature-andforesttherapy.org/about/the-practice-of-forest-therapy.

Torre, J. A.-D. L., Puigdomenech, E., García, X., Valderas, J. M., Eiroa-Orosa, F. J., Fernández-Villa, T., ... Espallargues, M. (2020). Relationship between depression and the use of mobile technologies and social media among adolescents: Umbrella review. *Journal of Medical Internet Research*, 22(8).

Totaforti, S. (2020). Emerging biophilic urbanism: The value of the human–nature relationship in the urban space. *Sustainability*, 12(13), 5487.

Unger, S., Rollins, M., Tietz, A., & Dumais, H. (2020). INaturalist as an engaging tool for identifying organisms in outdoor activities. *Journal of Biological Education*, 1-11.

Vries, S., Dillen, S., Groenewegen, P., & Spreeuwenberg, P. (2013). Streetscape greenery and health: Stress, social cohesion and physical activity as mediators. *Social Science & Medicine,* 94, 26–33. Print.

White, R. L., Eberstein, K., & Scott, D. M. (2018). Birds in the playground: Evaluating the effectiveness of an urban environmental education project in enhancing school children's awareness, knowledge and attitudes towards local wildlife. *PLOS One*, 13(3).

World Health Organization. (2020, September 28). Adolescent mental health. *World Health Organization*. https://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health.

WHO. (2016). Urban green spaces and health. *WHO Regional Office for Europe, Copenhagen.*

Zarr, R., & Henderson, J. (2020). Nature prescribed. *Park Rx America*. https://www.parkrxamerica.org/.

Zijlema, W., Triguero-Mas M., Smith, G., Cirach, M., Martinez, D., ... Julvez, J. (2017). The Relationship between natural outdoor environments and cognitive functioning and its mediators. *Environmental Research*, 155, 268–75. Print.