The Motivational Home:

Designing Smart Home Service Provisions for Human Flourishing

by

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A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Approved April 2013 by the
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ARIZONA STATE UNIVERSITY

May 2013

ABSTRACT

This dissertation explores the role of smart home service provisions (SHSP) as motivational agents supporting goal attainment and human flourishing. Evoking human flourishing as a lens for interaction encapsulates issues of wellbeing, adaptation and problem solving within the context of social interaction.

To investigate this line of research a new, motivation-sensitive approach to design was implemented. This approach combined psychometric analysis from motivational psychology's Personal Project Analysis (PPA) and Place Attachment theory's Sense of Place (SoP) analysis to produce project-centered motivational models for environmental congruence. Regression analysis of surveys collected from 150 ($n = 150$) young adults about their homes revealed PPA motivational dimensions had significant main affects on all three SoP factors. Model one indicated PPA dimensions Fearful and Value Congruency predicted the SoP factor Place Attachment ($p = 0.012$). Model two indicated the PPA factor Positive Affect and PPA dimensions Value Congruency, Self Identity and Autonomy predicted Place Identity ($p = .0003$). Model three indicated PPA dimensions Difficulty and Likelihood of Success predicted the SoP factor Place Dependency.

The relationships between motivational PPA dimensions and SoP demonstrated in these models informed creation of a set of motivational design heuristics. These heuristics guided 20 participants ($n = 20$) through co-design of paper prototypes of SHSPs supporting goal attainment and human flourishing. Normative analysis of these paper prototypes fashioned a design framework consisting of the use cases "make with me", "keep me on task" and "improve myself"; the four design principles "time and timing", "guidance and accountability", "project ambiguity" and "positivity mechanisms"; and the seven interaction models "structuring time", "prompt user", "gather resources", "consume content", "create content", "restrict and/or restore access to content" and "share content".

This design framework described and evaluated three technology probes installed in the homes of three participants (n = 3) for field-testing over the course of one week. A priori and post priori samples of psychometric measures were inconclusive in determining if SHSP motivated goal attainment or increased environmental congruency between young adults and their homes.

DEDICATION

To my wife, Joie, my life’s love, my best friend, my anchor, my rock, my hard place and everything in between. This accomplishment is not mine, but ours, made possible by your love, support and, especially, your patience. To my boy, Owen, whose arrival hardened my resolve to complete this work in the hopes that in some small way, it contributes to a better world for him to explore, enjoy and thrive in.

ACKNOWLEDGMENTS

While this document may bare my name in authorship, the endeavors undertaken to complete the research described in these pages could not have been accomplished without my advisor, Dr. Winslow Burleson, my advisory committee, Dr. William Heywood and Dr. Jodi Forlizzi and fellow researchers Jisoo Lee, Justin Rosales and Quintana Carter. I also must thank Dr. Jay Melican, Michael Payne, Dr. Genevieve Bell and Dr. Tony Salvador for allowing time for my dissertation efforts while under their employment, as well as to Dr. Brian Little, for providing mentorship to a student outside of his stewardship.

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INTRODUCTION

This research is motivated by an interest in understanding the ways motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) can play a role in informing the design of interactions between people and their tools in the home. *Motivation* (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) is defined as the interplay between efficacy and self-efficacy that allow people to define, seek out and attain personal goals (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004). *Efficacy* is a person's objective capability to act in response to stimuli (Ormrod 2006), while *self-efficacy* is the perception of a person's capabilities to act in response to environmental stimuli (Ormrod 2006). *Home*, is a valuable environment to situate the exploration of motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) in because it functions as a platform for everyday activities that relate to many types of goals, including the acquisition of new skills (Cooper Marcus 2006; Stokols 1977), the raising of families (Cooper Marcus 2006; Pennartz 1999), maintenance of health and wellness (Cooper Marcus 2006) and, with the rise of work-from-home in professional practice, professional development (Tietze & Musson 2010).

Through the course of this research agenda, a model of Motivation Sensitive Design (MSD) is proposed and assessed through the design and evaluation of smart home service provisions (SHSP) (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) supporting goal attainment of young adults. SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) are a category of ubiquitous computing (Weisner 1991) technologies whereby a network of sensors, modeling and filtering software and digital feedback mechanisms are integrated into the home environment to monitor and respond to the activities of occupants in order to support desired behavioral outcomes. The SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) market is projected to increase dramatically over the next several years, growing from the six million USD valuation sampled in 2011, to approximately 25 million USD by the end of 2014, to five billion USD by the end of 2015 in the US alone (IMS Research 2011). This initial uptake in SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) is projected to focus on energy management, home controls, security and media content delivery, with a transition into more sophisticated roles for SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), such as care taking and domestic activity support, emerging over the next five to 10 years.

The majority of academic research on SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) focus on either home management activities, such as energy control (Allerding & Schmeck 2011; Zhu, Mishra, Irwin, Sharma, Shenoy, & Towsley 2011) and security (Brush, Lee, Mahajan, Agarwal, Saroiu, & Dixon 2011), or on delivering care provisions to disabled populations, such as the very frail elderly (Abowd et al. 2002) and persons living with a variety of disabilities, including Alzheimer's (Lapointe, Bouchard, Bouchard, Potvin, & Bouzouane 2012) dementia (Vogt, Luyten, Van den Bergh, Coninx, & Meier 2012) and autism spectrum disorder (ASD) (Burleson et al. 2012) (Keintz et al. 2008).

Currently, there is an absence of knowledge concerning the value of SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) supporting the behavior of average people related to goal attainment. The absence of knowledge in this area of SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) research is an opportunity to investigate MSD because it requires explicit inquiry into the nature of the relationships between personal goals, human behavior and the built environment, all of which are core constructs for the social ecological perspective this research ascribes to. Additionally, SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) are interesting to interaction design because of their potential to transform the home from a passive container of an occupant's domestic artifacts and activities, into an actor capable of leveraging resources to influence activities (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), thereby enabling novel interactions.

This study focuses on the relationship between young adults and their homes because, as a population, young adults often have a wide variety of personal goals they are trying to accomplish as they establish an identity as an adult separate from their parents, seek out life mates, establish careers and engage in the process of home making (Erickson 1994). This richness of activity produces a wide breadth of personal goals within the young adult community, providing a rich space for exploring motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) as a design object.

This research agenda conducted three studies to explore the MSD for SHSPs. Each of these three studies represents an iteration of prototyping. The first study generates a behavioral prototype explaining the motivational relationships between young adults and their homes. This behavioral prototype consists of design heuristics concerning motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) as well as predictive models for evaluating future MSD SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) concepts. This study is significant to HCI because it demonstrates how MSD is a novel approach for situating the design space within human affective, cognitive and conative needs, thereby increasing the human-centeredness of solutions.

The second study implements a participatory design methodology to create paper prototypes of SHSPs. Analysis of these paper prototypes increases the breath of the behavioral model by revealing a comprehensive design framework that includes use cases, design principles, design qualities, positioning diagrams, interaction models and design insights for SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) targeting everyday domestic behavior. This framework is the first of its kind for SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) and supports planning and system development for future solutions in this space.

The third study discusses the production, field implementation and evaluation of three interactive SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) prototypes based on three paper prototypes created from the second study. These interactive prototypes were in developed using the *Game-as-Life, Life-as-Game* (GaLLaG) (Burleson, Ruffenach, Jensen, Bandaru, & Muldner 2009) ubiquitous computing platform (For a full description of GaLLaG [Burleson et al. 2009] technologies, refer to Chapter seven). This study is significant because it tests the value proposition of MSD by evaluating three solutions that were produced using the MSD process. When taken as a whole, these three studies demonstrate a robust, novel theoretical and practical to human-centered design that researchers and developers can wield to build more impactful solutions.

Chapter two describes the epistemological perspective framing this research agenda, as well as core theory and methods from motivational psychology (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) and place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) that construct the core of the MSD approach. Chapter three continues a review of previous work by defining the home environment as dynamic system. Chapter four discusses participatory design and prototyping, while chapter five discusses previous work on SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). Chapter six articulates the MSD conceptual framework. Chapter seven introduces the GaLLaG (Burleson et al. 2009) ubiquitous computing platform for user tailored SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). Chapter eight demonstrates the use of the MSD framework to produce design heuristics and predictive models for concept evaluation. Chapter nine illustrates the use of the MSD heuristics to scaffold participatory design of SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier

2011) paper prototypes that results in design framework and user cases. Chapter 10 shares the stories of thee SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) interactive prototypes that were field-tested and evaluated in the homes of end users. Chapter 11 concludes this dissertation with a discussion on the impact of MSD and motivation-centric SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) may have the field of HCI, as well as opportunities for future work.

Chapter 2

MOTIVATION: A SOCIAL ECOLOGICAL PERSPECTIVE

This chapter reviews theory and previous work related to this research agenda. It begins with a brief explanation of social ecology (Bailey 1996), the epistemological perspective underpinning the agendas approach and methodology. After grounding the agenda in social ecology, constructs and related work concerning motivational psychology (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) and place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) are discussed. This section concludes with an account of theory and previous work on participatory design and prototyping.

Social Ecology

As research domains that investigate the various dimensions of people's interaction with their environment, motivational psychology, place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) and participatory design fall under the social ecological epistemological perspective. Social ecology is a constructivist perspective that explains the emergence of a society as a bi-directional feedback loop between a population and its environment (Bailey 1996). Bailey defines a society as a:

> "Concrete social system consisting of a population bounded by societal or political boundaries. This society, in addition to its population size, possesses a certain culture, including language, religious beliefs, political ideology, etc. In addition, it possesses a given level of material culture comprising its technologies (or 'artifacts')," (1996).

The bi-directional feedback loop refers to the impacts a population has on its environment and it's associated resources and conversely, how those environmental impacts present new environmental constraints that a population must adapt to (Bailey 1996).

While the general idea of a system is defined as differentiated parts that impact one another to produce a unified structure, the actual definition of a system is ambiguous (Bailey 1996). System's theory founders viewed a system's environment as separate from the system (Bailey 1996). This assumption led to systems theory researchers either defining systems as "closed" or "open" (Bailey 1996). Closed systems are self-contained, lacking the ability to receive and respond to information flows from other systems (Bailey 1996). Open systems possess porous borders that allow for external information to enter and potentially change the internal structure of the system (Bailey 1996). However, autopoietic theorists smudge the lines of these early didactic system definitions through the observation of systems that are internally "closed", but are open to external information channels, such as the environment (Bailey 1996).

The following sections define social ecological constructions related to motivational psychology, including *motivation* (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004)*, affect* and *human flourishing (HF)* (Fredrickson 2002; Little et al. 2007; Seligman 2004), culminating with a social ecological model of personality (Little *et al.* 2007).

Motivation, Positivity and Human Flourishing

MSD proposes that by focusing on motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) as a subject of design, designers can produce experiences that directly address user needs and persuade users to engage in experiences to flourish. This section operationally defines constructs associated with this proposition, beginning with *motivation* (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004) and followed by *affect* (Fredrickson

2002; Seligman 2004)*, positivity* (Fredrickson 2002; Seligman 2004)*, HF* (Fredrickson 2002; Little et al. 2007; Seligman 2004) and *Personal Action Construct* (Little *et al.* 2007) theory.

Simply stated, motivation is the reasons why a person behaves a certain way (Ormrod 2006; Seligman 2004). The psychological literature on motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) defines it as the tension between efficacy (Ormrod 2006) (Seligman 2004) and self-efficacy. *Efficacy* refers to a person's actual capabilities to cause an effect (Ormrod 2006) (Seligman 2004). *Self-efficacy* refers to a person's *perception* of capabilities to achieve personal goals (Ormrod 2006; Seligman 2004). Efficacy is objective or as objective as imperfect, external scientific tools can measure), while self-efficacy is subjective, or based on the doer's belief (Ormrod 2006). Both efficacy and self-efficacy include a process of alignment during which a doer engages in a dialogue with the environment to assess internal capabilities and access to external resources against environmental constraints in order to formulate a *motivation* (Fredrickson 2002; Peterson 2007; Seligman 2004). Synonyms for motivation (Fredrickson 2002; Little Salmela-Aro & Phillips 2007; Peterson 2007; Seligman 2004) within psychology include the terms *goal* and *object* (Bødker & Bøgh 2005; Kaptelinin & Nardi 2009). The initial motivation to act takes place through a person's belief in the combination of her skills and available resources to achieve the goal. As the person's actions lead closer and closer towards goal attainment, the belief in one's capabilities is validated, thus sustaining motivation and approach to achieve the goal.

Motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) serves as the central construct for this feedback loop, both initiating self-reflection on one's personal capabilities to produce belief and sustaining action as an outcome to achieve. Dr. Brian Little further articulates this process with the concept of a *projec*t as a plan of actions instantiated to achieve a goal through utilization of personal capabilities to manipulation of environmental constraints (2007). Figure one presents a conceptual model describing the relationships between self-efficacy (Ormrod 2006), efficacy (Ormrod 2006) and motivation (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004).

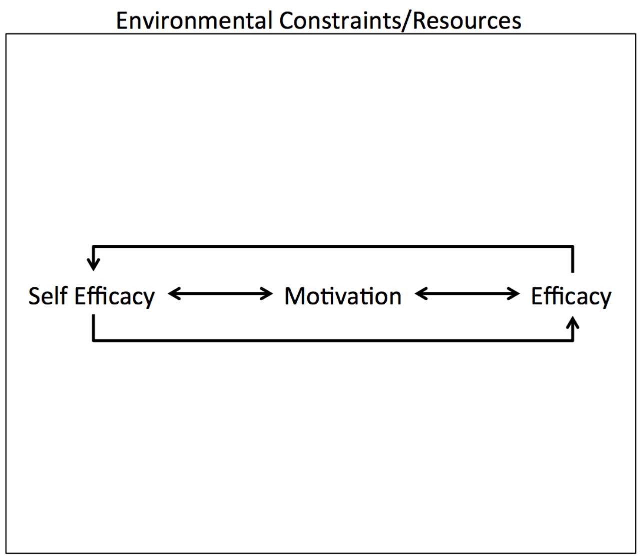


Figure 1. Social ecological model of motivation (Fredrickson 2002).

Affect, a person's overall capacity to feel as defined by emotion, mood and disposition, is a primary cause of motivation patterns. *Emotions* refer to an immediate, short-term (seconds to minutes) response to a stimulus (environmental cue). Emotions serve as one half of an affective-cognitive feedback loop people instinctively engage in to make decisions in response to environmental stimuli. For example, recognition of a predator appearing within a person's visual range triggers the emotion of fear, which in turn, prompts a person to match visual features of the predator to build a cognitive classification – or metaphor – that prompts the response of fleeing. Substitute a potential predator with a potential mate and a positive emotion and different cognitive construct result, which in turn, prompt a person to approach the stimulus (Peterson 2007).

Moods refer to longer, more stable, yet less intense periods (minutes to hours) of emotion that are reliant more on a person's neutral emotional state than an external stimuli. An emotion is to a mood as an external stimulus is to an emotion. This relationship means that when a person emotes in response to an external stimulus, that emotion sways a person's mood. Over time, the person returns to her "natural", or neutral, mood state (Seligman 2004).

A person's "natural" state is their disposition. The disposition is a combination of two macro-variables. The first variable is genetics, which, in alignment with social ecology (Little *et al*. 2007) provides the basis for emotional response and to stimuli during childhood learning. The second variable is historical experience, which is created through consistent exposure to identical or similar environmental stimuli (Little *et al*. 2007). Therefore, disposition, can be defined as a person's natural affective state as constructed through long-term engagement with the environment. As a person grows older, their disposition becomes more stable and acts as an anchor that weights responses to emotion and mood against stimuli. For instance, a person who has an optimistic disposition and has an accident that takes away her ability to walk may respond to the loss by accepting the new condition and constructing new ways to live, while a person with a pessimistic disposition may not recover from the event.

The burgeoning field of positive psychology has developed an argument that positive affect are an evolutionary adaptation crucial for creativity, problem solving and skills acquisition, all three behaviors of which are necessary for maintaining motivation to complete projects and attain personal goals (Seligman 2004) (Fredrickson 2002). The value proposition of positive affect is in stark contrast to that of negative affect, which centers on a visceral response to adverse stimuli resulting in the removal from an undesirable situation.

The proposition of positive affect is summarized in the Fredrickson's "Broaden and Build" theory (2002). This theory postulates that positive emotions stimulate prolonged interaction with an object of attention (Fredrickson 2002). During this prolonged engagement people are more creative, exploring possibility spaces through iterative cycles of *in situ* action and reflection (i.e., Schön's Reflective Practitioner theory [1983]). This creative exploration yields a procurement of new skills. Hence, "Broaden" refers to exploring possibilities, while "Build" refers to building new skills. Increasing skills correlates with efficacy, self-efficacy, which by proxy, stimulate motivation (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004).

A second theory supporting positive affect is Mihali Csikszentmihalyi "Flow State" (2008). Csikszentmihalyi defines Flow as, "- the state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people, will do it even at great cost, for the sheer sake of doing it," (2008). Csikszentmihalyi further expands on the concept by writing, "The best moments usually occur when a person's body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and worthwhile… Optimal experience is thus something we *make* happen," (2008).

While Fredrickson's "Broaden and Build" theory postulates an evolutionary reason why people are capable of positive affect, Csikszentmihalyi's theory of "Flow" postulates a behavioral state that people intuitively engage in to optimally "Broaden and Build". When applied to motivation (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004) Flow (Csikzentmihalyi 2008) is the optimal congruence of efficacy and self-efficacy leading to heightened performance to attain a goal.

Studies on the relationship between positive affect and goal setting indicate that individuals in positive moods, "- select higher goals, perform better and persist longer on a variety of laboratory tasks, such as solving anagrams," (2007). These studies suggest that despite the difference between efficacy and self-efficacy, that the two are intrinsically linked. Positive mood (which is subjective emotion) increases both belief (cognition) and performance (action). The increase in belief (i.e., self-efficacy) occurs through setting higher goals. As mentioned before, mood is highly subjective, yet performance is measureable and concrete. The increase in task performance and length of task engagement indicate an increase in efficacy due to positive emotion. Additionally these findings suggest a strong coupling between positive emotion and Flow states. As mentioned before, Flow states occur when a person's resources are fully engaged in a challenge to achieve a goal. The selection of higher goals due to positive emotions infers a higher desired level of challenge. The increase in engagement duration infers greater immersion, which historically, has been a predictor of Flow (Csikszentmihaly 2008).

The capacity of a person to experience positive affect over time and achieve "flow" (Csikzentmihalyi 2008) increases a person's motivation to seek out and attain personal goals. The process of seeking out and attaining personal goals is defined as HF (Fredrickson 2002; Little et al. 2007; Seligman 2004), which supports a person's perception of personal health, which is defined as *subjective wellbeing* (SWB) (Seligman 2004). The perception of wellbeing is important to the human condition because it has been shown to directly affect a person's resilience (Seligman 2004).

From the perspective of psychology, resilience is the capability of a person to cope with stress, adapt and achieve goals, or to strive and thrive. Resilience directly affects health and longevity. Seligman summarizes two studies that capture the importance of resilience:

- - Scientists at the Mayo Clinic in Rochester, Minnesota, selected 839 consecutive patients who referred themselves for medical care forty years ago. Of these patients, 200 had died by the year 2000, and optimists had 19 percept greater longevity, in terms of their expected lifespan, compared to that of the pessimists, (2007);

and a Harvard study, the results of which:

- - Of the 76 inner-city men who frequently displayed these mature defenses [Mature defenses are complex coping mechanisms associated with mentally healthy people. They include behaviors such as humor.] when younger, 95% could still move heavy furniture, chop wood, walk two miles and climb two flights of stairs without tiring when they were old men. Of the 68 inner-city men who never displayed any of these psychological strengths, only 53% could perform the same tasks. For the Harvard men at 75, joy in living, marital satisfaction and the subjective sense of physical health were predicted best by the mature defenses exercised and measured in middle age, (2007).

These two examples of aging populations that remain resilient through intuitively leveraging positive affect to remain optimistic show how positivity can enrich individual lives. The latter study's control of population location suggests the effect positivity can have on culture and society. The Harvard men displayed high levels of joy, marital satisfaction and physical health, which when scaled up, are indicators of healthier communities. Healthy communities typically enjoy lower crime rate and disease, and higher levels of production (Seligman 2007).

SWB (Seligman 2004) and HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) are often discussed together due to the former informing the state of the latter. HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) originates from the Greek word, *eudemonia*, which Aristotle defined as, "doing and living well" (1095). Positive Psychology defines HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) as a person's ability to seek out and solve problem (Fredrickson & Losada 2005; Fitzpatrick & Stalikas 2008; Little et al. 2007). In addition to the connection between SWB (Seligman 2004) and HF (Fredrickson 2002; Little et al. 2007; Seligman 2004), Fredrickson & Losada showed that experiencing higher instances of positive emotion increased a person's problem setting and problem solving capabilities (2005), and that there is threshold ratio of experiencing positive to negative emotions that predicts when these heightened capabilities engage. Seligman provides a similar, yet more detailed definition of HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) in his book *Authentic Happiness*, writing, "Herein is my formula for the good life: Using your signature strengths every day in the main realms of your life to bring abundant gratification and authentic happiness," (2007). A "signature strength" is a positive personality trait that fundamentally shapes a person's behavior (Seligman 2007). Examples of strength traits are *Curiosity*, *Wisdom* and *Bravery* (Peterson and Seligman 2004).

Comparing Aristotle to Seligman, the former references "living well", while the latter mentions, "the good life". Aristotle writes, "doing well", while Seligman operationalizes, "doing well" as drawing upon signature strengths during everyday activity to produce enduring gratitude and happiness. When compared to the general positive psychology definition, Seligman, rather than explicitly writing the word "problem", frames the process of "solving" within in the context of actions taking place in the "realms of life", which can be inferred as possibility spaces where a person can seek out and solve problems.

Place Attachment

According to place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) theorists, a person's relationships with their built environments also affect a person's ability to flourish (Stokols 1977). Place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) researchers develop new knowledge on these relationships using two broad research approaches. The first approach is through collecting thick descriptions (Geertz 1977) of relationships occupants have with their homes. Thick descriptions are detailed accounts of human behavior in context (Geertz 1977). Geographers (Tuan & Hoelscher 2001), anthropologists (Pennartz 1999) and architects (Cooper Marcus 2006). In 1977, geographer Yifu Tuan published the landmark work, *Space and Place: The Perspective of Experience*, defining the field of human geography, a qualitative branch of geography dedicated to understanding sociocultural interaction across space. In 1995, Clare Cooper Marcus, a retired professor of architecture and landscape architecture published the equally seminal work, *House as a Mirror of Self*. In this book, Cooper Marcus explores the relationships people have with their homes by having occupants tell their homes how they feel about them (1995).

In 1999, Paul J.J, Pennartz published a chapter entitled, "Home: The Experience of Atmosphere", in the anthology, *At Home: An Anthropology of Domestic Space.* Within the chapter, Pennartz delivers a phenomenological account of the relationships between family interactions and architectural features to construct an experiential account of atmosphere (1999).

The other vector of work in place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) produces models and metrics for subjective assessment of the goodness of fit between people and their environments (Stokols 1977; Wallenius 1999). This approach to place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) emerged in the 1970s with the maturation of environmental psychology. Dr. Daniel Stokols postulates that understanding subjective goodness of fit is imperative for measuring wellbeing (1979). Literature on personal projects (Little 1987; Little et al. 2007) aligns with this assertion. In 1986, Dr. Brian Little audited thousands of personal projects (Little 1987; Little et al. 2007) reported by university students, finding that 92% of those projects were linked to specific locations. A 1999 study indicated a strong main effect between life satisfaction and perceived environmental support of personal projects (Wallenius 1999). These findings suggest that the features of an environment affect goal attainment. The capability of environmental features to support personal goals was proposed by Stokols as *congruence* (1979). Congruence is the ratio between the perceived needs of an environment to support the attainment of a goal and an environment's actual capability to support goal attainment (Stokols 1979). The broader and deeper an environment's congruence is with a person's needs, the stronger sense of attachment a person develops with that environment (Stokols 1979). While fit theory serves as the foundation for models of subjective assessment of place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992), the theory has received criticism because subjective assessment only measures place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan &

Hoelscher 2001; Williams 1992) at a specific moment in time. In contrast, thick (Geertz 1977) descriptions capture data collected over a period of time.

Since the late 1960s, researchers have developed multiple assessment tools. Early attempts at assessment implemented ordinal measurement scales. In 1969, the Kilbrandon Report used a simple binomial assessment asking participants if they felt aware of their regions, or lacked awareness of their regions (Lewicka 2010). In 1985, a four-value scale was implemented to assess place attachment (Shamai & Kellerman). This scales values were (1) not having a sense of place; (2) knowledge of a place; (3) belonging to a place (4) attachment to a place (Shamai & Kellerman 1985). In 1991, Shamai produced a second, more sensitive scale consisting of seven values: (0) Not having any sense of place; (1) knowledge of being located in a place (2) belonging to a place; (3) attachment to a place; (4) identifying with the goals of a place; (5) involvement in a place; (6) sacrifice for a place.

A second approach to assessment arose in the early 1990s was the use of multidimensional scales constructed, each of which was loaded with dimensions measured on interval scales. Williams introduced one of, if not the first, multidimensional tool, consisting of two scales: (1) Place Attachment and (2) Place Identity (1992). Each scale consisted of seven dimensions. Place Attachment measured the perceived affective relationship between a person and an environment (Williams 1992). Place Dependency measured the perceived conative – or physical relationship – between a person and an environment (Williams 1992).

One of the most recent multidimensional model measuring subjective fit is the Sense of Place (SoP) model (Jorgensen & Stedman 2001; 2006). This tripartite model consists of both of Williams' scales and further defines the model with a third dimension, *Place Identity*: The degree to which a person feels that a place reflects who she is (Scanell & Gifford 2010) (Jorgensen & Stedman 2001; 2006). In addition to the third multidimensional scale, Jorgensen and Stedman, the progenitors of this tripartite model, reduced the number of dimensions for each scale to four, for a total of 12 dimensions (Jorgensen & Stedman 2001).

These three factors assess a person's affective (Place Attachment), cognitive (Place Identity) and conative (Place Dependency) relationships with a place. In 2001, this model was used to measure relationships between occupants and second homes located in a lakeside community. In 2006, Jorgensen & Stedman continued to demonstrate the value of the tripartite model by using it across different demographic cohort groups to produce predictive models for SoP (Jorgensen & Stedman 2001; 2006) The predictor variables owner's age, duration of ownership, participation in recreational activities, days spent on property, extent of property development and perceptions of environmental features demonstrated a significant main effect on the criterion variable SoP (Jorgensen & Stedman 2001; 2006).

This study implements Jorgensen and Stedman's SoP model within, within the context of a social ecological model of personality proposed by Little (2007). The choice to use SoP model over other models is based on the model's proven statistical reliability (Jorgensen & Stedman 2001) as well as its implementation with other variables to produce predictive models (Jorgensen & Stedman 2006). The subsequent section presents Little's social ecological model of personality.

The Social Ecological Personality

Little developed PPA (Little et al. 2007) to model a person's personality and measure HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) within the context of a project-centric, social ecological framework (Figure two) (Little et al. 2007).

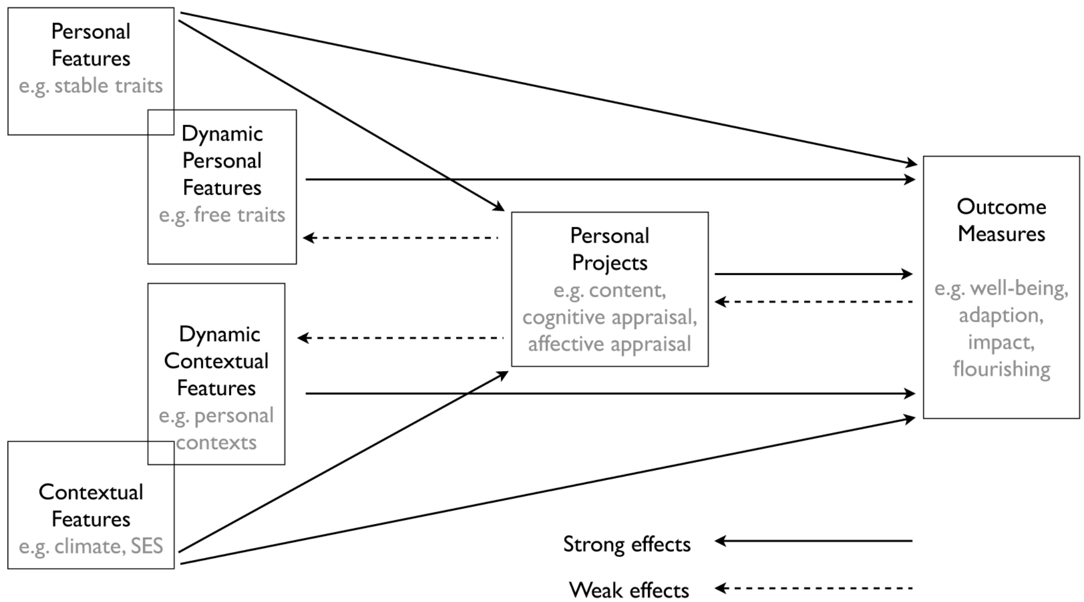


Figure two. Social ecological model of personality (Little et al. 2007)

"The central tenet of the social ecological model is that well-being depends on the sustainable pursuit of core personal projects," (Grant, Little, & Phillips 2007).

In her 2007 dissertation, Jodi Forlizzi, Assistant Professor at Carnegie Mellon University's College of Design, defines social ecology theory, writing:

> In social science, social ecology theory focuses simultaneously on the environment and the social relationships among the people within it. The underlying assumption is that human behavior can be understood as an adaptive fit to an external environment, and that the relationships between the human and environmental factors are complex and dynamic [Netting 1986]. Context shapes these relationships, and is understood as a complex, dynamic set of factors, including social context (social networks and support systems), historical context, cultural context and institutional context, (7).

The social ecology framework illustrates "how biological, cultural and environmental systems of influence impinge on an individual," (Little 2007). In figure two, the *Personal Feature* box refers to genetically programmed behavior patterns inherent in any given individual, representing the biological influence on flourishing. The *Contextual Features* box introduces the physical attributes of an environment or situation that pressure a person into action. The *Dynamic Personal Features* refer to, "culturally scripted sets of actions," (Little 2007) that an individual must adopt to pursue a project. *Dynamic Contextual Features* are a person's subjective interpretation of environmental or situational attributes (Little 2007). Within the context of this research agenda, the *Dynamic Contextual Features* box is measured through the use of Jorgensen and Stedman's SoP model (2001; 2006). Both *Dynamic Personal Features* and *Dynamic Contextual Features* represent cultural influences of a person's ability to flourish.

The interaction between *Personal Features* (biological influences) and *Contextual Features* (environmental influences) directly affect the formulation of *Personal Projects* (Little 1987; Little et al. 2007) and *Outcome Measures* that determine flourishing. *Dynamic Personal* and *Dynamic Contextual* features (cultural influences) directly affect the formulation of *Outcome Measures*. The consolidation of the biological, environmental and cultural influences as *Outcome Measures* for flourishing produces a positive feedback loop, further informing project content, what a person thinks about a project and how a person feels about a project. Finally, the instantiation of a project continues the positive feedback loop by changing the state of *Dynamic Personal* and *Contextual* features as the person manipulates environmental factors to complete the project.

Personal Project Analysis

This section connects affective and cognitive dimensions of PPA (Little et al. 2007) to SWB) (Seligman 2004) positive psychology and various scientific findings generated by PPA (Little et al. 2007) research on HF (Fredrickson 2002; Little et al. 2007; Seligman 2004). Table one lists the core affective and cognitive appraisal dimensions for use as reference during this discussion (A compendium of alternative appraisal dimensions can be found at http://www.brianrlittle.com/PPA/index.htm).

Table one.

Personal project analysis (Little et al. 2007) *appraisal dimension list*

Affective appraisal dimensions	Cognitive appraisal dimensions	Conative appraisal dimensions
Sad Fearful/Scared Full of love Angry Happy/with enjoyment Hopeful Stressed Uncertain Depressed Other participant defined emotion	Stage Autonomy Competence Support Absorption Challenge Progress Value congruency Others' view Self-identity Outcome/Likelihood of success Time adequacy Responsibility Control Visibility Difficulty Importance	Project category

Little developed the PPA (Little et al. 2007) methodology to measure SWB (Seligman 2004) within the context of social ecology. SWB (Seligman 2004) consists of affective, cognitive, trait, state and time duration criteria to measure wellness (Andrews & McKennell 1980). In this context, subjective refers to the self-evaluation of a person, while wellness means the psychological and social health of a person. Intrinsic to SWB (Seligman 2004) is HF (Fredrickson 2002; Little et al. 2007; Seligman 2004). Ian McGregor and Little ensure PPA's (Little et al. 2007) relevance to SWB (Seligman 2004) and HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) through their dual functional personal project (Little 1987; Little et al. 2007) model, during which they state:

> "-that personal projects serve both an instrumental function via the experience of efficacy and a symbolic function via feeling of integrity. Both experiences are expected to relate to wellbeing, although to different facets: Efficacy is expected to relate to happiness (i.e., life satisfaction, positive affect, absence of negative affect), whereas integrity is expected to relate to meaningfulness (i.e., feelings of connectedness, purpose, and growth)," (1998, 171).

In 1989, as prelude to the two function project model, Carol Ryff proposed six dimensions of positive psychology as part her conceptualization of wellness: self-acceptance, positive relations with others, autonomy, environmental mastery, purpose in life and personal growth. During her discussion of these dimensions, Ryff references having meaningful goals to the dimension, purpose in life. Additionally, she refers to the notions of self-efficacy and self-development (Ryff 1989). These connections align with McGregor and Little's two-function project model (1998). Finally, in response to the legitimacy of Flow within psychology, Little added the absorption dimension to cognitive appraisal. To date, HCI has not leveraged the social ecological personality framework or PPA (Little et al. 2007) methodology. In response to this knowledge gap, this section discusses previous PPA (Little et al. 2007) research in HF (Fredrickson 2002; Little et al. 2007; Seligman 2004).

PPA (Little et al. 2007) defines health projects as, "any activities involving the individual's appearance, health, health improvement, or fitness" (Little 1987). Examples of health projects are "lose 10 pounds," "quit smoking," "update vision prescription," and "lower cholesterol." Conducting statistical analysis of over 2,500 PPA (Little et al. 2007) showed a 14% mean incidence of health projects. Despite age and life circumstance filtering, this number remains consistent (Peterman & Lecci 2007). Researchers correlated abnormally high levels of unrelated health projects with clinical pathologies such as hypochondria (Little 2007). The analysis of appraisal dimensions also led to recognition of surface patterns predicting depression. In 2004, researchers validated the use of PPA (Little et al. 2007) to assess treatment burden on quality of life in cancer patients (Peterman et al. 2003).

Andrew Elliot and Ron Friedman showed that people who listed projects that moved towards a perceived desired outcome, rather than avoid a perceived negative outcome, reported higher levels of wellbeing (2007). In addition, high frequencies of avoidance projects corresponded with negative physical symptoms such as headaches, chest or heart pain and stomachaches (2007). The study correlated people who listed approaching projects with higher levels flourishing.

Neil Chambers conducted additional analysis of project phrasing (2007). Chamber's initial findings indicated that participants who phrase projects as direct statements, as in "Learn to fish," flourish more than people who use modifiers on their statements. People who phrase projects as in terms of effort, such as "Try to learn to fish," displayed lower measures of flourishing when compared to people who phrase projects as direct statements. A high occurrence of increase statements, as in, "Fish more," displayed lower levels of belief that they would succeed. Finally, projects phrased as continuation of current actions, as in, “Keep my room clean,” showed higher levels of efficacy and structure. However, high frequencies of any of the three non-direct project phrasings reflected a lower perception of competence to achieve their goals, which in turn, produced lower HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) measurements (Chambers 2007).

Research on interpersonal projects (Little 1987; Little et al. 2007) indicated that they predicate higher HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) in individuals across a variety of contexts. In 1997, a study of people who reported family-related projects displayed higher self-esteem (Salmela-Aro & Nurmi). In 2001, a study of young adults transferring from vocational school to work life showed a positive relationship between increased reporting of interpersonal projects and positive mood frequency (Salmela-Aro). Young adults who reported many social, interpersonal projects had higher grades in secondary school (Salmela-Aro 2001). In 2004, a study on satisfaction reported adults with family-related projects displayed high levels of satisfaction in both their personal and work life (Salmela-Aro & Nurmi 2004). An examination of female young adults, social confidence and interpersonal projects indicated a positive relationship between low confidence and negative interactions with their parents and with intimate relationships, and also fewer new acquaintances when compared to socially confident young woman (Salmela-Aro & Nurmi 1996).

Researchers also used PPA (Little et al. 2007) to evaluate a number of work related issues. Studies of job satisfaction indicated that participants who reported low ratings across the affective dimension of stress and high ratings across the cognitive dimensions of control and efficacy experienced higher levels of job satisfaction (Little et al. 2007; Slack-Appotive 1982). In 2004 psychotherapy researchers deployed an intervention against employee burnout. A PPA (Little et al.

2007) analysis of employees who received the intervention showed increases in the cognitive dimensions of progress and social support, despite the ontological lack of change in the project's status or their social network (Salmela-Aro et al. 2004). These rating increases suggest that for a person to flourish in the workplace, she must perceive making headway towards project completion and that she have strong ties to management and colleagues. A 1992 study up-scaled PPA (Little et al. 2007) to address organizational projects (Phillips). The results proved PPA (Little et al. 2007) as a viable tool for predicting and measuring the outcomes of organization level projects (Phillips 1992).

This section surveyed PPA (Little et al. 2007) concepts and case studies, validating the methodology's value for evaluating HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) and HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) related factors. Discussion of McGregor and Little's two function model of projects (1998), Ryff's six dimensions of positive psychology (1989) and Little's inclusion of the absorption dimension in acknowledgement of Mihaly Csikszentmihalyi's Flow (2008) experience argue PPA's (Little et al. 2007) direct alignment to both HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) and positive psychology. The use of PPA (Little et al. 2007) across age groups, multiple project scales, genders and life circumstances coupled with the methodology's use to explore and measure HF (Fredrickson 2002; Little et al. 2007; Seligman 2004) within clinical, medical, personal and professional situations illustrates the utility across a wide variety of activities.

The implementation of PPA (Little et al. 2007) (Little et al. 2007) in this research agenda allows for subjective assessment of motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) and positivity (Seligman 2004) (Fredrickson 2002) within the context of a person's personal projects (Little 1987; Little et al. 2007). The combination of this assessment with Jorgensen and Stedman's SoP (2006; 2001) model with PPA (Little et al. 2007) furthers the capability of the methodology to measure social ecological relationships by introducing a means of assessing environmental relationships. Chapter eight explores the merger of these two methodologies within the context of young adults, personal projects (Little 1987; Little et al. 2007) and their homes. The previous sections defined motivation (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004) affect, SoP (Jorgensen & Stedman 2001; 2006) and situated them with Little's social ecological model of personality (2007). The following section defines *home* and summaries the complex relationships people have with their homes.

Chapter 3

HOME: A DYNAMIC SYSTEMS PERSPECTIVE

Defining Home

In this chapter, the social ecological perspective is expanded to the home to the home environment. Within the context of Little's social ecological personality model, the home is considered the environment in which *Contextual Features* (Little 2007) are derived. As stated previously, *Contextual Features* are the objective features of an environment (Little 2007).

A major assumption is that the home is a system containing interaction between people and artifacts that determine everyday activity. At the most basic level, people perceive their homes as spaces that offer " - permanence, presumed security and privacy," (Chapman 2001). In Pierre Bourdieu's 1984 book, *Distinction: A Social Critique of Judgments of Taste*, the author recognizes the home as a, "structuring structure," that is ubiquitous and therefore, often overlooked or taken for granted as a building block of society. However, the home is complex reflecting not only the biological imperatives of survival, but also the material, technological, sociocultural and political modus operandi of a given population (Birdwell-Pheasant & Lawrence-Zuniga 1999; Bryden & Floyd 1999; Cieraad 1999; Cooper Marcus 1995). Adding to this complexity is the home's capacity to mirror these various aspects at a number of social scales and through a number of power structures, ranging from an individual, to a family unit, to an "expert" designer or design organization, and expanding to the size of multi-national government organizations such as the European Union (Cieraad 1999). In the research anthology, *The Home: Words, Interpretation, Meanings and Environments,* editor David Benjamin pens an intricate definition of the home:

"The home is that spatially localized, temporally defined, significant and

> autonomous physical frame and conceptual system for the ordering, transformation and interpretation of the physical and abstract aspects of domestic daily life at several simultaneous spatiotemporal scales, normally activated by the connection to a person or community such as a nuclear family," (1995).

This definition recognizes five ontological attributes of the home:

1. The home as a place in a specific geography ("- spatially localized -").
2. The home takes place within a specific timeframe ("- temporally defined -").
3. The physical and conceptual importance of the home for structuring everyday domestic activity ("- significant and autonomous physical frame and conceptual system for the ordering, transformation and interpretation of the physical and abstract aspects of domestic daily life -").
4. The propensity of the home to mediate such activity within multiple spaces and time scales ("- at several simultaneous spatiotemporal scales - ").
5. The home is explicitly tethered to people who play the role of occupants ("normally activated by the connection to a person or community such as a nuclear family.").

Those attributes describe the physical properties coupling the domestic environment and occupants. Clare Cooper Marcus expands on these attributes by summarizing some of the psychological and sociocultural associations:

> "A home fulfills many needs: a place of self-expression, a vessel of memories, a refuge from the outside world, a cocoon where we can feel nurtured and let down our guard. A person without a fixed abode is viewed with suspicion in our society, labeled 'vagrant', 'hobo,' 'street person'. The lack of a home address can be a serious impediment to someone seeking a job, renting a place to live, or trying to vote," (1995).

The psychological aspects of this passage span from "self-expression" to "feel nurtured and let down our guard". The remainder of the passage describes how the home normalizes an occupant by allaying the "suspicions" of other citizens with the same social status and by supporting other types of rituals such as employment, finding future domestic spaces and civic action. The role of home in sustaining both intrapersonal and interpersonal development supports the formulation of personal identity (Cooper Marcus 1995).

This section briefly touched on the home as a social ecological construct by defining it as a place located in a specific geographical location within a certain timeframe that supports everyday activity. Through these activities, the people who occupy a home make meaning that significantly contributes to the construction of identity. These definitions of home recognize the social ecological relationship that exists between the occupant and domicile. They support my logical argumentation regarding the opportunity for HCI approaches that can discover and evaluate linkages between activity, personality and the domestic space. The following paragraphs further discuss these various facets of the home.

One role of the home is as a container for gender, community and government power relationship. A power relationship refers to a common, underlying cultural value or values that shape beliefs and practice between members of that culture (Cieraad 1999). Bryden and Floyd argue that the domestic space buttresses power relationships, writing:

> " - the domestic [space] is accorded a much more active role in the enforcement of the authority of the dominant powers than the complicity at the periphery formerly attributed to it in studies of feminism, philanthropy and urban reform ... When colonized space is constructed as marginal, domestic space can be accorded a position at the center (1999)."

Both the architecture of the home and the social interactions the home contains attest to the influence of the domestic space to support sociocultural power relationships. For example, in the 1950s and 1960s, American architects often positioned kitchens of suburban homes in the back of the house with the sink and counter spaces situated against the back wall and windows looking out at the backyard. This design was prescribed by architects to support the role of mid-20th century housewife by allowing the woman of the house to prepare meals while simultaneously watching over children playing in the back yard. In addition, the kitchen was a partitioned space, kept separate from the dining and living rooms. The separation of spaces maintained the gender divide between the kitchen, or the woman's domain, and the living room, which was where the man of the house relaxed after a day at the office (Tuan 2000). Additionally, the separation of the kitchen from the dining room hides acts of food preparation from the manicured eating area where families employ table manners and engage in interpersonal communication (Tuan 2000).

The modern, American/Northern European kitchen, which often functions as an integrated space within an open floor plan that includes a family room and informal dining room, support different gender and privacy paradigms. Such designs display the food preparation process, which has become distributed across multiple household members (Cieraad 1999). The reduction in privacy and who prepares family meals reflects a shift in values, gender relations and practical everyday life where women have joined the workforce and two-parent households often have two working parents (Cieraad 1999).

These negotiations of intra-family responsibility and corresponding activity are further complicated by the dynamics of presence/absence of family members in the home. In the 1990 article, *Gender and Meaning in the Home*, the authors reveal that women relish in periods of sole ownership of the home when the rest of the family is away, but "feel owned themselves when the children and the men come back," (Chapman 2001). Additionally, the joy those women found in solitude often transforms into anxiety when they thought about an unannounced visitor dropping by and possibly finding the home disheveled (Chapman 2001). These findings illustrate how fluctuations in absence, presence and/or potential for presence of people and the social interactions they bring with them affect the experience of the home.

The exterior of the home, and the degree to which a given occupant maintains that exterior in relation to her neighbors represents values corresponding to inter-home relationships, community and belonging (Cieraad 1999). A well-manicured yard and swept driveway radiates a sense of responsibility to neighbors of that household, while conversely, an ill-kept home exterior in an otherwise maintained neighborhood potentially alienates the occupant(s) from the rest of the community (Cieraad 1999). However, augmenting a home's exterior with new structures, or higher-end finishes that set a house apart from its neighboring structures can also sever neighborhood ties, as other community members can interpret such changes as a flaunting of wealth and status (Cieraad 1999). This tension between home upkeep and modesty can have a normalizing affect on neighborhoods, producing a sense of aesthetic cohesiveness and adherence to a set of community values (Cieraad 1999).

In addition to reflecting the power structures and values of occupants and the immediate community, the modern home embodies the vision of the architect or design expert and the policies of governing organizations. In 2002, Judith Attfield published an ethnographic study in *The Journal of Architecture*, detailing the conflict between the post World War II (WWII) domestic architecture and its occupants in a burgeoning British suburb. Attfield collected data through a combination of historic records and semi-structured interviews. The post-war, mid-century modern architecture movement viewed design as a tool for behavior modification and social change. Of particular distaste to this design movement was the large, formal "parlour" situated in the front of homes. Such spaces preserved what architects of the time felt was a, " – formality of hierarchical space that enforced a pattern determined by everyone not only 'knowing', but also keeping to 'their place'," (Attfield 2002). However, redesigning homes without such hierarchical spatial patterns led to a conflict between the architects' visions of what the social values of the home should be, and what occupants expected out of their living space. This discontinuity between the designer and the occupant manifested in a juxtaposition of space and artifact placement. For example, architects built in glass-fronted bookcases into the traditional parlour as a method of, "- minimiz[ing] the clutter of the parlour and encourag[ing] self-improvement through reading,' (Attfield 2002). However, occupants continued to propagate their own values of space use, subverting those bookshelves into china closets for their formal dinnerware, thereby maintaining the functionality of space as a parlour (Attfield 2002).

In addition to the pressures associated with the "expert" designers and the everyday users, public policy also intersects with form, function and meaning of the home. During the late 1700s through the mid-1800s, abolitionists would transform the exterior of their homes into information displays voicing their outrage at slavery by showcasing engravings of black Africans on slave ships (Cieraad 1999). This tradition of the home exterior as a medium for civic discourse continues today with the placement of posters announcing political party affiliation, backing a specific candidate or supporting a stance on social or economic issue such as legalizing gay marriage or funding public education.

In contrast to the use of the home as a tool used by occupants for public discourse, a home's architecture represents shifts in governance. In the 1900s, concern for hygiene, sanitation and health in Northwestern Europe and the United States stimulated a movement for improving the living conditions of the "working-class" (Cieraad 1999). Part of this agenda included educating people on domestic cleanliness. Many would-be recipients resisted this agenda due to the infiltration of religious groups, who coupled "moral cleanliness" with hygiene and sanitation, into the transformation process (Cieraad 1999). In many neighborhoods, this initial interjection of political and religious programs failed because citizens felt their privacy was being infringed upon.

More recently, the consolidation of Northern European countries under the European Union has led to the development of standard regulations for energy efficiency, facility planning and safety (Birdwell-Pheasant & Lawrence-Zuniga 1999). In the 1999 book, *House Life: Space, Place and Family in Europe*, the authors state, "- the homogenization of house should also tend to homogenize families. In this sense, the material dimensions of the home play a crucial role in the global transformations of family life and local culture," (Birdwell-Pheasant & Lawrence-Zuniga). The underlying assumption of this supposition argues that the physicality of the home can shape the organization and behavior of occupants. Thus, standardizing the material aspects of the home across cultures that formally relied on their own distinct building criteria can reduce cultural diversity.

These connections between intra-home relationships, the values of designers and the agendas of public agencies shape both the domestic built environment and behavior. The tensions between these values shape both the architecture of the home and the behavior of occupants. The interactions embedded in domestic behavior play a significant role in shaping a person's identity. The following subsection continues to express the complexity of the home by describing how domestic interactions support the identities of occupants.

A second, and equally important role of the home is as a platform for physical interactions with artifacts to construct meaning. Over time, these interactions assimilate to produce memories, which in turn, influences a person's identity (Csikszentmihalyi & Halton 1981). In, *At Home: An Anthropology of Domestic Space* (Cieraad 1999), Chapter Seven author, Sophie Chevalier, recounts her work on suburban households in Paris (Cieraad 1999). During her account, she indicates how people mentally attach stories to objects, writing, "- objects are by their material condition a reminiscent link to other individuals," (Cieraad 1999). The home provides a platform for generating, using and collecting such story-laden artifacts (Cieraad 1999).

In part, through this meta-process, occupants produce organizing systems (Taylor & Swan 2005) and common beliefs about the notion of home, which multiple texts propose create a, "-microcosm of cultural life which should, at least in theory, be readable by people in that society," (Chapman 2001). This narrative of what home means has been examined by a multitude of phenomenologists and motivational psychologists. Heidegger identifies the role of the home, as a dwelling, the existence of which was vital for defining what it means, "to be a human being living in the world," (1971; cited in Moore 2000). This idea led to the study of place and rootedness to describe the processes of emotional attachment and environmental satisfaction, which foster the evolution of domestic narratives and continual co-construction of identity (Moore 2000). These meta processes of meaning making, narrative and identity construction, in part, take place within the aesthetic domain of the home (Brown 2007; Moore 2000; Nansen, B., Arnold, Gibbs, & Davis 2009), through interactions with artifacts that afford a range of domestic activities and atmospheres (Brown 2007; Moore 2000; Nansen *et al*. 2009).

In the 2003 *Journal of Social Analysis* article, *Representing the Sensory Home*, author Sarah Pink conducts an ethnography focused on sensory aesthetics in the home. She captures data using video ethnography and semi-structured interviews. One of the insights Pink produces is the manipulation of products within the domestic space to control aesthetic conditions and provoke desired activity and mood (2003). Pink provides an example of a girl in her mid-twenties changing her sensory atmosphere by turning on the radio while getting ready for work (2003). In response to this audio stimulus, the girl reports changes in her activity, including, "sing[ing] and dance[ing] all over the place," (Pink 2003). She also reports music having an affect on her mood, stating, "You see, I've got time to myself and then I stick on music. That gets me going. Sort of lifts me up in the morning," (Pink 2003). This simple scenario exemplifies the home as a flexible environment where seemingly simple changes in stimuli can restructure daily routines. Additionally, this scenario demonstrates the reciprocal, adaptive relationship between people and their domestic environments. The woman in question changes her environment by turning on the radio. The music, in turn, changes her morning behaviors and feelings.

Jodi Forlizzi's work on cleaning practices in the home echoes Pink's ethnography (2007). Forlizzi presents a model of "Product Ecology", which she defines in the following passage: "The product ecology combines social ecology theory and an ecological approach centered in the domain of design to create a framework describing the relationship between a product and a group of people that develop a relationship through using it. The product ecology is an interrelated system of a *product*, surrounded by other products, often acting as a system; *people*, along with their attitudes, dispositions, norms, relationships and values; products; *activities*; *place*, including the built environment and the routines and social norms that unfold there; and social and cultural context of use. Important dimensions of a product include function, aesthetics, and symbolic, emotional, and social responses," (2007).

Forlizzi supports this model through a field study consisting of four households. Two families receive a standard vacuum, while the other two families were given Roomba™ robot vacuums. Prior to receiving the vacuums, Forlizzi conducts interviews with the family members and home tours to understand the current state of cleaning practices. While the two vacuums were evaluated and deemed equal in their cleaning effectiveness, the material and autonomous properties of the Roomba™ alter the power structures, values, narrative and practices associated with house cleaning (Forlizzi 2007). Families with a Roomba™ report a shift in behavioral dynamics, with vacuuming and other cleaning activities becoming distributed across multiple family, rather than remaining the sole responsibility of the "woman of the house" (Forlizzi 2007). Additionally, elders engage in opportunistic, or unplanned cleaning events, rather than adhering to fixed cleaning schedules they reported during initial interviews. In houses with a Roomba™, families reported vacuuming more often. Families also demonstrated additional emotional attachment to the Roomba™ vacuum by giving it a name and personifying its behavior (Forlizzi 2007). Forlizzi's results further demonstrate the power of the home as a nexus where people, things and architecture interact to define and redefine the human behavior. This continuous redefinition falls in line with proposition of the home as porous social ecological system and illustrates the power technology has to influence projects such as, "keeping the house clean".

This section explored theory and methodology related motivational psychology and place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) theory to define the epistemological perspectives supporting this research agenda. At the center of this work is Little's social ecological model of personality (2007). The model functions as a meta-construct containing motivation (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004) affect, sense of place and the home. Figure three illustrates how these constructs integrate in the Little's Model.

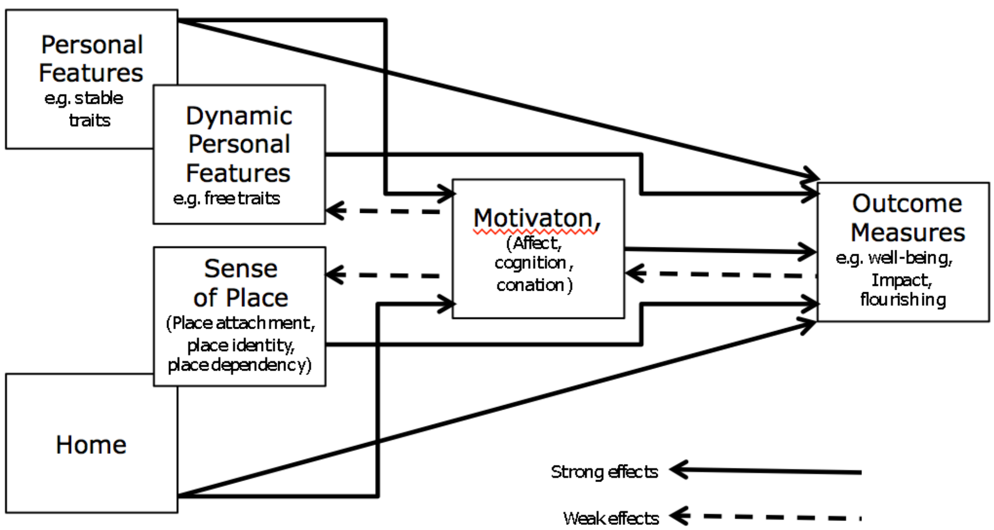


Figure three. Social ecological model of personality (Little et al. 2007) with embedded motivational home conceptual framework.

The following chapter discusses participatory design and prototyping, which serve as this research agenda's ontological approach for design for motivation (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004).

Chapter 4

PARTICIPATORY PROTOTYPING

According to Michel Beaudouin-Lafon and Wendy Mackay a prototype is a, "-concrete representation of part of or all of an interactive system," (Jacko & Sears 2007). Their definition requires unpacking of some key terminology embedded within the quote. The idea of *concrete*-ness is taken within in a broad context, ranging from clusters of post-its® that form conceptual frameworks (Langford & McDonagh 2003), to comic book derived storyboards (Beaudouin-Lafon & Mackay 2007), to people acting out interactions in front a video camera (Beaudouin-Lafon & Mackay 2007), or taking on the role of a computer (Erickson & McDonolad 2008) moving up the development chain to robust interactive systems. The notion of the *representation*, refers to the need for embedment of either all of, or a combination of, sociocultural context, physical use, cognitive processes and/or affective response. Ideally, the physical nature of the prototype combined with the embedding of knowledge produces a transparent, tangible artifact, rather than an "abstract description that requires explanation," (Beaudouin-Lafon & Mackay 2007).

Braudouin-Lafon and Mackay define the construct of a prototype in relationship to an interactive system within the context of human-computer interaction (HCI). For the purpose of this discussion, an interactive system is a computational system that allows for user input and produces feedback to inform the user of outcomes. These can range from Solid User Interface device (Øritslund & Burr 2000), which are products with small displays and a limited number of keys (calculators, cell-phones, PDAs), to standard computational systems such as desktop computers, laptops and videogame systems, to fully immersive environments such as media caves and virtual reality, to ubiquitous computing environments, including sensored environments such as smart homes and domestic robots such as the PLEO™ pet and the Roomba™ vacuums.

During a critique of Henry Dreyfuss' 1955 book *Designing for People*, Terry Winograd writes that HCI is, "shaped by an ongoing tension between designers and programmers." However, Winograd's statement ignores the trend of increased direct user engagement during the design process. The process of prototyping in interaction design has followed this trend of user inclusion. The remainder of this discussion takes place through the lens of participatory design (PD) (Muller et al. 1993).

Prototyping in PD, like many other PD activities, is cyclical and iterative. Beaudouin-Lafon and Mackay describe the prototyping process as two phases:

1. Exploring the design space and;
2. Contracting the design space (2007).

These phase coincide with divergent and convergent thinking (respectively). During exploration of the design space, teams engage in activities such as brainstorming to generate prototype possibilities. Contracting the design space refers to making decisions about which possibilities to change/delete in order to arrive at the "finished" prototype. Critique of the finished prototype is included with in contracting. This deceptively simple process is supported by four theoretical constructs:

1. Emergence and open systems (Asaro 2000);
2. Reflective practice (Schön 1983);
3. Interaction through negotiation (Bødker & Anderson 2005) and;
4. Situated action (Suchman 1987).

Reflective practice has served as theoretical underpinning of design practice in general. During reflective practice, the designer interacts with their design through reflection-in and reflection-on action. Reflection-in-action takes place during the creation of the design. Schon used the example of an architect sketching a building. During sketching, the architect chooses where to draw initial lines, erase existing lines and replace old lines with new lines. Such actions demonstrate micro instances of reflection during which the architect makes rapid decisions. Reflection-on-action takes place after the completion of the initial drawing (which can be viewed as prototype). In the scenario of the architect, she may share her drawing with others for group critique or review the drawing in private. Applying this concept of reflective practice to the process of prototyping, reflection-in-action occurs through collaboration among PD team members during the construction of the prototype. Reflection-on-action occurs as the design team evaluates the latest prototype iteration. Reflection-in-action and reflection-on-action repeat with each iterative prototyping cycle.

Interaction through negotiation places a, "-focus on interaction as an ongoing, dynamic process with different levels of detail and involving multiple mediators," (Bødker & Anderson 2005). During the process of exploring and contracting the design space, technical and lay team members constantly debate and build consensus around the prototype, with the finished product embodying the tensions, desires and power structures of the team. The creation of mock-ups that reflected the tacit knowledge of union workers and the technical knowledge of software developers in the UTOPIA project exemplify the results of proper interaction through negotiation.

Situated action (Suchman 1987) refers to the authenticity of the interactions between team members and that those actions are dependent on the environment they are being performed in. It also refers to a recognition and acceptance of embedding environmental context into the prototype by allowing lay participants to ingrain the prototype with their tacit knowledge.

Constructing prototypes often depends on project logistics (time, budget and system scope) as well as what stage of interaction development the team is at. As a rule of thumb, early stage interaction prototyping relies on low fidelity materials as means of reducing risk. Risk is mitigated in two ways:

1. Reducing the direct cost of early stage prototypes that may or may not yield viable interactions by using inexpensive materials (general office supplies, WoZ experiments, etc.)
2. Minimizing the likelihood of risks in future, higher fidelity prototypes by providing opportunities to fail early and often without much financial investment.

A prototyping typology consisting of four fidelities of prototypes illustrates the various investments related to mediate risk. While the stages are presented in a linear fashion, it is important to note that each phase is permeable, allowing for iteration between phases, or the choice to omit certain prototyping tiers altogether depending on the needs/wants/desires of the user, available of funding, manpower and technology, as well as the project scope (including the type of interactive system, agreed upon fidelity of the final deliverable and whether the final deliverable is a new product of redesign of an existing product) and results of testing prior prototype iterations. These phases are Low-fidelity, Non-interactive, Interactive and Final prototyping. The presentation of these four prototyping phases also includes commentary on tradeoffs in participation that occur between technical and lay participants within each tier. This commentary is a product of synthesis of literature and the author’s personal experience developing different fidelities of prototypes.

Low fidelity prototyping can be characterized through the use of inexpensive materials and high levels of end-user input to develop and test initial proofs of concepts. Early stage prototype methods include:

- Affinity diagrams: Affinity diagrams consist of building maps of post-its® to generate relationships between high-level user-centered concepts (i.e., task flow, social structures, physical environment, etc.) and potential features.
- Mock-ups: Mock-ups can include the use of sketches, cardboard and foam core to produce representations of physical form.
- WoZ experiments: WoZ experiments require the production of a script that declares rules of interaction to guide a human actor who takes on the role of interactive system (unknown to the user).
- Scenario building/storyboarding Relies on collaboration between technical and lay team members to build either a text (scenario) or visual (storyboard) representation of what people do and how they experience interaction with the system (Jacko & Sears 2007).

Each of the above mentioned methods afford different types of interaction prototyping: concept cohesion, physical form, multimodal interaction and situated tasks (respectively). Such methods are often used either in parallel or serially during early interaction design efforts and prior to investing more substantial resources into developing higher resolution prototypes.

Upon providing initial proof of concept through the early stage prototyping methods, interactive system design teams increase the resolution of prototypes by producing more accurate non-interactive digital simulations and device forms. Non-interactive digital simulations generally refer to GUI development without producing the underlying system logic (modeling & filtering) or system architecture to support interaction. Examples of such prototypes include:

- Using Adobe Photoshop™, Flash™, Flex™, etc., to build web sites that lack the code and resources to support interactivity within and among web pages as well as the ability to go live to the public via the internet;
- The use of graphics environments such as Adobe Flash™ or AutoDesk 3DStudioMax to render 2D and 3D character models of digital agents that lack animation or the ability to communicate to users and other digital assets and;
- The construction of iPhone/iPad™ application displays using Apple's interface builder.

In addition to the development of non-functional GUIs, if the PD team has determined that the prototype is some sort of physical device (a smart appliance, mobile phone, PDA, robot, etc.) non-interactive prototypes can also include a second, physical component to account for actual size, weight and relationship of physical input devices to the display screen. Prototyping processes and materials very from using laser cutters to cut foam and plastic, to 3D printing a virtual prototype. During this phase of physical prototyping, issues such as force activation to interact with buttons, integration of digital and physical components remains tabled for later iterations. Instead the focus remains on producing a more accurate prototype with regards to general physical characteristics.

As prototyping enters this phase, technical complexity increases dramatically, yet because of the limited ability to interact with prototypes, opportunities for end user input is minimized during prototype production. During this phase, lay team members typically transition into a role of a prototype critic.

Continuing to escalate prototyping efforts entails rapid prototyping of interactive capabilities into digital and physical models, effectively producing first generation interactive simulations. For digital prototypes this process can entail the use of scripting languages, which are high level and easier for technical developers to learn, yet lack compilers which harm system performance and autonomy (Jacko and Sears 2007). In the case of physical computing systems, rapid prototyping of interactions include the use of breadboards, off-the-shelf microprocessors (such as the Arduino), off-the-shelf sensors (such as Davenport SRF04 Ultrasonic Range Finders) and robot kits (such as Lego NXT or iRobot Roomba platforms), or hacking third party devices (such as Wiimotes) to produce bench top prototypes. While utilizing such technologies may not provide the physical dimensions required to embed into the proposed final device form, they do facilitate rapid prototyping of interactions for systems that extend into the physical world for testing and evaluation.

Prototyping of non-computational related portions of a device (such as a cell-phone casing) at this stage begin to test usage of actual proposed materials, the integration of working physical interaction controls (buttons, dials, etc.) and begin to tackle issues of design for assembly and disassembly as well as sustainability. During this phase ergonomic issues of activation force, user fatigue and product durability also come into play.

At this point, prototypes can also begin to move out of the lab and into field for testing, where they are given to end-users for use in their intended environment of use. The return to field testing marks an increase in participatory collaboration between technical team members and lay team members as lay collaborators assume ownership of the prototype and have greater opportunity to provide *in-situ* feedback on changes that need to be made.

Final stages of interactive system prototyping deal with issues of digital and physical systems integration, manufacturing processes and commercialization, which, in many cases requires developing strategic partnerships to either license technologies or produce custom technologies (microprocessors, graphics engines, sensors, power sources, etc.). In the case of systems that are only software, final prototyping can include large-scale alpha/beta field-testing. If the PD team has developed prototypes that align with end-users, then this prototyping phase becomes less about design and more about engineering and business factors. Depending on the organizational structure of the development team, the designer can be minimized significantly. However, as with the *Interaction Prototyping* phase, end users have the opportunity to participate more directly than during non-interactive stage prototyping through continued field-testing.

One of the earliest and most well known examples of participatory prototyping is the UTOPIA project that took place in 1981. The project, led by, Pelle Ehn, included researchers from the Royal Institute of Technology, Stockholm and the University of Aarhus, Denmark collaborating with representatives of the Nordic Graphic Workers Union (Asaro 2000). The research team took a collective resources approach to the product they were designing. This approach entailed drawing from concepts of biological systems, psychology and citizenship that valued emergent behaviors open systems and the empowerment of union members by providing them a voice in not only developing product prototypes, but also develop research methods used to design and evaluate the prototypes.

Emergent behavior refers to behaviors that develop serendipitously through a process of interaction between actors, their motivations and the environment over time (Asaro 2000). An open system is one where users of the system can make contributions to the systems structure and content at any time. Do to the adaptability of open systems, they are seen as inherently sustainable (Asaro 2000).

In addition to the desire to develop a product that accounted for emergence and open-endedness, the UTOPIA research team also applied these concepts to their research and development process by allowing union member participants codevelopment rights to research methods as well as research outcomes. One product of this partnership was the implementation of the mock-up. The UTOPIA team used the mock-up as a means to tap into to the tacit knowledge of union workers and provide a space for communication between technical and lay participants. While the commercial software that resulted from the mock-ups failed, the use of the mock-up for providing an activity space where lay participants could leverage tacit knowledge and transform that knowledge into interactive system features succeeded. In addition, the mock-up introduced a means for technical experts to feel comfortable relinquishing project control to users (Asaro 2000). Since UTOPIA, subsequent PD projects have used both traditional and non-traditional mediums including to create mock-ups including standard pencils and papers, post-its®, cardboard, foam core, plastic and found materials (Beaudouin-Lafon & Mackay 2007).

The PICTIVE (Plastic Interface for Collaborative Technology Initiative through Video Exploration) (Muller 1991, 1992; 1993) project was both an experiment in low-fidelity, visual prototyping and a toolkit for producing such prototypes (Muller 1991, 1992; 1993). During a PICTIVE (Muller 1991, 1992; 1993) session researchers videotaped a design space and provided two categories of materials:

> "The "design objects" mentioned above fall into two categories. The first category is simple office materials. These include pens, highlighters, papers, Post-It™ notes of various sizes, stickers and labels, and paper clips — all in a range of bright colors. The second category is materials prepared by the developer — either generically for multiple design exercises e.g., command line, query fields, menu bars, dialogue boxes, etc.), or specifically for the project being designed."

The second category of materials was plastic icons that served as visual markers for interface elements. Prior to engaging in PD sessions, researchers asked participants to commit to homework. Lay participants were asked to prepare job/task scenarios while developers were asked to come to the table with an initial list of assumed system components. When shared with the group, the content of the individual assignments generated a dialogue between user needs and system requirements. The PICTIVE plastic icons supported this dialogue by allowing team members to rapidly add/change/delete interface elements in response to emergent design issues (Muller 1991, 1992; 1993). PD teams documented use of PICTIVE to develop prototypes for both VISAR and Bell Operating Companies (Muller 1991, 1992; 1993). In both cases, PICTIVE succeeded in facilitating knowledge sharing and building consensus on software interface and functionality (Muller 1991, 1992; 1993).

While both UTOPIA mock-ups and PICTIVE (Muller 1991, 1992; 1993) afforded a collaborative design space for product development, John Gould developed what would later be called the “Wizard of OZ” method for evaluating interaction with non-existent systems (1983). The method involved developing a set of rules that mimic the would-be interactive system’s behavior. A member of the research team would then take on the role of the interactive system, behaving in accordance with the system’s rules. The actor-researcher would then hide from the system user while the user interacted with a mock-interface. Gould and his team used the method to test hypothetical interactions between users and a listening typewriter, which relied on a microphone, a computer monitor and researcher in a separate room who typed in the user’s dictation, which would then appear on the user’s monitor. The method has proven invaluable for simulating the interactions between users and systems in cases where system development requires the invention or purchase of new core technologies, yet have little to no research validating the expenses of the technology (Erickson & McDonald 2008). However, the methodological contribution to prototyping lay in the ability of interaction designers to gather data on an interactive system prior to the system's existence. Through a clever use of role playing, experiment design and focusing on multimodal interaction rather than system features, Gould *et al*. was able to evaluate a prototype without writing a line of code.

Thus far, the use of everyday office materials, custom interface feature representations and the researcher-as-actor have been shown to produce compelling prototypes that embody user-centered context and the technological considerations of developers. However, once costly technologies have dropped in price considerably over the last three decades, allowing prototype developers to produce higher-fidelity prototypes earlier on in the design process. Two recent prototyping projects have utilized a combination of sophisticated technologies, everyday office items, and craft materials to support higher fidelity prototypes capable of providing interactive functionality in part or in full.

In 2008, Lahey, Burleson, Jensen, Freed, & Lu collaborated with primary school students to produce functional prototypes of robotic learning agents. Robotic agent development combined iRobot Roomba platforms that responded to fiducial marker commands with traditional craft materials (construction paper, tape, scissors and stickers to mock-up agent aesthetic attributes). The research team created robotic agents that looked like frogs and birds for the students to relate to while using the robots to learn about science, technology, engineering and math (STEM) content.

Also in 2008, Brotman, Spicer and Kelliher used a similar, mixed-media approach to test a mediated design studio space intended for organizational knowledge management. This project included a wall display that provided access to storytelling software, while an office table, the top of which was made of whiteboard, was meant to simulate a digital surface for collaborative generation of design artifacts such as sketches, conceptual frameworks and scenarios. The storytelling software provided a means for reflection-on action by allowing users of the space to take ethnographic footage of their activity and construct stories of design practice. The whiteboard table was used as a space for collaborative reflection-in action during design practice. The prototype space illustrated that design studios that provided distinct spaces for reflection-on and reflection-in action increased brainstorming activities.

Both of these projects, while focused towards different application domains (Computer Supported Collaborative Learning in the case of Lahey et al*.* and Computer Supported Cooperative Work for Brotman *et al*.) shared several design decisions. First is the use of both high fidelity and low fidelity materials to construct prototypes. Second is the collapse of the design and evaluation phases through situated interaction (Suchman 1987). In the case of Lahey et al., children played with the robots after decorating them, testing the fundamental technology and the hypothesis of using robots to teach children about STEM learning (2008). In the case of Brotman, the design space underwent a process of design and evaluation by authentic users to produce insights into how designers engage in processes of reflection and how mediates spaces can support that process during creative practice (2008).

This chapter presented theory and methods for prototyping and participatory design. Additionally, five case studies were surveyed to illustrate different fidelities of prototypes used as design objects within the context of PD.

As interactive system development teams continue to blur the boundaries between physical and digital interactions through the production of ubiquitous and pervasive computing, mobile computing, embedded systems and distributed computing systems, new challenges emerge for including end-users in prototype development. For example, ubiquitous computing is highly dependent on making many traditional components of interactive systems (such as input devices) invisible to the user. This leads to the challenge on how interaction designers engage end users in designing invisible systems? While the WoZ has had some success in this field, this success is tempered by the increasing complexity of interaction within these systems. As this complexity escalates, so does the effort associated with having researchers take on the role of the system. At some point, this method will not be cost effective.

Many developers are also striving to develop ambient intelligent systems (Aarts 2009) - systems that continually monitor end-users and proactively act in the user’s best interest. Such systems require a fundamental redefinition of interaction based on the concept of intentionality. What types of situations should computers display intentionality and how are such intentions realized within interaction? How will shifting the power relationships between human and computer to one of shared intent change human responses to computational agents and how will such a shift influence the design and evaluation of prototypes

The mass implementation of networking to connected multiple devices produces computational ecosystems populated by multiple interactive systems. As information flows between networked devices and interaction with this information takes place in different physical environments, the interaction space with that information multiplies. This phenomena leads to questions regarding how to make prototypes that account for the multiplicity of the same content in different environments through different devices?

Finally, the introduction of robots into everyday environments provides interaction designers with new realms of aesthetics to consider. How can interaction designers produce prototypes that test concepts of the end-user's perception of safety, social attachment and trust in task delegation?

Answering these questions may also change the current state of what is considered to be a low-fidelity or non-interactive prototype. For instance a non-interactive robot prototype could take the form of a researcher controlling a robotic agent remotely in the field. This could be considered non-interactive from the standpoint that the robot lacks the robust logic structures needed to act autonomously.

Regardless of changes that may take place in prototyping methodologies, the fundamental reasons behind prototyping within the context of PD will most likely remain the same. Prototyping has proven to be a powerful tool for supporting end-user collaboration during PD by creating a space where end-user participants can communicate their tacit knowledge and technical users can feel comfortable relinquishing control of the design process. The proven capability of prototyping to enhance knowledge sharing and empower end-users with a voice during the design process makes prototyping an invaluable PD tool.

Chapter 5

SMART HOME SERVICE PROVISIONS

This section summarizes prior HCI studies to develop ubiquitous computing systems for the home. There is a large volume of work in this field and covering all of it falls outside of the scope of this dissertation. The related work presented in this chapter is constrained by the following criteria:

- User Centered: All of the cases discussed in this section deal with HCI research aimed at understanding the relationship between domestic human behavior and ubiquitous computing technologies.
- Methodologically Focused: One of the contributions of this research agenda is the proposition and evaluation of a new research approach for dealing with a number of current challenges HCI researchers experience during design and evaluation of ubiquitous computing systems for the home. The previous work presented in this chapter focus on studies that have contributed to HCI methodology within the context of PD and prototyping.

Four methodological approaches have emerged in research of smart home service provisions:

1. High fidelity smart home prototypes that function as living labs
2. Field testing of technology probes (Hutchinson et al. 2003) within the homes of end users
3. Ethnographic studies of domestic behavior and;
4. Participatory design activities to iteratively co-create system prototypes.

A number of high fidelity prototypes have been developed as platforms to probe connections between domestic behavior and computational systems. In 1999, the Georgia Institute of Technology began the *Aware Home* (Kientz *et al*. 2008). Over the past 12 years, *Aware Home* has explored issues concerning chronic care (Mamykina & Mynatt 2007), aging and resiliency (Kientz et al. 2007) and home media and entertainment. The *house_n* project by MIT serves as a "living lab" for testing new domestic ubiquitous technologies (Intille et al. 2003). While the stated objective of the house_n research group are to tackle a number of issues ranging from supporting healthy living to developing green housing and the next generation of homes (Intille *et al. 2003)*, a large portion of published works deal with pattern recognition of occupant activity (Intille, Tapia, Rondoni, Beaudin, Kukla, Agarwal & Larson 2003) and maintaining health (Intille 2004) and independent living (Intille 2004). The *Ambient Kitchen* allows researchers to prototype ubiquitous technologies to support the cooking practices of people living with autism (Olivier et al. 2009). This approach for research on domestic ubiquitous technologies gives researchers robust, controlled environments to test interventions and collect both quantitative and qualitative data. There are three weaknesses of this approach. First, research teams often do not consult end users during design and construction of the lab space. Second, this approach requires participants to leave their home and live in a foreign environment, which may bias behavior patterns. Third, this approach has a high price tag and long timeline.

Other prototyping efforts have included field-testing of lower fidelity, interactive prototypes. Hutchinson, Mackay, Westerlund, Bederson, Druin and Plaisant introduced technology probes as a means to explore how to design new technologies for families (2003). A number of subsequent studies adopt this approach to facilitate participatory dialogue with end users and inform iterative prototyping efforts. The *Digital Selves* project deploys a series of technology probes within the homes of couples living apart to investigate how to support intimacy (Grivas 2006). *Homenote* field-tests a technology probe revealing new purposes of interpersonal communication in the home (Sellen, Harper, Eardley, Izadi, Regan, Taylor, & Wood 2006*).* The *Tableau Machine* field test shows complexities associated with using cameras to sense human activity, as well as the value of allowing occupants to interpret and experiment with ubiquitous computing technologies to foster technology adoption (Pousman, Romero, Smith, & Mateas 2008). This approach has three primary strengths. First, it reduces development costs by focusing on "good enough" prototypes that support desired interactions. Second, it allows researchers to observe how potential new technologies function within a participant's natural domestic environment. Third, it includes end user feedback earlier in the design process by testing non-permanent ubiquitous computing systems. The weakness behind this approach is that as with the living labs approach, researchers tend to produce the initial probe without engaging the user, which can reduce the effectiveness of the probe for gathering authentic data on human behavior.

Since Crabtree and Rodden's paper on domestic routine (2004), ethnography has emerged as a popular methodology to inform design of ubiquitous computing for the home. Elliot, Neustaedter, & Greenberg observe the interdependencies of location and information context within the home to create an in-home messaging system (2007). Neustaedter, Elliot, & Greenberg conducted an ethnographic study on interpersonal awareness in the home to produce a behavioral prototype for designing ambient systems (2006). Taylor and Swan reveal how families use artifacts in both intended and serendipitous ways to organize their everyday activity and from their findings provide a set of heuristics for guiding design of domestic interventions (2005). Ethnography's strength is that it can generate rich data on human behavior to construct grounded theories of domestic activity (O'Leary 2009). These theories can improve alignment of ubiquitous computing technologies with end-user needs. However, ethnographic studies can drastically increase project budgets and schedules. Previous studies using this approach have also indicated that access to the domestic space is often limited to specific times of the day and specific areas of the domestic space. This issue with access to the home can reduce the authenticity of the data (Cieraad 1999). Finally, critics of this approach argue that the qualitative nature of the data, the focus on a small population sample size and the dependence on the researcher as the instrument of analysis reduces the reliability of the data (Robson 2002). This perceived lack of reliability becomes a potential challenge for formal evaluation of relationships between new systems and occupant behavior.

Participatory design activities stress constant collaboration with end users to produce a series of prototypes. According to Beaudouin-Lafon and Mackay a prototype is a, "- concrete representation of part of or all of an interactive system," (Jacko & Sears 2007). These prototypes often start as low fidelity paper mock-ups that describe behavior and potential interaction schemes, and end with partial or fully interactive systems (Jacko & Sears 2007). In some cases, participatory design agendas begin with ethnography to situate future co-creation activities (Sellen et al. 2006), such as Affinity diagramming (Jacko & Sears 2007), sketching (Buxton 2007) and paper prototyping (Lancaster 2003; Buxton 2007). In 1996, Mateas, Salvador, Scholtz & Sorensen co-construct models of domestic computing usage through an activity that involved making felt maps with occupants (Erickson & McDonald 2008). Iacucci, Kuutti & Ranti introduced role-playing as a way to engage participants to act out scenarios for everyday uses of wireless devices (2000). One strength of a participatory approach is the end-user is involved in making early stage design decisions, which can reduce the risk of product failure. Another strength of this approach is the focus on prototyping many versions of the proposed intervention which aligns with recent shifts to agile development cycles in industry. A weakness of this approach is that users often do not know what they want until it is shown to them. To address this weakness, researchers must often spend a great deal of time and resources educating end-users on baseline proficiencies to foster critical thinking about they need (Miller *et al*. 2009). As with ethnography, critics of this approach question it's ability to produce reliable data for formal evaluation.

These related works discussed above demonstrate the disparate efforts and their related approaches towards developing a body of knowledge regarding the relationships between occupants and smart homes. The range of variability across these studies structures an opportunity for a unifying framework to inform the design of mediated, domestic environments. The following chapter presents a framework for MSD, a design approach for exploring relationships between people and their environments.

Chapter 6

CONCEPTUAL FRAMEWORK: MOTIVATION SENSITIVE DESIGN

MSD synthesizes theory and methodology from motivational psychology and place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) theory to provide a possibility space for exploration, definition and evaluation of new products and services. At the center of MSD is the synthesis of PPA (Little et al. 2007) and SoP (Jorgensen & Stedman 2001; 2006) to introduce a construct called Project-Centered Sense of Place (PCSoP). This construct proposes that a person's motivation and their relationship to a place are dynamic, rather than static, changing in response to the personal project (Little 1987; Little et al. 2007) a person is engaged in. While PPA (Little et al. 2007) has already demonstrated this phenomenon between motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) and personal projects (Little 1987; Little et al. 2007), the addition of place relationships through synthesis of the SoP (Jorgensen & Stedman 2001; 2006) model into a project-centered construct is new. Figure four provides an illustration of the proposed relationships between motivation (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004) SoP (Jorgensen & Stedman 2001; 2006) and personal projects (Little 1987; Little et al. 2007).

Personal projects $\longleftrightarrow$ Motivation $\longleftrightarrow$ Sense of place

Figure four. Project-centered sense of place conceptual framework.

In this model, a person's motivation acts as a functional bridge between a person's personal projects (Little 1987; Little et al. 2007) and her relationship to a place to produce affective, cognitive and conative behavior in pursuit of the project. PPA (Little et al. 2007) dimensions represent a person's affective, cognitive and conative attributes related to a project. The SoP (Jorgensen & Stedman 2001; 2006) assessment factors represent a person's relationship with a place. Figure five illustrates the proposed relationships between PPA (Little et al. 2007) dimensions and SoP (Jorgensen & Stedman 2001; 2006) factors.

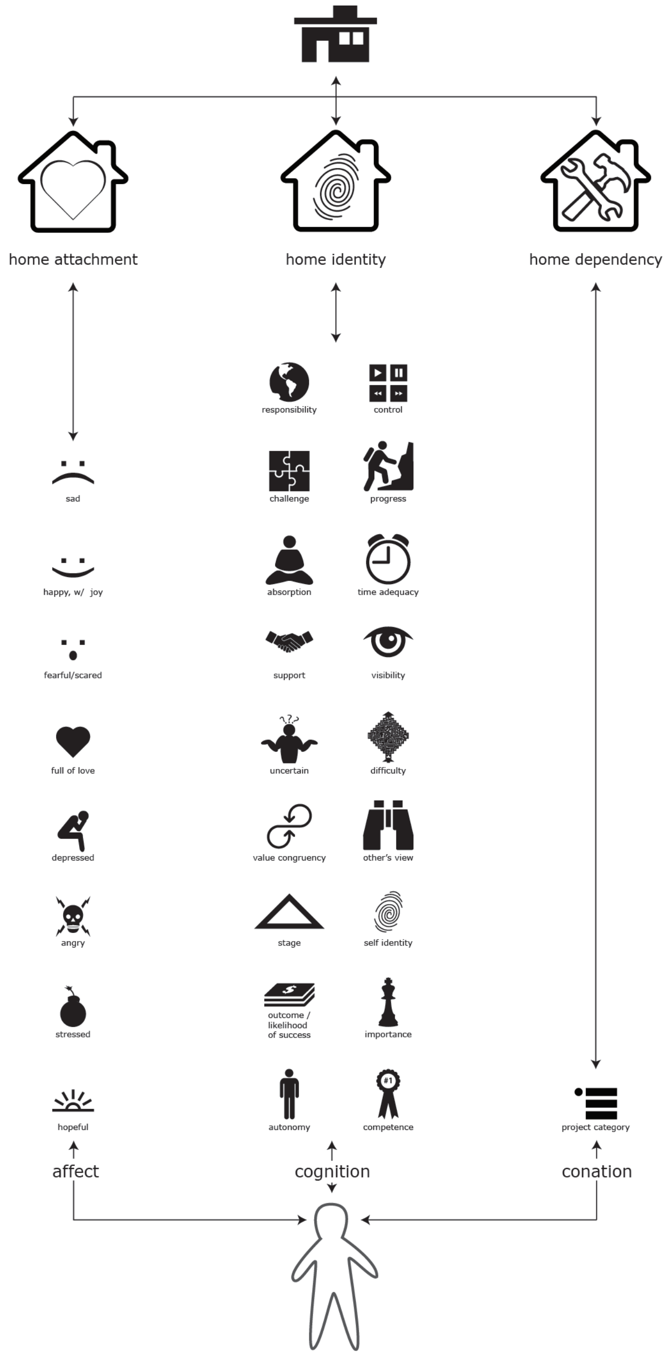


Figure five. Personal project assessment dimension (Little et al. 2007) to sense of place factor (Jorgensen & Stedman 2006; 2001) alignment.

In this model, the PPA (Little et al. 2007) dimensions *Hopeful, Stressed, Angry, Depressed, Full of Love, Fearful/Scared, Happiness/Enjoyment* and *Sad* align with the SoP (Jorgensen & Stedman 2001; 2006) factor *Place Attachment* to measure affect. The PPA (Little et al. 2007) dimensions *Autonomy, Competence, Outcome/Likelihood of Success, Importance, Stage, Self Identity, Value Congruency, Other's View, Uncertain, Difficulty, Support, Visibility, Absorption, Time Adequacy, Challenge, Progress, Responsibility* and *Control* align with the SoP (Jorgensen & Stedman 2001; 2006) factor *Place Identity* to measure cognition. The PPA (Little et al. 2007) project category index aligns to the SoP (Jorgensen & Stedman 2001; 2006) factor *Place Dependence.* If there is perfect alignment between all PPA (Little et al. 2007) dimensions and the respective SoP (Jorgensen & Stedman 2001; 2006) factors, then that would indicate a perceived perfect environmental fit between a person and an environment within the context of a personal project (Little 1987; Little et al. 2007). However, as a framework supporting design, the PCSoP model is used to identify where breakdowns occur between person-environment alignment, with the assumption that such breakdowns present opportunities for new products and services that support completion of a personal project (Little 1987; Little et al. 2007). The underlying assertion of this perspective on design is that goodness of fit, or environmental congruence (Stokols 1977), is desirable for personal project (Little 1987; Little et al. 2007) completion, goal attainment and HF (Fredrickson 2002; Little et al. 2007; Seligman 2004), and therefore, designers should strive to foster such congruence (Stokols 1977).

This model is proposed for use as both a normative and/or idiosyncratic tool for design. As a normative tool, PCSoP can define a set of statistical relationships between a specific population and specific environment, e.g. young adults and their homes. Relationships that are statistically significant serve as design heuristics for conceptualization of new solutions. Second, parametric modeling of significant relationships yields can yield predictive models that designers can implement during evaluation cycles to test whether or not a solution produces the desired affect on motivation (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004). Through these relationships, a design space is produced for thoughtful conceptualization and evaluation of new solutions.

As an idiosyncratic tool, PCSoP can be used as a boundary object for designers to engage in participatory dialogues with participants to design tailored solutions. When combined with the results of a normative use of PCSoP, MSD heuristics can be employed in the form of an interview guide to structure participatory practice.

The PCSoP framework is proposed as a highly extensible meta space that can account for dynamics across motivation (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004) personal projects (Little 1987; Little et al. 2007) and SoP (Jorgensen & Stedman 2001; 2006). For example, if hypothetical participant define a project called, "Lose 10 lbs.", environmental congruence (Stokols 1977) of this project could be modeled within the home, the workplace and the gym, and produce three completely different, yet potentially equally informative sets of motivational relationships. Likewise, two cohort groups that report the project, "Lose 10 lbs." could demonstrate two completely different motivational relationships between that project and their homes. Third, the exact same cohort group and environment could be modeled across multiple personal projects (Little 1987; Little et al. 2007) to generate a deep understanding of motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) within the context a specific population and specific environment. For example, the relationships of young adults and their homes could be modeled for the personal projects (Little 1987; Little et al. 2007) "lose 10 lbs.", "learn how to cook" and "maintain a tidy household" to build a more complete understanding of how young adults experience their homes. This ability to reveal motivational relationships at both normative and idiosyncratic scales of use, as well as the ability to translate across environments, projects and cohort groups, defines “extensibility” for the PCSoP construct.

The following studies test the reliability and extensibility of the MSD model to construct a case for the *Motivational Home* (MH). MH is design toolbox that assists developers of smart home service provisions in conceptualization and evaluation of solutions. The first study tests the reliability of PCSoP constructs, as well as the capability of PCSoP to generate statistically significant relationships and design heuristics that represent motivation sensitivities when designing for young adults and their homes.

The second study, implements design heuristics in an idiosyncratic manner through a series of co-design sessions to make paper prototypes of smart home service provisions. The results from this second study are used in two ways. First, idiosyncratic solutions are normatively analyzed to produce a user experience framework for smart home service provisions. Second, three of the paper prototypes are chosen for further development to support a third and final study.

The third study consists of implementation of three of the paper prototypes as fully interactive technology probes (Hutchinson et al. 2003) and installed in the homes of occupants. Predictive models produced from the first study will be used to evaluate the affects of the applications on motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) and environmental congruence (Stokols 1977). Chapters Eight through 10 present these studies in the sequence described above.

Chapter 7

TECHNOLOGY IMPLEMENTATION: GAME-AS-LIFE, LIFE AS GAMEUBIQUITOUS COMPUTING PLATFORM

The Game-as-Life, Life-as Game (GaLLaG) (Burleson et al. 2009) research group developed the system to facilitate hybrid-reality, personalized game scenarios. Hybrid reality refers to the ability of physical interactions to produce digital outcomes and vice-versa. GaLLaG (Burleson et al. 2009) developers defined personalized games as games that not only provide user-centered, context sensitive content, but also tailors the interactions to align with the user's personality, affective response to the current situation and preferences (such as favorite color and preferred feedback modalities) (Burleson *et al.* 2009).

The GaLLaG (Burleson et al. 2009) system integrates a number of off-the-shelf software and hardware technologies. Indigo 4.0, a commercially available home automation software suite, acts as the system's core. It provides a channel for multiple programming languages to send information to multiple devices, as well as data logging via an SQLite database. The "Digital GaLLaG Space" (Burleson et al. 2009) allow developers to produce programs using a variety of common languages including Applescript, Objective C, JavaScript, Python and Ruby. Program commands can travel through web services to the GaLLaG (Burleson et al. 2009) server and out to devices to trigger interactions.

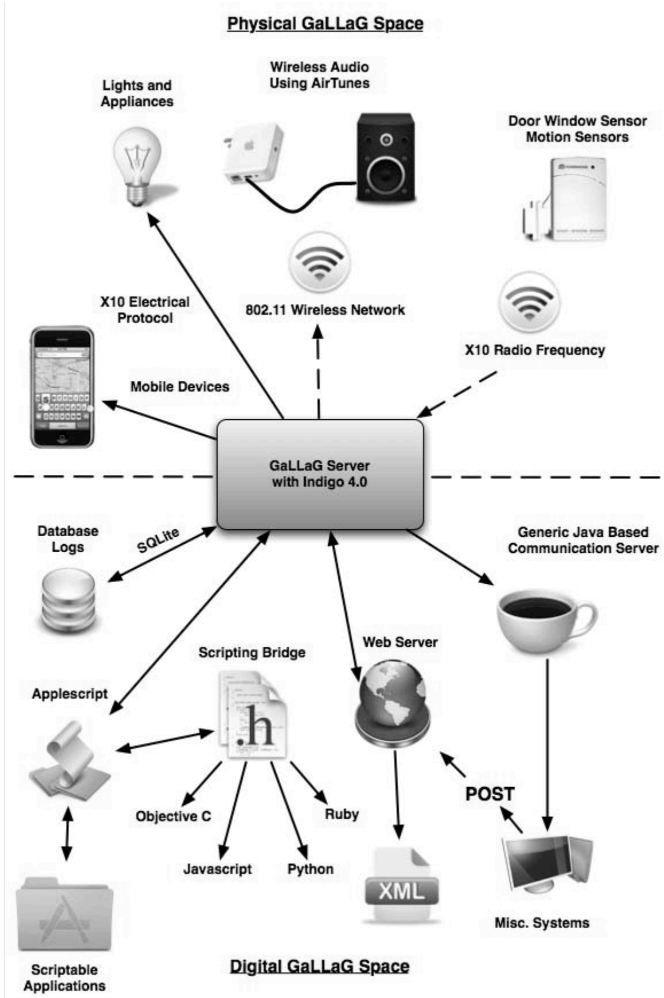


Figure six. Game-as-life, life-as-game (Burleson et al. 2009) system architecture diagram.

The end-user can determine interactions with GaLLaG (Burleson et al. 2009) by incorporating a number of "Physical GaLLaG Space" (Burleson et al. 2009) objects. Mobile device sensors allow GaLLaG (Burleson et al. 2009) to monitor end-users as they travel from among physical locations throughout their day. The mobile device also acts as an audiovisual and haptic interface for receiving and responding to GaLLaG (Burleson et al. 2009) content. Light and appliance controllers determine whether lights and appliance are either off or on. End-users can affix door/window sensors to physical objects to integrate virtual functionality. End-users may also set up motion sensors to track their location and the locations of other household members within the home. Wi-Fi enable audio speakers allow end-users to enable environments with spatialized audio feedback. A radio frequency antenna receives information sent from lamp and appliance controllers and door/window sensors. The analog-to-digital converter (ADC) then converts the signal received by the antenna into information recognized by the Indigo software. Indigo software only runs on Apple computers.

This section described the technologies comprising the GaLLaG (Burleson et al. 2009) ubiquitous computing platform. The following section describes the development of motivational home design heuristics for framing the design of SHSPs built using the GaLLaG (Burleson et al. 2009) platform.

Chapter 8

MOTIVATION SENSITIVE DESIGN HEURISTICS FOR SMART HOME SERVICE PROVISIONS

Introduction and Rationale

This study was conducted to explore the theory of PCSoP. This study is important to the overall research agenda because PCSoP is the core construct supporting the theoretical framework of the motivational environment (See Chapter six). The underlying assumption informing PCSoP is that a person's relationship to a place is not fixed across time, but rather, correlates to the emotions, and thoughts a person has about their personal projects (Little 1987; Little et al. 2007), and how their personal projects relate to that place. As a person adds new personal projects (Little 1987; Little et al. 2007) to their project ecosystem (Little et al. 2007), removes current personal projects (Little 1987; Little et al. 2007) from their project ecosystem (Little et al. 2007), or redefines what a personal project (Little 1987; Little et al. 2007) means to them, their relationship with places adapt to accommodate those changes. This assumption expands the role of the personal project (Little 1987; Little et al. 2007) as a meta carrier unit to include place relationship data on a person's feelings towards a place (affective relationships), a person's identification with a place (cognitive relationships) and a person's dependence on a place (conative relationships).

SoP (Jorgensen & Stedman 2006,2001), is a recent model meant to measure the affective, cognitive, and conative relationships between a person and a place. This study merges this model with the Personal Project Analysis (PPA) (Little et al. 2007) (Little *et al*. 2007) methodology. This merger represents a contribution at the level of both theory and methodology. From a theoretical standpoint, Personal

Projects (Little 1987; Little et al. 2007) are a construct developed to support PAC (Little et al. 2007), while the SoP (Jorgensen & Stedman 2001; 2006) is a model derived to support Place Attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) theory. At a methodological level the items that construct the three SoP (Jorgensen & Stedman 2001; 2006) factors are rephrased to assess project-place relationships and assimilated into the PPA (Little et al. 2007) methodology to become additional traits used to measure personal projects (Little 1987; Little et al. 2007).

PCSoP is critical to the concept of the motivational environment because personal projects (Little 1987; Little et al. 2007) are groups of activities that represent personal goals (Little *et al*. 2007). Goals fuel motivation (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004) and motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) spurs actions that when networked together, construct personal projects (Little 1987; Little et al. 2007). This suggests that personal projects (Little 1987; Little et al. 2007) and sense of place are related -- that place often functions as a platform for motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) and goal attainment. This implies that design of the physical spaces and digital spaces that comprise a smart home based on (context aware) goal pursuit can be an important design activity in service of personal projects (Little 1987; Little et al. 2007) and HF (Fredrickson 2002; Little et al. 2007; Seligman 2004).

This PCSoP study focuses on young adults and their relationships with their homes to develop. Young adults have been studied in both the PPA (Little et al. 2007) and place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) theory literature, providing previous knowledge to benchmark results against. The home has long been a subject of research in place attachment theory (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992), which also provides previous results to benchmark against. Additionally, focusing on the home supports additional design and evaluation research related to smart home service provisions.

This study deployed PPA (Little et al. 2007) surveys containing the typical set of PPA (Little et al. 2007) dimensions, as well as PCSoP items to measure Project-Centered Place Attachment, Project-Centered Place Identity and Project-Centered Place Dependency. The purpose of the survey was to validate the construct reliability of the new PCSoP factors, as well as to identify potential relationships between Sense of Place personal project (Little 1987; Little et al. 2007) scales and PPA (Little et al. 2007) dimensions indicating the existence of PCSoP. The results indicated that each of the SoP (Jorgensen & Stedman 2001; 2006) factors were reliable. In addition, the relationships identified between SoP (Jorgensen & Stedman 2001; 2006) and standard PPA (Little et al. 2007) dimensions indicate a network of complex, and overlapping relationships that support the assumption that a person's relationship with their home, in part, is affected by their personal projects (Little 1987; Little et al. 2007), and their relationships to their personal projects (Little 1987; Little et al. 2007). These findings support both the theoretical framework of the motivational environment and provide a framework and toolkit for designing the motivational home.

The following sections define the variables and hypotheses, present the methodology and procedures, report the results and discuss the implications of the study, and propose future work aimed at advancing the theory and practical application of motivational environments.

Variables and Hypotheses

The variables of this study consist of four distinct content groups generated within the context of a PCSoP psychometric survey:

1. Participant demographic data
2. Personal project (Little 1987; Little et al. 2007) qualitative data
3. Standard PPA (Little et al. 2007) dimensions
4. PCSoP dimension data focused on the home.

Participant demographic data variables consisted of the participant's age, sex, relationship status, cohabitation status, if they had children and their race. The variable, *Age*, was measured on a ratio scale, while all other demographic variables were nominal in nature. The values for the nominal demographic variables and their associated numeric codes in the Statistical Package for Social Science application (SPSS) are as follows:

- Sex, 1 = Male, 2 = Female;
- Relationship status, 1 = Single, 2 = Domestic partnership (including marriage), 3 = Widow, 4 = Divorced;
- Parent, 1= Yes, 2 = No;
- Live alone, 1 = Yes, 2 = No;
- Ethnicity, 1 = White, 2 = Hispanic, 3 = African American, 4 = Asian, 5 = Native American, 6 = Other.

Personal project (Little 1987; Little et al. 2007) qualitative data consisted of two variables: the string variable *Project* and the nominal variable *Project Category*. The *Project* variable is a user generated, short description of the personal project (Little 1987; Little et al. 2007). Examples of such descriptions are "lose 10 lbs.", "learn how to play 'Blackbird' on my guitar" and "read *The Bible* more". The *Project Category* variable consists of a list of project types previously established in the PPA (Little et al. 2007) literature. The categories for this variable are as follows: 1 =

Academic, 2 = Health and Fitness, 3 = Interpersonal, 4 = Intrapersonal, 5 = Leisure and Entertainment, 6 = Daily Routine, 7 = Work Related, 8 = Home and Vehicle Improvement, 9 = Volunteer Work, 10 = Pet Care, 11 = Holiday Related, 12 = Other (Little et al. 2007).

The complete set of standard PPA (Little et al. 2007) affective and cognitive assessment dimensions, coupled with an additional 12 dimensions on PCSoP were used in this study. All of these dimensions were measured on a zero-to-10 interval scale with zero as the minimal value and 10 as the maximum value. PPA (Little et al. 2007) affective dimensions are *Sad*, *Fearful/Scared*, *Full of Love*, *Angry*, *Happy/with Enjoyment*, *Hopeful, Stressed*, *Uncertain* and *Depressed*. PPA (Little et al. 2007) cognitive dimensions and their operational definitions (along with their instructions) are as follows:

- *Importance*: How important is this project to you? (Use 10 if you consider it to be very important, and 0 if it is not at all important)
- *Difficulty*: How difficult do you find it to carry out each project? (Use 10 for a project that is extremely difficult to carry out, and 0 for one that is not difficult at all.)
- *Visibility*: How visible is this project to others that are close to you? (Use 10 for a project that is very visible to those around you, and 0 for a project that is not at all visible to those around you).
- *Control*: How much do you feel you are in control of this project? (Use 10 if you feel completely in control of the project, and 0 if you feel you have absolutely no control over the project.)
- *Responsibility*: How responsible are you for carrying out this project? (Use 0 is you do not feel any responsibility for making progress in this project, and 10 if you feel entirely responsible for the project.)

- *Time Adequacy*: How adequate is the amount of time you spend working on this project? (Use 10 if you feel the amount of time is perfectly adequate, and 0 if you feel that the amount of time you spend working on the project is not at all adequate.)
- *Outcome (Likelihood of Success)*: How successful do you believe this project will be? (Use 10 if you expect the project to be entirely successful, and 0 if you think the project will turn out to be a total failure.)
- *Self-Identity*: All of us have things we do that we feel are typical or truly expressive of us. These things can be thought of as our "trade marks". For example, some people engage in sports every chance they get; others prefer to read, while others prefer to socialize. Think of what your own personal "trade marks" are, and then rate this project on the extent to which it is typical of you. (Use 10 if a project is very typical of you, and 0 if it is not typical at all.)
- *Others' View of Importance*: How important is this project seen to be by those people who are close to you? (Use 10 if others see a project as very important, and 0 if it is seen as not important at all.)
- *Value Congruency*: To what extent is each project consistent with the values that guide your life? (Use 10 if a project is totally consistent with your values, and 0 if a project is totally at odds with them.)
- *Progress*: How successful have you been in this project so far? (Use 10 to indicate that you have been very successful and 0 to indicate that you have had no success at all.)
- *Challenge*: How challenging do you find this project? (Use 10 if it is very challenging, perhaps more than you can handle, and 0 if it is not at all challenging, indeed you find it almost boring.)

- *Absorption*: To what extent do you become engrossed or deeply involved in a project (Use 10 if you generally get absorbed in an activity, and 0 if you tend to be uninvolved when doing it.)
- *Support*: To what extent do you feel other people support each project? Support may come in different forms, e.g. emotional (encouragement, approval), financial (money, material possessions) or practical (active assistance) (Use 10 if you feel other people support the project a lot, and 0 if there is no support at all.)
- *Competence*: To what extent do you feel competent to carry out this project? (Use 10 if you feel completely competent to carry out the project, and 0 if you do not feel competent to carry it out).
- *Autonomy*: How much is this project one which you feel you are pursuing autonomously, that is, you are engaged of your own free will in the project, not because anyone else wants you to do it. (Use 10 if you are engaged in this project entirely of your own free will, and 0 if this project is one that you feel totally obliged to complete because of or for someone else.)
- *Stage*: Projects often go through several stages, which can be visualized along a time-line, such as:

  0........1........2........3........4........5........6........7........8........9........10.

  Think of each project as moving through stages on such a time-line. Using the scale on this page, rate each project's stage:

Table two.

Personal project analysis (Little et al. 2007) "stage" dimension measurement categories.

0 - 1	Awareness	The idea for the project has just come to you.
2	Transition	You have decided to proceed with the project.
3 - 4	Planning	You are planning it and obtaining whatever personal and material support it may require.
5	Transition	You have the project planned out and you are beginning to (or trying to) actively start the project.
6 - 7	Action	You are actively working on the project and trying to balance it with your other projects, resources and time commitments.
8	Transition	You are evaluating the project and your motivation to continue with it, or bring it to completion/disengage from it.
9 - 10	Completion	The project is coming to a close or has actually been completed or terminated.

The final data group consists of the PCSoP dimensions to assess relationships between a person's personal projects (Little 1987; Little et al. 2007) and the home. These 12 dimensions distribute evenly across three factor loadings. The set of PPA (Little et al. 2007) Sense of Place dimensions and associated factors were derived from Jorgensen & Stedman's tripartite model of Sense of Place (2006; 2001). The PPA (Little et al. 2007) Sense of Place dimensions and factors are as follows:

- *Factor One: Home Attachment*: The degree to which a person feels a positive emotional attachment with her home while engaged in a specific personal project (Little 1987; Little et al. 2007).
    - *Home Attachment Dimension One*: I feel happiest at home when I do this project.
    - *Home Attachment Dimension Two*: When I engage in this project, I feel relaxed at home.
    - *Home Attachment Dimension Three*: My home is my favorite place to be when I do this project.
    - *Home Attachment Dimension Four*: When I am away from home, I think about this project and I miss my home.
- *Factor Two: Home Identity*: The degree to which a person feels most like herself at home while engaged in a specific personal project (Little 1987; Little et al. 2007).
    - *Home Identity Dimension One*: When I do this project, everything about my house is a reflection of me.
    - *Home Identity Dimension Two*: This project says very little about who I am as a person.
    - *Home Identity Dimension Three*: When I do this project at home, I feel I can really be myself.
    - *Home Identity Dimension Four*: This project reflects the type of person I am at home.

- *Factor Three: Home Dependency*: The degree to which a person is dependent on her home environment while engaged in a specific personal project (Little 1987; Little et al. 2007).
  - *Home Dependency Dimension One*: I enjoy doing this project most at home
  - *Home Dependency Dimension Two*: My home is the best place to do this project.
  - *Home Dependency Dimension Three*: My home is not a good place to do this project.
  - *Home Dependency Dimension Four*: As far as I am concerned, there are better places to do this project than at home.

The PPA-SoP factors were calculated by adding the scores of the four items loaded to each factor and then dividing the total score by the number of items. The equations for calculating each factor score are:

- *Home Attachment Factor* = (*Home Attachment Dimension One* + *Home Attachment Dimension Two* + *Home Attachment Dimension Three* + *Home Attachment Dimension Four*) / 4
- *Home Identity Factor* = (*Home Identity Dimension One* + *Home Identity Dimension Two* + *Home Identity Dimension Three* + *Home Identity Dimension Four*) / 4
- *Home Dependency Factor* = (*Home Dependency Dimension One* + *Home Dependency Dimension Two* + *Home Dependency Dimension Three* + *Home Dependency Dimension Four*) / 4

Based on the current state of the art with regards to both PPA (Little et al. 2007) and Place Attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) theory, this study makes the following hypotheses:

- H1: SoP (Jorgensen & Stedman 2001; 2006) items rephrased as PCSoP dimensions will remain reliable within the context of the three-factor SoP (Jorgensen & Stedman 2001; 2006) model. This reliability will be demonstrated with *Place Attachment*, *Place Identity*, and *Place Dependency* scales yielding Crombach Alpha score of greater than 0.70.
- H2: *Place Attachment* positively relates to the PPA (Little et al. 2007) dimensions *Hopeful*, *Happy w/Enjoyment,* and *Full of Love,* or in other words, controlling for all other variables, when people engage in projects at home that make them feel hopeful, happy, and/or in love, they will feel more attached to their home.
- H3. *Place Attachment* negatively relates with the PPA (Little et al. 2007) dimensions *Depressed, Stressed, Angry, Uncertain,* and *Sad.* This hypothesis states that as people feel their personal projects (Little 1987; Little et al. 2007) make them more attached to their homes, they will feel less depression, stress, anger, uncertainty, and sadness.
- H4**.** *Home Identity* positively relates to the PPA (Little et al. 2007) dimensions *Importance*, *Responsibility*, *Self Identity*, *Value Congruency* and *Absorption*. As people feel their personal projects (Little 1987; Little et al. 2007) make them identify more with their homes, they will believe the project is more important, feel more personal responsibility for completing the project, believe the project is more aligned to their sense of who they are and what they believe in and report high levels of engagement.
- H5**.** *Home Identity* negatively relates to the PPA (Little et al. 2007) dimension *Difficulty*. As people feel their personal projects (Little 1987; Little et al.

2007) make them identify more with their homes, they will find projects less difficult to accomplish.

- H6. *Place Dependency* will indicate significant relationship with the PPA (Little et al. 2007) qualitative variable *Project Category*. This hypothesis states that the type of project reported by a person predicts the amount of dependency a person has on the home to complete the project.
- H7: The Place Attachment theory literature shows that young adults move more often and live more of their life outside of the home than middle-aged adults and older. Because of these previous findings, while significant predictive models between standard PPA (Little et al. 2007) dimensions and project-centered PCSoP factors will emerge, the correlations indicating the strength of association will prove weak, $\beta < 0.30$ for positive relationships, $\beta < -0.30$ for negative relationships.

Participant Characteristics

This section describes demographic qualities of the participant population. Arizona State University's Institutional Review Board approved all research protocols and participant solicitation methods prior to the start of the study. All participants were solicited using approved procedures. Out of the 151 participants, 148 of them reported their age. These 148 participants range between the ages of 19 and 42, with a mean age of 22.6 years old, median age of 21.50 years old, and mode age of 21 years old. Out of the participants, 61 (40%) participants were male, while 90 (60%) were female. One-hundred-and-twenty (79%) participants reported being single, while 30 (20%) participants reported being in a significant relationship and seven (>1%) participants reported being divorced. Twelve (8%) participants reported having a child, or children, while 139 (92%) reported having no children. Twenty-one (14%) participants reported living alone, while 130 (86%) participants reported living with someone else. One-hundred-and-four participants (69%) were Caucasian, 18 (12%) were Hispanic, 14 (9.3%) were Asian, nine (6%) were African American and six (4%) reported a race of "Other". One-hundred-and-thirty-three (88%) participants were undergraduate juniors and seniors solicited from ASU Design School courses. Eighteen (12%) were a mix of recent hires and college student interns working at a large technology company.

Data Collection

A PPA (Little et al. 2007) survey augmented with additional project-centered sense of place variables was the only method used to collect data for this study. For the remainder of this document, this survey is referred to as the "PCSoP survey". The survey was delivered as an excel workbook consisting of seven work sheets. The first worksheet included general instructions for the survey as well as questions on participant demographics. The second worksheet provided a space for participants to brainstorm about all of the personal projects (Little 1987; Little et al. 2007) they have in their lives, while worksheet three instructs participants to categorize their personal projects (Little 1987; Little et al. 2007) according the *Project Category* variable nominal values. Worksheet four instructs participants to choose a maximum of 10 personal projects (Little 1987; Little et al. 2007) to assess across the standard PPA (Little et al. 2007) and PPA (Little et al. 2007) Sense of Place dimensions. On worksheet five participants assess their top projects by the PPA (Little et al. 2007) affective dimension set. Worksheet six introduces the PPA (Little et al. 2007) cognitive assessment dimensions, while worksheet seven concludes the workbook with the PCSoP assessment matrix. Appendix C provides the workbook in its entirety.

Data Analysis

This research study implements an exploratory, within-subject, single measure research design. All statistical processes adhere to standard social science conventions (Cohen 1988). The study's statistical power (sensitivity to type II errors, which is that a null hypothesis is falsely accepted.) is set to 80% ($1 - \beta = 0.80$), while the significance (sensitivity to type I errors, which is that a null hypothesis is falsely rejected.) is at the 95% confidence interval ($\alpha = 0.05$).

In accordance with normative analysis standards of PPA (Little et al. 2007) data, averages for each participant's ratings were produced prior to any analysis. Imputation using a Maximum Likelihood Estimation method was conducted to produce values for any missing data points. This method of imputation has been cited as providing more accurate estimations for missing data points due to its use of Bayesian estimation techniques common in machine learning. Little's Missing-Completely-at-Random (MCAR) (Little & Ruben 2002) method was used to assess whether or not the Maximum Likelihood Estimation method was appropriate for estimating missing values. As the name implies, the MCAR (Little & Ruben 2002) determines if data is missing at random, or if there is significant patterning. In the case of MCAR, it is preferable for the group of missing data to fail the test of significance at the 95% ($\alpha = .05$) confidence interval.

Once missing data was accounted for, five methods of analysis were implemented. Two of these methods were diagnostic in nature. First descriptive statistics and distribution charts with normal curves were generated to investigate potential challenges with skewing, kurtosis and bimodal distributions. Second, Cronbach's Alpha (Cronbach 2005) measures were taken for each of the three PCSoP factors to indicate whether or not factor loadings were reliable. In order for a factor loading to be considered reliable, a Cronbach's Alpha (Cronbach 2005) measure of 0.7 or greater was required.

Upon completing the data diagnostics, a Pearson Correlation matrix was generated to identify relationships of interest between standard PPA (Little et al.

2007) dimensions and the PCSoP factors for predictive modeling. Correlations that demonstrated significance at 95% confidence (α = .05) were targeted for regression analysis. In addition to running regression analysis between the standard PPA (Little et al. 2007) dimensions and the PCSoP dimensions, ANOVA was conducted with the nominal variable *project category* as the predictor and each of the project-centered Sense of Place factors as a criterion variable.

Procedure

A cut off sampling method was used to solicit 151 participants (n= 151). This method was chosen for two reasons. First, the exploratory nature of this research allowed for a more relaxed sampling method. Second, by setting the cut off minimum as the minimum amount of participants needed to meet power analysis conventions, the analysis would meet the necessary criteria to argue significance should hypotheses failed to be rejected. This minimum value was 85 participants to meet the requirement for Pearson’s correlation analysis, which was exceeded.

Participants were solicited in person and through online communities and email. Out of the 151 participants, 133 participants were college students attending courses at a university. The choice to use college students for this study was informed by two lines of reasoning. First, college students are widely used in the existing PPA (Little et al. 2007) literature, allowing comparisons with previous work to look for results in this research that may not correspond with the state of the knowledge. Second, college students were easily accessible. These college students were recruited from two college courses: one taking place in the Spring of 2012 and the other taking place in Fall of 2012. The Spring 2012 course instructor used an IRB approved verbal script to solicit student participation. Students interested in participating in the research were provided an email address to contact the researcher and request the materials. Fourteen students (n = 14) requested the survey. In response to their requests, a cover letter explaining the study and their rights as participants as well as the PPA (Little et al. 2007)-PCSoP survey were emailed to them. This initial sample was treated as a pilot study sample and used to confirm the reliability of the PPA (Little et al. 2007) Sense of Place factors as well as to draw some initial statistical relationships between the standard PPA (Little et al. 2007) dimensions and the PCSoP factors.

The researcher, who visited a course seminar to ask for participation in person, conducted Fall 2012 recruitment. As with the previous solicitation, a verbal script was used to communicate the terms of participation and a cover letter explaining the study and their rights as participants was presented. For this sampling, participants were given one hour of class time to complete the survey. One hundred and nineteen (n = 119) participants completed and returned the survey. All students who completed the survey were given extra credit for their course.

In parallel to sampling college students, a secondary solicitation effort focused on recent college graduates and college students interning at a large technology manufacturing company also took place. A call for participation was posted on recent college graduate and intern forums. Eighty-nine candidates responded to the online solicitation, but upon reading the cover letter, only 18 of those candidates chose to move forward with participation. These 18 participants, as well as two college student participants were later chosen to participate in a second study focused on using their PCSoP assessment to co-design smart home service provisions (refer to Chapter nine).

Surveys were collected in both digital and paper form. Digital surveys were kept on a laptop protected by both a full disk encryption that required a user password, as well as the standard login security provided by Microsoft Windows.

Paper surveys were stored in a locked facility. Data from both digital and paper copies were consolidated in the IBM SPSS statistical package for analysis. All participants were given a numeric participant ID to ensure participant anonymity in compliance with IRB regulations.

Results

Participants generated 1,135 personal projects (Little 1987; Little et al. 2007). Project phrasing ranged from one word statements such as "Guitar", to nine word phrasings such as, "Obtain better makeup skills," with project phrasings averaging around four words. During data input of the survey results into SPSS, the researcher noticed that the ratings for the *Stage* dimension were nonsensical, with most rating either indicating zero or 10. When put in context of the *Stage* dimensions operational definition, a rating of zero means that the participant just thought up the project *in-situ* while taking the survey, while rating of 10 means that a participant has completed a project. After consulting a third party expert in PPA (Little et al. 2007), the decision to remove the dimension *Stage* from further analysis was made. After removing this dimension from analysis project scores were averaged across each participant, resulting in 151 measures for final analysis.

The data set demonstrated four missing values. These missing values occurred across four separate participants with two of the missing values attributed to the *Value Congruency* dimension, and the other two attributed to the dimensions *Visibility* and *Other's View.* This set of missing values failed to demonstrate significance (α = .757), thus indicating that the missing values were missing at random and that the Maximum Likelihood Estimation method could be implemented for imputation of the missing values.

While still collecting data to run a full analysis, the first 14 (n = 14) participants sampled were used to run a pilot study. The pilot study had two purposes. The first purpose was to run a Cronbach's Alpha assessment testing the reliability of the PCSoP factors. The sample size of the study was chosen based on power analysis results indicating that 14 participants was the minimum threshold needed to produce a reliable Cronbach's Alpha analysis. The second purpose was to explore any initial correlations emerging between the standard PPA (Little et al. 2007) dimensions and the PCSoP factors (Table four). Significant correlations were used to create a set of initial motivational home design heuristics that were implemented as part of an iterative prototyping cycle to guide co-design activities described in Chapter nine of this document.

Descriptive statistics of the pilot sample set indicated prominent positive skewing for the dimensions of *Depressed*, *Fearful/Scared*, *Angry*, *Uncertain* and *Sad*, and prominent negative skewing with *Hopeful* and *Outcome/Likelihood of Success*. These results aligned with previous PPA (Little et al. 2007) research conducted with college students that show them to feel, in general, more optimistic about their current endeavors.

All three project-centered Sense of Home factors indicated reliability with Cronbach Alpha scores greater than 0.7. Table three shows the Cronbach alpha ratings from the pilot study for all three factors.

Table three.

Pilot study project-centered sense of place factor reliability measures.

Factor Name	**Cronbach's Alpha (α)**
Project-Centered Home Attachment	0.891
Project-Centered Home Identity	0.835
Project-Centered Home Dependency	0.850

The Pearson's correlation matrix revealed several emerging significant relationships between the standard PPA (Little et al. 2007) dimensions and the PCSoP factors. *Factor One: Place Attachment to Home (Home Attachment)* reported significant positive relationships with *Control*, *Value Congruency*, *Self Identity*, *Absorption*, *Time Adequacy* and *Autonomy. Factor Two: Place Identity to the Home (Home Identity)* reported significant positive relationships with *Control*, *Absorption* and *Autonomy*. *Factor Three: Place Dependency to the Home (Home Dependency)* reported significant positive relationships with *Control* and *Time Adequacy*, and significant negative relationships with *Full of Love*, and *Uncertain*. Table four lists the results of the pilot correlation analysis.

Table four.

Pilot study Pearson correlation matrix exploring relationships between personal project analysis (Little et al. 2007) dimensions and project-centered sense of home factors.

		Project-Centered Sense of Place Factors		
		Home attachment	Home identity	Home dependency
Personal Project Analysis (Little et al. 2007) appraisal dimensions.	Depressed	.444	.310	.192
	Fear/Scared	-.320	-.462	-.406
	Hopeful	.181	-.094	.078
	Stressed	.261	.087	.281
	Happy, w/ Joy	.065	.043	-.228
	Full of Love	-.350	-.398	.-.593*
	Angry	-.205	-.218	-.518
	Uncertain	-.231	-.095	-.597*
	Sad	-.023	-.052	-.257
	Control	.839**	.579*	.534*
	Value Congruency	.657*	.421	.516
	Visibility	.428	.531	.144

Table four continued.

Pilot study Pearson correlation matrix exploring relationships between personal project analysis (Little et al. 2007) dimensions and project-centered sense of home factors.

		Project-Centered Sense of Place Factors		
		Home attachment	Home identity	Home dependency
Personal Project Analysis (Little et al. 2007) appraisal dimensions (continued).	Importance	.244	-.099	.255
	Difficulty	.172	-.024	-.153
	Competence	.512	.281	.418
	Outcome/ Likelihood of Success	.101	-.081	.466
	Self Identity	.711**	.403	.409
	Support	.342	.052	.167
	Responsibility	.419	.113	.126
	Progress	.295	.420	-.159
	Challenge	.287	.133	.050
	Absorption	.759**	.554**	.480

Table four continued.

Pilot study Pearson correlation matrix exploring relationships between personal project analysis (Little et al. 2007) dimensions and project-centered sense of home factors.

		Project-Centered Sense of Place Factors		
		Home attachment	Home identity	Home dependency
Personal Project Analysis (Little et al. 2007) appraisal dimensions (continued).	Other's View	.358	.247	-.074
	Time Adequacy	.593*	.117	.615*
	Autonomy	.672**	.543*	.307
	** Correlation is significant at the .01 level (2-tailed). * Correlation is significant at the .05 level (2-tailed).			

The significant relationships that emerged within the Pearson correlation matrix served as a basis for the assessment of the hypotheses. For example, contrary to H^2 and H^3 that proposed that PPA (Little et al. 2007) positive affect dimensions will demonstrate significant positive relationships with *Home Attachment* and that PPA (Little et al. 2007) negative affect dimensions will demonstrate significant negative relationships with *Home Attachment* (respectively), *Home Attachment* indicates no significant relationships with any affective PPA (Little et al. 2007) dimensions. However, *Home Identity* indicates significant positive associations with both *Control* and *Absorption*, which support H^7.

Encouraged by the results of the pilot study, additional PPA (Little et al. 2007) surveys were collected using the procedures described in the preceding section. As with the pilot study, descriptive statistics, a Cronbach's Alpha test of reliability (Table five) and a Pearson Correlation Matrix (Table six) were generated as initial means of exploring the data sets shape, reliability and relationships (respectively).

Descriptive statistics indicated prominent negative and positive skewing, as well as kurtosis across the entirety of the dataset. When conducted on the full sample set, results of the Cronbach's Alpha test for reliability yielded similar results to that of the pilot study, with all three factors demonstrating alpha above the .70 minimum needed.

Table five.

Final project-centered sense of home factor reliability measures.

Factor Name	Cronbach's Alpha (α)
Project-Centered Home Attachment	0.821
Project-Centered Home Identity	0.728
Project-Centered Home Dependency	0.854

Pearson's correlation analysis on the final data yielded further refinement of relationships between the standard PPA (Little et al. 2007) dimensions and the PCSoP factors. All previously significant relationships identified in the pilot study between PPA (Little et al. 2007) dimensions and *Home Attachment* failed to continue to demonstrate significance during analysis of the final data set. A significant negative relationship between *Fear* and *Home Attachment* emerged, as well as a significant positive relationship between *Value Congruency* and *Home Attachment* emerged – both at the .05 level. *Control* and *Absorption*, PPA (Little et al. 2007) dimensions that demonstrated a significant relationship with Home Identity in the pilot study, failed to demonstrate significance in the primary analysis, while positive significance between *Autonomy* and Home Identity persisted across both pilot and primary analyses at the .05 level. During primary analysis *Hope*, *happiness* and *Love* and *Self Identity* all emerged as positive significant relationships with *Home Identity* at the .05 level, while *Value Congruency* emerged as a positive significant relationship with *Home Identity* at the .01 level. *Love*, *Uncertainty*, *Control* and *Time Adequacy* all failed to maintain a significant relationship with *Home Dependency* from pilot analysis through primary analysis. From the primary analysis, *Difficulty* and *Likelihood of Success* emerged as significant negative relationships with Home Dependency at the .05 level. Table six displays the full results of primary analysis correlations.

Table six.

Primary study Pearson correlation matrix exploring relationships between personal project analysis (Little et al. 2007) dimensions and project-centered sense of home factors.

		Project-centered sense of home factors		
		Home attachment	Home identity	Home dependency
Personal Project Analysis (Little et al. 2007) appraisal dimensions.	Depressed	.012	-.005	.111
	Fear/Scared	-.160*	-.112	-.138
	Hopeful	.086	.163*	-.115
	Stressed	-.098	-.028	-.154
	Happy, w/ Joy	.152	.201*	-.026
	Full of Love	.065	.180*	-.081

Table six continued.

Primary study Pearson correlation matrix exploring relationships between personal project analysis (Little et al. 2007) dimensions and project-centered sense of home factors.

		Project-centered sense of home factors		
		Home attachment	Home identity	Home dependency
Personal Project Analysis (Little et al. 2007) appraisal dimensions (continued).	Angry	.002	-.011	.017
	Uncertain	-.140	-.146	-.117
	Sad	-.140	.055	.046
	Control	.089	.094	-.030
	Value Congruency	.189*	.313**	.122
	Visibility	-.017	.104	-.106
	Importance	-.024	.026	-.068
	Difficulty	-.106	-.164	-.193*
	Competence	.093	.110	.004
	Outcome/ Likelihood of Success	-.142	-.070	-.183*

Table six continued.

Primary study Pearson correlation matrix exploring relationships between personal project analysis (Little et al. 2007) dimensions and project-centered sense of home factors.

		Project-centered sense of home factors		
		Home attachment	Home identity	Home dependency
Personal Project Analysis (Little et al. 2007) appraisal dimensions (continued).	Self Identity	.074	.186*	.005
	Support	-.045	.057	-.130
	Responsibility	.011	.122	-.036
	Progress	.029	.039	-.064

These final correlations between standard PPA (Little et al. 2007) dimensions and PCSoP factors led to the selection of three predictive models for regression analysis. As the PPA (Little et al. 2007) literature has previously reported that *Hope*, *Happiness* and *Love* load to create the PPA (Little et al. 2007) factor *Positive Affect*, the subsequent predictive model for *Home Identity* utilizes the *Positive Affect* factor, rather than the individual dimensions. The models are as follows:

- *Model One: Home Attachment =* β_0 + (β_1)*Fearful* + (β_2)*Value Congruency*
- *Model Two: Home Identity =* β_0 + (β_1)*Positive Affect* + (β_2)*Value Congruency* + (β_3)*Self Identity* + (β_4)*Autonomy*
- *Model Three: Home Dependency =* β_0 + (β_1)*Difficulty* + (β_2)*Likelihood of Success*

Distribution charts of models one through three indicated normal distributions. Additionally, P-P Plots of models one through three demonstrated tight fit of residuals on regression lines, indicating model linearity. Scatter plots of residuals for all three models showed even distribution, indicating no major violations of homoscedasticity, indicating that variance is spread evenly across the distribution and coefficients generated by the analysis are accurate.

Testing of model one indicates a significant main effect between the predictor variables *Fearful* and *Value Congr*uency on *Home Attachment* at the .01 level (*p = 0.012)*, with the F statistic value (*F = 4.54)* exceeding the critical F statistic of 3.84, indicating that the analysis explained enough variance to be considered confirmatory in nature. Correlations for both *Fear* (β = -.148) and *Value Congruency* (β = .180) indicate weak associations between both predictor variables and *Home Attachment*. The results for model one suggest that while the model has strong predictive capability, the predictor variables have a low impact on the criterion variable.

Testing of model two indicates a significant main effect between the predictor variables *Positive Affect*, *Value Congruency*, *Self Identity* and *Autonomy* on *Home Identity* at the .001 level (*p = .0003)*, with the F statistic value (*F = 5.5)* exceeding the critical F statistic of 3.84, indicating that the analysis explains enough variance to be considered confirmatory in nature. Correlations for *Positive Affect* (β = .21), *Self Identity* (β = -.12) and *Autonomy* (β = .04) indicated weak associations with *Home Identity*. *Value Congruency's* correlation (β = .33) approaches a medium strength association with *Place Identity*. Results for model two suggest that while the model demonstrates a strong predictive capability, the predictive variables have a low impact on the criterion variable.

Testing of model three indicates a significant main effect between the predictor variables *Difficulty* and *Likelihood of Success* on *Home Dependency* at the .01 level (*p = .004)*, with the F statistic value (*F = 5.87)* exceeding the critical F statistic of 3.84 indicating that the analysis explains enough variance to be considered confirmatory in nature. Correlations for *Difficulty* (β = -.20) and *Likelihood of Success* (β = -.19) indicate weak associations with *Home Dependency*. The results for model three indicate that while the model demonstrates a strong predictive capability, the predictive variables have a low impact on the criterion variable.

ANOVA was run on three additional models to test the predictive value of a project's category on *Home Attachment*, *Home Identity* and *Home Dependency*. The models for the ANOVA analysis are as follows:

- *Model Four: Home Attachment* = $\beta_0 + (\beta_1)$*Project Category*
- *Model Five: Home Identity* = $\beta_0 + (\beta_1)$*Project Category*
- *Model Six: Home Dependency* = $\beta_0 + (\beta_1)$*Project Category*

Distribution charts of models four through six indicated normal distributions. Additionally, P-P Plots of models four through six demonstrated tight fit of residuals on regression lines, indicating model linearity. Scatter plots of residuals for all three models showed even distribution, indicating no major violations of homoscedasticity, indicating that variance is spread evenly across the distribution and coefficients generated by the analysis are accurate. While diagnostics of the models indicate all assumptions are met, testing of models four through six failed to demonstrate significant main effects.

Discussion

With the exceptions of H^1 and H^7 all other hypotheses failed to some degree. For H^1, the null hypothesis was rejected because all PCSoP factors demonstrated reliability by generating Cronbach's Alpha scores greater than 0.70. For H^7 all significant relationships generated through analysis showed weak associations with coefficient scores lower than .35.

H^2 failed to reject the null hypothesis, with *Home Attachment* indicating no significant relationships with *Hopeful*, *Happy* or *Love*. H^3 is partially rejected, as *Home Attachment* failed to indicate significant relationships with *Depressed*, *Stressed*, *Uncertain*, or *Sad*, yet did demonstrate a negative, significant relationship with *Fearful*. In addition to the relationships hypothesized in H^2 and H^3, *Home Attachment* did indicate a positive significant relationship with *Value Congruency*. This outcome is unexpected as *Place Attachment*, within the context of the original SoP (Jorgensen & Stedman 2001; 2006) model, refers to an occupant's affective relationship with a place, and *Value Congruency*, within the context of PPA (Little et al. 2007) is a cognitive assessment dimension. This relationship, as well as the relationships discussed below, suggest a far more complex relationship between place and motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) in which affective, cognitive and conative relationships are intermingled, rather than separated into three discrete categories of relationships.

H^4 is partially rejected, with *Home Identity* failing to demonstrate significant relationships with *Control*, *Importance*, *Responsibility* and *Absorption*, yet did demonstrate significant relationships with *Value Congruency* and *Self Identity*. H^5 fails to reject the null hypothesis, with *Home Identity* failing to demonstrate any sort of significant relationship with the dimension *Difficulty.* Of note, is that the relationship with *Self Identity* was expected to indicate a positive association, yet it reported as a negative association. This unexpected flip in directionality could be another symptom of the weak relationship young adults, in general, have with their homes, with personal projects (Little 1987; Little et al. 2007) that are more indicative of their sense of self occurring outside of the home environment. The emergence of the additional significant relationships between *Home Identity* and

Hopeful, *Happy* and *Love* was an unexpected outcome because the original SoP (Jorgensen & Stedman 2001; 2006) model documents *Place Identity* as a person's cognitive relationship with a place, yet these specific PPA (Little et al. 2007) dimensions are affective in nature. As with the resulting relationship between *Home Attachment* and *Value Congruency*, the relationship between *Home Identity* and *Hopeful*, *Happy* and *Love* suggest a more fluid model for SoP (Jorgensen & Stedman 2001; 2006) of the home and motivation (Fredrickson 2002; Little et al. 2007; Peterson 2007; Seligman 2004).

H^6 failed to reject the null hypothesis, with *Place Dependency* failing to demonstrate significant relationships with the nominal variable *Project Category*. Additional model runs testing relationships between *Place Attachment* and *Project Category* and *Place Identity* and *Project Category* also failed to demonstrate significant relationships. This outcome, especially where the factor *Home Dependency* is concerned, is surprising as the variable *Project Category* is designed to capture conative data on a project, and *Home Dependency* is designed to capture conative data about the relationship an occupant has with her home. However, again this lack of relationship could be explained by the sample population's general lack of association to the home and to what extent personal projects (Little 1987; Little et al. 2007) reported actually take place in the home.

The relationships between standard PPA (Little et al. 2007) dimensions and PCSoP factors present a motivational environment design framework for young adults and their homes. Figure seven illustrates this framework while table seven presents a set of design heuristics.

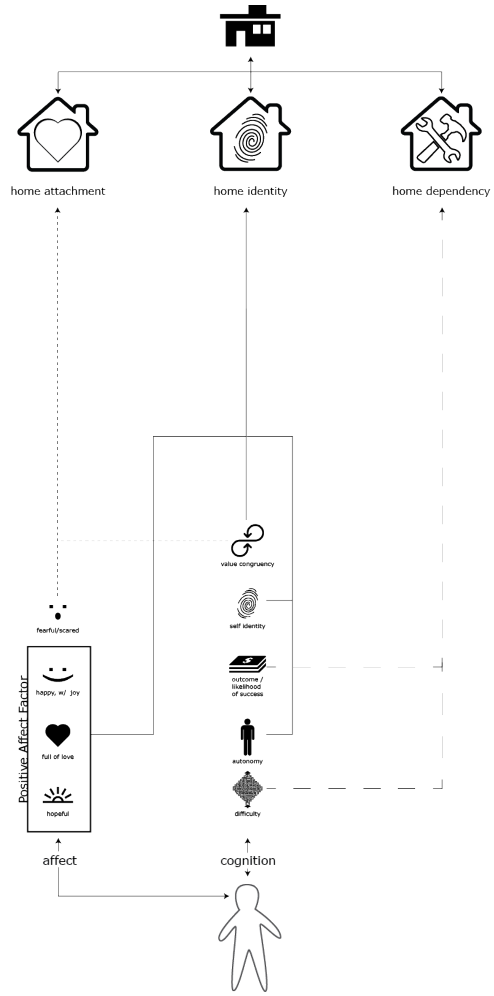


Figure seven. Motivational sensitive design framework for young adults and their homes.

Table 7.

Project-Centered sense of place design heuristics for motivation sensitive smart home service provisions serving young adults.

Motivation sensitive design heuristic	Informs home attachment	Informs home identity	Informs home dependency
Fearful: Designers should explore elements within a person’s project that makes the person fearful and seek solutions to reduce those feelings of fear.	X		
Value Congruency: Smart home interactions should maintain, or increase a person’s perception that the personal project (Little 1987; Little et al. 2007) aligns with their personal value system. Designers should explore what values a person lives by and seek ways to further align the project with those values.	X	X	

Table 7 continued.

Project-Centered sense of place design heuristics for motivation sensitive smart home service provisions serving young adults.

Motivation sensitive design heuristic	Informs home attachment	Informs home identity	Informs home dependency
Happiness w/Joy: Smart home interactions should either maintain, or increase, a person's perception of happiness/enjoyment related to a personal project (Little 1987; Little et al. 2007). Designers should explore what aspects of a personal project (Little 1987; Little et al. 2007) make her happy, or feel joy and try to embed those aspects to interactions with smart home service provisions.		X	

Table 7 continued.

Project-Centered sense of place design heuristics for motivation sensitive smart home service provisions serving young adults.

Motivation sensitive design heuristic	Informs home attachment	Informs home identity	Informs home dependency
Full of Love: Smart home interactions should either maintain, or increase, a person's perception of love related to a personal project (Little 1987; Little et al. 2007). Designers should explore what a person loves about the project		X	
Hopeful: Smart home interactions should bring a person hope that they can complete the project. Designers should investigate what about a project makes the person hopeful, as well as why they are hopeful, and then design to support those aspirations.		X	

Table 7 continued.

Project-Centered sense of place design heuristics for motivation sensitive smart home service provisions serving young adults.

Motivation sensitive design heuristic	Informs home attachment	Informs home identity	Informs home dependency
Self Identity: Smart home interactions should maintain, or increase, a person's perception that the personal project (Little 1987; Little et al. 2007) supports reflection and self-definition. Designers should explore how a personal project (Little 1987; Little et al. 2007) introduces moments of reflection into a person's home life and then seek to design interactions that trigger such reflection.		X	

Table 7 continued.

Project-Centered sense of place design heuristics for motivation sensitive smart home service provisions serving young adults.

Motivation sensitive design heuristic	Informs home attachment	Informs home identity	Informs home dependency
Autonomy: Smart home interactions should maintain, or increase, a person's perception of independence. Designers should explore social, and/or environmental dependencies related to the project and engage the occupant to understand why those dependencies make them feel less autonomous. The designer should then seek to develop interactions that mitigate those dependencies.		X	

Table 7 continued.

Project-Centered sense of place design heuristics for motivation sensitive smart home service provisions serving young adults.

Motivation sensitive design heuristic	Informs home attachment	Informs home identity	Informs home dependency
Difficulty: Smart home interactions should decrease the perception of difficulty of a personal project (Little 1987; Little et al. 2007). The designer should explore aspects of the personal project (Little 1987; Little et al. 2007) the project owner finds difficult, and why, and then seek to develop interactions that mitigate those difficulties.			X

Table 7 continued.

Project-Centered sense of place design heuristics for motivation sensitive smart home service provisions serving young adults.

Motivation sensitive design heuristic	Informs home attachment	Informs home identity	Informs home dependency
Outcome/Likelihood of Success: Smart home interactions should seek to minimize dependency on the home in order for a young adult to feel they will reach a successful outcome. Designers should explore what dependencies a young adult specifically relates to the home and then develop interactions that reduce that dependency.			X

In the near-term, these heuristics are envisioned as a roadmap for exploring personal projects (Little 1987; Little et al. 2007) with end users in order to co-design motivation-inspired user experiences in the home. For example, if a person reports feeling high emotions of fear about a project, a designer can explore why the person feels fearful about the project, and how the home can play a role in lower those feelings of fear. Conversely, if a person reports not feeling any fear regarding a project, the designer can explore why the person feels safe about the project, and how the home plays a role in creating that safety in order to design interactions that support those feelings. Chapter eight demonstrates the use of heuristics in this manner.

These heuristics are presented to serve two purposes. First, as technologies for socially oriented smart home service provisions become less expensive and require less technical knowledge to implement, end users will increasingly be empowered to leverage these heuristics to guide self-development of tailored experiences. Second, as technologies for socially-oriented smart homes gain the capability to recognize an occupant's projects and construct applications on behalf of the occupant, the heuristics can serve as an a logic set to guide correct inference of interactions appropriate to the use context.

While the heuristics serve as a starting point for designers, developers and end-users to explore motivation-inspired interactions, the regression models serve as an end point, allowing evaluation to appraise if the application was beneficial. Researchers, working hand-in-hand with end users, can assess the impact on PCSoP within the context of a repeated-measure study where the end-user provides PCSoP measures prior to, during, and after implementation of a smart home service provision. Comparative analysis of the measures will indicate the affects of the application, which can lead to conversations regarding application successes, failures and opportunities for improvement. Chapter 10 demonstrates the use of the models in this manner.

Conclusion

This study explored relationships between PPA (Little et al. 2007) and SoP (Jorgensen & Stedman 2001; 2006) for young adults and their homes to develop a model of PCSoP of the home. This exploration yielded two contributions to the field of motivational psychology and environmental psychology. First, in order to explore relationships between PPA (Little et al. 2007) and SOP to prove the existence of

PCSoP, a new set of PPA (Little et al. 2007) assessment dimensions focused on person-place relationships was developed and validated. Second, using a PPA (Little et al. 2007) survey augmented with these person-place assessment dimensions revealed new significant relationships between motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) and place, and yielded predictive models within the use context of young adults and their homes. These relationships and models represent a novel contribution to theory by bridging motivational psychology and place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) theory. For designers of smart homes, these statistical relationships and predictive models provide a theoretical backbone and toolkit for design and evaluation of smart home service provisions that support project completion, goal attainment and general health and wellbeing.

Yet a number of avenues of exploration and confirmation remain. This study focused on the relationships between a specific demographic population and a specific place: namely, young adults and their homes. The study, while exploratory, produced a number of results with strong enough statistical significance that they could be considered confirmatory in nature. However, replication of this study with another population of similar qualities will need to be conducted to confirm these outcomes.

While the original hypotheses proposing a clear-cut model where affective PPA (Little et al. 2007) dimensions relate to *Home Attachment*, cognitive PPA (Little et al. 2007) dimensions relate to *Home Identity* and conative PPA (Little et al. 2007) dimensions relate to *Place Dependency* was rejected within the bounds of young adults and their homes, this model may prove valid for other populations and places. The specificity of population and place mean that the statistical relationships, as well as the design tools based on those relationships, should only be considered valid when working with young adults to design for the home. Replicating this study with either different populations groups and/or different places will most likely yield completely different results. For example designing for elders and their homes, or young adults and their places of work, or elders and their places of work may generate different results. Such studies should occur to support continued theory bridging between motivational psychology and place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) theory, as well as expanding heuristic sets to support designers seeking to design smart home service provisions and other socially-oriented products for the home. Finally, while the methodology and heuristics were designed to support design of socially oriented smart environments, there are no theoretical or methodological obstacles in applying the strategy and tactics of this study to designing other artifacts, interactions or experiences. For example, designers could focus on projects related to child rearing, or health and nutrition to gain insight into relationships between motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) and place to design new products and services supporting parenting or cooking. Such vectors for future work present a rich opportunity space for convergence between motivational psychology, place attachment (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) theory and design that promote building of new transdisciplinay theory and methodology for design research. The subsequent chapters continue to demonstrate the value of building such theory and methodology through utilization of PPA (Little et al. 2007)-PCSoP design heuristics to scaffold co-design of smart home service provisions and implementation of PCSoP models to evaluate if smart home service provisions support completion of personal projects (Little 1987; Little et al. 2007).

Chapter 9

CO-DESIGN OF THE MOTIVATIONAL HOME

Introduction and Rationale

This study translates the theoretical PCSoP model for young adults and their homes to contribute to the motivational home research program in two ways. First, three hypotheses on personal projects (Little 1987; Little et al. 2007) qualities and smart home service provisions are tested to further articulate the underlying relationship between PCSoP and smart home service provisions. These hypotheses explore the differences of *Home Dependency, Control* and *Stress* between personal projects (Little 1987; Little et al. 2007) chosen for smart home service provision support and projects not chosen for provision support.

Second, this research study develops an initial grounded theory for motivational smart home service provisions. This grounded theory is presented as a design framework consisting of a set of design principles, design qualities, design tensions, use definitions and interaction models. A design framework is a visual representation of a grounded theory that both explains a phenomenon, and functions as a toolkit for development teams to conceptualize and evaluate new experiences, products and services. Design principles are the fundamentals that situate all other design framework assets. Design qualities are features ascribed to each principle that further operationalize each principle. Design tensions are relationships between design qualities that describe how end-users are affected by the qualities, providing reference points for ideation and judgment during the design process. Use definitions refer to the general ways in which a specific population uses a product/service. An interaction model describes a sequence of actions between a person and a product/service.

In addition to development of these design assets, this study also presents the perceived affects of smart home service provisions on cognitive and affective behavior as a means of initial assessment regarding the relationships between service provisions and user motivation. This work is significant to HCI because it presents new knowledge on what occupants need from smart home service provisions within the context of personal goals and everyday domestic practice, and, for the first time, integrates affective and cognitive behavior assessment into participatory user experience prototyping in the home setting. This new knowledge impacts both HCI theory and practice in three ways:

- Contributes to design theory with a novel model of how human-environment interaction supporting decision making and the development of new methodology.
- Provides development teams of smart home service provisions with a toolkit to aid in concept development and evaluation.
- Serves as a case study testing the value of motivation (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) as a design meme for HCI.

Twenty participants (n = 20) completed a three-phase research approach consisting of: (1) Information gathering, (2) Co-design and (3) Assessment. During the *Information Gathering* phase participants filled out a PCSoP survey described in Chapter eight and then chose a single personal project (Little 1987; Little et al. 2007) to focus on as they designed their own smart home service provision. Completing the PCSoP survey supports participants as they engage in divergent thinking through ideation on all projects in their ecosystem, and then empowers their convergent thinking through making judgments on what individual project within their ecosystems to design a smart home service provision for.

The *Co-Design* phase consists of a semi-structured interview and a paper prototyping session framed within a two-hour workshop. As with phase one, phase two activities were also designed to engage participants in both divergent and convergent thinking. The semi-structured interview lead participants through an exploration of the underlying motivations, obstacles and physical interactions related to their chosen personal projects (Little 1987; Little et al. 2007). The design heuristics generated in chapter eight guides the interview. PICTIVE (Muller 1991, 1992; 1993) interaction and psycho-cartographic mapping (Wójcik, Bilewics, & Lewicka 2010) (Foland & Lewicka 2007) activities were completed to produce a paper prototype in the form of a collage representing a project-centered smart home service provision. The collage activity continues the divergent thinking process by beginning with a brainstorm on the different scenarios and interactions the GaLLaG (Burleson et al. 2009) platform could afford to support completion of the chosen personal projects (Little 1987; Little et al. 2007), as well as a brainstorm on additional capabilities that participants would like GaLLaG (Burleson et al. 2009) to deliver. Participants then engage in convergent thinking by making design decisions regarding how they would interact with a smart home to complete their personal project (Little 1987; Little et al. 2007), resulting in paper prototypes of smart home service provisions.

During the *Assessment* phase, participants complete a Session Evaluation Questionnaire (SEQ) (Stiles, Reynolds, Hardy, Rees, Barkham, & Shapiro 1994) to understand how participants felt about the participatory process. This survey to account for any bias due to affective or cognitive stress perceived by participants during the co-design process. Accounting for such stress is necessary to understand if bias due to participant discomfort exists in the data.

A normative, qualitative analysis of the interview and collage data resulted in organization of design qualities, design tensions, use definitions and interaction models that define four user experience principles: (1) Time and Timing; (2) Guidance and Accountability; (3) Project Ambiguity and (4) Positivity Mechanisms. SEQ (Stiles et al. 1994) results show that participants perceived the co-design process as a positive one, resulting in self-discovery and enthusiasm regarding the potential of smart home service provisions.

The section immediately following this introduction discusses the variables and hypotheses of this study, while section the *Approach* section presents the research rationale and design. Descriptions of the data collection and data analysis methods follow the presentation of the approach. Subsequent to the account of methods utilized for this study is an explanation of research procedure and a presentation of results. A discussion of the results ensues, during which hypotheses are addressed the design framework is articulated. This chapter ends with a summary of the study's contributions and trajectories for future work.

Variables and Hypotheses

The variables of this study form seven distinct content groups used across the three phases of the participatory process:

1. Participant demographic variables;
2. PCSoP survey dimensions;
3. Areas of the home;
4. GaLLaG (Burleson et al. 2009) interaction tokens;
5. PPA (Little et al. 2007) tokens;
6. Commentary data and;
7. SEQ (Stiles et al. 1994) variables.

With the exception of commentary data, which is managed on paper documents, all variables are managed in SPSS. *Participant demographic variables* and *PCSoP survey dimensions* are identical in data type and measurement scales to those described in Chapter eight. *Areas of the home*, *GaLLaG* (Burleson et al. 2009) *interaction tokens, PPA (Little et al. 2007) tokens* and *Commentary data* are all variable sets related to collages. Figure eight illustrates these three groups of variables within the context of an example collage.

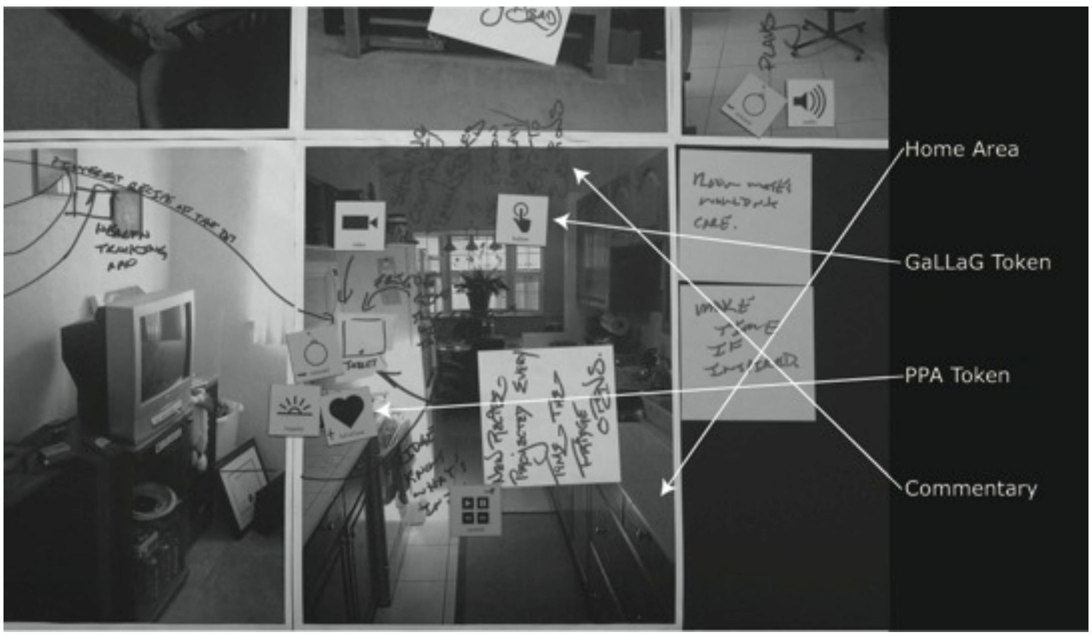


Figure eight. Motivation-sensitive smart home service provision collage paper prototype example.

The *Areas of the Home* variable is nominal, capturing which areas of the home have been photographed and placed on a collage. The values for this variable were developed *post hoc,* after data collection, by tabulating what rooms were present across collages. The decision to develop the variable in the manner was made to ensure that the variable was user centered and that all values were relevant to the study. Table eight presents geographic areas of the home variable

Table eight.

Geographical areas of the home identified from co-design collages.

Geographic areas of the home
Garage Entry
Front Entry
Family Room
Kitchen
Dining Room
Formal Dining Room
Living Room
Hallway
Stairs
Other Bathroom
Other Bedroom
User Bedroom
User Bathroom
Basement
Balcony
Back Patio
Back Yard
Front Porch
Front Yard
Laundry Room
Geographic areas of the home
Den

Table eight continued.

Geographical areas of the home identified from co-design collages.

Home Office
Garage
Closet

GaLLaG (Burleson et al. 2009) *interaction tokens* and *PPA (Little et al. 2007) tokens* are paper icons placed on top of home area photos to indicate smart home interactions that construct a smart home service provision and the hypothesized affects of the provision on psychological behavior (respectively). The values for GaLLaG (Burleson et al. 2009) interaction tokens were developed based on the platform's current capabilities, as well as the capabilities participant's requested for future development. *GaLLaG* (Burleson et al. 2009) *interaction token* values and their corresponding dummy codes in SPSS are presented in table nine.

Table nine.

Game-as-life, life-as-game (Burleson et al. 2009) interaction list for interaction tokens.

Game-as-life, life-as-game (Burleson et al. 2009) interaction
Engage Tablet
Engage Phone
Engage Smart Television
Engage Laptop
Engage PC
Remote audio
Remote video capture/playback
Social network

Table nine.

Game-as-life, life-as-game (Burleson et al. 2009) interaction list for interaction tokens.

Master bathroom
Entry/exit recognition
Light controls
Appliance controls
Button
Game controller
Send/receive web content
Recognize artifact use
Recognize furniture use
Microphone

PPA (Little et al. 2007) *tokens* are icon representations of the standard set of PPA (Little et al. 2007) affective and cognitive dimensions. Each PPA (Little et al. 2007) token is treated as a nominal variable with three values:

1. Absent: The icon representation of the PPA (Little et al. 2007) dimension is absent from the collage.
2. Positive: The icon representation of the PPA (Little et al. 2007) dimension is present on the collage and the participant has hypothesized that the smart home service provision would increase the perception of the dimension related to the project.
3. Negative: The icon representation of the PPA (Little et al. 2007) dimension is present on the collage and the participant has hypothesized that the smart home service provision would increase the perception of the dimension related to the project.

Positive or negative designations were indicated on the collage by placing either a + or – sign next to the PPA (Little et al. 2007) icon. Appendix E contains the set of tokens used in this study.

Commentary data consists of the additional drawn and written information the user places onto the collage to explain the token presence and placement. Examples of such information include drawing arrows to connect interactions, written explanations describing the context of the interactions or written explanations regarding why they expect a specific PPA (Little et al. 2007) dimension to either increase or decrease in response to the service provision.

The SEQ (Stiles et al. 1994) instrument measures how a participant feels *in-situ* directly after a work session, as well as a participant's overall response to a session. SEQ (Stiles et al. 1994) data consists of a set of 20 dimensions that load onto four factors. Each dimension is measured on a 0 – 7 interval scale with zero as the minimum value and seven as the maximum value. Two factors measure how a participant feels *in-situ*, while the two other factors measure overall response to the session. The factors and their loadings are as follows:

- In-the-moment factors and loadings
    - Factor One: Positivity – The degree to which a participant feels happy right now (Sad; Pleased; Definite; Afraid; Unfriendly).
    - Factor Two: Arousal – The degree to which a participant feels excited right now (Still; Excited; Fast; Peaceful; Aroused).
- Overall session factors and loadings
    - Factor Three: Depth - The degree to which the participant felt the session was effective and dove deep into the subject matter (Worthless; Deep; Empty; Powerful; Ordinary).

- Factor Four: Smoothness – The degree to which the participant felt at ease with process and content of the session (Easy; Tense; Pleasant; Smooth; Uncomfortable).

The SEQ (Stiles et al 1994) items *Sad, Afraid* and *Unfriendly* are negative items within the factor *Positivity*. This means that the lower the value a participant assigns to these items, the more positive she feels at the moment of completing the survey. The SEQ (Stiles et al 1994) items *Pleased* and *Definite* are positive items within the factor *Positivity*. This means that the higher the value a participant assigns to these items, the more positive she feels at the moment of completing the survey. The SEQ (Stiles et al 1994) items *Still* and *Peaceful* are negative items within the factor *Arousal*. This means that the lower the value a participant assigns to these items, the more aroused she feels at the moment of completing the survey. The SEQ (Stiles et al 1994) items *Excited, Fast* and *Aroused* are positive items within the factor *Positivity*. This means that the higher the value a participant assigns to these items, the more aroused she feels at the moment of completing the survey. The SEQ (Stiles et al 1994) items *Worthless, Empty* and *Ordinary* are negative items within the factor *Depth*. This means that the lower the value a participant assigns to these items, the more deep she feels at the session was in terms of promoting reflection and personal growth. The SEQ (Stiles et al 1994) items *Deep* and *Powerful* are positive items within the factor *Depth*. This means that the higher the value a participant assigns to these items, the deeper she feels at the session was in terms of promoting reflection and personal growth. The SEQ (Stiles et al 1994) items *Tense* and *Uncomfortable* are negative items within the factor *Smoothness*. This means that the lower the value a participant assigns to these items, the more at ease she felt during the session. The SEQ (Stiles et al 1994) items *Easy, Pleasant* and *Smooth* are positive items within the factor *Smoothness*. This means that the higher the value a participant assigns to these items, the more at ease she felt during the session.

This study follows a grounded theory approach to develop a rich design framework for smart home service provisions. As such formal hypothesis testing is not the focus of the study. However, a number of exploratory hypotheses are proposed regarding potential qualities that will emerge through normative analysis of the collages and SEQ (Stiles et al. 1994) data. These hypotheses are proposed based on results from previous PPA (Little et al. 2007) literature, as well as the results from chapter eight.

- H^1: Despite the sample population's relatively low SoP (Jorgensen & Stedman 2001; 2006) scores, participants will choose projects that demonstrate higher dependency on the home to complete relative to other projects in their ecosystem as indicated by their PCSoP survey. This hypothesis is proposed based on the assumption that participants will identify with smart home service provisions as best suited for projects that they already rely on the home to complete.
- H^2: Participants will choose to design for projects that demonstrate low perceptions of *Control* and/or high perceptions of *Stress* as indicated by their PCSoP survey. This hypothesis is proposed based on the recognition in PPA (Little et al. 2007) literature of *Control* and *Stress* as the two dominant dimensions determining if a person completes a personal project (Little 1987; Little et al. 2007). As smart home service provisions are positioned as tool for completing a personal project (Little 1987; Little et al. 2007), the logical argumentation is that participants will refer to increasing *Control* and decreasing *Stress* as primary motivational functions of provisions. An alternative possibility to H2 is that participants will purposefully avoid projects

with either or both low perceptions of *Control*/high perceptions of *Stress* because the thought of dealing with such projects may prove intimidating. However, it is the assumption of the current hypothesis that participants will intuitively gravitate to design for projects demonstrating the *Control*/*Stress* relationships because they will perceive a SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) as an opportunity reconcile such projects.

- H^3: Participants will design smart home service provisions that increase *Happiness, Love, Hopeful, Value Congruency, Self-Identity, Autonomy* and *Likelihood of Success,* and decrease *Fear* and *Difficulty*, thereby improving their attachment to their homes. In chapter eight, these dimensions demonstrated significant relationships with SoP (Jorgensen & Stedman 2001; 2006) which supports the assumption that participants will intuitively gravitate towards addressing these motivational relationships during co-design of SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011).
- H^4: Participant SEQ (Stiles et al. 1994) scores will demonstrate high *Depth, Smoothness* and *Positivity* scores and low *Arousal* scores. The methods of the procedures of this study were chosen with the intent of including participants as co-designers through a crafts-based approach to design. This hypothesis proposes that such a process will allow participants space for deep reflection on their personal project (Little 1987; Little et al. 2007) with minimal conceptual challenges, while instilling a positive atmosphere that excites participants.

These four hypotheses present informed proposals associated with the motivational relationships young adults describe towards their smart home service provisions, as well as how people will perceive the co-design process. However, additional knowledge informing user experience design of smart home service provisions is also proposed as part of this study. This knowledge is expressed through the emergence of a grounded theory in the format of a design framework consisting of design principles, design qualities, design tensions, use definitions and interaction models. While no formal hypotheses are associated with such techniques, several topical areas of interest for design exploration are proposed:

- Occupant conative needs: The functional needs of occupants related to personal projects (Little 1987; Little et al. 2007) that smart home service provisions can assist with.
- Occupant affective needs: The affective needs of occupants related to personal projects (Little 1987; Little et al. 2007) that smart home service provisions can assist with.
- Occupant cognitive needs: The cognitive needs of occupants related to personal projects (Little 1987; Little et al. 2007) that smart home service provisions can assist with.
- Smart home sensing: The types of human behavior a smart home service provision needs to sense in order to support occupant conative, affective and cognitive needs associated with personal projects (Little 1987; Little et al. 2007).
- Smart home feedback: The types of feedback occupants desire from smart home service provisions to support conative, affective and cognitive needs associated with personal projects (Little 1987; Little et al. 2007).
- Spatial Distribution: The location of smart home service provision interactions

within the home.

This section has set the focus and purpose of this research study by operationally defining variables, proposing hypotheses and framing the design topics relevant to motivational smart home service provisions. The following section describes the participatory approach and related constructs implemented to address the hypotheses and explore design topics.

Approach

Participatory research studies are typified by a number of qualities that constrain the research space, as well as a number of assumptions that support the value of the research approach. A participatory approach was chosen in order to balance the need to rapid prototype to the increased speed of technology development with the need to produce designs that are authentic representations of participant needs. Participatory design, if implemented appropriately, strikes this equilibrium by removing much of the time overhead associated with design ethnography in favor of participant inclusion during the design process. This study includes participants by ascribing to five research principles that compose the design approach:

1. Open systems (Asaro 2000);
2. Emergent behavior (Asaro 2000);
3. Interaction through negotiation (Bødker and Anderson 2005);
4. Reflective Practice (Schön 1983) and;
5. Situated action (Suchman 1987).

Both the PCSoP survey and the collage activity serve as two instances of open systems (Asaro 2000). While the general idea of a system is defined as differentiated parts that impact one another to produce a unified structure, the actual definition of a system is ambiguous (Bailey 1996). System’s theory founders view a system’s environment as separate from the system (Bailey 1996). This assumption led to system theory researchers either defining systems as "closed" or "open" (Bailey 1996). Closed systems are self-contained, lacking the ability to receive and respond to information flows from other systems (Bailey 1996). Open systems possess porous borders that allow for external information to enter and potentially change the internal structure of the system (Bailey 1996).

The PPA (Little et al. 2007) survey was developed by Brian Little to support "plug and play" (Little *et al*. 2007) interactions with researchers and participants. Depending on the research goal, researchers can choose to use a standard PPA (Little et al. 2007) survey, or choose a more cooperative path in which researchers and participants can either invent their own assessment dimensions adjust measurement scales and enrich the evaluation space with qualitative descriptions of personal projects through follow up interviews and laddering techniques (Little *et al*. 2007). This flexibility supports a constructive dialogue between participants and researchers to not only define a participants project ecosystem, but also the framework by which the ecosystem is assessed.

The ability for both researchers and participants to redefine portions of PPA (Little et al. 2007) defines the methodology as an open system. Yet some constraints to the underlying PPA (Little et al. 2007) structure must remain in tact. For instance, a completed PPA (Little et al. 2007) survey ultimately produces a data matrix, the shape of which must be maintained to allow for parametric modeling of orthogonal relationships. Additionally, once researchers and/or participants have defined the rules of a PPA (Little et al. 2007) study, including project categorization, assessment dimensions and measurement scales, these rules must be adhered to in order to produce consistent data set for normative analysis.

The collage space follows a similar "plug and play" model to PPA (Little et al. 2007). While this study focuses on the home environment, researchers and participants can negotiate what environment they choose to design for. Participants can also affect the system's structure in a number of ways. First, the areas of an environment participant's choose to share photographic representations of can have dramatic affects on the design space. For example, constructing a photographic backdrop of a home consisting only of a participant's bedroom presents a completely different set of design considerations than a photographic backdrop that comprehensively documents the entire home. Second, while a core set of GaLLaG (Burleson et al. 2009) interaction and PPA (Little et al. 2007) tokens are provided, researchers and participants negotiate which tokens enter the design space through placement on the photographic backdrop. Additionally, participants can create their own GaLLaG (Burleson et al. 2009) interaction and PPA (Little et al. 2007) tokens in order to meet the needs of their design. Finally, the inclusion of freehand drawing and written explanation expands the possibility space within the system by allowing participants to produce unique design assets beyond the photographic representations and tokens.

One of the benefits of the collage is its low barrier of access, thereby democratizing the design space. This democratization allows researchers and participants to contribute on equal terms. Collage, permits participants to engage in visual thinking to express their ideas without the need for high levels of sketching, modeling or linguistic skills that professionals may possess. In addition, the act of collage often centers on a common space where people move about, share creative ideas and collage assets, physically collaborating to produce the collage.

This democratization of the design space affords opportunities for researchers and participants to engage in what Asaro refers to as "emergent behavior", which is behavior that forms serendipitously through a process of interaction between actors, their motivations and the environment over time (2000). The opportunity for *emergence*, in turn, introduces a meta space for interaction through negotiation, which places a, "-focus on interaction as an ongoing, dynamic process with different levels of detail and involving multiple mediators," (Bødker & Anderson 2005). Within the context of this study, interaction through negotiation (Bødker & Anderson 2005) takes place during the collage activity as the researcher and participant collaborate to design a service provision that not only meets the motivational needs of the participant, but also describes a cohesive sociotechnical experience.

The open system framework buttressing this approach, as well as the interaction potential for "emergent behavior" (Asaro 2000) and "interaction through negotiation" (Bødker & Anderson 2005) that it affords, build the foundation for reflective practice (Schön 1983) and situated action (Suchman 1987) needed to ensure authenticity of paper prototype smart home service provisions.

Reflective practice has operated as a theoretical underpinning of design practice for 30 years. During reflective practice, the designer interacts with their design through reflection-in-action and reflection-on-action (Schön 1983). Reflection-in-action (Schön 1983) takes place during the creation of the design. Schön uses the example of an architect sketching a building. During sketching, the architect chooses where to draw initial lines, erase existing lines and replace old lines with new lines. Such actions demonstrate instances of *in-situ* reflection during which the architect makes rapid decisions to realize her design. Reflection-on-action (Schön 1983) takes place after the completion of the design (which can be viewed as a prototype). In the scenario of the architect, she may share her drawing with others for group critique or review the drawing in private.

Completing the PCSoP survey is similar to sketching in that participants are confronted with a series of interactions designed to engage them in reflection-in-practice (Schön 1983) and reflection-on-practice (Schön 1983). For example, a person brainstorming across all of their personal projects (Little 1987; Little et al. 2007) can be seen as analogous to sketching the initial lines of a building in order to define a rough shod form. Likewise, choosing which personal projects (Little 1987; Little et al. 2007) are the important one's to categorize and assess are analogous to erasing unnecessary line work and further refining the remaining line work within a sketch. Then, much like an architect shares sketches through a process of critique to engage in reflection-on practice (Schön 1983), PCSoP participants discuss their survey results with the researcher (or in the case of clinical practice, a councilor or psychologist.) to explain, expand on and further refine the content.

Collage is a far more direct comparison with Schön's example of the architect in terms of physical activity and results. As with the architect, collage creators can freehand draw, yet the addition of mixed media in the form of photography and tokens increases the breadth of rich information that can be produced to communicate the concept. The collage also shares the material properties of an architect's sketch in that, adhesive materials notwithstanding, both artifacts are constructed of paper and ink. From a content perspective, both the architect and collage creators focus on explorations of environment and the interactions afforded by the environment. During collage, reflection-in-practice (Schön 1983) occurs as participants take photos of their home and choose which ones to construct the collage backdrop from versus which one's to omit, consider and define their own tokens, move tokens onto and off of the photographic backdrop and draw and write on the collage surface to define their smart home service provision. Reflection-on-practice (Schön 1983) occurs as the participant explains the collage to the researcher, and the researcher, in kind, provides critique. These choices in collage content result in a design that is both situated and authentic. Situated action (Suchman 1987) refers to the authenticity of the interactions between team members and that those actions are dependent on the environment they are being performed in. It also refers to a recognition and acceptance of embedding environmental context into the prototype by allowing lay participants to ingrain the prototype with their tacit knowledge. The value proposition of situated action (Suchman 1987) is that it yields rich, authentic data to construct grounded theory and inform the design space. However, methods such as ethnography, which strive to construct a situated account of a subject, are often offset by their expense in terms of the time a researcher must spend in the field collecting data and the invasiveness of entering a participant's home. The PCSoP survey and collage represent a tradeoff in situated action, by removing the overhead and invasiveness of ethnography, in favor of a rapid approach that seeks to simulate true situatedness through user generated data and user participation. The PCSoP survey is the first step in simulating situatedness by challenging participants to define the meaningful actions in their lives in the form of personal projects (Little 1987; Little et al. 2007), and then defining how those actions relate to their home environments. The simulation continues as participants photograph their home environments and choose which photos to construct their collage backdrops out of. Through these two grounding activities, the situatedness of the design space is ensured as researchers and participants negotiate authentic smart home service provisions. Figure nine illustrates the relationships between open systems (Asaro 2000), emergent behavior (Asaro 2000), reflective practice (Schön 1983), interaction through negotiation (Bødker & Anderson 2005) and situated action (Suchman 1994) that construct this studies participatory design framework.

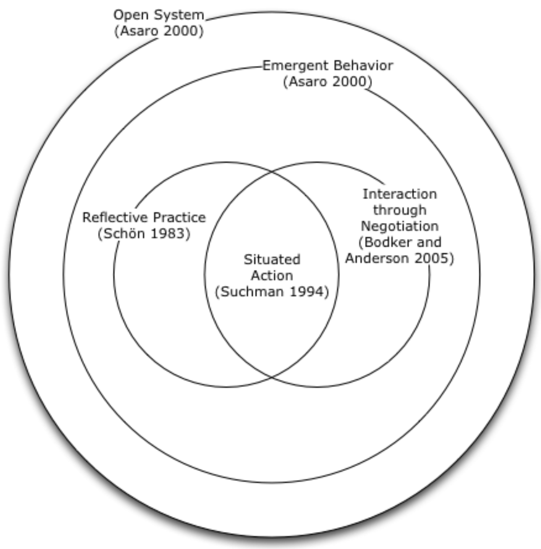


Figure nine. Participatory design conceptual framework.

This section reviewed key concepts and underlying assumptions supporting the participatory approach of this study. In addition, it discussed how the choice in method coincides with the approach. The following sections further define the approach through a detailed account of data collection and analysis methods.

Data Collection

This study implements surveys, interviews, photo-documentation, interaction mapping and psycho-cartography (Wójcik et al. 2010) (Foland & Lewicka 2007) to collect data during co-design activities. Participants complete two surveys: the PCSoP survey at the beginning of the study and an SEQ (Stiles et al. 1994) survey at the end of the study. For a detailed description of the PCSoP survey, refer to Chapter eight. In contrast to the *Motivational Heuristics* study, which implements the PCSoP survey in a normative fashion, this study utilizes the tool as part of an idiosyncratic approach to explore the project ecosystem (Little et al. 2007) and related dimensionality of a single participant. The difference between normative and idiosyncratic approaches is based on the desired outcome of the research agenda. Normative studies utilizing the PPA (Little et al. 2007) methodology produce results based on comparison of project ecosystems either within a single cohort group, or between cohort groups to establish generalizable insights related to human behavior. In contrast, PPA (Little et al. 2007) surveys, when used in an idiosyncratic manner, are often used by clinicians to broker a dialogue with a patient to explore and assess that patient's individual condition. When situated within the goals of this study, idiosyncratic implementation of the PCSoP survey serves two functions. The survey first allows participants to define their project ecosystem and then choose a single personal project (Little 1987; Little et al. 2007) to design for. In the context of the co-design process, the divergent thinking participants engage in to define their project ecosystems, followed by the convergent thinking participants engage in to choose a single personal project (Little 1987; Little et al. 2007), completes the first prototyping iteration. Second, once a single personal project (Little 1987; Little et al. 2007) has been chosen, the dimension scores related to that personal project (Little 1987; Little et al. 2007) are then cross-referenced against the motivational heuristics set to inform creation of a personalized interview guide. The researcher then uses this guide to facilitate the interview process.

The SEQ (Stiles et al. 1994) instrument was used at the end of the process to gather data on how each participant perceived the co-design process, which was defined as beginning with PCSoP survey and ending with the completion of the mapping activities. The rationale for using the SEQ (Stiles et al. 1994) as a process assessment tool stems from two assumptions. First, with the exception of interaction mapping, all methods used within the co-design process were adopted from either environmental or social psychology. Therefore, assessment using a psychological instrument, such as the SEQ (Stiles et al. 1994) appears to support both theoretical and methodological consistency. Second, the literature validating the credibility of the SEQ (Stiles et al. 1994) and detailing its instructions of use is well established, which reduced overhead that can be associated with inventing a new process assessment instrument. The SEQ (Stiles et al. 1994) was originally developed to track the impact of clinical sessions longitudinally across a treatment plan. Each column of the SEQ (Stiles et al. 1994) provides a space for measurement at the end of a single clinical session. Figure 10 shows seven blank columns, allowing for capture of seven SEQ (Stiles et al. 1994) over the course of seven clinical sessions. The cluster of four rows containing *Depth, Smoothness, Positivity* and *Arousal* are linked to equations that calculate the item scores to produce the overall factor scores. These factor scores automatically update as participants repeat measures. For the purpose this study, participants only complete one SEQ (Stiles et al. 1994) at the end of the co-design session. Figure 10 presents the SEQ (Stiles et al. 1994) worksheet.

The session was:							
Good							
Easy							
Worthless							
Deep							
Tense							
Pleasant							
Empty							
Powerful							
Ordinary							
Smooth							
Uncomfortable							

Right now I feel:							
Sad							
Pleased							
Still							
Definite							
Excited							
Afraid							
Unfriendly							
Fast							
Peaceful							
Aroused							

Depth:	
Smoothness:	
Positivity:	
Arousal:	

Figure 10. Session evaluation questionnaire (SEQ) (Stiles et al. 1994) for evaluating the quality of a clinical session.

*P*rior to interaction and psycho-cartographic (Wójcik et al. 2010) (Foland & Lewicka 2007) mapping activities, the participant completes photo documentation of her home. Photo documentation of the home consists of the participant photographing the interior of her home with a digital camera. The participant stands in the middle of each room of her home that she feels comfortable sharing with the researcher, and takes pictures of all four sides of the room, the ceiling, and the floor. The participant would then email the researcher the photos she desired to use in her collage for the researcher to print and bring to the co-design session.

At the start of the co-design session, the researcher conducts a semi-structured interview to further define a participant's chosen project to inform the collage activity. Pairing PPA (Little et al. 2007) surveys with follow-up interviews is a well established best known practice in the PPA (Little et al. 2007) literature because while PPA (Little et al. 2007) excels at systematic definition of *what* a person has going on in her life, but does not probe as to *why* a person reports those happenings in the first place. With the ultimate purpose of the co-design study aimed at developing a smart home service provision that aligns with a participant's motivations to complete a personal project (Little 1987; Little et al. 2007), understanding both what a personal project (Little 1987; Little et al. 2007) entails and why it exists in it's current state, was deemed necessary prior to engaging in interaction and psycho-cartographic (Wójcik et al. 2010) (Foland & Lewicka 2007) mapping activities.

A semi-structured interview protocol (Robson 2002) was specifically chosen based on the nature of the questions, which are characterized by the use of a predefined set of open-opened, lead-in questions (Robson 2002) coupled with improvised follow-up questions. Semi-structured (Robson 2002) protocols are situated as a means of exploring a specific topical area designated by the researcher, yet still allowing leeway for participants to control a portion of the conversation (Robson 2002). This method of interviewing nests between open-ended interview (Robson 2002) protocols, which take place as pure improvisational dialogue and fixed-interview (Robson 2002) protocols, which presents subjects with a series of selection-based questions (true/false, yes/no, multiple choice, etc.).

After completing the semi-structured interview (Robson 2002) participants collaborate with the researcher to complete a mixed-media collage consisting of their home photos, PICTIVE (Muller 1991, 1992; 1993) interaction maps and psycho-cartography (Wójcik et al. 2010) (Foland & Lewicka 2007). From an idiosyncratic analytical perspective, a collage provides the researcher with a concrete scenario that communicates the behavioral needs of the participant, and the smart home service provision interactions hypothesized to meet those needs, within the context of the personal project (Little 1987; Little et al. 2007) to guide future prototyping cycles. From a normative analytical perspective, the group of 20 collages generated across the sample population provides a data set that informs development of design principles and interaction models for motivation-centric smart home service provisions.

The PICTIVE (Muller 1991, 1992; 1993) mapping method is used to map smart home service provision interactions onto the physical space. The technique consists of placing paper tokens representing individual GaLLaG (Burleson et al. 2009) interactions onto the collage of the home interior. Participants are given a set of predefined tokens, with each one representing a current available sensing or feedback interaction facilitated by the GaLLaG (Burleson et al. 2009) system, as well as blank tokens to designate new interactions absent in the GaLLaG (Burleson et al. 2009) system. During PICTIVE (Muller 1991, 1992; 1993) mapping, the researcher and the participant engage in a negotiation leading to placement of PICTIVE (Muller 1991, 1992; 1993) interaction markers onto the collage in response to the psycho-cartographic (Wójcik et al. 2010) (Foland & Lewicka 2007) content on the collage. Throughout this conversation, the researcher and the participant annotate the placement of the PICTIVE (Muller 1991, 1992; 1993) tokens with drawings and text. The tokens, drawing and text all support judgments on behavior relationships made during psycho-cartography (Wójcik et al. 2010) (Foland & Lewicka 2007).

Psycho-cartography (Wójcik et al. 2010) (Foland & Lewicka 2007) is a method adopted from environmental psychology. The method consists of using pictorial markers that represent behavioral relationships between an occupant and her environment. These markers range from freestyle drawing, and written text, to predefined tokens and are placed on an environmental map to communicate where in the environment those behaviors occur. For this study, participants use a set of predefined markers, each one representing a PPA (Little et al. 2007) dimension and are also given the option of using blank tokens to designate behaviors absent in the PPA (Little et al. 2007) dimension set. During the psycho-cartography (Wójcik et al. 2010) (Foland & Lewicka 2007) activity, the researcher and the participant engage in a conversation leading to placement and annotation of the PPA (Little et al. 2007) dimension markers across the collage of the home interior to describe how the smart home service provisions could affect the current state of PPA (Little et al. 2007) dimension ratings. The outcome of these methods is a collage visualizing relationships between the participant's behavior and smart home service provision interactions within the context of a personal project (Little 1987; Little et al. 2007) within her home.

Data Analysis

The data collected using the PCSoP survey, semi-structured interview protocol (Robson 2002), collage making and the SEQ survey (Stiles et al. 1994), generate a diverse set of information for exploration and interpretation. To account for this heterogeneity in the data types, this study takes a mixed method approach focused on comparative analysis and triangulation (Robson 2002) to reject or uphold hypotheses, as well as qualitatively explore surface patterning (Robson 2002) of potential design principles and interaction models hidden within the data.

Comparative analysis is a common analytical approach used by researchers to describe and explore data. For this study, three methods centered on comparison are utilized to address hypotheses and explore design patterns. The first method compares various types of descriptive statistics to either reject or confirm hypotheses. This method consists of tabulating mean values and ratio values that describe relationships between areas of the home and PPA (Little et al. 2007) tokens.

To address H^1, the hypothesis that participants, when given a choice of projects to design for, will select projects with higher than average *Home Dependency,* mean values of the *Home Dependency* factor are calculated twice. First, a mean value representing the average for *Home Dependency* is calculated for the combined scores of the participants' 20 project ecosystems. Second, the mean value for the subset of 20 projects chosen for co-design is calculated. The comprehensive mean value is then compared to the subset mean value to determine if H^1 is upheld. The same mean comparison process is used for the *Control* and *Stress* dimensions to determine if H^2 is upheld. A similar approach of mean comparisons is also employed for H^5, that participant SEQ (Stiles et al. 1994) scores will demonstrate high *Depth, Smoothness* and *Positivity* scores and low *Arousal* scores. The deference between H^5 and H^1, H^2 is the success criteria. For H^1, H^2 success depends on if the mean score of the subsample population is greater than the total population mean. Because all mean measures for H^1, H^2 are dependent on participant generated data, the success threshold is not absolute, but relative to participant responses, and therefore can change between sample populations, or between measures within the same sample population. For H^5, success depends on if the mean score for each of the four SEQ (Stiles et al. 1994) factors is greater than the absolute mean of the measurement scale, which incidentally, is also the median value of 3.5 on the 7-point scale. Unlike H^1, H^2 success criterion, the H^5 success criterion is absolute in nature.

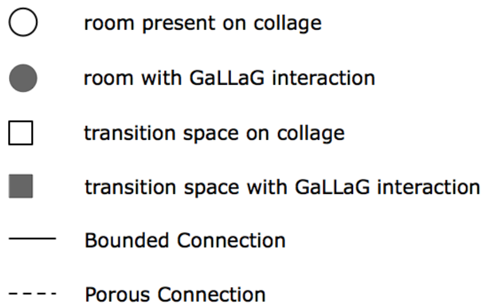
A comparative analysis based on ratios explores H^3, which states that participants will primarily design for PPA (Little et al. 2007) outcomes associated with positive affect dimensions (*Happy, Hopeful* and *Love*), *Value Congruency*, *Self-Identity,* *Autonomy, Likelihood of Success, Fear* and *Difficulty*. Two types of proportion modeling investigate the merit of this hypothesis. First, percentages of each PPA (Little et al. 2007) dimension token and its related positive or negative descriptor are calculated against the total number of PPA (Little et al. 2007) tokens. The percentages of PPA (Little et al. 2007) dimensions of interest to H^3 are summed, as are the percentages of variables not specified in H^3 to produce a proportional description comparing the percentages of H^3 PPA (Little et al. 2007) dimensions against other dimensions. The second exploration of proportion illustrates the percentage of participants that report one or more of the H^3 variables against those that did not. If the percentage of the former outweighs the latter, than H^3 is upheld and merits further investigation through the course of future work.

The second method of comparison leverages content analysis (Hsieh & Shannon 2005) to produce Affinity diagrams (Beyer & Holtzblatt 1997) that describe patterns leading to design insights. Content analysis has two primary areas of usefulness. In computer science, content analysis refers to various machine learning and pattern recognition methods used to construct meaning from data. In social science research, it refers to the rigorous, subjective analysis of written and visual data by the researcher, or a group of researchers, to construct meaning. This study implements content analysis in the sense of the latter, rather than the former.

Building affinity diagrams is a common design research method for design researchers to visualize comparisons, construct mental models of design spaces and reveal design insights. Researchers often construct mental models and fledgling prototypes using affinity diagrams as a method of analysis within contextual inquiry (Beyer & Holtzblatt 1997). The process consists of physically modularizing observations by recording a single observation onto a post-it® or other small piece of paper, looking for commonalities between observations and then iterating various physical arrangements of the observations to reflect these commonalities.

The validity of the Affinity diagram is proven through theory and methodological triangulation (Guion, Diehl & McDonald 2011). Theory triangulation refers to the review of qualitative analysis outcomes by investigators of different theoretical backgrounds (Guion et al. 2011). During this study, the resulting design insights are reviewed by an advisory board consisting of a clinical psychologist, interaction designer and computer scientist. Methodological triangulation refers to the use of multiple methods to collect data for analysis. The content used to construct the affinity diagrams includes transcripts from the semi-structured interviews as well as text and sketches taken form the collages.

The third method of comparison is space syntax (Hansen & Hillier 1982) analysis. This method consists of comparing the areas of the home captured and used as part of collages, as well as the GaLLaG (Burleson et al. 2009) PPA (Little et al. 2007) tokens within each area of the home across all collages. This comparison results in a space syntax (Hansen & Hillier 1982) model explaining interactions between occupants and motivational smart home service provisions within the domestic environment. The first step in this process is coding each collage using the scheme illustrated in figure 11.



1. Garage Entry
2. Front Entry
3. Family Room
4. Kitchen
5. Dining Room
6. Formal Dining Room
7. Living Room
8. Hallway
9. Stairs
10. Other Bathroom
11. Other Bedroom
12. User Bedroom
13. User Bathroom
14. Basement
15. Balcony
16. Back Patio
17. Back Yard
18. Front Porch
19. Front Yard
20. Laundry Room
21. Den
22. Home Office
23. Garage
24. Closet

Figure 11. Space syntax (Hansen & Hillier 1982) configuration diagram key.

White circles represent primary activity rooms, such as kitchens and living rooms, that are present on a collage, yet lack GaLLaG (Burleson et al. 2009) PICTIVE (Muller 1991, 1992; 1993) interaction tokens. Gray circles represent primary activity rooms, such as kitchens and living rooms that are present on a collage and contain GaLLaG (Burleson et al. 2009) PICTIVE (Muller 1991, 1992; 1993) interaction tokens. White squares represent transitions areas in a home, such as front entryways, hallways and staircases, that are present on a collage, yet lack GaLLaG (Burleson et al. 2009) PICTIVE (Muller 1991, 1992; 1993) interaction tokens. Gray squares represent transitions areas in a home, such as front entryways, hallways and staircases that are present on a collage that are present on a collage and contain GaLLaG (Burleson et al. 2009) PICTIVE (Muller 1991, 1992; 1993) interaction tokens. Numbers in the center of circles or squares denote the specific room. The choice to separate rooms from transitional spaces is informed by standards of analytical practice in both ethnoarchaeology and architecture which treat these two categories as separate in order to define areas of transition and areas of activity within a location.

Solid lines connecting various circle and square combinations indicate contiguous areas of the home that have formal boundaries, such as a doorway. Dotted lines connecting various circle and square combinations indicate contiguous areas of the home that have porous boundaries indicative of open floor plans. Lack of a line connecting areas of a home indicates that the room(s) was present on the collage, yet there is no indication of what other rooms it is directly related to.

The result of applying this coding scheme is a visual abstraction of each collage that allows for comparative analysis leading to synthesis of an interaction model describing the relationships between areas of the home and GaLLaG (Burleson et al. 2009) interactions. Of note, is the resulting diagrams do not capture rooms that were incidentally captured through photography. For example if a participant has taken a photo of their bedroom, and her bedroom door is open, capturing part of the hallway outside of the bedroom, yet the hallway is not captured as the primary subject of the photo, then the hallway is not captured on the diagram. This omission is made in an attempt to accurately catalog the rooms participants intend for a collage to contain.

The subsequent sections have detailed the research approach, data collection methods, and now, the data analysis methods to describe a comprehensive research plan for co-design of motivation-centric smart home service provisions. The following section describes the procedures researchers and participants underwent to realize the research plan.

Procedure

This section describes the journey twenty (n = 20) participants undertook with the researcher to co-design their own smart home service provisions. Participants for this study were chosen from the larger sample set of participants who completed PCSoP surveys during the course of the *Motivational Home Heuristics* study (Chapter eight). The first criterion for participation was an indication from the participant on their willingness to collaborate with the researcher to build a smart home service provision. Prior to handing in their PCSoP surveys, participants who desired to continue onward with the co-design process placed a "Y" in the upper left corner of the demographic information page of the PCSoP survey. Forty-three participants agreed to participate in the co-design session. The researcher initiated one-on-one phone calls with each candidate to detail the expectations of the study, rights as participants and compensation, in accordance with IRB standards. Out of the initial 43 candidates, 20 (n = 20) of them proceeded with the co-design study.

A cutoff sampling procedure was used to reach a maximum number of 20 participants. Like many qualitative research approaches, participatory designs are typified by a small sample size, generally between five and 12 or until data saturation is reached. Data saturation refers to the emergence of consistent redundancy in content across participant data, which indicates that the subject matter has been comprehensively explored within the scope of a study. Twenty participants were viewed as an adequate amount of participants likely to yield saturation. Eighteen of the participants were interns or recent college graduates working at a large technology manufacturing corporation, while two of the participants were college seniors. Employees of the technology manufacturing corporation were compensated with $50 for completing the study. College students were compensated with course extra credit. Co-design sessions occurred during summer, fall and winter of 2012 in Portland, OR and Tempe, AZ. The location of the study was determined based on the location of the participant.

Once participants agreed to move forward with the co-design study, they were asked to review the data from their PCSoP survey and email the researcher with a personal project (Little 1987; Little et al. 2007) they wanted to design a smart home service provision for. The project selection criteria were purposefully left vague to see if participants would respond with project choices that demonstrate PCSoP dimension ratings that either support or reject H^1 and H^2. Participants also received instructions on how to photo document their home environment and where to email the digital copies of the photos to in preparation for the co-design session. Co-design sessions were schedule through email exchanges.

After receiving a participant's project choice, the researcher reviewed the PCSoP dimensions associated with the project to devise a personalized interview guide for the semi-structured interview. For example, if a participant reported a value of eight for the dimension *Fearful*, then the question, "*You report being vary afraid of this project, can you explain what about this project you find frightening."* Once complete, the interview guide was printed on standard office paper for use during the co-design session

All co-design sessions were conducted in conference rooms and lasted two hours. When participants entered the conference room, they were presented with their home photos, which were mounted on poster board by room. For example, all living room photos were mounted together on the same board or boards. This initial configuration was deemed the most appropriate one for maintaining a sense of cohesion regarding the home environment. The home photography boards were placed flat on the conference table. GaLLaG (Burleson et al. 2009) PICTIVE (Muller 1991, 1992; 1993) tokens, PPA (Little et al. 2007) tokens and craft materials, including colored markers and various sizes of post-its® spread out around the boards.

Prior to beginning the collage activity, the participant completed the semi-structured interview. The interview process was purposefully kept informal and transparent. Light refreshments were provided. The researcher explained the reason for the interview as a method to better understand the participant's perspective on the chosen personal project (Little 1987; Little et al. 2007). Participants were also instructed to refuse to answer a question if it made them feel uncomfortable. As a measure intended to make participants feel comfortable in the interview, the researcher took interview notes on post-its®, which were then placed in front of participants *in situ* so that they could see what the researcher was writing down. This method of note taking was chosen to increase transparency of the process and build trust with participants. Additionally, participants were given their own stack of post-its® and a marker to add their own feedback to the interview notes.

Upon completing the interview, the collage space and various assets were explained to the participant. The choice to wait to explain the collage space was made in attempt to reduce bias in the interview answers. After explaining the collage assets, the participant was given the option to restructure photo compilations on the poster boards, restructure the layout of the poster boards in relation to each other and, if desired, they could hang the poster boards on the conference room walls, rather than working on the table. Once finished with reconfiguring the space, participants began collaging

The collage process began with identifying initial GaLLaG (Burleson et al. 2009) interactions that participants believed could be useful in supporting their efforts to complete their personal projects (Little 1987; Little et al. 2007), and then placing the corresponding GaLLaG (Burleson et al. 2009) PICTIVE (Muller 1991, 1992; 1993) token on the place in the home where they wanted the interaction to occur. Participants would then annotate the interaction token, either by writing or drawing directly on the home photo, or by writing or drawing on post-it® that was then added to the collage next to the token. Multiple interaction tokens were conceptually linked together either through physical proximity to one another, or by drawing arrows on the collage space to connect them. Participants described the conceptual links through drawing or writing. If participants became stuck (Burleson & Picard 2007) on how to proceed, the researcher would ask them questions to test whether or not they were stuck (Burleson & Picard 2007) because they believed the application was complete, or because they genuinely needed help in defining new interactions. If the answer was the latter, the researcher asked additional questions to facilitate brainstorming. Questions were not scripted, but rather improvised in response to the needs of the participant.

After completing an initial iteration of GaLLaG (Burleson et al. 2009) PICTIVE (Muller 1991, 1992; 1993) interaction mapping to define the smart home service provision, participants began psycho-cartography (Wójcik et al. 2010) (Foland & Lewicka 2007) by positing how the provision would affect their thoughts and feelings towards their personal projects (Little 1987; Little et al. 2007). They did so by placing PPA (Little et al. 2007) dimensions onto the collage space and attributing either a + sign to indicate an increase in the dimension, or – sign to indicate a decrease in the dimension. Participants could also further describe the relationship between the provision and the PPA (Little et al. 2007) dimension through drawing or text annotation. PPA (Little et al. 2007) tokens could be attributed to the provision either at a global level, whereby the participant asserts that the application, as a whole, would generate the affect on the PPA (Little et al. 2007) relationship, or they could specify a specific interaction within the provision as the reason for hypothesized change in the PPA (Little et al. 2007) relationship. As with the GaLLaG (Burleson et al. 2009) PICTIVE (Muller 1991, 1992; 1993) interaction mapping, when participants became stuck (Burleson & Picard 2007), the researcher proposed questions to identify the reasons for feeling stuck (Burleson & Picard 2007) and defining the next steps in the process.

After participants completed the first iteration of interaction mapping and psycho-cartography (Wójcik et al. 2010) (Foland & Lewicka 2007), they were given an opportunity to engage in a second iteration of mapping. During the second iteration, participants went through the same mapping process to make additions, deletions and augmentations to the GaLLaG (Burleson et al. 2009) PICTIVE (Muller 1991, 1992; 1993) tokens, PPA (Little et al. 2007) tokens and annotations. Once they either opted out of, or completed the second mapping iteration, participants completed the SEQ (Stiles et al. 1994).

The SEQ (Stiles et al. 1994) was provided to participants in digital format on a laptop. The laptop contents were protected through whole disk encryption and user account encryption. The researcher explained the purpose of SEQ (Stiles et al. 1994) as a way to assess the co-design process, reminded participants of their participant rights in accordance with IRB standards and encouraged participants to ask any questions if they did not understanding the meaning of an SEQ (Stiles et al. 1994) dimension. Upon completing the SEQ (Stiles et al. 1994), participants were asked to provide any final thoughts on the process. As with other researcher-generated notes, final thoughts were captured using post-its®.

Upon completing the co-design and process assessment activities, participants were compensated in one of two ways. Interns and recent college graduates working the technology manufacturing corporation were compensated on-site with $50 for their time. College students not working at the corporation, were compensated with extra course credit. The researcher sent an email of student names that participated in the study to their professor, who then logged the extra credit into their profiles in an electronic grade book.

All participants were given a participant ID number ranging from the number one to the number 20. This ID was ascribed to all data associated with a participant in order to anonymize the data and allow for tracking during analytics. All collages were captured using a digital camera in a .tiff format. These images were transferred to a laptop and erased from the camera. Interview notes, which were captured on Post-its®, were kept in their pen and paper form. Survey data was entered into SPSS for analysis. All digital assets were stored on a laptop featuring both password protected hard disk encryption and user account authentication. This laptop, as well as the Post-it® notes, were stored at a secure site.

This section described the procedures and activities participants were involved during this participatory design study. The following section presents the results of the study.

Results

This section presents data collected through the course of the PCSoP surveys related to the co-design population subset, the collages developed through the co-design and the SEQ (Stiles et al. 1994) surveys. First, personal projects (Little 1987; Little et al. 2007) chosen for co-design are discussed in terms of their categorization, followed by descriptions of PCSoP and SEQ (Stiles et al. 1994) data related to the hypotheses. The collages are then dissected by areas of the home present across collages, GaLLaG (Burleson et al. 2009) PPA (Little et al. 2007) tokens present across all collages and PPA (Little et al. 2007) tokens present across all collages.

Projects chosen as the subject of co-design sessions demonstrate a wide variety of participant interests. Table 10 presents each personal project (Little 1987; Little et al. 2007) and related project categories by participant.

Table 10.

Participant personal project (Little 1987; Little et al. 2007) selections for co-design sessions.

Participant ID	Co-design project	Project category
1	Learn to play “Blackbird” on my guitar	Leisure and entertainment
2	Sow a fox stuffed animal	Other
3	Plan meals for the week, buy/cook appropriately	Health and fitness
4	Try different cuisine	Leisure and entertainment
5	Workout 5x week	Health and fitness
6	Grow tomatoes	Leisure and entertainment
7	Build a new bike	Home and vehicle maintenance
8	Redesign “music table” for art installation	Academic
9	Learn to brew beer better	Intrapersonal
10	Present at an important meeting	Work related
11	Maintain a fitness routine	Health and fitness
12	Cook healthy food 3x a week	Health and fitness
13	Keep in touch with old friends	Interpersonal

Table 10 continued.

Participant personal project (Little 1987; Little et al. 2007) selections for co-design sessions.

Participant ID	Co-design project	Project category
14	Eat healthier	Health and fitness
15	Learn how to play the keyboard	Leisure and entertainment
16	Complete homework in a timely manner	Academic
17	Spend less time online	Intrapersonal
18	Complete a fitness routine	Health and Fitness
19	Create family photo collage	Home and vehicle maintenance
20	Write Autobiography	Academic

During the course of the co-design sessions, participants 10 and 18 changed their personal projects (Little 1987; Little et al. 2007). Participant 10's personal project (Little 1987; Little et al. 2007) evolved from "present at an important meeting", to "practice presenting". This change in project phrasing implies that the project is no longer about seeking out a specific event, but rather improving a skill. Participant 18's personal project (Little 1987; Little et al. 2007) evolved from "complete a fitness routine" to "prepare healthier meals". The participant chose to enact this change because he saw little value in a service provision for his fitness routine as it took place outside of the home. participant 17 entered the co-design session without having identified a personal project (Little 1987; Little et al. 2007) from her PCSoP survey. After considering the content on her survey, she realized that multiple projects were indicative of online behavior consuming her time, which in turn, reduced the time she needed to complete many of her projects. This realization led her to develop the new personal project (Little 1987; Little et al. 2007) “spend less time online”.

Participants chose projects ranging in duration from one month (i.e. participant 02’s “sew a fox stuffed animal” and participant 07’s “build a new bike) to several years (i.e. participant 03’s “Plan meals for the week, buy/cook appropriately” and participant 09’s “learn to brew beer better”). However, with the exception of diet and exercise projects, participant’s reported most projects as one’s that should be completed within a three to six month timeline. With the exception of participant 18, who had a well-defined project stop date for his exercise related project, diet and exercise projects were considered opened. When pressed through interview laddering (Little et al. 2007) techniques to define concrete outcomes for health and fitness projects, participants struggled, often defaulting to answers that such as, “I don’t have a specific thing, like lose weight or anything. I just want to feel healthy,” as stated by participant 11. Multiple participants also reported that they had started these projects sometime in the past, quit the project for various reasons, and were now looking to resume the project (participant 01’s “learn to play ‘Blackbird’ on my guitar”, participant 02’s “sew a fox stuffed animal, participant 05’s “work out 5x a week”, participant 06’s “grow tomatoes”, participant 07’s “build a new bike”, participant 11’s “maintain a fitness routine”). Reasons for quitting the project ranged. Participants 01, 05, 06 and 11 all reported quitting their projects because of lack of time. Participant 11 moving across country removed her from her social support system that kept her accountable for project completion, as well as a sustaining a previous injury from working out also were factors in quitting the project. Participants 02 and 07 reported that they quit the project because they could not find the materials necessary to complete the project. Participant 02 stated that she could not find a fabric that aligned with her sense of style in order to make the stuffed animal. Participant 07 reported that the bicycle he sought to build was a vintage model and he was challenged with finding original parts at a price he could afford.

While participants initially categorized their personal projects (Little 1987; Little et al. 2007) according to the PPA project categories (Little et al. 2007), the semi-structured interviews reveal areas of overlap not typified by the PPA project category schema (Little et al. 2007). For example, participant eight reported his project as "academic" in nature, but during the course of his interview discussed the project in terms of a hobby pursuit that he turned into an academic project as a means of motivating himself to complete the project.

When grounded within the context of the interview data, the multidimensionality of what projects mean to participants produces overlap across several vectors external to discrete PPA project categorization (Little et al. 2007) . Out of the 20 personal projects (Little 1987; Little et al. 2007) selected for co-design sessions, 30% of them revolve around health and fitness (participants three, five, 11, 12, 14 and 18), while 30% of them focused on food (participants three, four, six, nine, 12 and 14). 30% of projects center on learning and skills improvement (Participants one, four, six, nine, 10, 12 and 15). Learning and skills improvement were reported across the categories of *leisure and entertainment* (participants one, four, six, nine and 15), *work related* (participant 10) and *intrapersonal* (participant 12). 45% of participants chose projects aimed at making something (Participants two, six, seven, eight, nine, 10, 12, 19 and 20), yet what they focus on making fell across multiple project categories, including *other* (participant two), *leisure and entertainment* (participants six), *home and vehicle maintenance* (participants seven and 19), *academic* (participants eight and 20), *intrapersonal* (participant nine), *work-related* (participant 10) and *health and fitness* (participant 12).

Nineteen out of 20 participants reported values for *Home Dependency.* Participant two did not report a *Home* Dependency value for her chosen co-design project, which omits her from analysis related to the *Home Dependency* factor. The normative mean value of PPA (Little et al. 2007) *Home Dependency* for the project ecosystems of the co-design population was slightly larger than the mean value of only projects chosen for co-design (5.41 versus 5.10). The minimum value of chosen projects was zero, while the maximum value of chosen projects was 10, indicating that ratings were reported across the full range of the PPA measurement scale (Little et al. 2007). Six participants report very low *Home Dependency* values for their chosen co-design projects (*Home Dependency* ≤ 2.5). Five participants reported very high *Home Dependency* values for their chosen co-design projects (*Home Dependency* ≥ 7.5). Eight participants reported moderate *Home Dependency* values for their chosen co-design projects (*Home Dependency* > 2.5, *Home Dependency* < 7.5). Table 11 presents the *Home Dependency* mean value for each participant's project ecosystem and the individual *Home Dependency* value of the chosen project across participants.

Table 11.

Home dependency mean values across participants.

Participant ID	Home dependency mean value	Co-design project home dependency value
1	4.15	10
2	4.92	-

Table 11 continued.

Home dependency mean values across participants.

Participant ID	Home dependency mean value	Co-design project home dependency value
3	6.02	9.75
4	5	0
5	3.8	.75
6	6.9	7
7	6.15	6
8	2.65	2.25
9	7.07	9.5
10	3.95	.25
11	3.21	.75
12	8.07	10
13	4.32	6.5
14	6.72	5.75
15	6.25	8.75
16	5.97	1.25
17	5.7	
18	7.1	5.25
19	4.65	9.5
20	6.2	4

Across all 20 collages, participants placed a total of 147 PPA (Little et al. 2007) tokens to indicate how they believe their smart home service provisions would change motivational aspects related to their projects. Figure 12 dissects these 147 observations by percentage.

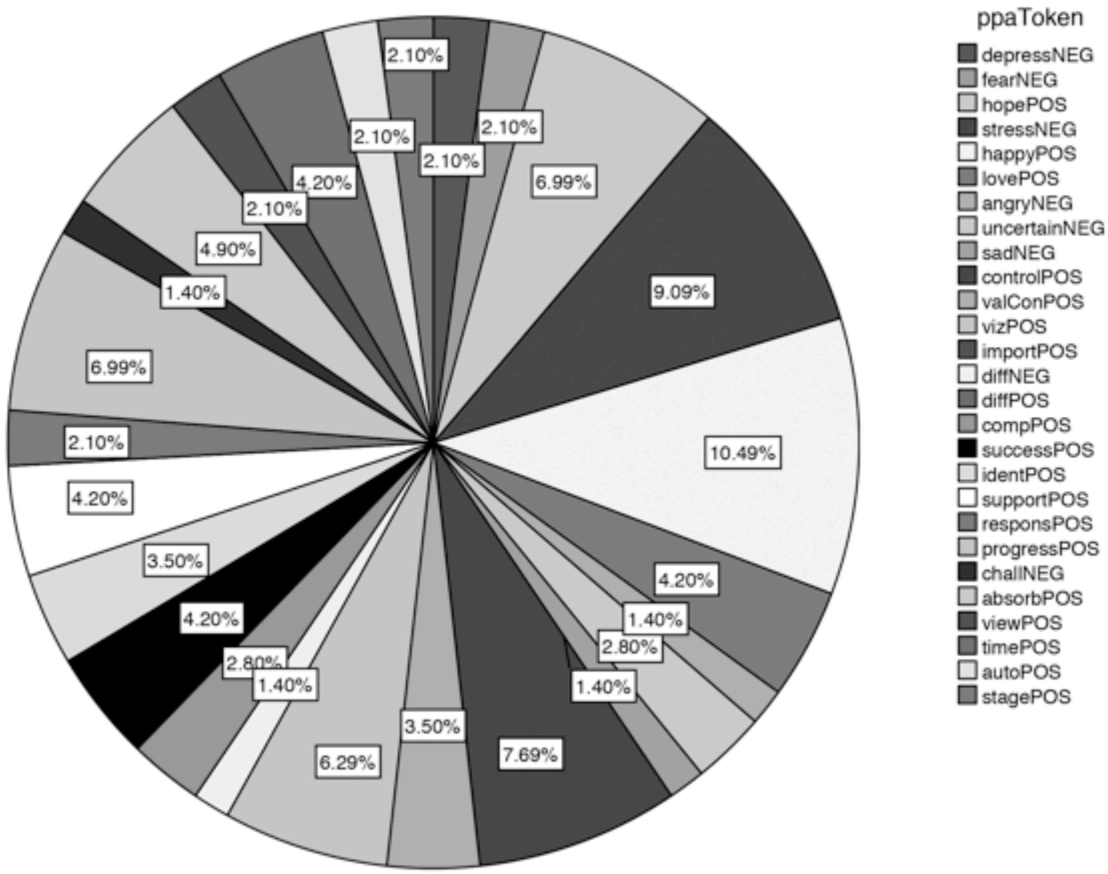


Figure 12. Distribution percentages of personal project dimension (Little et al. 2007) tokens tabulated across all co-design participant collages.

PPA (Little et al. 2007) tokens representing PPA (Little et al. 2007) dimensions that comprise PCSoP models produced in Chapter eight that predict *Place Attachment* (Jorgensen, & Stedman 2006, 2001) *Place Identity* (Jorgensen, & Stedman 2006, 2001) and *Place Dependency* (Jorgensen, & Stedman 2006, 2001) account for 37.4% of tokens chosen by participants. Table 12 presents each of the PCSoP model predictor variable along with each variable's related total percentage of presence across participant collages. (*Positive Affect Factor* = 20.36% [*Happy* = 10.2%, *Hope* = 6.08%, *Love* = 4.08%], *Outcome/Likelihood of Success* = 4.08%, *Value Congruency* = 3.4%, *Self Identity* = 3.4%, *Autonomy* = 2.04%, *Fear* = 2.04%

and *Difficulty* = 1.36%). These seven predictor variables account for 26.96% of the PPA (Little et al. 2007) token set available for participants to choose from during collage, yet account for approximately 10% more of PPA (Little et al. 2007) tokens present on across collages.

According to the PPA (Little et al. 2007) literature, *Control* and *Stress* are the primary dimensions that determine the likelihood of project success. The higher the perceptions of *Control* are related to a project, and the lower perceptions of *Stress* are related to a project, the more likely a person is to complete a project to the desired outcome (Little et al. 2007). The mean values for *Control* and *Stress* for the co-design populations' project eco-systems, as a whole, were 6.39 and 3.73, respectively. The *Control* and *Stress* mean values for the personal projects (Little 1987; Little et al. 2007) chosen for co-design sessions were 6.45 and 2.65, respectively. For *Control*, the minimum value reported on chosen projects for co-design was 4.00, while the maximum value was 10.00. For *Stress*, the minimum value reported on chosen projects for co-design was zero, while the maximum value was 10.00. Table 12 presents the mean values for each participant's project ecosystem against the values of each participant's chosen co-design project.

Table 12.

Comparison of participant project ecosystem control and stress mean values against control and stress mean values of personal projects (Little 1987; Little et al. 2007) chosen for co-design activities.

Participant ID	*Control* mean value	Co-design *control* value	*Stress* mean value	Co-design *stress* value
1	7.30	6.00	2.40	2.00
2	9.00	9.00	3.50	2.00
3	9.00	10.00	3.62	5.00

Table 12 continued.

Comparison of participant project ecosystem control and stress mean values against control and stress mean values of personal projects (Little 1987; Little et al. 2007) chosen for co-design activities.

Participant ID	*Control* mean value	Co-design *control* value	*Stress* mean value	Co-design *stress* value
4	3.90	10.00	4.75	0.00
5	7.10	7.00	4.0	5.00
6	7.20	4.00	1.60	0.00
7	8.60	10.00	3.75	2.00
8	7.40	10.00	4.60	4.00
9	8.50	8.00	1.70	0.00
10	5.60	5.00	2.60	3.00
11	5.37	5.00	1.50	0.00
12	8.10	6.00	1.40	0.00
13	4.60	6.00	5.20	2.00
14	6.10	5.00	4.40	2.00
15	6.80	7.00	2.40	0.00
16	7.88	10.00	3.67	8.00
17	9.85	7.4	4.70	5.9
18	.50	5.00	3.00	2.00
19	4.90	5.00	3.50	4.00
20	9.85	00	3.71	10.00

Tabulation of PPA (Little et al. 2007) tokens administered on collages indicates that both *Control* and *Stress* appear on a majority of collages. 85% of participants hypothesize either an increase in *Control* or a decrease in *Stress* due to their smart home service provision. 58% of participants reported that they believe their smart home service provisions will increase their sense of *Control* over a project, while zero cases emerged where a participant indicates a provision would decrease *Control* over a project. 68.50% of participants reported that they believe their smart home service provisions would decrease stress associated with their projects, while zero cases emerged where participants reported they believe their provisions would increase stress.

SEQ (Stiles et al. 1994) results produced high mean values for the factors *Depth*, *Smooth* and *Positivity* and a close-to-average value for the factor, *Arousal.* Table 13 presents the group averages for the four SEQ (Stiles et al. 1994) factors.

Table 13.

Session evaluation questionnaire (SEQ) (Stiles et al. 1994) Factor Mean Values for co-design participants.

Depth	Smoothness	Positivity	Arousal
Mean = 5.58 Minimum = 4.00 Maximum = 7.00	Mean = 6.06 Minimum = 5.00 Maximum = 7.00	Mean = 6.50 Minimum = 5.20 Maximum = .00	Mean = 3.85 Minimum = 2.40 Maximum = 4.80

Table further detail the SEQ (Stiles et al. 1994) results by presenting the responses of each participant.

Table 14.

Session evaluation questionnaire (SEQ) (Stiles et al. 1994) data by participant.

Participant	Depth	Smoothness	Positivity	Arousal
1	6.40	5.00	7.00	4.80
2	5.40	5.20	5.80	3.60

Table 14 continued.

Session evaluation questionnaire (SEQ) (Stiles et al. 1994) data by participant.

Participant	Depth	Smoothness	Positivity	Arousal
3	4.6	5	5.2	3.2
4	6.6	7	7	4.6
5	6	6.6	6.6	3.8
6	4.4	5.4	6.6	3.8
7	5.2	6	6.4	4.6
8	6	5	6.2	4
9	6.4	6.2	7	4
10	5.4	6.6	6.4	2.4
11	6	6.6	6.6	3.8
12	6	6	6.4	4.2
13	5.4	6	6.4	2.6
14	6	6.2	6.3	4.6
15	5	6.2	5.8	4.4
16	4	6.2	6.6	4.4
17	6	7	7	4.4
18	5.2	6.2	6.4	2.8
19	4.6	6.8	7	4.4
20	7	6	7.4	2.6

Semi-structured interviews (Robson 2002) yielded 396 observations. The majority of these observations are shown in figure 13 in the form a wall of Post-its® segmented by participant. Interview notes captured data regarding project definition and project logistics. Questions regarding project definition included inquiries into a project's start date and success criteria, as well as the questions representing the

PCSoP heuristics produced in chapter eight of this document. Examples of questions included, “When did you start this project?”, “How do you know when you have completed this project?”, “Tell me a little bit about what sorts of things you value in life? How is this project related to those personal values?” and “What about this project do you find difficult and why?”. Three hundred and eighteen notes on project definition were captured. For a full list of interview questions, refer to Appendix D. Questions on project logistics dealt with topics such as access to appropriate resources to complete the project and interactions participants engaged in while pursuing the project outcome. Seventy-four notes were taken on project logistics. In some instances, these two categories of project related notes demonstrated overlap. For example, when participant 20 was probed on the PPA (Little et al. 2007) dimension *Difficulty* regarding her project “Write Autobiography”, she referenced a change in access to environmental resources, “When I wrote the biggest segment of it [my autobiography], I was at my ex-boyfriend’s house. He had this really cool space that was all red brick, had a fireplace and stuff, it was really cozy.”

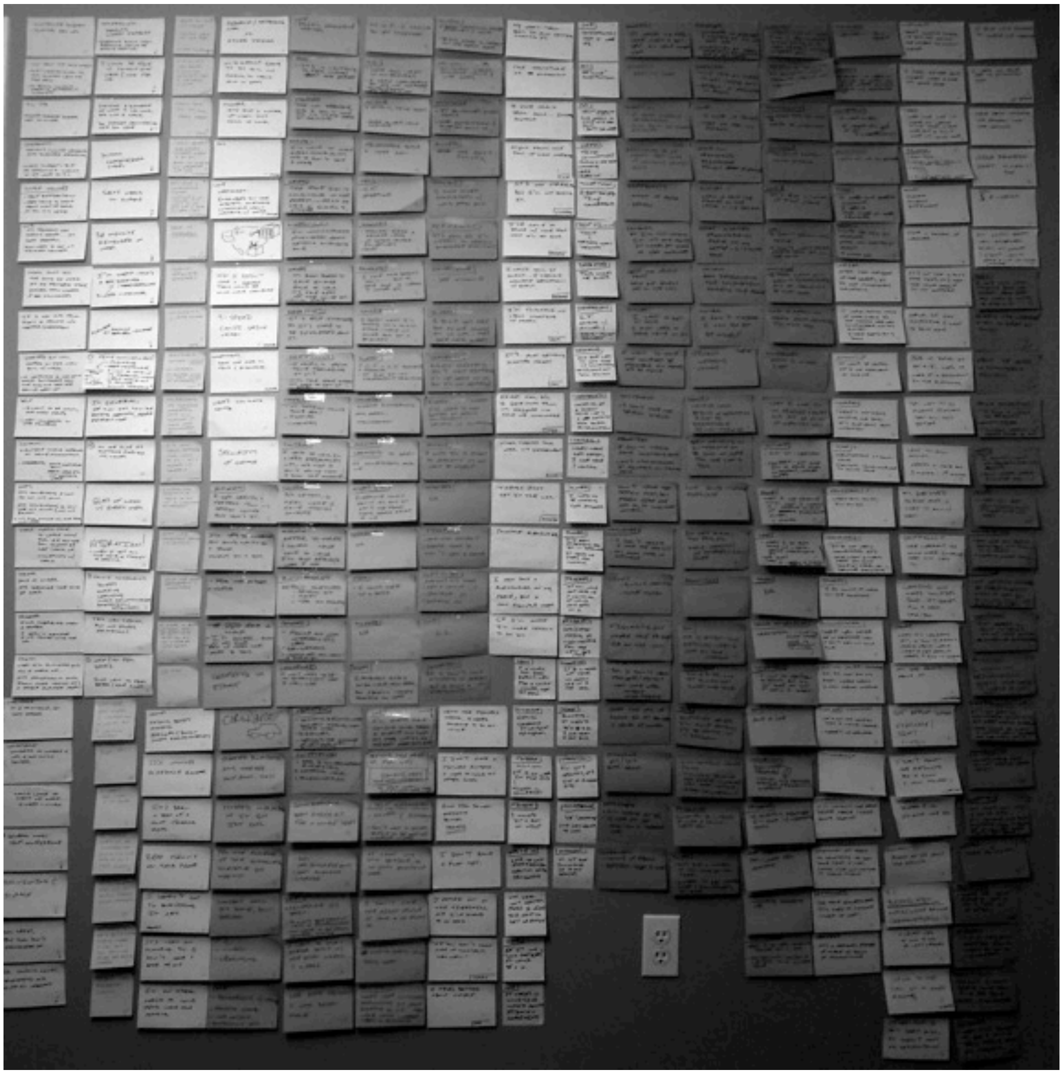


Figure 13. Semi-structured interview (Robson 2002) notes posted to the affinity diagram space.

Interview notes underwent two cycles of affinity diagramming. The affinity diagramming process occurred over a three week time period, consisting of approximately 23 hours of active synthesis. Final results were checked against the literature on young adults and PPA (Little et al. 2007) as well as reviewed by an expert on young adults and motivation to authenticate the diagrams. During the first cycle, interview notes were clustered within the context of two themes:

- PPA (Little et al. 2007) dimension: For example, all notes focusing on *Love* were clustered together, all notes focusing on *Autonomy* were clustered together, etc. and;
- Project qualities: When projects began, definition of success criteria, physical interactions committed while undertaking the project, environmental hindrances and supports and artifacts necessary for project completion

This first cycle of affinity diagramming was formatted in this manner to directly explore the three motivational environment model themes of affect, cognition and conation. Affect and cognition were addressed by reviewing the PPA (Little et al. 2007) dimension affinity clusters, while conation was addressed through the project quality clusters. Multiple commonalities within the PPA (Little et al. 2007) dimensions *Autonomy, Control, Difficulty* and *Progress* emerged.

Sixteen out of the 20 projects chosen for co-design were individual pursuits that were highly autonomous in nature. Examples of notes supporting this pattern of autonomy are, "It's something I do by myself," as stated by participant 11; "It's something for me. It's on me to practice," as stated by participant 15; and "No one else is putting food in my mouth," as stated by participant 03.

Eight participants felt a lack of control with regards to their time, which contributed to their feelings of stress. Examples of notes supporting this cluster are, "Mostly time, I have so little time to complete all of my personal projects (Little 1987; Little et al. 2007). Playing guitar is the last thing I think of," as stated by participant 01; "My job is eight to five, and I used to have a second job at a restaurant in the evenings," as stated by participant 16; and, "When work gets hectic, I lose track of time," as stated by participant 12. When these snippets are reviewed against the complete set of PPA (Little et al. 2007) dimensions, this clustering of time-based notes attributed to *Control* and *Stress* can be cataloged under the dimension *Time Adequacy*.

The second set of clusters produced by *Control* and *Stress* focuses on either lack of appropriate resources to complete a project, or access to resources that conflict with project completion. Notes contributing to these clusters include, “I have to make Radio Shack runs, and I do not have a car,” as stated by participant 08; “I have all of the other materials and tools [I need to make a fox stuffed animal]. Once I get the fabric, I’ll be ready to execute,” as stated by participant 01; and “All my stuff – computer, television – it’s all in my room, which means I can relax anytime,” as stated by participant 16.

As with *Control* and *Stress*, the dimension *Difficulty* primarily focused on a lack of time adequacy. Examples of notes in this cluster included, “The time investment. It’s hard to motivate myself to start,” as stated by participant 16; “The time it takes to cook – going to the store, prepping the food, cooking the food, cleaning up afterwards,” as stated by participant 12; and, “Maintaining consistency and managing my time,” as stated by participant 05.

The notes on the dimension, *Progress*, revealed a common thread on the notion of consistency. Participants often reported an inability to maintain steady engagement on their projects, leading to long pauses in progress, or in some cases, reversals in progress. Examples of notes in this cluster are, “The hardest thing is maintaining [eating healthy] for the next business cycle,” as stated by participant 12 in reference to how he ceases to eat healthy at the end of business quarters when his job responsibilities become more frenetic; “If you asked me a month ago, it [my *progress* dimension score] would have been eight,” as stated by participant 08, who reported a score of four for *Progress* on his project “Redesign ‘music table for art installation”.

When data across PPA (Little et al. 2007) dimension and project quality clusters was reviewed, three principles emerged. These three principles were identified based on keyword association and similarities in meaning and are as follows:

- Time and Timing;
- Guidance and Accountability;
- Project Ambiguity;
- And Positivity Mechanisms

The first principle, *Time and Timing*, was an extension of the commonalities first identified in *Control, Stress* and *Difficulty*, and was comprised of 25 notes spanning the PPA (Little et al. 2007) dimensions *Absorption, Control, Challenge, Difficulty, Progress, Stress* and *Stage*. "Time" refers to the availability of the perceived time necessary to engage and make progress towards completion of a project. "Timing" refers to the sequencing of a project's actions within the greater context of a person's project ecosystem. Examples of notes contributing to this cluster are, "I don't think of anything else [when I'm doing it]. What's challenging is finding continuous time," stated by participant 13; "The entire thing depends on time allocation," stated by participant 01; and "It's a personal epitaph of myself, in terms of procrastination," stated by participant 16.

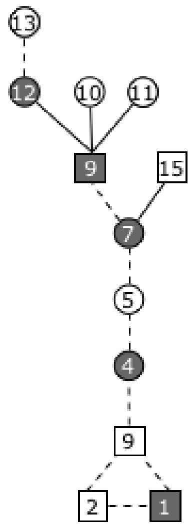
The second principle, *Guidance and Accountability* consists 24 notes spanning the PPA (Little et al. 2007) dimensions *Absorption, Autonomy, Control, Difficulty, Stage, Success, Support* and *Visibility*. "Guidance" refers to the need for prompting to start project engagement, and scaffolding of actions during engagement. " Accountability" refers to the need to feel there are consequences for not accomplishing their actions. These consequences can either exhibit positive qualities, such as receiving a reward for maintaining project engagement, or negative qualities, such as the removal of an amenity or broadcasting lack of progress to cohorts to increase social pressure. Examples of notes contributing to this cluster are, "With the fitness thing, I need someone to do it with me," as stated by participant 11; "I just want someone to guide me through it," as stated by participant 18; and, "It makes me feel like when I get help, my time matters more," as stated by participant 13.

The cluster regarding *Project Ambiguity* consists of notes spanning the PPA (Little et al. 2007) dimensions *Difficulty, Progress, Stress, Success* and *Support*. "Ambiguity" refers to a lack of definition with regards to resources necessary to complete a project, interactions that participants need to complete to progress in the project and/or a lack of clarity with regards to success criteria. This principle is comprised of the PPA (Little et al. 2007) dimensions *Control, Difficulty, Progress, Success* and Uncertainty. Examples of notes informing this principle are, "Can I do it, and if so, what does success look like," stated participant 14 in to eating healthier, "I want to perform publicly, but I'm not sure how that is going to happen," stated participant 15 in reference to learning the keyboard and "I fell like I'm out of control because when I sit down to fulfill my vision, I don't know what the steps to complete it are," stated participant 20 in reference to finishing her autobiography. The exploration of these issues through each participants semi-structured interviews primed design of the smart home service provisions supporting personal projects (Little 1987; Little et al. 2007) and the configuration of smart home interactions within the home environments of end users. These applications and their related interactions were instantiated within the collages.

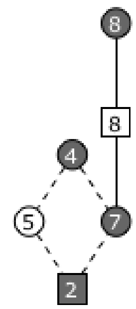
The fourth principle, *Positivity* Mechanisms, define the types of positive feedback that young adults yearn for in order to stay motivated to complete the project. Three reward mechanisms emerged to further define this fourth principle. These mechanisms are as follows:

1. Gratification - The feeling of satisfaction achieved by progressing towards and/or completing a noteworthy accomplishment. This cluster consisted of nine notes spanning the PPA (Little et al. 2007) dimensions *Happy* and *Love*.
2. Connection - Feeling closer to people important in their lives. This cluster consisted of seven notes spanning the PPA (Little et al. 2007) dimensions *Happy* and *Love*.
3. Immersion – Experiencing *in* situ project-related actions more fully, resulting in feeling lost in the task so much so that their perception of the world around them and time fades into the background. This cluster consisted of 12 notes spanning the PPA (Little et al. 2007) dimensions *Absorption, Happy* and *Love*.

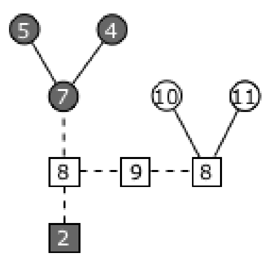
The home configurations portrayed across collages produced a dynamic set of space syntax (Hansen & Hillier 1982) configurations. No two collages produced the same space configuration or GaLLaG (Burleson et al. 2009) PICTIVE (Muller 1991, 1992; 1993) interaction token configuration. Figures 14 through 18 illustrate the space syntaxes (Hansen & Hillier 1982) captured across the collages. Figure 19 provides a summary of areas of the home present across all collages, while figure 20 summarizes GaLLaG (Burleson et al. 2009) interactions present across all collages. One hundred and fifty two GaLLaG (Burleson et al. 2009) interactions were tabulated by interaction type and distributed across each area of the home. Figures 21 through 33 detail GaLLaG (Burleson et al. 2009) interactions by each area of the home across all collages. Despite the presence of GaLLaG (Burleson et al. 2009) interactions in the home areas *garage entry, basement* and *laundry room*, figures for these rooms are not presented as each of these home areas only demonstrate a single type of GaLLaG (Burleson et al. 2009) interaction. *Garage entry* demonstrated two observations of recognizing an occupant has returned home. *Basement* demonstrated one observation of triggering a users mobile phone. Laundry room demonstrated one observation of streaming remote audio.



Participant 01: Collage Space Syntax



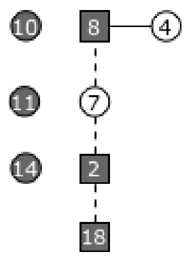
Participant 02: Collage Space Syntax



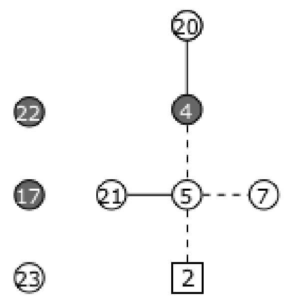
Participant 03: Collage Space Syntax

Participant 04: Collage Space Syntax

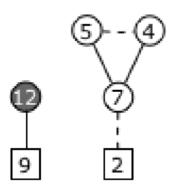
Figure 14. Participants' one through four smart home space syntax.



Participant 05: Collage Space Syntax



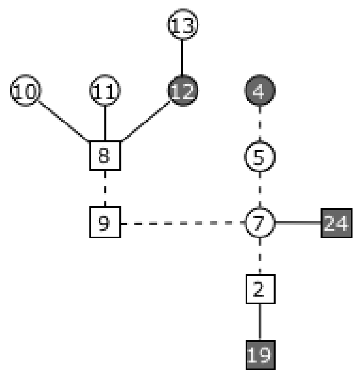
Participant 06: Collage Space Syntax



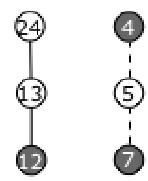
Participant 07: Collage Space Syntax

Participant 08: Collage Space Syntax

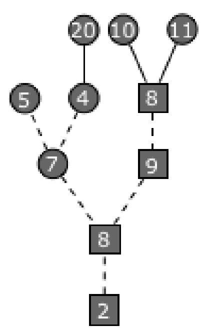
Figure 15. Participants' five through eight smart home space syntax.



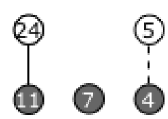
Participant 09: Collage Space Syntax



Participant 10: Collage Space Syntax



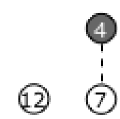
Participant 11: Collage Space Syntax



Participant 12: Collage Space Syntax

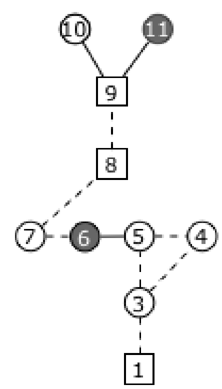
Figure 16. Participants’ nine through 12 smart home space syntax.

Participant 13: Collage Space Syntax



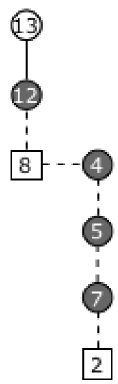
Participant 14: Collage Space Syntax

Participant 15: Collage Space Syntax

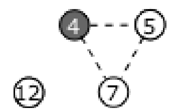


Participant 16: Collage Space Syntax

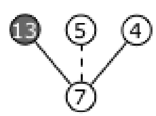
Figure 17. Participants' 13 through 16 smart home space syntax.



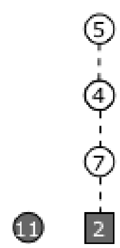
Participant 17: Collage Space Syntax



Participant 18: Collage Space Syntax



Participant 19: Collage Space Syntax



Participant 20: Collage Space Syntax

Figure 18. Participants' 17 through 20 smart home space syntax.

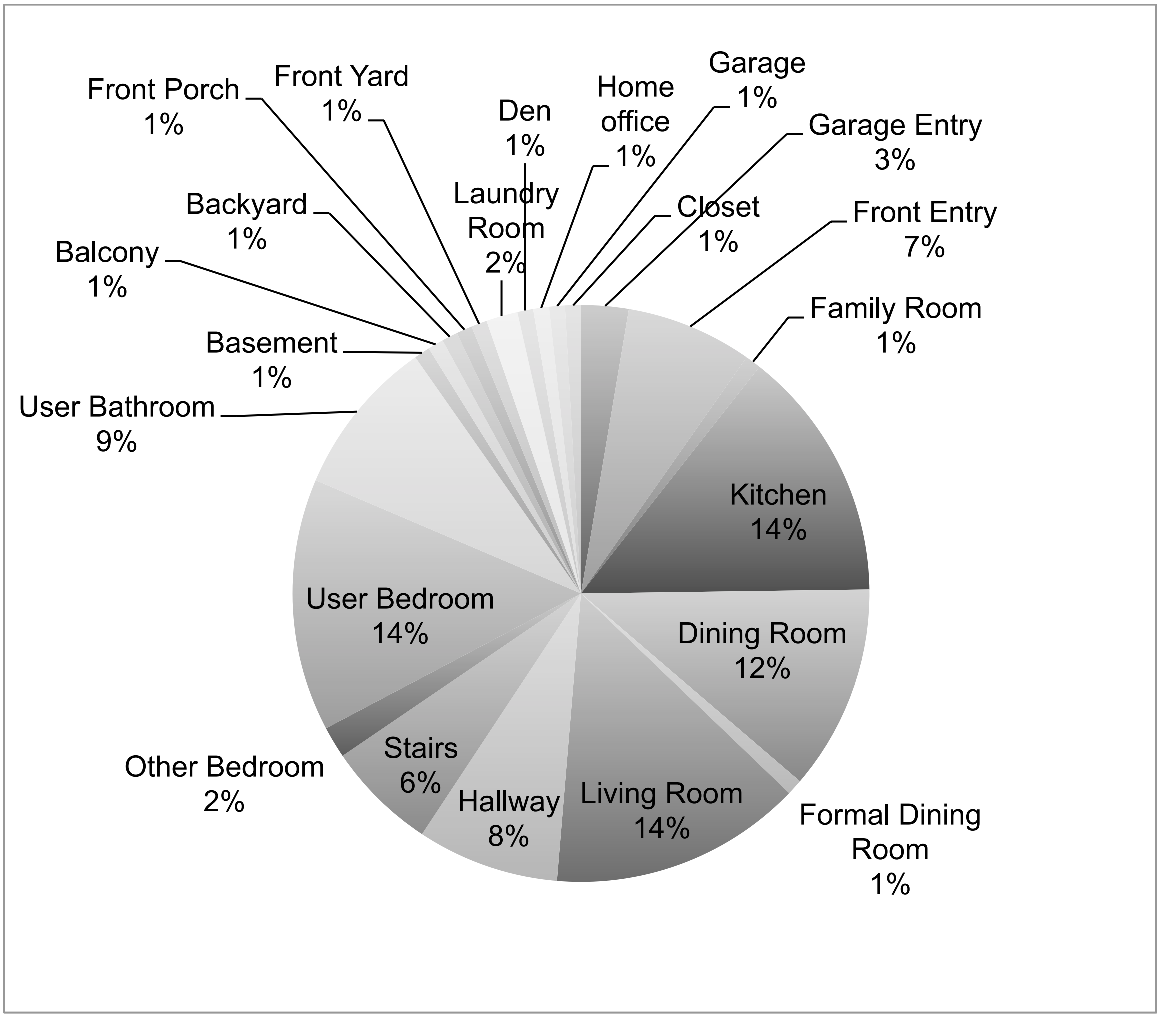


Figure 19. Geographical areas of the home present on participant collages.

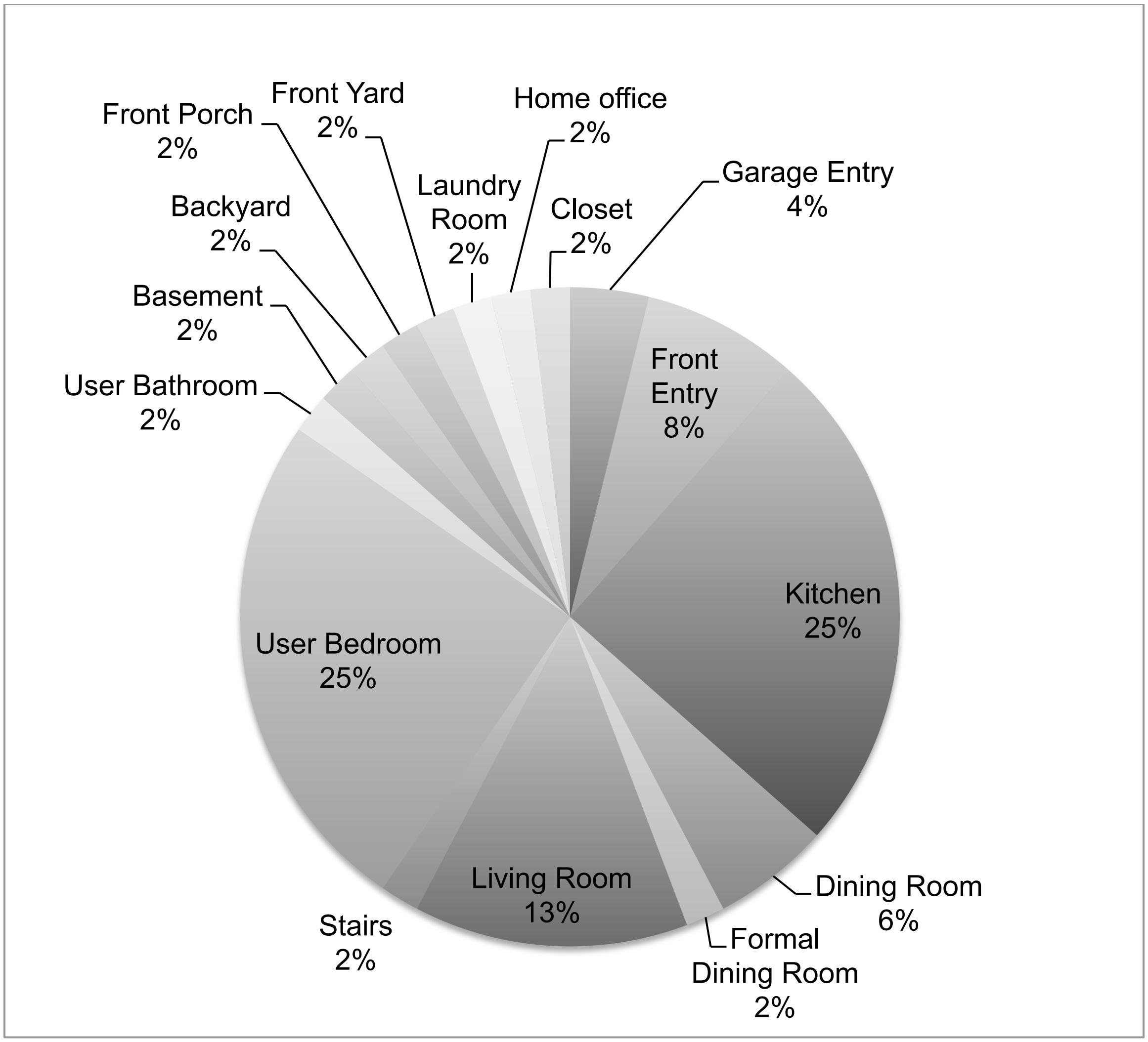


Figure 20. Geographical areas of the home on participant collages with game-as-life, life-as-game (Burleson et al. 2009) interactions.

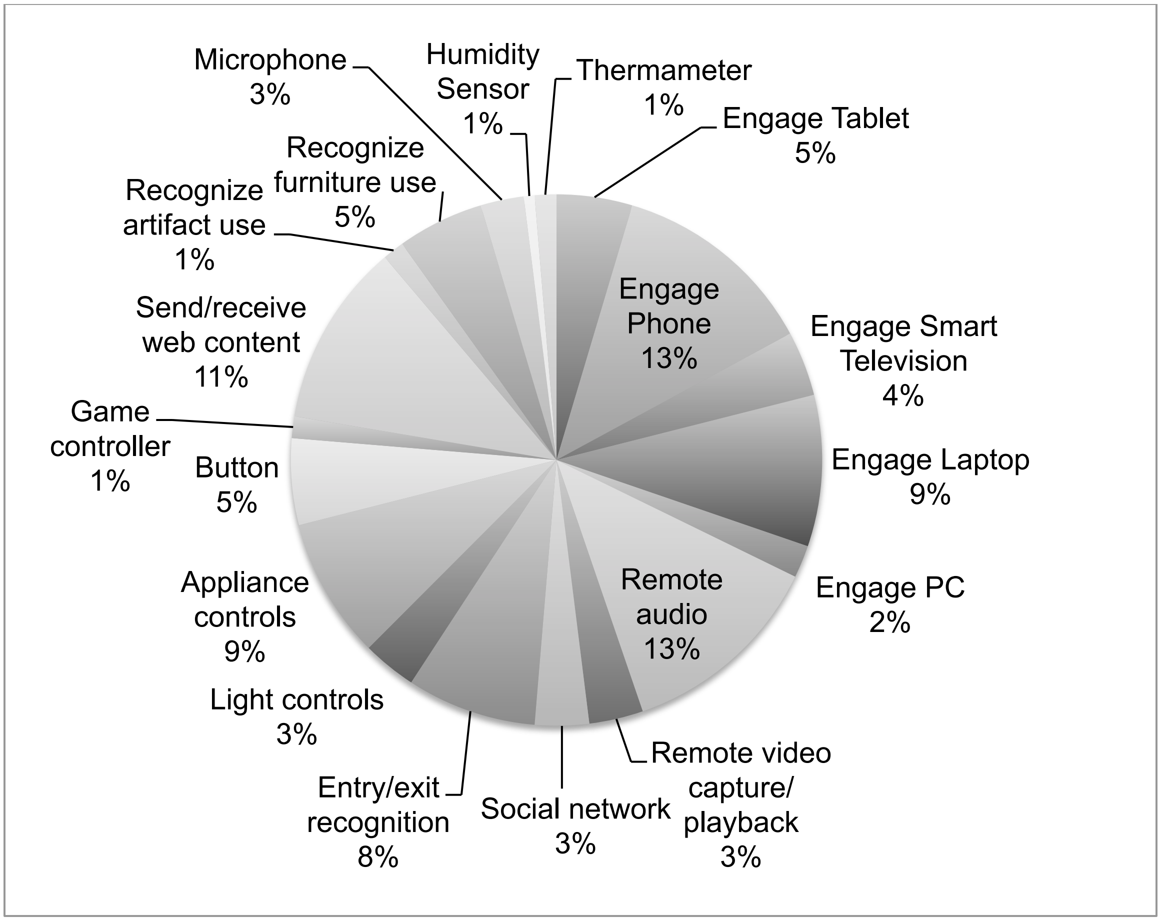


Figure 21. All categories of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens percentages across participant collages.

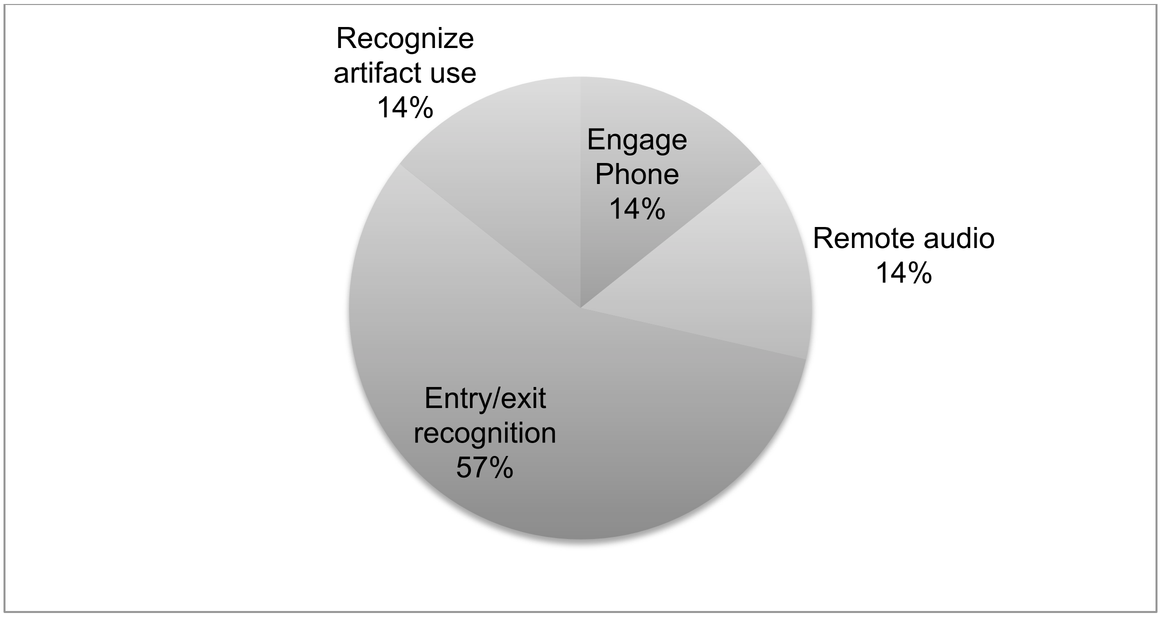


Figure 22. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present on participant collages within the front entry.

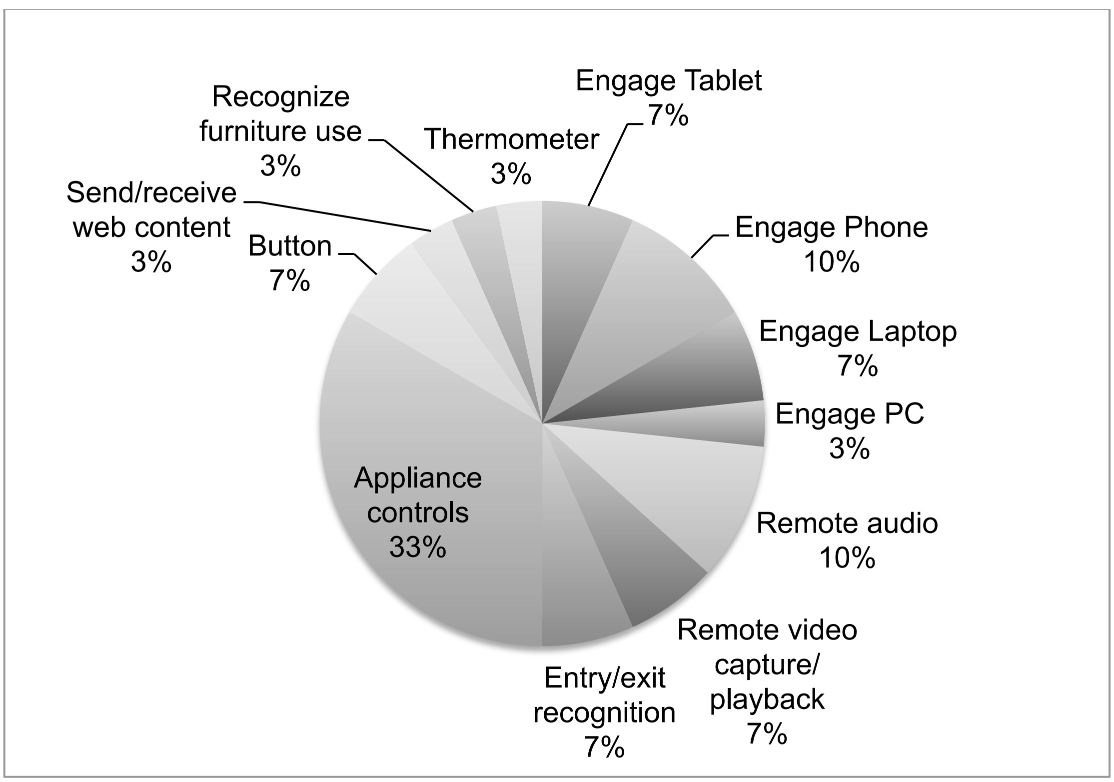


Figure 23. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present across participant collages within the kitchen.

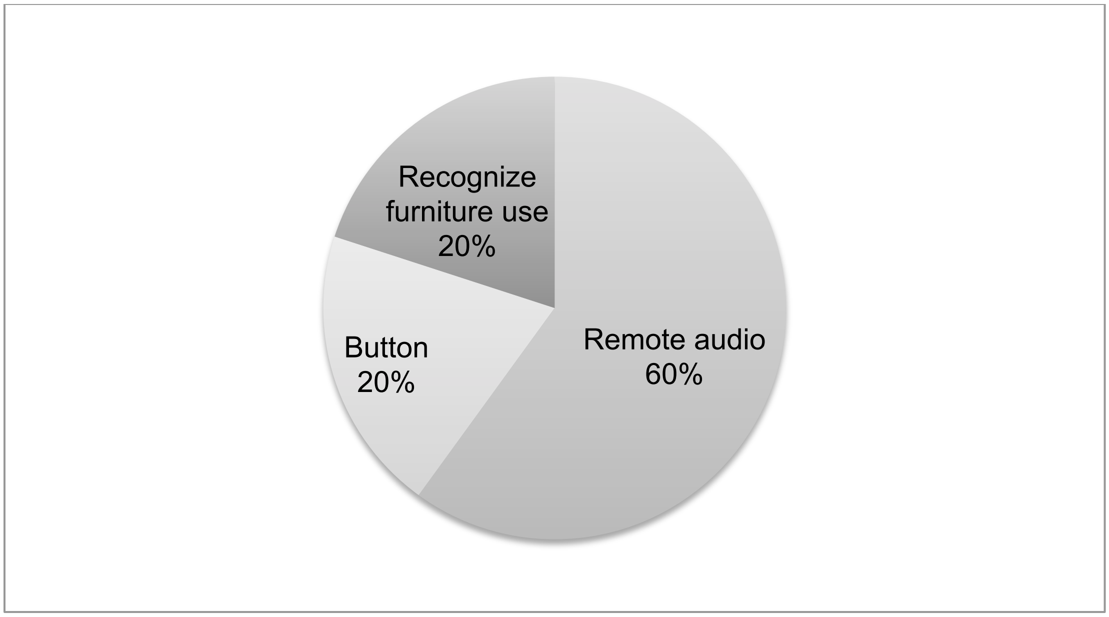


Figure 24. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present across participant collages within the dining room.

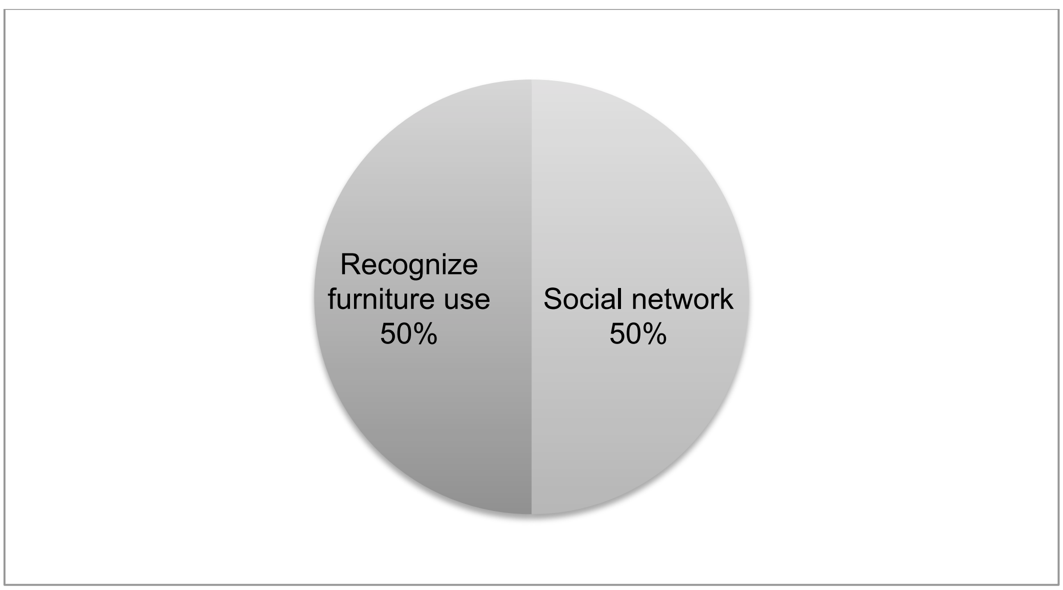


Figure 25. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present across participant collages within the formal dining room.

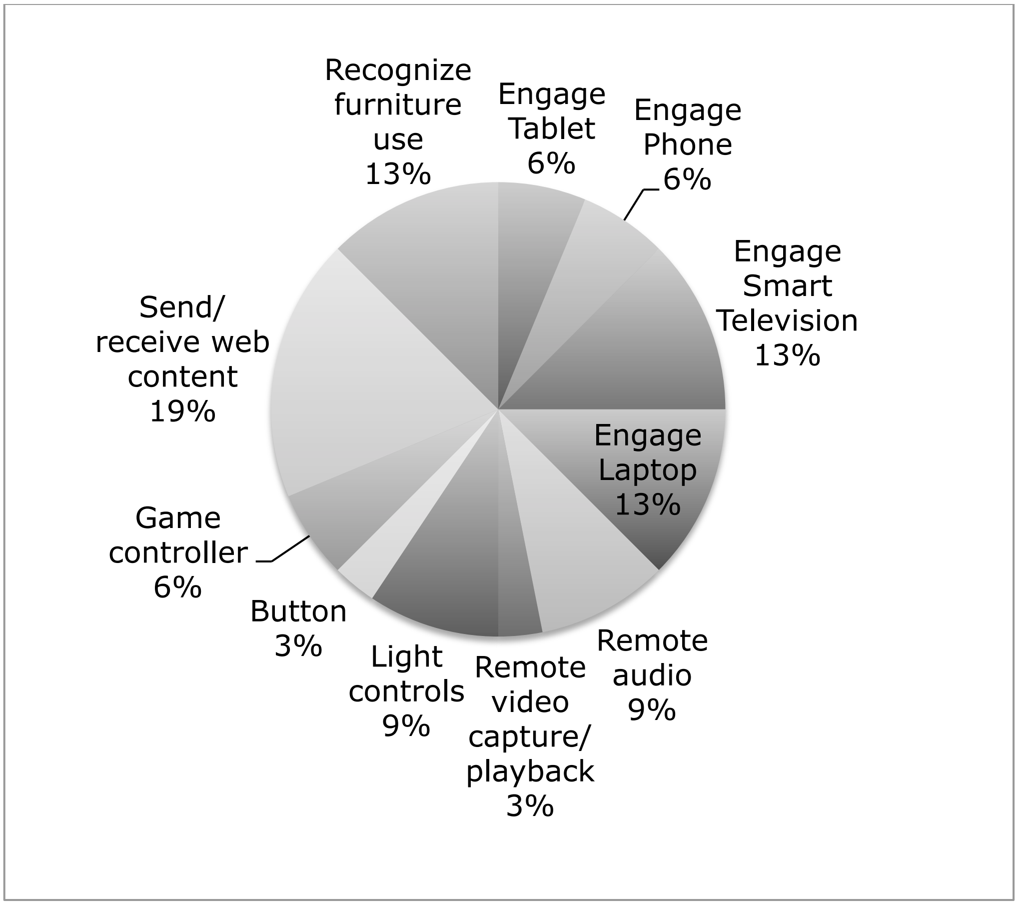


Figure 26. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present across participant collages within the living room.

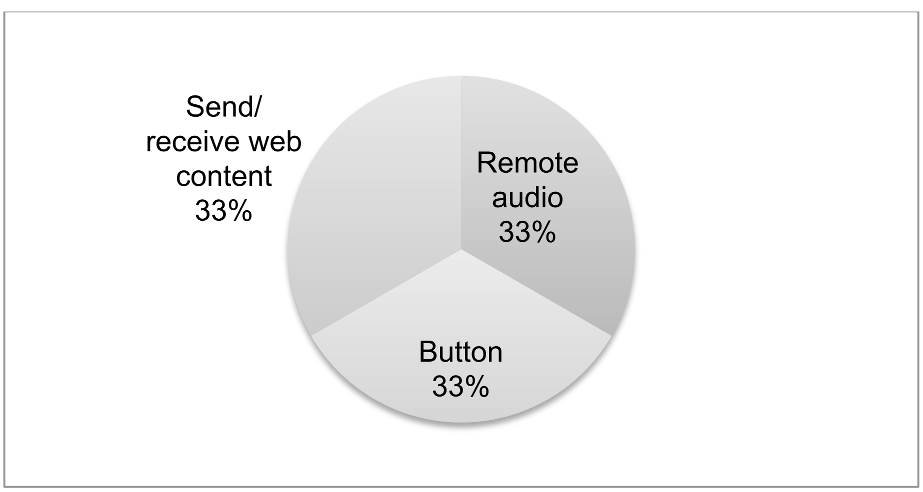


Figure 27. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present across participant collages within the stairway.

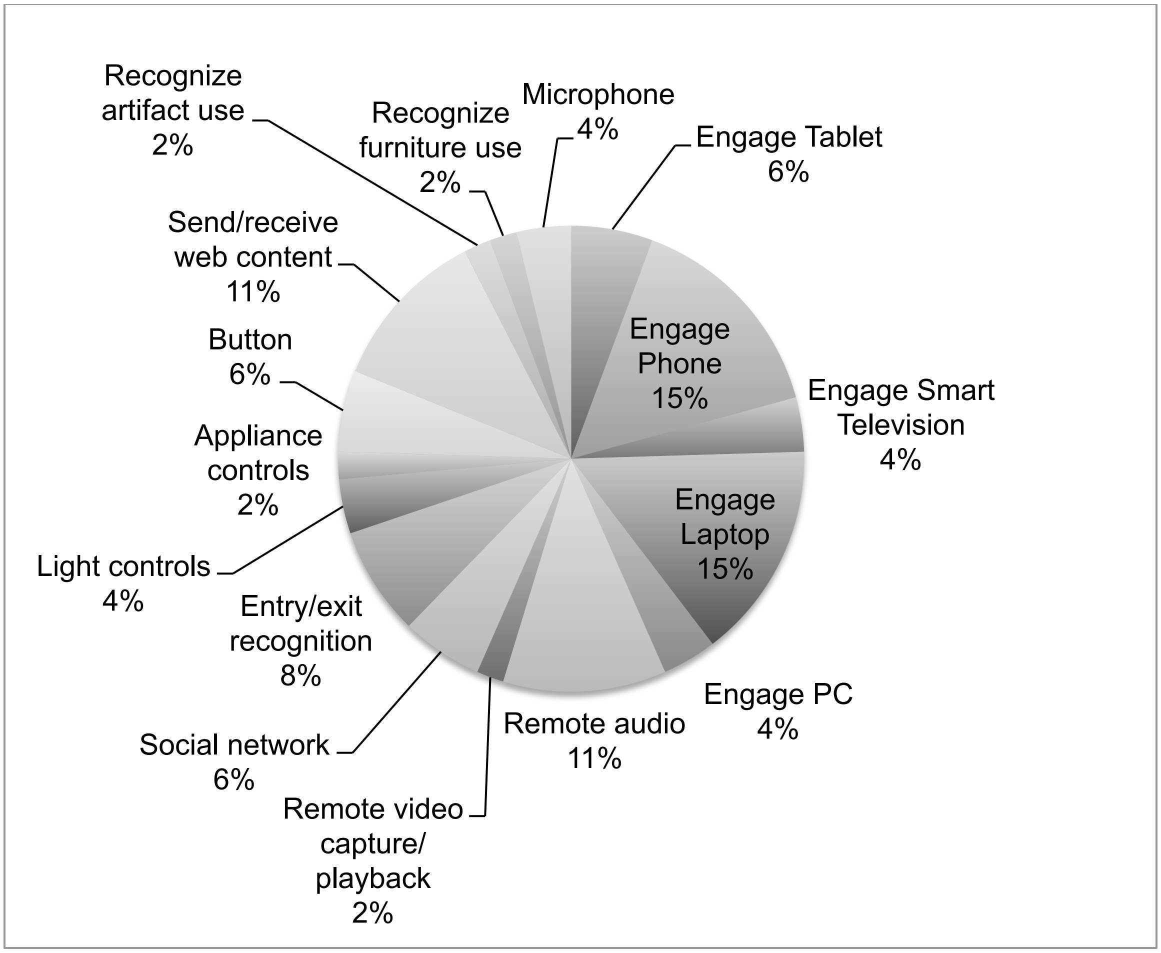


Figure 28. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present across participant collages within the user's bedroom.

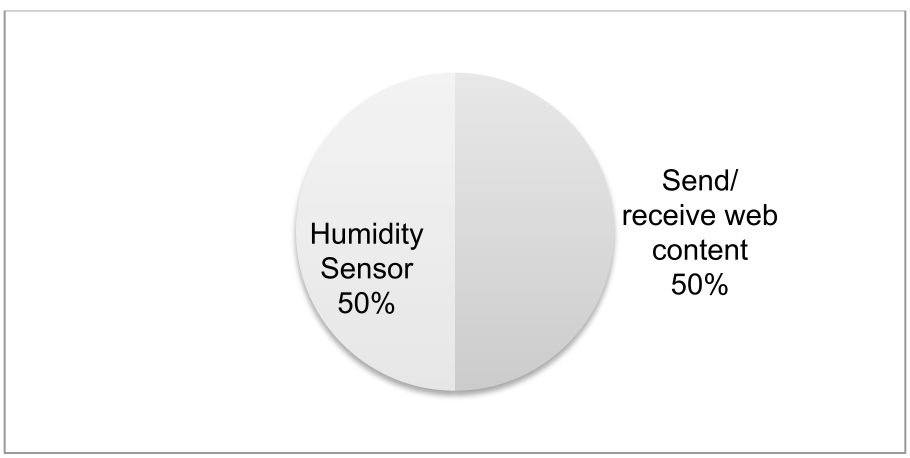


Figure 29. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present across participant collages within the backyard.

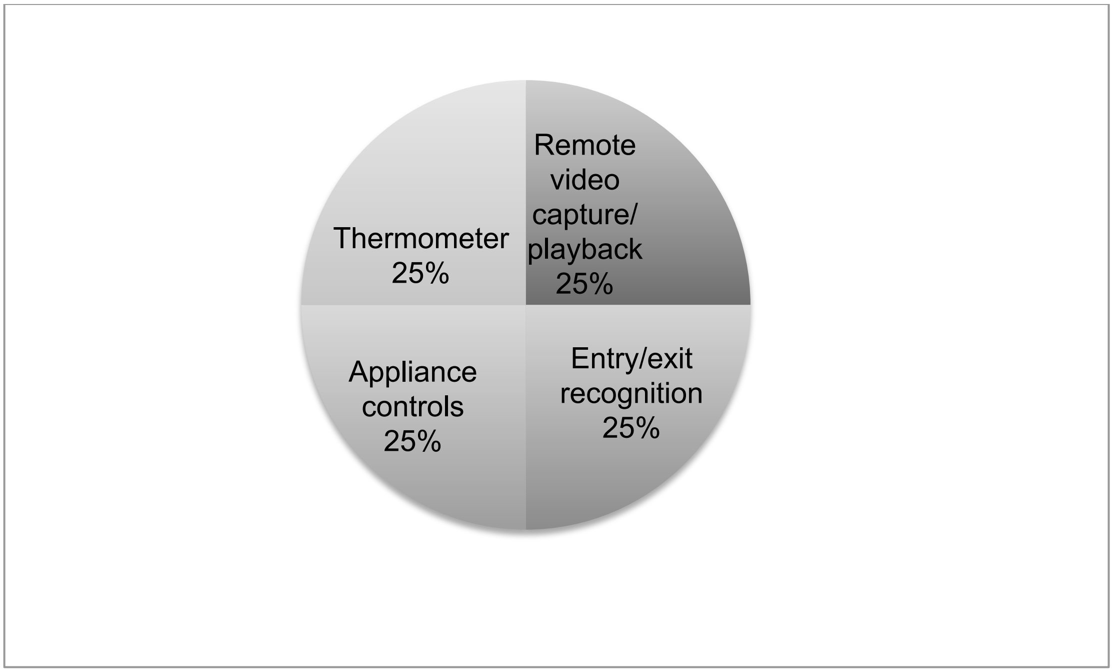


Figure 30. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present across participant collages within the closet.

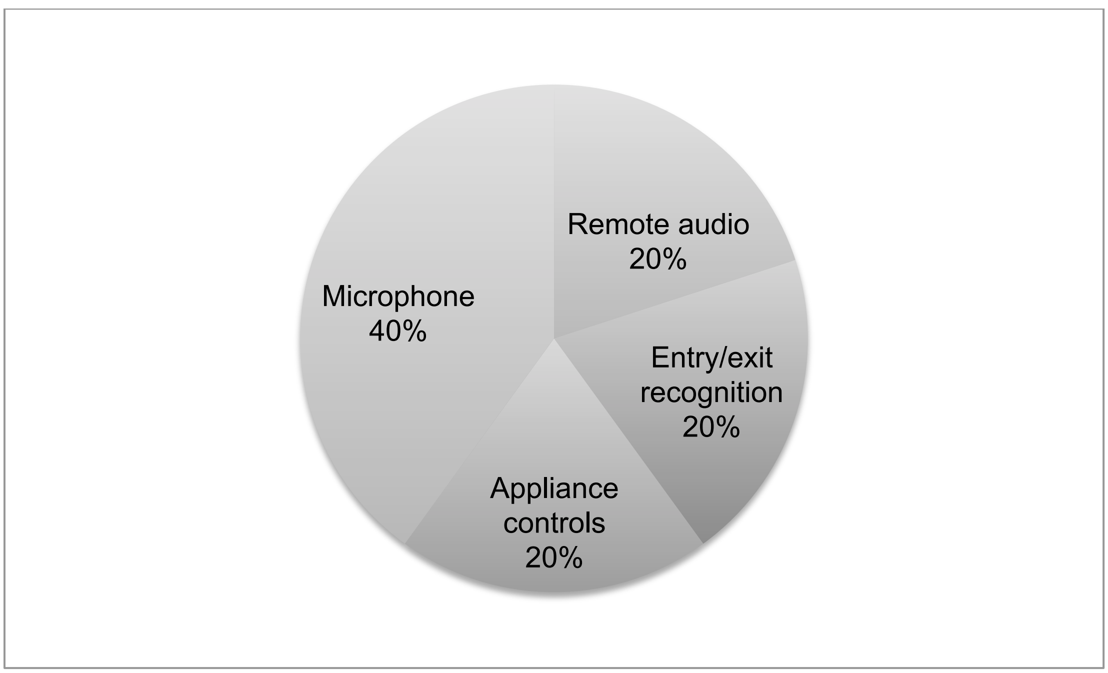


Figure 31. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present across participant collages within the bathroom.

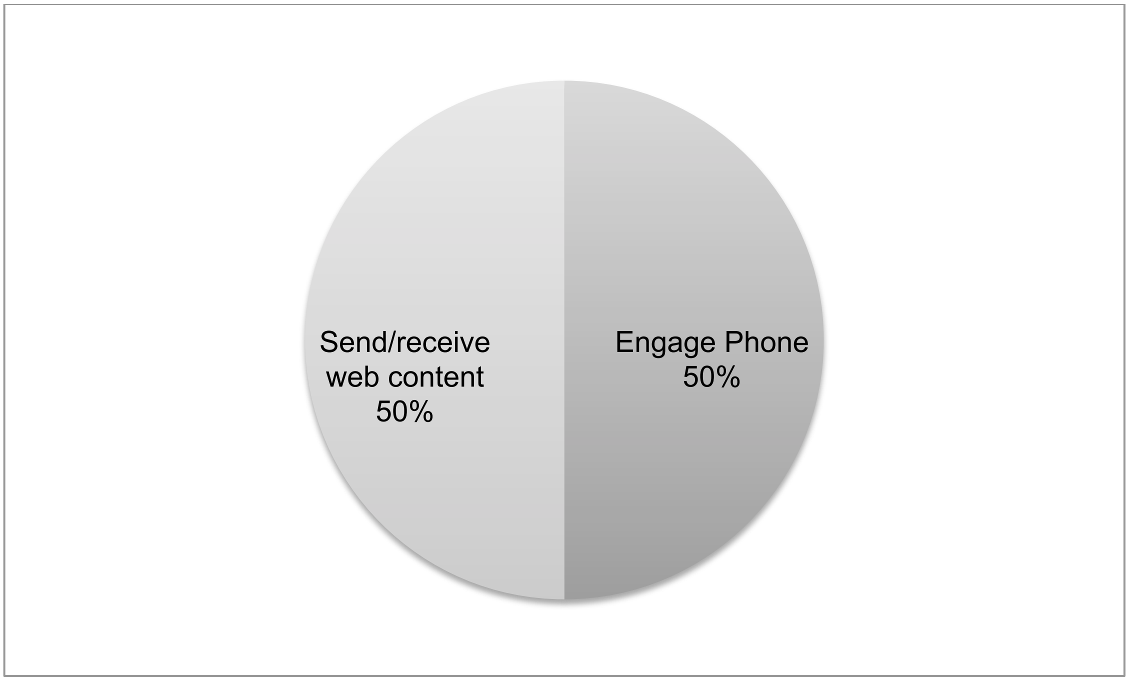


Figure 32. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present across participant collages within the home office.

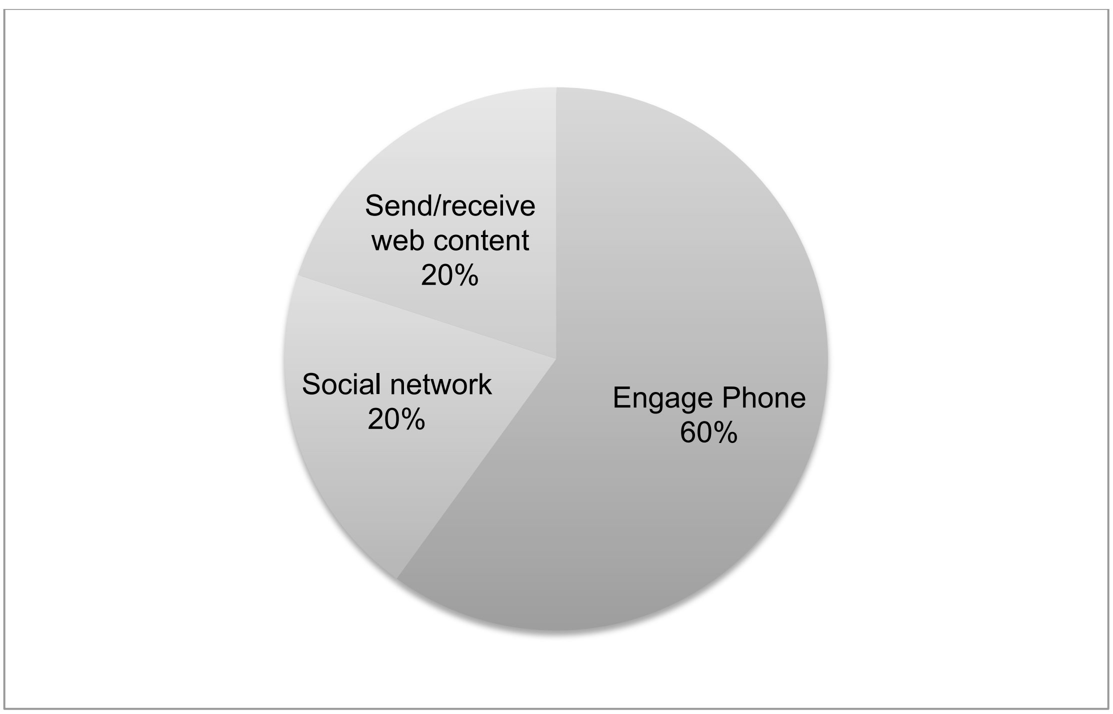


Figure 33. Types of game-as-life, life-as-game (Burleson et al. 2009) interaction tokens present across participant collages on the user's body.

This section presented PCSoP survey data, SEQ (Stiles et al. 1994) data, semi-structured interview data and collage data containing space syntax (Hansen & Hillier 1982) information on the home, and GaLLaG (Burleson et al. 2009) interaction information describing smart home service provisions. The data demonstrates strong heterogeneity of data across three subject areas:

- Personal projects (Little 1987; Little et al. 2007) and the supporting motivations participants chose to design smart home service provisions for;
- Home space syntax (Hansen & Hillier 1982) configurations participants generated as the foundation for collage-based PICTIVE (Muller 1991, 1992; 1993) mapping of GaLLaG (Burleson et al. 2009) interactions and;
- Configurations of GaLLaG (Burleson et al. 2009) interactions in the home.

The following section discusses the findings synthesized from this data and the implications of these findings for designing smart home service provisions that support HF (Fredrickson 2002; Little et al. 2007; Seligman 2004).

Discussion

This section describes the findings abstracted from the results. The section begins with a discussion of the results related to H^1 through H^4 and continues with a presentation of a design framework describing the experiences young adults have with their personal projects (Little 1987; Little et al. 2007) and the motivational needs embedded in their personal projects (Little 1987; Little et al. 2007). The section closes with a discussion of an interaction model for smart home service provisions that support the completion of personal projects (Little 1987; Little et al. 2007) by young adults.

H^1 proposes that given a choice of personal projects (Little 1987; Little et al. 2007) from their project ecosystems to design for, participants would choose projects with higher perceived dependency on the home as demonstrated by *Home*

Dependency factor scores. The mean *Home Dependency* value for projects chosen for co-design was less than the overall mean value of *Home Dependency* (5.10 and 5.41, respectively). H^1, therefore, is rejected, meaning that a project's perceived dependency on the home environment is not a factor in participant decision making when choosing a project to design a smart home service provision for.

H^2 proposes that given a choice of personal projects (Little 1987; Little et al. 2007) from their project ecosystems to design for, participants would choose projects demonstrating low *Control* and high *Stress*. Mean values for *Control* and *Stress* for the co-design population project ecosystem are 6.39 and 3.73, respectively. The mean values for *Control* and *Stress* of the 20 projects chosen for co-design are 6.45 and 2.65, respectively. H^2, therefore, is rejected, meaning that perceived control over a project's operations and success, as well as perceived stress felt when engaged in a project, are not factors for participants when choosing projects to design smart home service provisions for.

H^3 proposes that participants will primarily design applications that increase *Happiness, Love, Hope, Value Congruency, Self Identity, Autonomy* and *Likelihood of Success* and decrease *Fear* and *Difficulty*. This hypothesis is tested by tabulating up the total number of PPA (Little et al. 2007) tokens placed on collages during psycho-cartography (Wójcik et al. 2010) (Foland & Lewicka 2007) and then comparing the ratio of the above dimensions against the other reported dimensions. The subset mentioned above account for 27.96% of the total possible PPA (Little et al. 2007) token choices available to participants, yet accounted for 37.40% of PPA (Little et al. 2007) tokens present on the collages. H^3, therefore, is upheld, meaning that the PPA (Little et al. 2007) dimensions identified as predictor variables for the PCSoP models (see chapter eight) are a priority for participants when designing smart home service provisions.

H^4 proposes that SEQ (Stiles et al. 1994) scores assessing the co-design process will demonstrate high *Depth, Smoothness* and *Positivity* and low *Arousal* scores. This hypothesis is tested by comparing the mean values of these scores against the mean of the measurement scale. *Depth, Smoothness, Positivity* and *Arousal* scores (5.58, 6.06, 6.50 and 3.85 respectively) all exceeded the measurement scale mean value (3.5). H^4, therefore, was partially upheld and partially rejected, as participants found the co-design process meaningful, free of disruption and enjoyable, yet also found the sessions moderately exciting.

The design framework describing the relationships participants have with the projects they chose to co-design further articulates the constructs discussed in the analysis subsection of this chapter. A design framework provides two types of value. First, a design framework is a visual description of a theoretical model that is derived from research data. Second, it functions as a tool for design practice, providing definition of the design space for conceptualizing and evaluating ideas for new experiences, products and/or services. This design framework consists of four key elements:

- Design Principles: Overarching theoretical constructs that when viewed as a whole, describe an experience. From a complex systems perspective, design principles define the system ecology at a theoretical level. In this case, the experience being described is that of young adults and completion of personal projects (Little 1987; Little et al. 2007).
- Design qualities: Physical constructs, that when grouped together, operationally define a design principle. From a complex systems perspective, design qualities identify the social ecological factors that dynamically change in response to a targeted end user, the personal project (Little 1987; Little et

al. 2007) in question and how the relationship between the person and the project adapt over time.

- Positioning diagrams: Relationships between two or more qualities that further operationalize design principles, as well as provide professional and lay designers with specific, functional guidelines to design for. From a complex systems perspective, design tensions are functional relationships that drive adaptation of design qualities. Multiple tensions may exist between two or more qualities.
- Interaction models: Process models that articulate a sequence of generalized interactions between participants and the smart home service provisions they design for personal project (Little 1987; Little et al. 2007) support. From a dynamic systems perspective, activity models describe human-system behavior instantiated in response to a person's desire to support or disrupt the current state of their behavior patterns. In the case of this framework, such support or disruption is achieved through implementation of a smart home service provision.

Figure 34 illustrates the structure of this design framework.

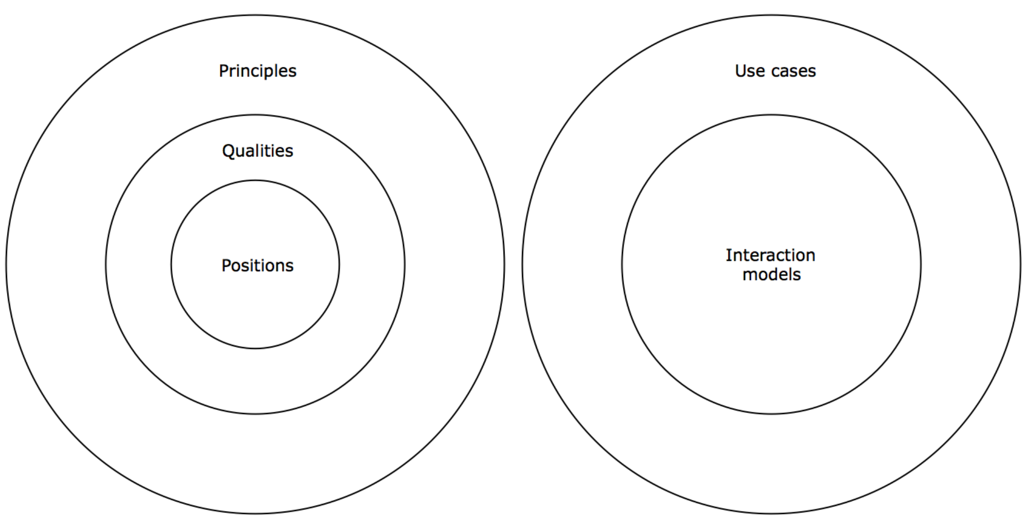


Figure 34. Motivational home design framework structure

This design framework comprises four design principles that describe young people and their experiences with the personal projects (Little 1987; Little et al. 2007) they chose to design smart home service provisions for. Figure 35 states these principles.

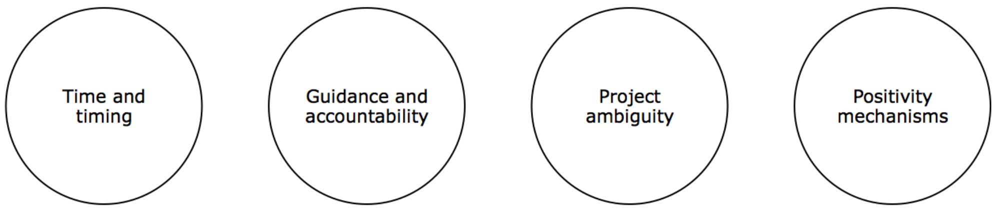


Figure 35. Motivational home design principles

The *Time and Timing* principle contains design qualities and tensions related to the perception of time adequacy, as well as the sequencing of interactions over time necessary to succeed at a project. The design qualities that comprise the *Time and Timing* design principle are:

- Time Perception: A person's perception of how much time it will take to complete a personal project (Little 1987; Little et al. 2007).
- Capability: A person's perception of how capable she is at completing a personal project (Little 1987; Little et al. 2007).
- Focus: The amount of attention a person commits to a personal project (Little 1987; Little et al. 2007) .
- Project Plan: The perceived order of operations for completing a personal project (Little 1987; Little et al. 2007).

The PPA (Little et al. 2007) dimensions *Absorption, Challenge, Control, Depressed, Difficulty* and *Success* support these design qualities*.* These relationships resulted during affinity diagramming by coding the notes comprising affinity diagram clusters against personal project analysis (Little et al. 2007) dimensions related to each note.

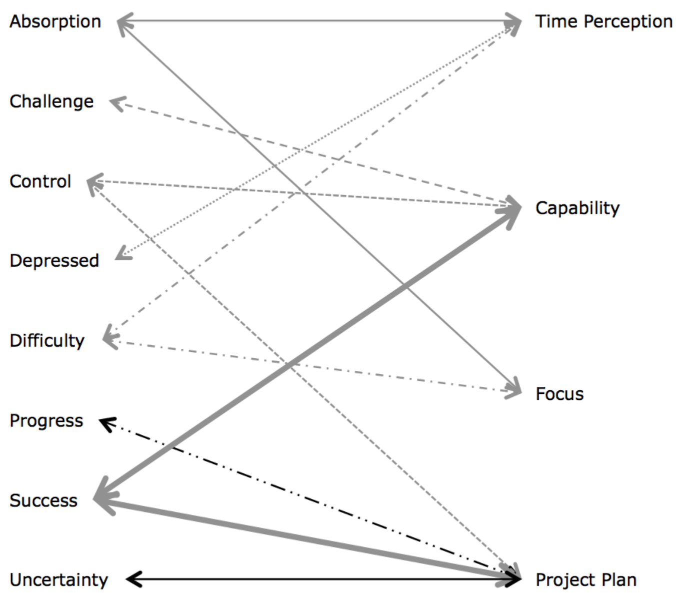


Figure 36 illustrates the relationships between PPA (Little et al. 2007) dimensions and "Time and Timing" qualities.

When combined, the *Time and Timing* qualities produce a number of positioning diagrams. These positioning diagrams both describe behavior related to how young adults respond to perceived time adequacy and timing within the context of personal projects (Little 1987; Little et al. 2007) and function as a set of design memes for professionals and lay researchers to conceptualize and evaluate concepts.

The quadrant diagram shows *Capability* as the x-axis, and *Time Perception* as the y-axis. Each axis is treated as a semantic differential (Himmelfarb 1993). A semantic differential is a scale representing an oppositional pair (Himmelfarb 1993). For example, the left end of the *Capability* semantic differential is labeled "Novice", while the right end of the *Capability* semantic differential is labeled "Expert", indicating a level of perceived skill a person reports related to the capabilities needed to complete a personal project (Little 1987; Little et al. 2007). The *Time Perception* semantic differential illustrates whether or not a person perceives it will take a long time or a short time to complete a personal project (Little 1987; Little et al. 2007). People who perceive that they have expert capabilities and that a project will take a long time to complete consistently make progress on those projects. People who perceive that they have expert capabilities and that a project will take short time to complete often procrastinate. One participant stated that he intentionally procrastinates because when he does engage in the project, he feels a sense of urgency that makes the project feel more challenging. People who perceive that they have novice capabilities and that the project will take a long time either find the project to daunting to start, or start the project only to disengage, essentially pausing the project. People who perceive that they have novice capabilities and that the project will take a short time to complete engage in the project, learn through doing, and either succeed or fail at the project.

The relationships described in this quadrant diagram allow designers to account for skill sets of participants in relation to the perceived duration of a project. For a novice tackling a long-term project, smart home service provisions should segment the project into short-term goals, creating a space for learning and skills acquisition and an environment where the consequences of failure are minimized. For experts engaged in a project that they perceive as taking little time to complete, smart home service provisions should seek to create a sense of urgency to promote engagement. For experts engaged in a long-term endeavor, smart home service provisions should provide regularly scheduled opportunities to make consistent gains towards project completion.

The second tension of *Time and Timing* qualities is between *Time Perception* and *Focus.* Figure 37 illustrates this tension.

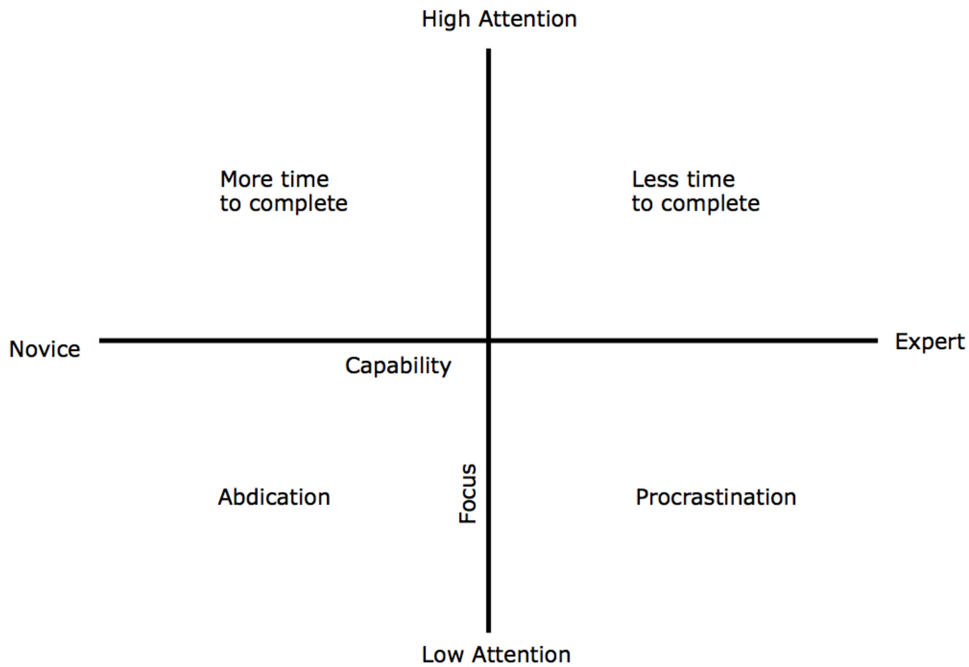


Figure 37. Capability – focus positioning diagram.

The x-axis of figure 37 contains the *Capability* semantic differential, with "Novice" on the right end and "Expert" on the left end. A person who perceives she is a novice within the context of their personal project believes that they lack the skills necessary to complete the project and therefore must either learn those skills or outsource activities associated with the project, thereby minimizing their ownership. A person who perceives she is an expert believes that they possess all of the knowledge and skills necessary to complete the personal project with ease. The y-axis describes the *Focus* semantic differential, with "Low Attention" on the bottom end and "High attention" on the top end. A person who reports low attention admits she spends little time reflecting on the project and/or actively pursuing completion of the project. A person who reports high attention believes that the project is pervasive in their daily thoughts and actions. These two differentials produce four ownership states:

1. Abdication: The combination of a person believing she is a novice, combined with little attention paid to a project leads to abdication.
2. More time to complete: The combination of a person believing she is a novice, combined with paying little attention to project leads to a perception that the project will take more time than other projects to complete because of the need to acquire new knowledge and skills in order to succeed.
3. Procrastination: The combination of a person believing she is an expert combined with low attention leads to procrastination because the when the person recognizes the project, she believes she can complete the project with minimum effort at any time.
4. Less time to complete: The combination of a person believing she is an expert, combined with paying attention to project leads to a perception that the project will take less time than other projects to complete because she possesses all of the necessary knowledge and skills necessary to succeed.

While the quadrant diagram presents these relationships between *Capability* and *Focus* models as absolutes, in reality the relationships are incremental in nature. For example, Participant 20 reported herself as an expert writer, yet also admitted that she performed poorly when she had to structure what she wrote into longer works, which adversely affected her ability to complete her autobiography. Additionally, the relationship between *Capability* and *Focus* changes in response to changes in perceived level of contribution on a project as the person gains knew knowledge and skills. These incremental and dynamic attributes apply to all of the positioning diagrams.

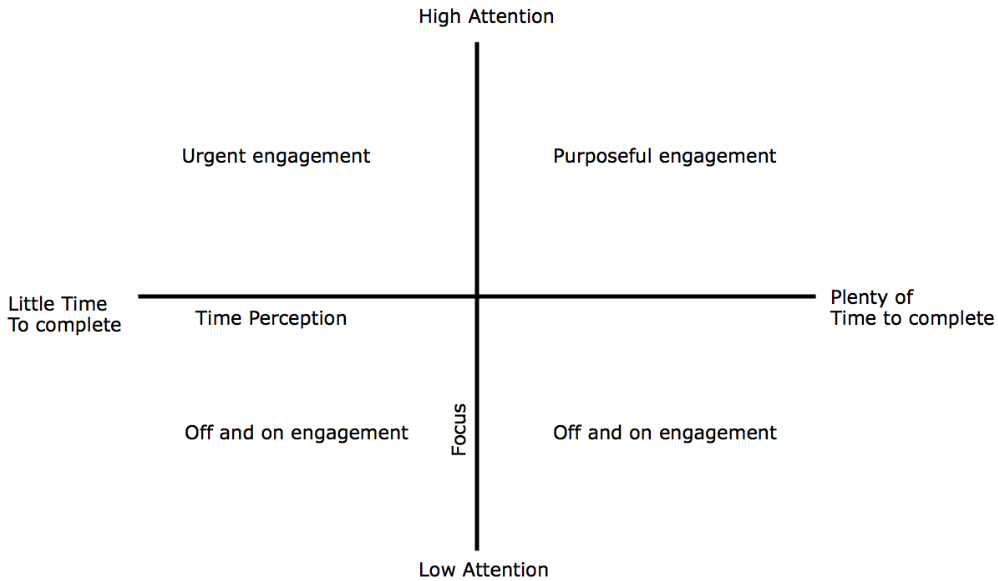


Figure 38. Time perception - focus positioning diagram.

The quadrant diagram consisting of *Time Perception* and *Focus* describes the relationships between the perceived amount of time needed to complete a project and the extent to which a person perceives a clear plan of action to achieve the project. The x-axis illustrates the semantic differential for *Time* Perception, with "Little time to complete" on the left end and "Plenty of time to complete" on the right end. The y-axis illustrates the semantic differential for *Focus,* with "Low attention" on the bottom end and "High attention" on the top end. These two differentials produce four engagement states:

1. Off and on engagement: Projects that are perceived as having little time to complete and are low attention result in sporadic engagement, which occurs when a person remembers the project.
2. Urgent engagement: Projects that a person perceives as having little time to complete and require a high amount of attention result urgent action in which the person feels time pressure to complete.

3. Off and on engagement: Projects that are perceived as having a lot of time to complete yet require little attention result in sporadic engagement, which occurs when a person remembers the project.
4. Purposeful engagement: Projects that a person believes have plenty of time to complete and requires a high level of attention results in structured action, which is defined as a planned sequence of steps to obtain a goal.

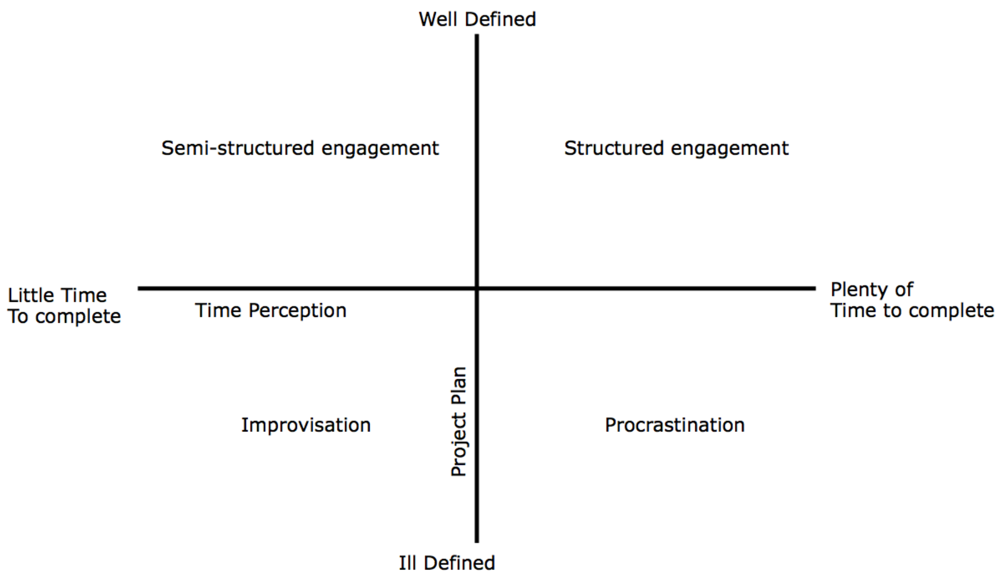


Figure 39. Time perception – project plan positioning diagram.

The final *Time and Timing* quadrant describes the relationship between *Time Perception* and *Project Plan.* Figure 39 presents the quadrant diagram. Explanation of figure 38 defines the semantic differential for *Time Perception*. The Project Plan semantic differential consists of the poles “Ill defined” and “well defined”. If a project plan is perceived as “ill defined”, then the participant does not believe she understands the sequence of operations she needs to commit to succeed at the project; the types and amounts of resources needed to support the necessary project operations; and/or the time frame she has to complete the project operations. Conversely, “well defined” means that the participant has conceived a plan that takes actions, resources and timing into account.

These two differentials produce four ownership states:

1. Improvisation: Projects that are perceived as having little time to complete and lack a plan to move forward lead to improvised action in which a person engages with the project without little to any preparation.
2. Semi-structured engagement: Projects that a person perceives as having little time to complete, yet feel they have a plan leading to completion, lead to semi-structured action in which a person engages with the project through use of her plan, with the expectation that due to a lack of time, portions of the plan may be inappropriate, leading to spurts of improvisation.
3. Procrastination: Projects that are perceived as having a lot of time to complete and lack a plan for project completion result in procrastination.
4. Structured engagement: Projects that a person believes have plenty of time to complete and that they have devised a plan to complete, result in structured action, which is defined as a planned sequence of steps to obtain a goal.

Guidance and Accountability describes qualities related to feelings of social support, consequences and rewards related to the project. The design qualities comprising this principle are:

- Contribution: The degree to which participants perceive they can contribute to the completion of a project.

- Scaffolding (Kaptelinin & Nardi 2009): The need for guidance prior to and during actions aimed at making a contribution towards the completion of a project.
- Progression: The pace at which participants advance towards completion of a project.
- Incentive: Negative or positive feedback motivating project engagement.

The PPA (Little et al. 2007) dimensions *Autonomy, Control, Other's View, Progress, Success, Support, Visibility* and *Uncertainty* support these design qualities. Figure 40 illustrates the relationships between PPA (Little et al. 2007) dimensions and *Guidance and Accountability* qualities. These relationships resulted during affinity diagramming by coding the notes comprising affinity diagram clusters against personal project analysis (Little et al. 2007) dimensions related to each note.

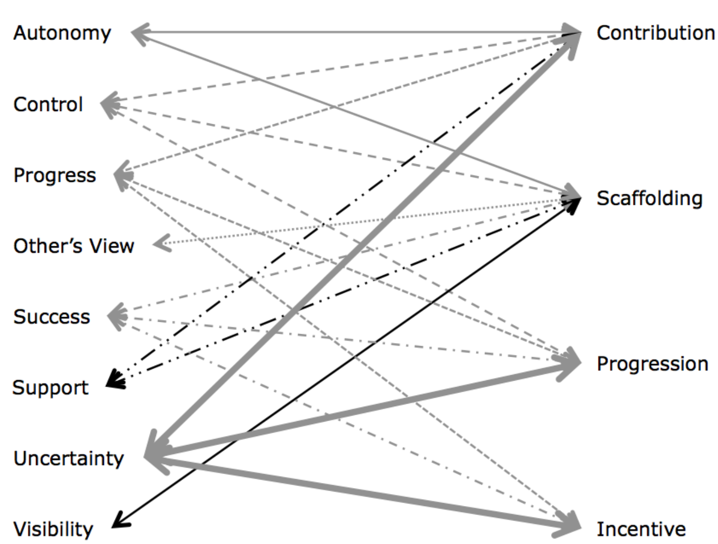


Figure 40. Personal project (Little 1987; Little et al. 2007) dimensions to "guidance and accountability" qualities mapping.

A number of tensions emerged between these four qualities. First the tensions between *Contribution* and *Scaffolding* introduce four types of project ownership models. “Ownership” refers to what extent and by what method a person feels in charge of a project. Figure 41 presents a quadrant diagram showing four states of ownership based on semantic differentials for *Contribution* and *Scaffolding.*

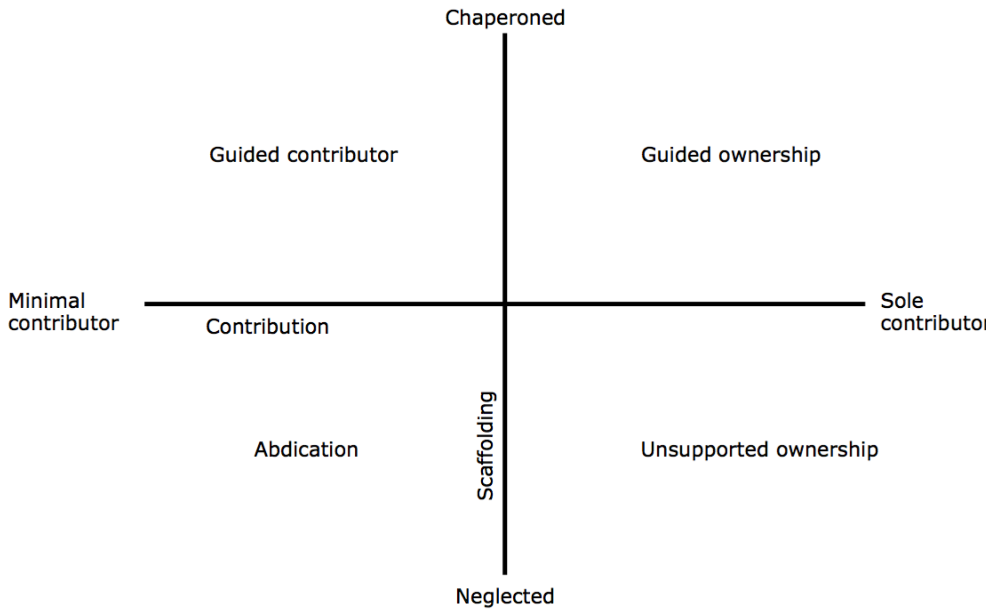


Figure 41. Contribution – scaffolding positioning diagram.

The x-axis describes the *Contribution* semantic differential, with “Minimal contributor” on the right end and “Sole contributor” on the left end. A person who perceives they are a minimal contributor to a project believes she has very little ownership of a project and will have little impact on the project outcome. A person who perceives they are a sole contributor believes they success of the project relies completely on their shoulders. The y-axis describes the *Scaffolding* semantic differential, with “Neglected” on the bottom end and “Chaperoned” on the top end. A person who perceives neglect with regards to scaffolding believes that she has no social support for competing a project. A person who perceives she is chaperoned throughout the project believes she is being guided every step of the way towards successfully completing her project.

These two differentials produce four ownership states:

5. Abdication: The combination of a person believing they are a minimal contributor and that her actions are neglected results in a person removing herself from the project.
6. Guided contributor: The combination of a person believing they are a minimal contributor and that her actions are chaperoned results in belief of ownership for her portion of the project.
7. Unsupported ownership: The combination of a person believing they are the sole contributor and that her actions are neglected results in a person acting autonomously.
8. Guided ownership: The combination of a person believing they are a sole contributor and that her actions are chaperoned results in a person seeking advisement from her chaperones to drive the project forward.

While the quadrant diagram presents these ownership models as absolutes, in reality the relationships are incremental in nature. For example, while many participants stated that they wished they had someone to provide guidance on a project, they're were no instances of a participant stating that they wanted someone to monitor their every action in the way that a chaperone does. Additionally, the ownership model is not fixed across the life a project, but rather dynamically changes in response to changes in perceived level of contribution on a project and the social structure associated with the project. For example, a person may abdicate responsibility of a project, only to become the project's sole contributor later in the project's life cycle.

The second tension in *Guidance and Accountability* resides between *Contribution* and *Progression*. This tension presents models of project completion. Figure 42 presents a quadrant diagram showing four social states of project completion based on semantic differentials for *Contribution* and *Progression.*

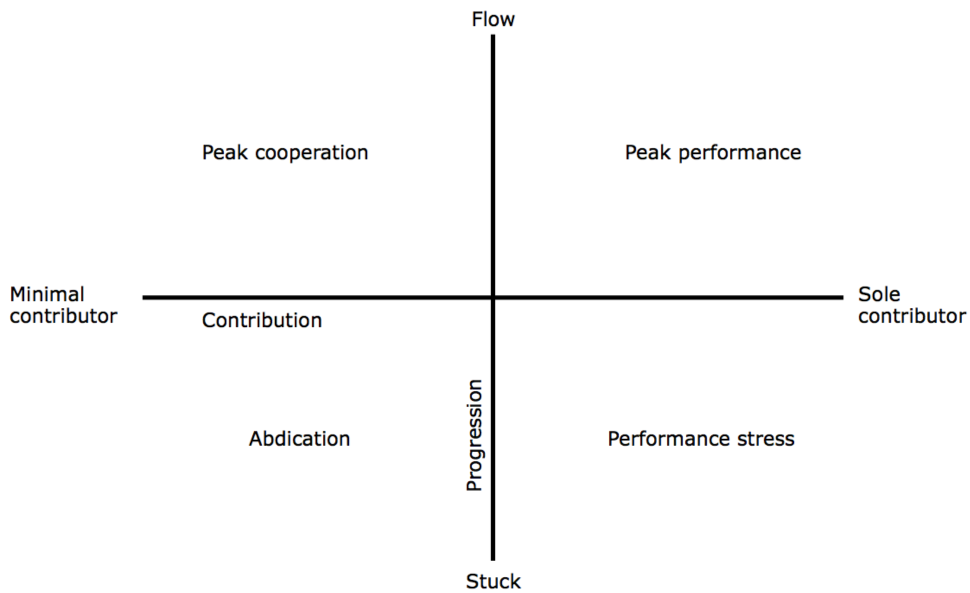


Figure 42. Contribution – progression positioning diagram.

The x-axis describes the *Contribution* semantic differential, with "Minimal contributor" on the right end and "Sole contributor" on the left end. The y-axis describes the *Progression* semantic differential, with "Stuck" (Burleson & Picard 2007) on the bottom end and "Flow" (Csikzentmihalyi 2008) on the top end. A person who perceives they are "stuck" (Burleson & Picard 2007) with regards to progression believes that she has no means of moving forward with the project. A person who perceives she is in "Flow" (Csikzentmihalyi 2008) with regards to progression believes they are optimally performing on the project. These two differentials produce four ownership states:

1. Abdication: The combination of a person believing they are a minimal contributor and that she has no means of moving forward with a project results in a person removing herself from the project.
2. Peek cooperation: The combination of a person believing they are a minimal contributor and that she is performing optimally on her portion or the project to meet the needs of the larger group effort.

3. Performance stress: The combination of a person believing she is the sole contributor and that there is no means of moving forward with a project results in an increase of stress related to the project as she seeks out a new path forward.
4. Peek performance: The combination of a person believing she is a sole contributor and that she is performing at optimal capacity results in personal peek performance to complete the project on her own.

As with the other quadrant diagrams, the four models of project completion representing the tension between *Contribution* and *Progression* are not static, but change over time in response to changes in project conditions.

The third tension in *Guidance and Accountability* resides between *Incentive* and *Progression*. This tension presents models related to consequences. Within the context of this framework, consequences are not viewed as a negative response to action or inaction, but rather *a response* to action or inaction. Figure 43 presents a quadrant diagram showing four states of project completion based on semantic differentials for *Incentive* and *Progression.*

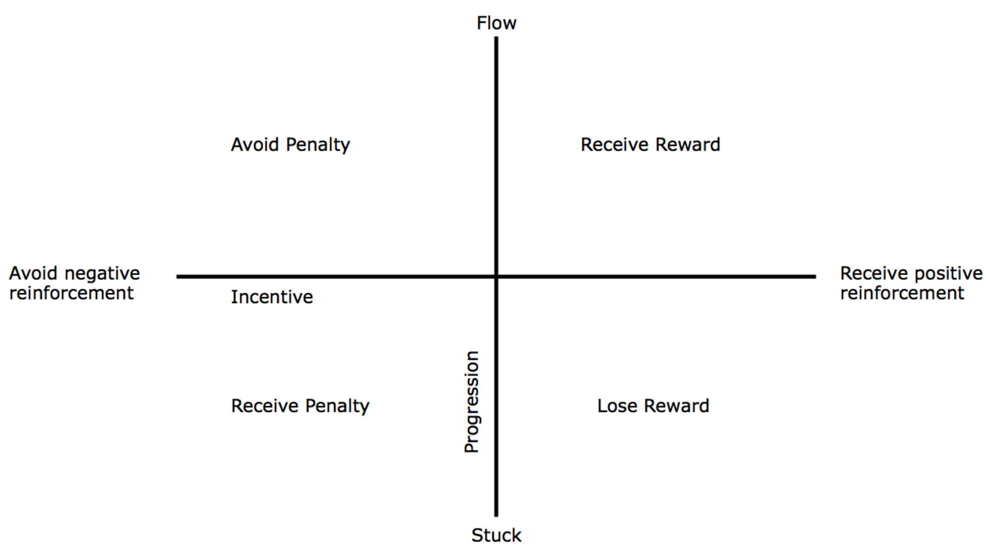


Figure 43. Incentive – progression positioning diagram.

The x-axis describes the *Incentive* semantic differential, with "Receive negative reinforcement" on the right end and "Receive positive reinforcement" on the left end. The y-axis describes the *Progression* semantic differential, with "Stuck" on the bottom end and "Flow" on the top end. Together, these two differentials describe conditions related to an avoidance/approach model for incentivization by producing for states:

1. Receive penalty: The combination of a person seeking to avoid negative reinforcement, yet feeling stuck (Burleson & Picard 2007) on a project results in a failed avoidance attempt that produces a penalty.
2. Avoid penalty: The combination of a person seeking to avoid negative reinforcement while operating at peek performance results in successful avoidance of a penalty.
3. Lose reward: The combination of a person seeking to obtain positive reinforcement, yet feeling stuck (Burleson & Picard 2007) on a project results in a failed attempt resulting in the loss of a reward.
4. Receive reward: The combination of a person seeking to obtain positive reinforcement while operating at peek performance results in successful collection of a reward.

As with the other quadrant diagrams, the four models of project completion representing the tension between *Incentive* and *Progression* are not static, but change over time in response to changes in project conditions. Additionally, incentives are often layered upon one another, with participants often seeking to both avoid negative reinforcement in parallel to seeking to obtain positive reinforcement. For example, participant 20 designed her smart home service provision to ban her Facebook account should she fail to complete daily actions related to her personal project (Little 1987; Little et al. 2007) progression and provide a reward in the form of a link to an extreme sports video should she complete daily actions related to her personal project (Little 1987; Little et al. 2007) progression.

Project Ambiguity describes what qualities a person defines projects by, and to what extent those project qualities are defined. These qualities are as follows:

- Project Plan: The perceived order of operations for completing a personal project (Little 1987; Little et al. 2007).
- Project Resources: People, places and things perceived necessary for completing the personal project (Little 1987; Little et al. 2007).
- Project Success Metrics: The means by which a person determines that the desired outcome has been achieved.

The PPA (Little et al. 2007) dimensions *Control, Challenge, Difficulty, Progress, Success* and *Uncertainty* support these design qualities. Figure 44 illustrates the relationships between PPA (Little et al. 2007) dimensions and *Project Ambiguity* qualities.

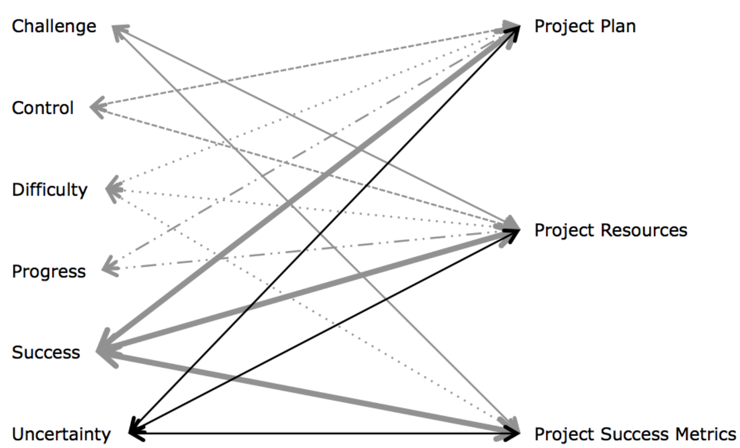


Figure 44. Personal project (Little 1987; Little et al. 2007) dimensions to *"Project Ambiguity"* qualities mapping.

A number of tensions emerged between these three qualities. First the tensions between *Project Plan* and *Project Resources* introduce four types of project action models. "Action" refers to the *modus operandi* of project engagement. Figure 45 presents a quadrant diagram showing four states of ownership based on semantic differentials for *Project Resources* and *Project Plan.*

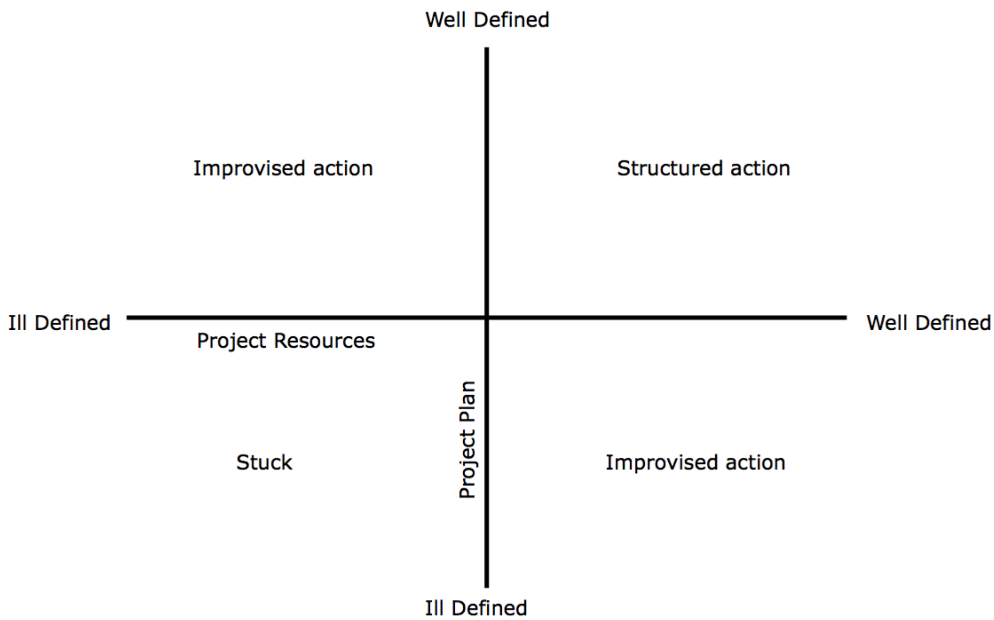


Figure 45. Project resource – project plan positioning diagram.

The x-axis describes the *Project Resources* semantic differential, with "Ill defined" on the right end and "Well defined" on the left end. The y-axis describes the *Project Plan* semantic differential, with "Ill defined" on the bottom end and "Well defined" on the top end. Together, these two differentials describe conditions related to how people act on their projects:

1. Stuck (Burleson & Picard 2007): The combination of both an ill defined plan and an ill defined understanding of resources available for completion of a project result in a person perceiving there is no means of moving forward with the project.
2. Improvised action: If only a project plan or the project resources are ill defined, then people improvise, either moving forward with the plan with the intent of gathering necessary resources *ad hoc*, or using the known resources

to act with the intent of adapting those actions as needed in response to environmental stimuli.

3. Structured Action: The combination of both a well-defined plan and an understanding of available resources results in implementing specific methods within the context of procedures.

As with the other quadrant diagrams, the four models of project completion representing the tension between *Project Resources* and *Project Plan* are not static, but change over time in response to changes in project conditions and a person's knowledge of those conditions.

The second tension produced by *Project Ambiguity* qualities is the intersection between *Project Plan* and *Project Success Metrics*. This tension describes a second set of project *modus operandi* for the project. Figure 46 presents a quadrant diagram showing four states of ownership based on semantic differentials for *Project Success Metrics* and *Project Plan.*

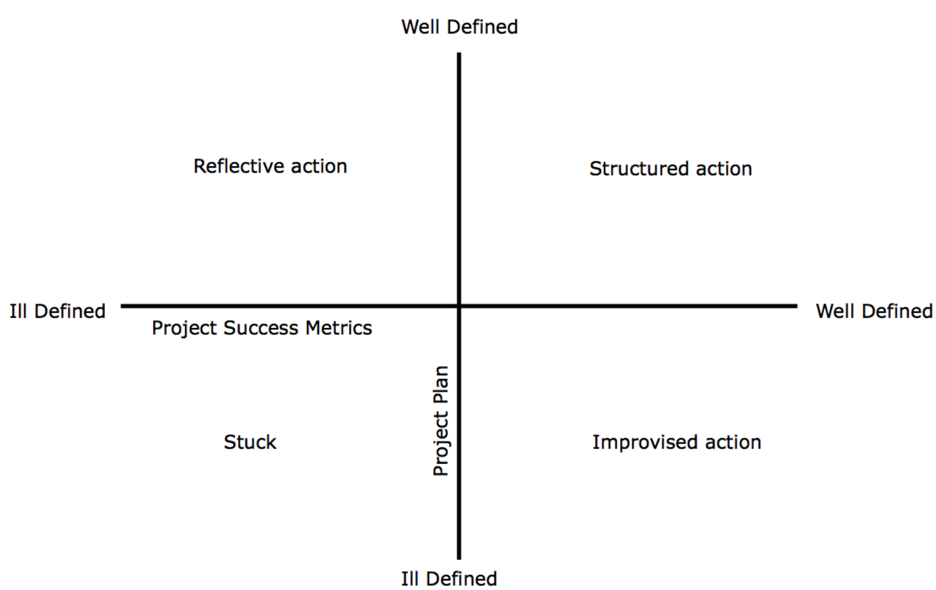


Figure 46. Project success metrics – project plan positioning diagram.

The x-axis describes the *Project Success Metrics* semantic differential, with "Ill defined" on the right end and "Well defined" on the left end. The y-axis describes the

Project Plan semantic differential, with "Ill defined" on the bottom end and "Well defined" on the top end. The "Stuck" (Burleson & Picard 2007), "Improvised Action" and "Structured Action" states are previously defined from the description of Figure 46. The fourth state, "Personal Reflection" occurs when a person has a well-defined plan but an ill defined understanding of the success metrics, requiring a person to reflect on the project's purpose, significance and success criteria of the project.

As with the other quadrant diagrams, the four states of representing the tension between *Project Success Metrics* and *Project Plan* are not static, but change over time in response to changes in project conditions and a person's knowledge of those conditions.

The third and final tension of *Project Ambiguity* describes the relationship between *Project Success Metrics* and *Project Resources*. This tension describes states that determine project initiation. "Initiation" refers to the making the decision to actively engage in a project. Figure 47 presents a quadrant diagram showing four states of initiation based on semantic differentials for *Project Success Metrics* and *Project Resources.*

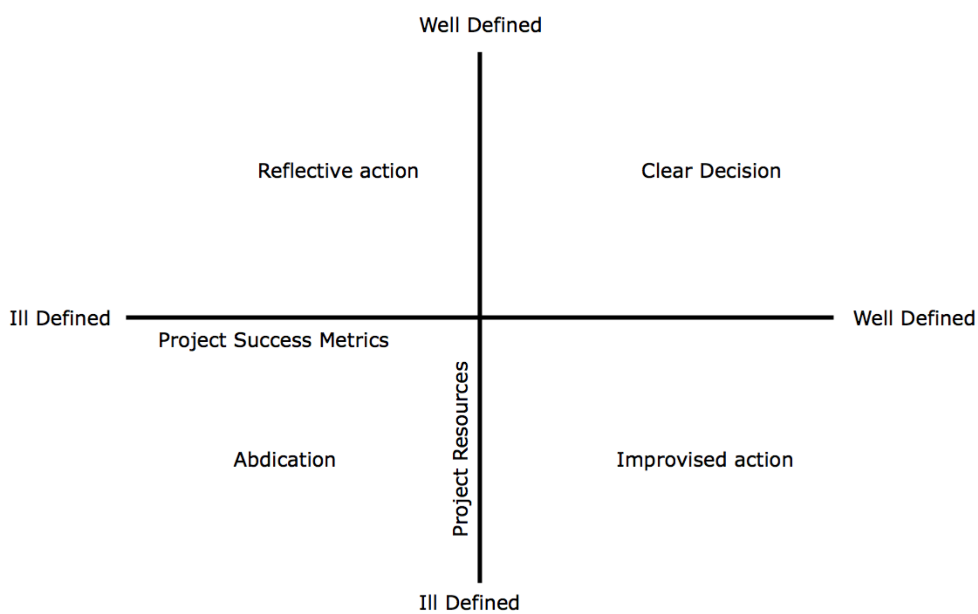


Figure 47. Project success metrics – project resources positioning diagram.

The states produced by the tensions between *Project Success Metrics* and *Project Resources* have been previously defined during the discussion of figure 46 and figure 45, respectively. The differentiators regarding these states are the reasons why they exist. Regarding "Abdication", participants who do not understand what makes a project successful, why the project success is valuable to them and also lack a clear understanding of resources necessary for completing the project, will walk away from the project until they can develop a working definition of success and resources. People who have a rich pool of resources to draw form, but do not understand what success means will retain the project, but pause to reflect on the project in order to understand what value the project has in order to make a decision on whether or not to allocate those resources. Conversely, if a person has a clear definition of success and the value of success, but does not understand if the resources are available to achieve success, they will pause to reflect on the project to determine if the value proposition is strong enough either improvise to achieve the end goal, or gather the necessary resources to engage in structured action. People whose projects have well defined success criteria and understand the value of success, as well as a clear understanding of available resources can make a substantive decision on whether or not to initiate the project.

Positivity Mechanisms refers to the methods of positive feedback that are meaningful to young adults when engaged in a personal project (Little 1987; Little et al. 2007). Unlike success criteria, which are the positive outcome of a project that signals to a person that they are done with the project and that the project was done well, *Positivity Mechanisms* are behaviors that elicit positive affective responses while progressing towards success. The PPA (Little et al. 2007) dimensions *Absorption, Happiness*, and *Love* support these mechanisms*.* These mechanisms are as follows:

- Social Connectedness: Feeling closer to people.
- Gratitude: Feeling a sense of appreciation for what they have accomplished.
- Immersion: Feeling a sense of oneness with the project during project engagement.

These relationships resulted during affinity diagramming by coding the notes comprising affinity diagram clusters against personal project analysis (Little et al. 2007) dimensions related to each note. Figure 48 illustrates the relationships between PPA (Little et al. 2007) dimensions and *Positivity Mechanism* qualities.

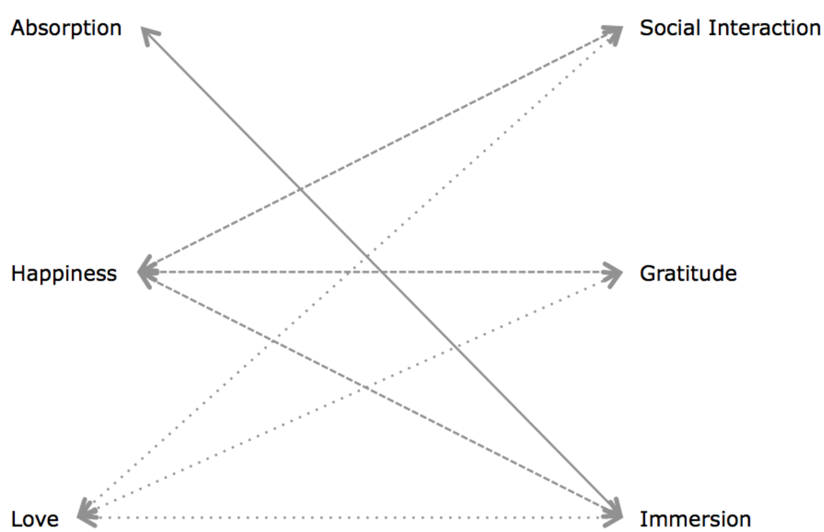


Figure 48. Personal project (Little 1987; Little et al. 2007) dimensions to “positivity” qualities mapping.

Unlike the other three sets of design principle qualities, analysis of the three *Positivity Mechanism* qualities did not reveal any tensions between them. This assertion is supported by the mapping the three types of mechanisms across the twenty co-design collages. This mapping showed that while a collage may house two discrete instances of mechanisms, mechanisms were never combined. For example, during participant 01’s application on “Learn to play ‘Blackbird’ on my guitar”, she developed a set of interactions that can be cataloged as *Immersion* where her picking up her guitar would trigger changes in her environmental conditions, as well as open up all the necessary applications to read guitar tablature and record her practice session. She also developed a set of interactions that can be cataloged as *Social Connectedness* where she could share her practice session with friends and family. However, participant 01 did not view the changes in environmental conditions and recording her practice session as means of feeling closer to her social circle. Nor did she view sharing her practice sessions as a means of making her experience more immersive. This pattern of positivity interactions only equating to one type of positivity mechanism is absolute across all participants. In terms of the design framework, despite the lack of tensions, the *Success Mechanism* qualities define methods of positive feedback smart home service provisions can influence young adults with.

The purpose of projects chosen for co-design, as well as the physical interactions captured on collages yielded a set of use definitions and interaction models. Use definitions are defined as the purposes and significance of smart home service provisions for young adults. Interaction models are modular sequences of interactions that can be mixed and matched to construct interactions for specific applications. An analogy for interaction models and applications is the use of shape primitives in a 3D modeling program and the artifacts constructed from those primitives.

Three use definitions became evident from comparing the personal projects (Little 1987; Little et al. 2007) chosen for co-design and their associated smart home service provisions. The projects supporting each use definition are listed in the definitions below. A single project can support multiple use definitions. For example, the project “learn to brew better” supports both *Make with Me* and *Self*

Improvement. The project supports *Make with Me* because involves "brewing beer" of which the process "brewing" is a specific means of making "beer". The project supports "Self Improvement" because it involves learning, which is the acquisition of new skill. The use definitions are as follows:

- Make with Me: This definition proposes that the home should recognize when an occupant is creating content (either physical content, as in brewing beer, building a bike, or growing tomatoes, and digital content, as in photo collages, a homework assignment, or an autobiography), and produce an environment that is conducive for making, provide resources for making, help the occupant when she is stuck (Burleson & Picard 2007) and celebrate the occupant's progress. This use definition supports creativity and productivity for occupants. Applications produced through co-design sessions that fall under this use definition are: "Sew a fox stuffed animal", "Grow Tomatoes", "Build a New Bike", "Redesign 'music table' for art installation", "Learn to brew beer better", "Complete homework on time", "Create family photo collage" and "Write autobiography".
- Get Me on Task: This use definition proposes that the home should recognize if an occupant is progressing on tasks that have been designated as priorities, and if not, attempt to motivate the user to do so through calls for action and negative and/or positive feedback. This use definition supports productivity, organization and fulfilling obligations to one's self and others. Applications produced through co-design sessions that fall under this use definition are: "Redesign 'music table' for art installation", "Complete homework on time", "Present at an important meeting", "Keep in touch with old friends", "Spend less time online", "Complete a fitness routine" and "Write autobiography".

- Self Improvement: This use definition proposes that the home should recognize an occupant's and health, wellness and skills acquisition related pursuits and structure time to afford these pursuits, manipulate digital and physical environments to support these pursuits, enlist social support for these pursuits, recommend actions that support these pursuits and track progress of these pursuits. Applications produced through co-design sessions that fall under this use definition are: "Learn to play 'Blackbird' on my guitar", "Try different cuisine", "Workout 5x a week", "Learn to brew beer better", "Maintain a fitness routine", "Cook healthy food 3x a week", "Eat healthier", "Learn to play the keyboard", "Spend less time online", "Complete a fitness routine" and "Write autobiography".

These three use definitions are supported by a core set of interaction models. Interaction models were derived through comparative analysis of GaLLaG (Burleson et al. 2009) PICTIVE (Muller 1991, 1992; 1993) tokens placed on the collages. Interaction models are presented with a text definition of the model, as well as an activity model. The activity model diagrams sequences of internal system actions, external system actions and occupant actions. An *internal system action* is an action the system commits that is invisible to the occupant. An *external system interaction* is an action the system commits that is visible to the occupant. An *occupant action* is an action committed by an occupant. An interaction is defined as a connection between two actions. Additionally, there is a two-state modifier that describes interactions as either necessary or optional. Solid arrows denote necessary interactions. Dashed arrows denote optional interactions. The set of three action types and the single two-state modifier affords 18 interactions. Figure 49 presents the interaction space.

	Internal system action	External system action	Occupant action
Internal system action			
External system action			
Occupant action			

Figure 49. Motivational home interaction model key.

The interactions defined by these models are:

- Structure time: The use of timers and triggers to sequence occupant, home environment and system interactions.

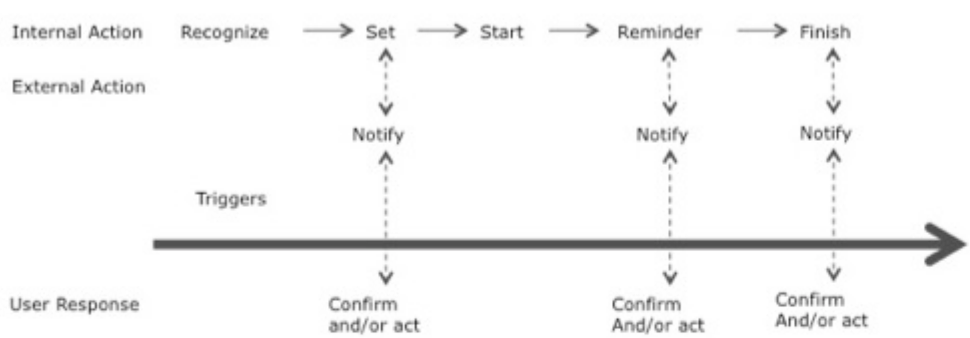


Figure 50. Structure time interaction model.

- Prompt action: The use of physical and digital feedback and incentives to motivate occupants to initiate an action.

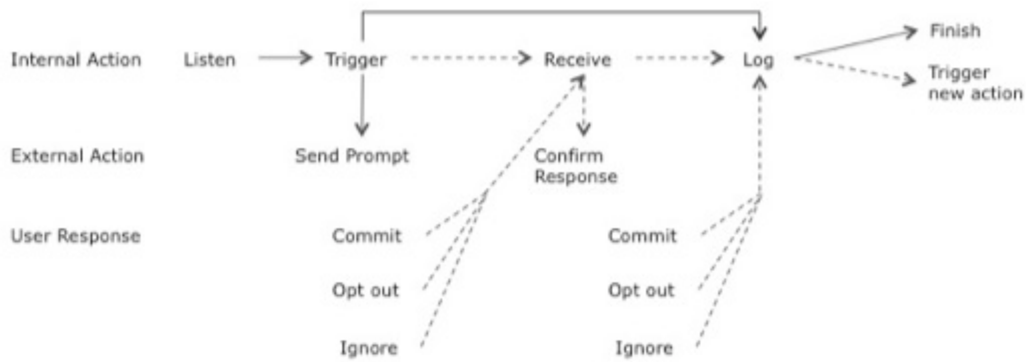


Figure 51. Prompt user interaction model.

- Gather resources: The search for, recommendation of and collection of assets that could support occupant pursuits.

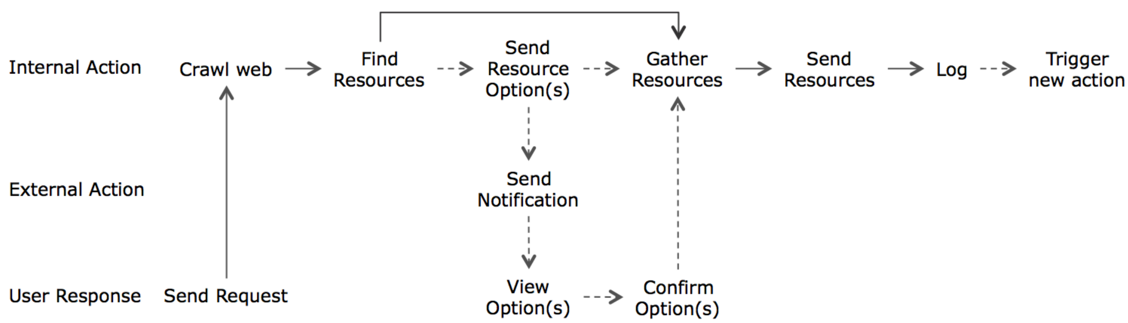


Figure 52. Gather resources interaction model.

- Consume resources: The presentation of content to occupants.

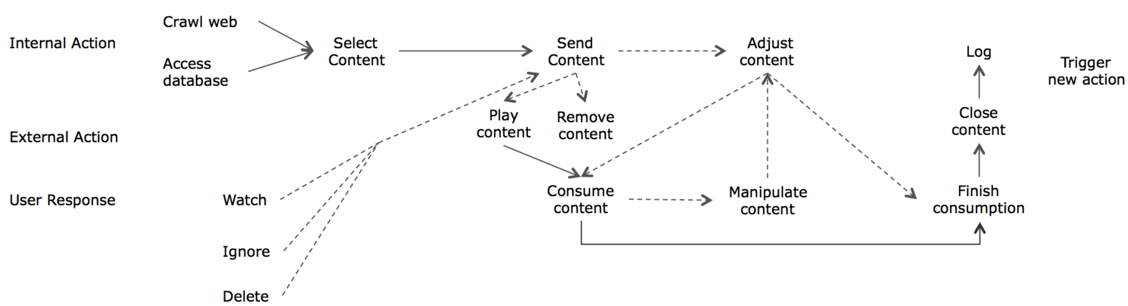


Figure 53. Consume resources interaction model.

- Create content: The delivery of assets that support creative practice, structuring of environment to support creative practice and the monitoring and logging of progress of creative pursuits.

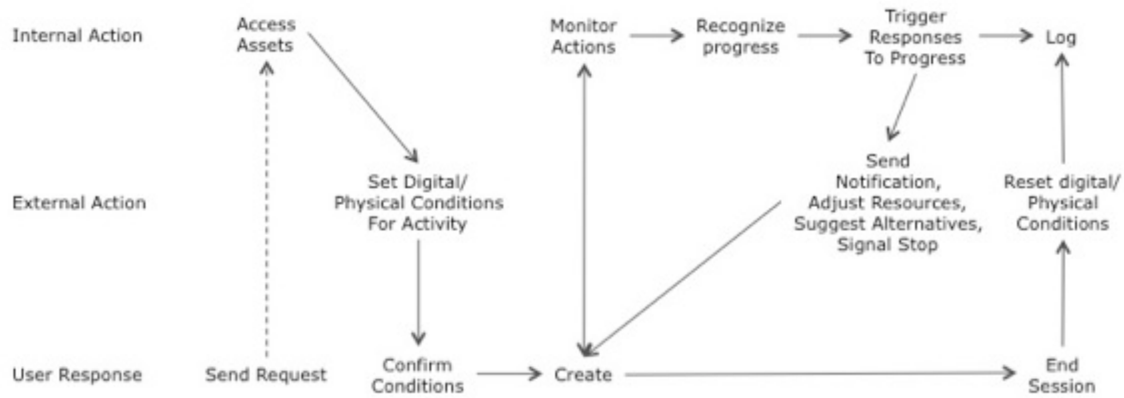


Figure 54. Create content interaction model.

- Restrict/restore access: The banning or restoration of content that occupants care about to incentivize action.

Figure 55. Restrict/restore access interaction model.

- Share content: The uploading of digital artifacts to the web.

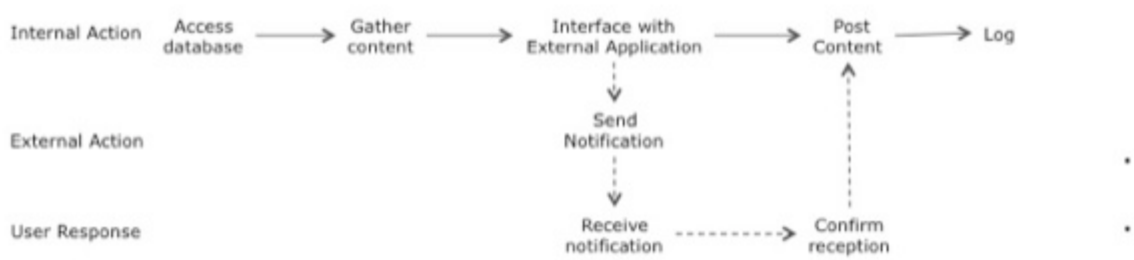


Figure 56. Share content interaction model.

These seven interaction models, either as individuals or in combination with one another, account for all interaction sequences cataloged across collages. For example, participant 08's project: "Redesign 'music table' for art installation consisted of the following scenario:

- While occupant is away, the home records environmental noise using a microphone array.
- While the occupant is away, the home posts randomly selected snippets of environmental noise to Sound Cloud, which, in turn get posted to the occupant's Facebook account.
- While away from the home, the occupant listens to the sound snippets posted to Facebook.
- When the occupant returns home, all of the sounds captured throughout the course of the day are played through remote speakers and his desk lamp turns on as a call to action for the occupant to begin working on the music table needed to interact with sound library.
- The occupant works on building the music table.
- Once finished for the day, the occupant turns off his desk lamp to notify the system.

Using the suite of interaction models, the sequence of idiosyncratic interactions related to participant 08's personal project (Little 1987; Little et al. 2007) listed above is abstracted to the following set of core interactions:

1. Create Content → 2. Share Content → 3. Consume Content → 4. Prompt → 5. Create Content → 6. Prompt

Figure 57. Build "music table" for art installation interaction sequence.

The value of such abstraction is four fold. First, it provides a snapshot of the application workflow of a specific application, serving as a communication tool for development teams while working on applications, and between developers and occupants as a way to build consensus on interactions. Second, such abstractions are technology agnostic, allowing developers to maintain and advance a human-centered approach to interaction. Third, abstraction of many applications into such interaction models can reveal patterns of interactions to inform development of new development tools and consumer technologies. For example, if comparison of multiple interaction sequences reveals a sequencing pattern of the interaction "Prompt" leading to the interaction "Create Content", then developers can explore the qualities of "Prompts" and "Create Content" interactions that either align or diverge and develop solutions to improve the coupling of the two. Finally, once an interaction sequence has been defined for an application, the sequence can be situated within a representation of the occupant's home environment to understand how the sequence of interactions is both implemented in space and potentially redefines the meaning of the space it is implemented in. The former is a matter of visually mapping the interaction models within the space syntax (Hansen & Hillier 1982) of a home. The latter occurs through presenting such visual representations to occupants as low fidelity prototypes to broker discussion. In the case of participant 08, his collage only provided two rooms, a bedroom and a bathroom. The interaction chain would overlay onto participant 08's space syntax (Hansen & Hillier 1982) in the following way:

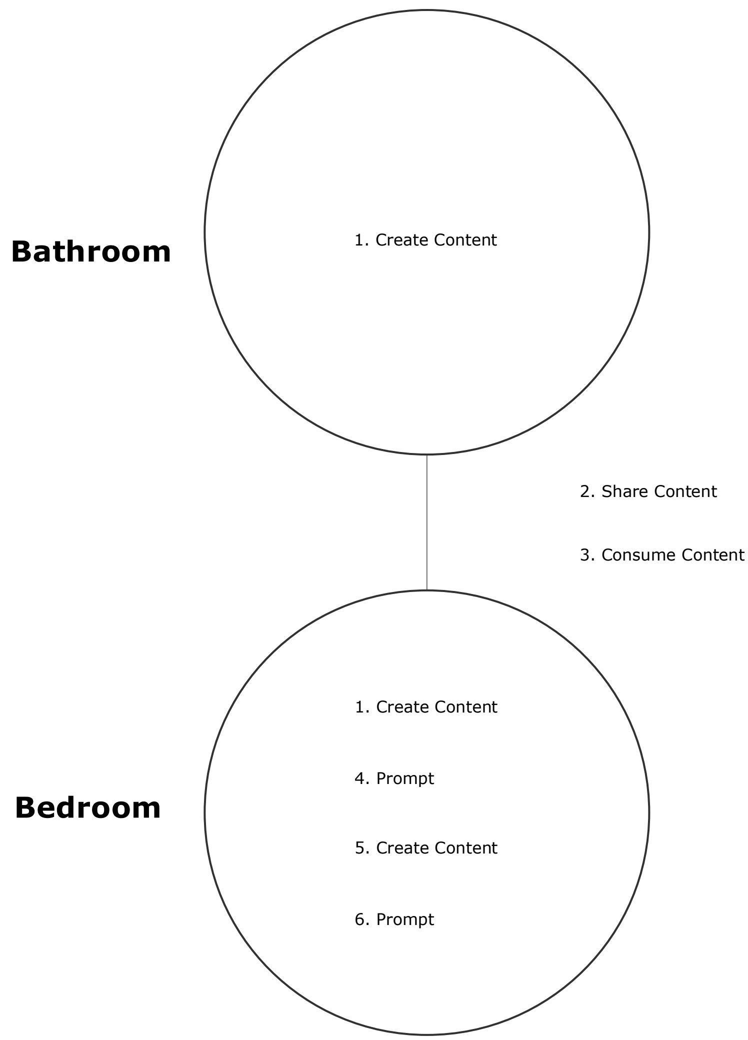


Figure 58. Mapping of interaction models onto participant 08's space syntax (Hansen & Hillier 1982) configuration.

Figure 58 describes a smart home service provision's physical and digital interaction space. It illustrates that the physical space consists of the bedroom and physically connected bathroom. Digital interactions primarily reside in the bedroom, with a single interaction in the bathroom and two interactions occurring outside of the home.

The final subject of this section presents a number of miscellaneous insights that emerged from the co-design sessions. These insights are not type to larger focal points of this section, such as the hypothesis results or the design framework.

Rather, each stands alone as an unexpected bi-product of the research. The emergence of unexpected insights is often a trait of participatory research approaches as the researcher relinquishes a portion of control of the process to the participant.

The first unexpected insight that emerged was that remote audio, rather than video or environmental feedback, appears to be the preferred method of feedback for smart home service provisions to communicate with young adults. This insight was derived by comparing the prevalence of "audio" tokens against the prevalence of other feedback mechanisms. While unanticipated, this insight aligns with the perceptual functionality of hearing versus sight. Hearing, combined with smell, are the sensory mechanisms by which people maintain peripheral sensing of their environment, while sight has a narrow bandwidth, yet affords focused attention on specific objects. Current computational devices, such as personal computers, laptops, tablets, phones and the burgeoning area of wearable computers utilize a display panel to focus the attention of the user on content for complex manipulation and task completion. Additionally, the size relationship between a user and current devices is one in which, in most cases, the user contains the device by holding it. The advent of the smart home does not adhere to the current use paradigm of computing a person can hold. Instead, the computer (i.e. the smart home) metaphorically holds the person as the home contains occupants, activities activity and supporting resources. This inversion of containment enlarges the interaction space so that the potential for feedback is distributed and surrounds the user of a system. The dominance of audio as the preferred feedback mechanism aligns with the new capability of feedback to surround the user by allowing the user to perceive feedback distributed across the home environment.

The second insight is that many interactions within a smart home service provision occur outside of the home. While human-smart home interactions to remotely monitor energy use and security are currently available through smart phones, an underlying assumption of designing a smart home service provision that was socially-oriented and personal project (Little 1987; Little et al. 2007) focused would constrain applications to the home. Participant 08's personal project (Little 1987; Little et al. 2007) to redesign his music table included interacting with smart home content while away from his home to listen to the sound bites the home recorded in his absence. Participant 20's project, "write autobiography", is another example of project in which the smart home interacts with occupant while the occupant is away. During participant 20's scenario, the home prompts the participant to go to the local coffee house to create new content on her autobiography. The home recognizes when the participant leaves the home, when the participant arrives at the coffee house, how long she writes while away, and when she returns home. The emergence of remote smart home service provision interactions aligns with the findings of the PCSoP surveys indicating that the personal projects (Little 1987; Little et al. 2007) of young adults lack strong attachment to their homes.

The third insight was the lack of routine centric projects participants chose to co-design provisions for. Many papers have explored technologies for understanding domestic rituals, such as hygiene. (CITE SOME PAPERS). While such approaches to service provisions demonstrate value for scaffolding domestic routines of impaired populations, this approach appears to have little merit for unimpaired young adults. The one exception to this insight is the routine of cooking, in which multiple participants chose projects for. However, unlike provisions for impaired populations, that focus on affording users the capability to complete baseline cooking actions associated with activities of daily living (ADL) (Bookman, Harrington, Pass, & Reisner

2007), provisions on cooking for unimpaired young adults focuses on variety of specializations. For example, participant 03 perceived her project on cooking healthy not only focuses on a specific style of cooking, but also focuses on cooking healthy food as a way of saving money. Participant 04’s cooking project centered on expanding her culinary horizons by trying new cuisines. The lack of projects that support domestic routine can be problematic for developers of provisions, as it means that applications are more idiosyncratic and require a design-for-one approach. In order to accommodate this non-typical behavior, the development of occupant-friendly development tools that support easy adaptation of the proposed interaction models to fit the idiosyncrasies of an occupant’s project.

This section discussed outcomes related to hypotheses on co-design of smart home service provisions, PPA (Little et al. 2007) output and SEQ (Stiles et al. 1994) output, introduced a grounded theory of smart home service provisions for HF (Fredrickson 2002; Little et al. 2007; Seligman 2004)in the format of design framework and concluded with a discussion on miscellaneous insights that emerged from the co-design sessions. The following section concludes this chapter by discussing opportunities for future work.

Conclusion

This study implemented a participatory design approach to co-design paper prototypes of smart home service provisions supporting personal project (Little 1987; Little et al. 2007) completion. Through the course of the study, 20 participants completed a two-hour, one-on-one design workshop consisting of a semi-structured interview, collage and the completion of a process assessment survey. The purpose of this research was to address four hypotheses concerning the relationships between personal projects (Little 1987; Little et al. 2007) and smart home service provision, develop case studies on smart home service provisions for HF (Fredrickson

2002; Little et al. 2007; Seligman 2004) and construct a design framework that embodies a grounded theory of smart home service provisions for HF (Fredrickson 2002; Little et al. 2007; Seligman 2004).

The hypotheses proposed in this study regarded the relationships between the projects participants desired smart home service provisions for and the PCSoP dimensions of *Home Dependency*, *Control* and *Stress* and assessed the co-design process participants completed to produce their paper prototypes. Projects chosen as subject matter to apply smart home service provisions to, on average, indicated average ratings of *Home Dependency*, lower ratings of *Stress*, and average ratings of *Control* relative to other projects in the cohort groups project ecosystems. Participants reported that they enjoyed the co-design process, perceiving the activities completed in the design workshop as eliciting a deep reflection on their projects within a non-confrontational, low-stress environment.

These design principles and qualities are framed within the context of three use definitions: (1) Make with Me, (2) Keep me on task and (3) Self Improvement. These thee use definition propose that the purpose of smart home service provisions for HF (Fredrickson 2002; Little et al. 2007; Seligman 2004)of young adults is to cultivate creative action, maintain focus on the goals that matter most to them and acquire new skills to foster holistic well-being, respectively. Seven interaction models were proposed as a set of interaction primitives to assist technical and lay designers with thinking about how to structure interactions between young adults and their smart homes to cultivate HF (Fredrickson 2002; Little et al. 2007; Seligman 2004).

Lastly, three insights that appear counterintuitive to how researchers have previously viewed smart home service provisions were discussed:

- Pervasive audio is the preferred method of communication between young adults and their smart homes.

- Smart home interactions do not always occur in the home.
- Smart home service provisions for HF (Fredrickson 2002; Little et al. 2007; Seligman 2004), with the exception of cooking, should not address domestic routines.

These contributions represent a significant proposition for understanding how non-impaired people perceive and interact with smart home service provisions, the findings need to be confirmed through future work. Confirmation could assume a number of forms. First, the study could be replicated to see if similar findings and design framework constructs emerge. While this form of confirmation would produce a different set of personal projects (Little 1987; Little et al. 2007) and support provisions, findings and the design framework should be relatively similar. Additionally, two variants of this study could be conducted to test the extensibility of the design frame. The first variation would conduct the study with a cohort group that exhibits far different qualities, such as single, working parents, to test the breadth of the design framework. The second variation would conduct the study with a different environmental focus, such as the work place. If the results from such studies yield similar results, then the design framework will be confirmed as extensible to other populations.

The second trajectory for the future is to implement the design framework as a toolkit for design practice to conceptualize and evaluate new smart home service provisions. This trajectory could demonstrate if, how and to what extent the design framework creates value for development teams. This trajectory of future work, while not research oriented, over time could identify capability gaps in the framework that need to be explored through additional research agendas.

Fourth, building interactive prototypes and field-testing them in the homes of participants could achieve confirmation of the value of the individual paper prototype applications. This research agenda, while not directly confirming the value of the design framework, would test the assumption of if, how and to what extent end users can conceptualize and design smart home service provisions and, in all likelihood, yield new research questions and design insights on how to increase the goodness of fit between occupants, development tools and smart environments. The subsequent chapter presents such a study.

Chapter 10

FIELD TESTING OF MOTIVATIONAL SMART HOME SERVICE PROVISIONS

Introduction

This study describes the development, implementation and evaluation of three motivational SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). This study contributes to the MSD agenda by demonstrating tangible instantiations of the Motivational Home that:

- Exemplify the use of the Motivational Home design framework as a toolkit for design planning and;
- Evaluate the affects of motivational SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) on goal attainment.

Three participants (n = 3) consented to field test motivational SMSP they developed during co-design sessions described in Chapter Eight. Participants 01, 17 and 20 designed for the personal projects "Learn how to play 'Blackbird' on my guitar", "Spend less time online" and "Write autobiography" (respectively).

Participants interacted with their respective SHSPS (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) for a period of one-week. Upon installation of an SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), a participant was asked to complete a second PCSoP survey populated with only the project chosen for SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) support. Upon completion of the one-week field test, participants were asked to complete a third PCSoP assessment on their chosen personal project (Little 1987; Little et al. 2007), and were asked a series of questions derived from the Motivational Home design framework presented in Chapter Eight. Data was analyzed in three ways. First, differences in SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) *a priori* and *posteriori* PCSoP survey data were contrasted to test whether the affects hypothesized by participants during paper prototyping of SHSP occurred. Second, SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) *a priori* and *posteriori* PCSoP values related to the Motivational Home predictive models (Refer to Chapter Eight) were entered into the models to determine if the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) increased environmental congruency (Stokols 1977) between participants and their homes. Third, answers to interview questions were compared across the three participants to seek out initial potential trends in how participants experience motivational SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) for HF (Fredrickson 2002; Little et al. 2007; Seligman 2004).

The following sections explain the specifics of the GaLLaG (Burleson 2009) ubiquitous computing platform, followed by discussion on data collection and analysis methods. Procedures for participant selection, and technology probe (Hutchinson et al. 2003) development and installation are then summarized. Following procedures, the field tests of Motivational Home SMSPs are expressed. Findings generated from the field tests are then presented. This chapter concludes with a discussion on future work opportunities on the Motivational Home.

Data Collection

During field testing of GaLLaG (Burleson et al. 2009) SMHPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), three types of data were collected:

1. PCSoP survey data;
2. *Post-hoc* interview data;
3. And photographic data of GaLLaG (Burleson et al. 2009) SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) installed in the homes of participants.

PCSoP survey data was captured on each project related to a GaLLaG (Burleson et al. 2009) SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). The variables and values for this survey are explained in Chapter Eight.

A semi-structured interview was conducted at the end of each field test. The questions for these interviews were derived from the Motivational Home design framework design principles described in Chapter Nine. Refer to appendix F. for the interview question set.

Finally, photo documentation of GaLLaG (Burleson et al. 2009) platform components was collected. This data served two purposes. First, it visually demonstrated consistencies or inconsistencies across subjects with regards to how GaLLaG (Burleson et al. 2009) components were integrated into their home to understand physical constraints associated with installation. Second, this data was collected for story telling purposes to support presentation of the research.

Data Analysis

Data analysis for this study consisted of comparative analysis and content analysis. Comparative analysis was conducted on PCSoP survey data in two manners. First, the repeated measures of PCSoP dimension ratings related to the projects chosen for GaLLaG (Burleson et al. 2009) SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) support were compared across participants. By the end of field-testing, participants completed three measures. The first observation occurred when participants originally completed the PCSoP survey as members of the sample used to define Motivational Home heuristics and predictive models (Chapter Seven). The second observations were collected at the time of GaLLaG (Burleson et al. 2009) SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) installations, but prior to actual interaction with the provisions. The third observations were collected upon completion of the field test, after participants had engaged with the GaLLaG (Burleson et al. 2009) SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) for a period of one week. PCSoP dimension ratings related to design qualities (refer to Chapter Eight) were tracked across measures to determine if the GaLLaG (Burleson et al. 2009) SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) stimulated desired outcomes as indicated by the motivational home position charts associated with each case study. Additionally, changes in environmental congruency (Stokols 1977 were tracked by calculating SoP (Jorgensen & Stedman 2001; 2006) factors based on the predictive models generated in Chapter Eight. A line graph was generated for the predictive model calculations to visual demonstrate dynamics between measurement calculations.

The answers to the *post-hoc* interview questions were analyzed using *directed* content analysis (Hseih & Shannon 2005). *Directed* content analysis differs from the *Conventional* content analysis utilized in Chapter Eight in that qualitative data is dispersed across categories that are derived from current theory with the intent of extending that theory (Hseih & Shannon 2005). In contrast, *Conventional* content analysis (Hseih & Shannon 2005) does not assume predefined categories, instead allowing for categories to emerge from a data set. For the purpose of this study, content analysis is directed by the design principles that were proposed as part of Chapter Eight's design framework, with each principle serving as a category for data organization and analysis.

The previous sections defined data collection and data analysis methods used to explore the three GaLLaG (Burleson et al. 2009) SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) case studies. The following section describes procedures associated with participant selection, installation of GaLLaG (Burleson et al. 2009), SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), as well as collection, analysis and treatment of data.

Procedure

This study describes the journey three participants (n = 3) traveled to test GaLLaG (Burleson et al. 2009) SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) in their homes. The three participants were purposefully sampled from a list of 20 participants who participated in co-design sessions (Refer to Chapter Nine). These three participants were chosen based on the current capabilities of the GaLLaG (Burleson et al. 2009) platform to meet the interactions described in the co-design collages as well as the willingness of participants to allow installation of SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) in their homes. Six participants from the co-design sessions indicated interest in having an SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) installed in their homes. Out of that initial group, one participant rescinded consent, while two other participant SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) paper prototypes were deemed too far outside of the scope of GaLLaG (Burleson et al. 2009) platform capabilities, making them unfeasible to develop. All three participants were once more presented with their rights as participants, expectations of the study and informed the study was completely voluntary and did not include compensation.

Prior to installation of SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), the collages of study participants were translated into pseudo code. Pseudo code is a high-level description of computational interactions that take place during application use. The pseudo code was developed through text translation of GaLLaG (Burleson et al. 2009) interaction tokens, as well as written and pictorial information on participant collages. This pseudo code was then provided to the GaLLaG (Burleson et al. 2009) development team as roadmap to guide SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) production. Probes were developed over the course of three months, during which the team attended weekly progress meetings to discuss progress and troubleshoot development challenges.

Prior to installation GaLLaG (Burleson et al. 2009) SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) interactive prototypes into the homes of participants, the prototypes underwent ongoing testing during development using two methods. First, SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) interactions were tested within an on-campus, research lab. Upon successful implementation of an application in the lab, prototypes were installed in the home of a researcher. These in-home tests were conducted to identify potential challenges with installation of applications in the wild and to test functionality of the applications within a home environment.

Upon completing development and testing of a GaLLaG (Burleson et al. 2009) SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), the research team scheduled installation appointments with participants. During installation, researchers integrated the application into participant home environments, provided a walk-through demonstration of the application to participants and had participants fill out a PCSoP survey measurement for the personal project (Little 1987; Little et al. 2007) identified as the focus of a GaLLaG (Burleson et al. 2009) SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). Photographs of GaLLaG (Burleson et al. 2009) technologies installed in participant homes were captured using a digital camera. Participants were also provided an instruction document for their respective SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005;

Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), as well as contact information for a technical lead should the SHSP cease functioning.

Participants lived with their respective GaLLaG (Burleson et al. 2009) SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) installed in their home for one week. At the week's end, participants completed a third PCSoP survey as well as the interview question presented in the data collection section of this chapter. Upon completing this measure, participants were given the option to either continue using the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), or to return the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). Participants who chose to retain the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) were provided a weekly PCSoP survey to complete and return to the team to continue to track what, if any variance in personal project (Little 1987; Little et al. 2007) ratings occurred.

Survey and interview data were stored on a laptop protected by both full-disk encryption and user account credentials. PCSoP trend line graphs and predictive model calculations were produced using Microsoft Excel 2011. Interview responses were placed in a table within a Microsoft Word 2011 document for directed content analysis (Hsieh & Shannon 2005). Photographs of GaLLaG (Burleson et al. 2009) technologies installed in participant homes were kept on-hand for presentation of the research.

The following sections present the results of the study in the format of three case studies. Each case study description includes the following:

1. A description of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) and it's implementation;
2. Articulation of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) within the context of the Motivational Home design framework.
3. Presentation and explanation of the PCSoP trend line graph related to the case study;
4. And presentation and explanation of interview data related to the case study.

Case Study One: Learn How to Play "Blackbird" on My Guitar

Participant one chose to design a SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) to assist her in learning to play *The Beatles* song "Blackbird" on her acoustic guitar. She reported this project as one that she started during the summer of 2011, but as new priorities, such as finishing her degree and undertaking an internship, consumed her time, she let the project fall to the wayside. Despite the lapse of commitment to the project, she reported it as important to her because playing guitar provided an escape from her more serious commitments and aloud her to do something that was physically immersive.

During the course of the co-design session, participant one divulged a number of motivational needs. First and foremost, she expressed a need to feel like she was making progress on mastering the song. When asked how she defined "mastery", she responded with being able to play the song from start to finish without making a mistake while keeping tempo. At times, the participant found herself frustrated with the song because it required playing with all of her fingers, rather than strumming the guitar. This frustration manifested on her PCSoP survey through her *Anger,* *Stressed, Difficulty* and *Challenge* dimension ratings. She reported feeling like she had lost control over the project because she no longer practiced regularly. She also reported that she used to practice with her boyfriend present and that he used to encourage her to practice. However, since moving across country for her internship, she had lost that connection, which decreased the project's *Visibility* and *Support.*

The collage created during the co-design session addressed those motivational needs. Her application scenario begins with waking up in the morning to a custom alarm clock that plays "Blackbird". The song plays through a pair of remote speakers placed in her bedroom. The speakers receive the song from a laptop set up in her dining room that function as the system's server. A wireless sensor affixed to a deformable substrate sits on her nightstand. The user can press the substrate to cause the sensor to trigger a snooze function, which pauses the song, allowing the participant to sleep for 10 additional minutes. The participant can engage the snooze function as many times as she wants.

The participant conveyed that the first thing she does when gets out of bed in the morning is travel downstairs to the kitchen and makes an espresso. As the participant traverses her stairs, a motion sensor triggers the song to transfer to a second set of speakers installed in her kitchen. Once the song completes a single play through, the system rests. During the co-design session, the participant stated that she loved the song so much that she would not tire of it playing every morning and that listening to the song every morning would serve as nice reminder for her to practice that evening.

During mid-day, while at her workplace, the participant receives an email. The email contains a link to an online video of another musician playing the "Blackbird". The participant designed this interaction with the intent of the daily video providing inspiration. During the co-design session, she stated that, "Seeing someone else playing the song, and listening to their version of it, will make me feel like I can do it too."

In the evenings, when the participant returns home from work, her home recognizes her arrival through a sensor affixed to her garage entrance. Upon recognizing her entry, a light in her living room turns on to illuminate her acoustic guitar, which sits on a stand. To turn the light off, the participant must pick her guitar up from the stand. A sensor attached to the guitar recognizes removal from the stand and infers the participant has picked it up. Picking up the guitar triggers several actions. First, the light shuts off. Second, guitar tablature, a visual language for reading guitar sheet music, of "Blackbird" appears on the GaLLaG (Burleson et al. 2009) server laptop's screen. Third, video recording software launches on the GaLLaG (Burleson et al. 2009) server laptop. Fourth, a fifteen-minute timer begins a countdown. The participant can choose to record her practice session by pressing a physical button that sits next to the GaLLaG (Burleson et al. 2009) server laptop. During the co-design session, the participant created the ability to record her sessions so that if she made significant improvement on playing the song, she could send the video to her boyfriend. Once the timer reaches zero, an audio prompt plays from the GaLLaG (Burleson et al. 2009) server laptop, alerting the participant that she has completed her practice for the day. If the participant is recording her practice session, the video is automatically saved into a practice folder. Placing the guitar back on the stand resets the system for the next day.

When placed within the context of the Motivational Home design framework, this project relates to the *Get Me on Task* and *Self-Improvement* uses. Interactions comprising the application align with the design with all four design principles (*Time and Timing, Guidance and Accountability, Project Ambiguity and Positivity Mechanisms*). The morning and mid-day interactions of playing "Blackbird" for the participant’s alarm clock and sending the participant a link to “Blackbird” cover video (respectively), were designed by the user as passive reminders of the project to impress a sense of accountability and immerse her in the song. The evening interactions structure her time by instituting a consistent time of day and time duration for her to practice. The evening interactions also provide guidance through her practice sessions by prompting her to initiate project engagement (i.e. picking up the guitar), provide resources for practice (i.e. providing the guitar tablature and recording software) and declaring when practice is over (i.e. the audio prompt and saving of the practice footage). Positivity mechanisms are exploited in multiple instances. First, the participant conveyed that she designed the totality of the morning, mid-day and evening interactions to immerse her in the song. Second, she hypothesized that completing daily practice sessions and recording videos of her practice sessions to send to her boyfriend would impart of a sense of gratification and social connectedness (respectively). Figure 59 illustrates the interaction model for Participant 01’s SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011).

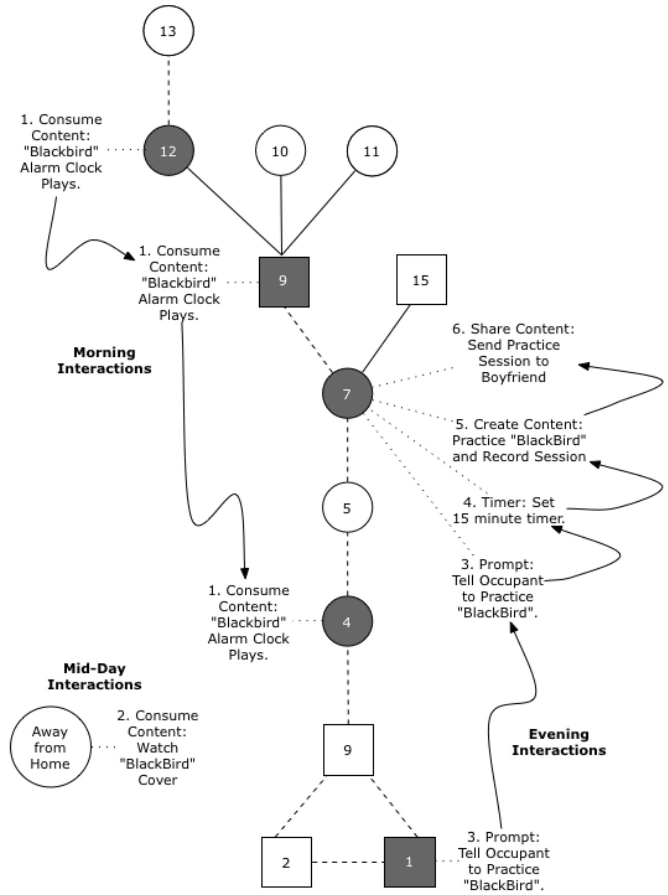


Figure 59. Participant 01 home space syntax (Hansen & Hillier 1982) with motivational home interactions for "Learn to play 'Blackbird' on my guitar" personal project (Little 1987; Little et al. 2007).

When mapping the current state of the project to the desired state of the project on the series of positioning diagrams, the following motivational propositions for the application emerge. Following each motivational proposition is a discussion on if, how and to what extent participant engagement with SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) succeeded at attaining the desired motivational state. Success is measured by tracking PPA (Little et al. 2007) (Little et al.2007) (Little 1987) dimension measures that comprise each position axis across multiple observations. All PCSoP dimensions were tracked across three observations:

the initial completion of the PCSoP survey for the participants entire project ecosystem, a second observation taken of the chosen personal project (Little 1987; Little et al. 2007) for SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) support captured at the installation of the system and a third observation taken at the end of the one-week field testing of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). Dynamics across the PPA (Little et al. 2007) dimension observations associated with positioning diagram axis provide an indication of movement from a project’s current state to the desired state. For a full explanation of mappings between PPA (Little et al. 2007) dimensions and the design qualities that structure the position diagrams, refer to the design framework presented in chapter nine.

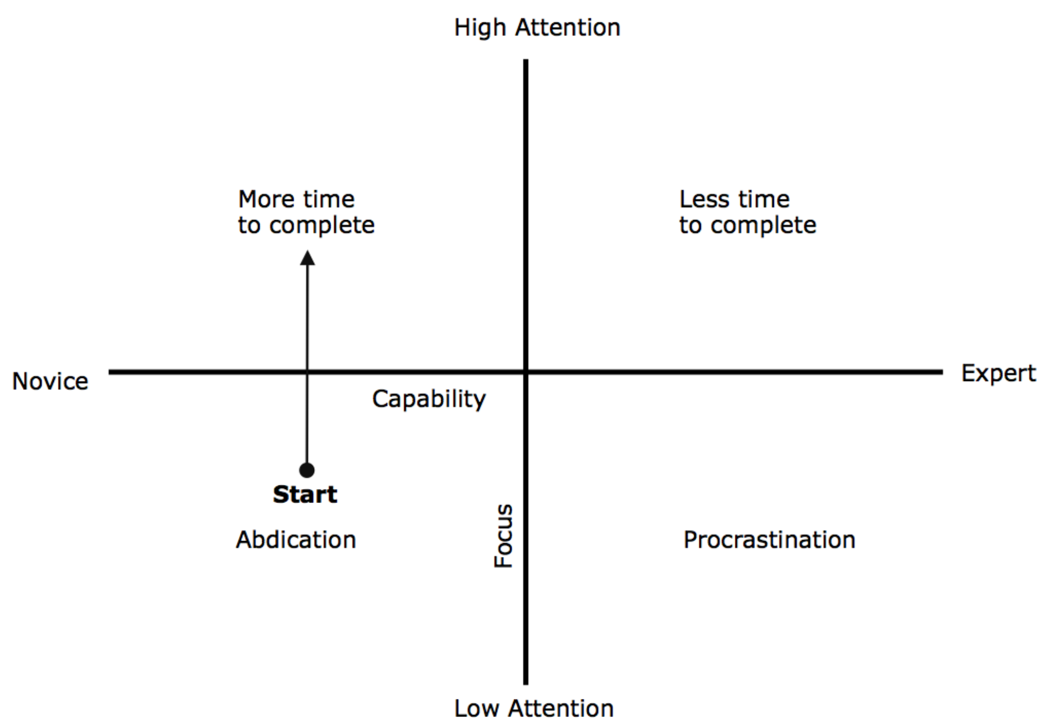


Figure 60. Participant 01 capability – focus positioning diagram.

During the course of the co-design session, Participant one stated that she had quit the project because the song was difficult and she lacked time to practice. One purpose of her SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) was to provide consistent time during the day for her to practice the song to improve her learning outcomes. The *Focus* axis of the positioning diagram consists of the PPA (Little et al. 2007) dimensions *Absorption* and *Difficulty*. The *Capability axis* of the positioning diagram consists of the PPA (Little et al. 2007) dimensions *Challenge, Control*, and *Outcome/Likelihood of Success*.

Participant 01 initially rated *Absorption* as a seven. At the installation of the application, *Absorption* fell to a two and then rose to a rating of three at the end of the field test. *Difficulty* dropped sharply, beginning a rating of eight, falling slightly to a rating of six at the time of system installation and then falling to a score of three by the end of the field test. Participant 01's perception of *Challenge* also fell sharply, beginning with a rating of nine, reducing to seven at the time of system implementation and falling to a rating of three upon completion of the one-week field test. *Control* demonstrated measurement eluding to the system returning a sense of control to the user. During her initial assessment, she reported a rating of six. This rating reduced to a value of three at the time of system installation and then rose to a rating of seven upon completion of the one-week field test.

Outcome/Likelihood of Success maintained a relatively flat rating across all three measures, beginning with eight and then resulting a rating of seven at both the start and end of the field test.

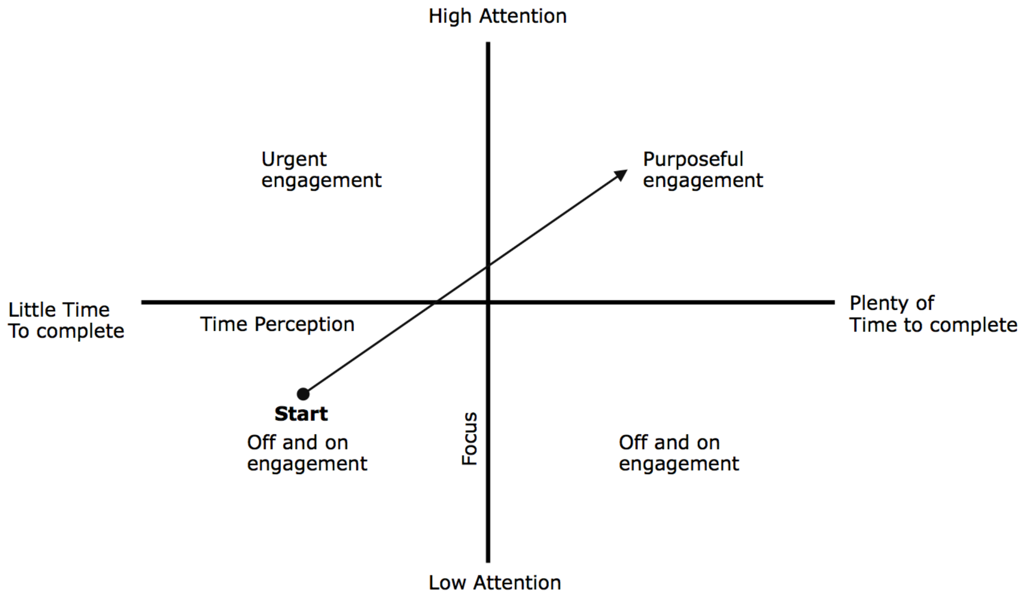


Figure 61. Participant 01 time perception – focus positioning diagram.

The *Time Perception* axis of the positioning diagram consists of the PPA (Little et al. 2007) dimensions *Absorption, Depressed*, and *Difficulty*. The dimensions *Absorption* and *Difficulty* were discussed during explanation of figure 35. The PPA (Little et al. 2007) dimension *Depressed* maintained a consistent score of zero. During her exit interview, Participant 01 stated that she was acutely aware of how much time she was practicing because she had other tasks she felt she could do that were a better use of her time. However, she stated she felt compelled to practice because the light shining on her guitar was constantly in her peripheral vision while she conducted other activities in her home. She stated that she also felt social pressure to practice because she committed to the study.

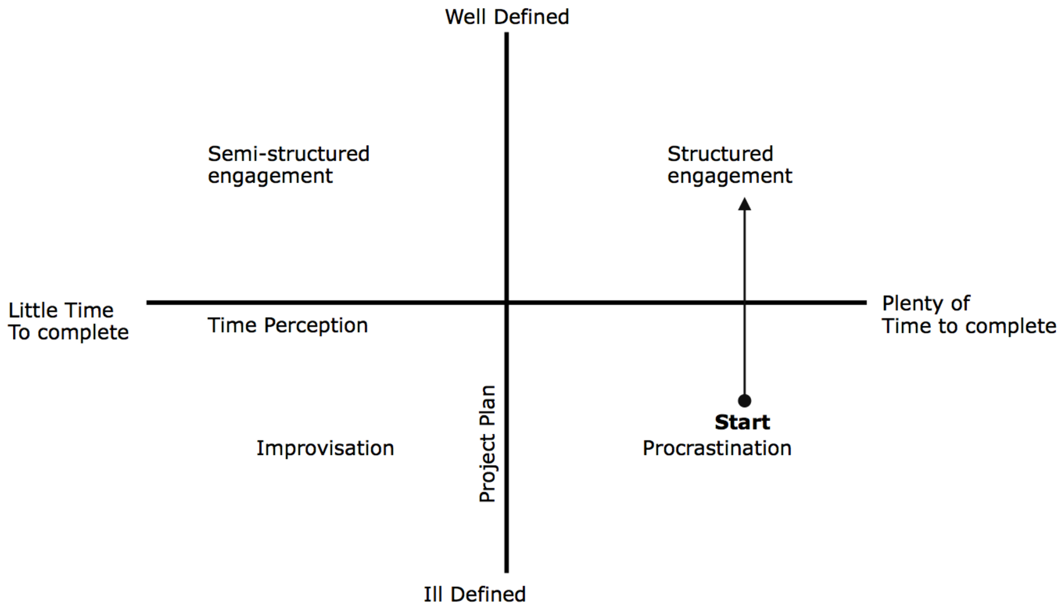


Figure 62. Participant 01 timer perception – project plan positioning diagram.

The *Project Plan* axis consists of the PPA (Little et al. 2007) dimensions *Control, Outcome/Likelihood of Success, Progress* and *Uncertainty.* As discussed during explanation of figure 60, *Control* demonstrated an increase, while *Outcome/Likelihood of Success* maintained near identical scores. As with dimension *Control*, the *Progress* dimension indicated a return to feeling as if she was progressing. During the initial survey, Participant 01 reported a value of five. At the time of system implementation, she reported a value of three. At the end of the one-week field test, the value rose to a six. *Uncertainty* rose slightly across all three measures, beginning with a rating of zero, then a rating of two and ending with a rating of three.

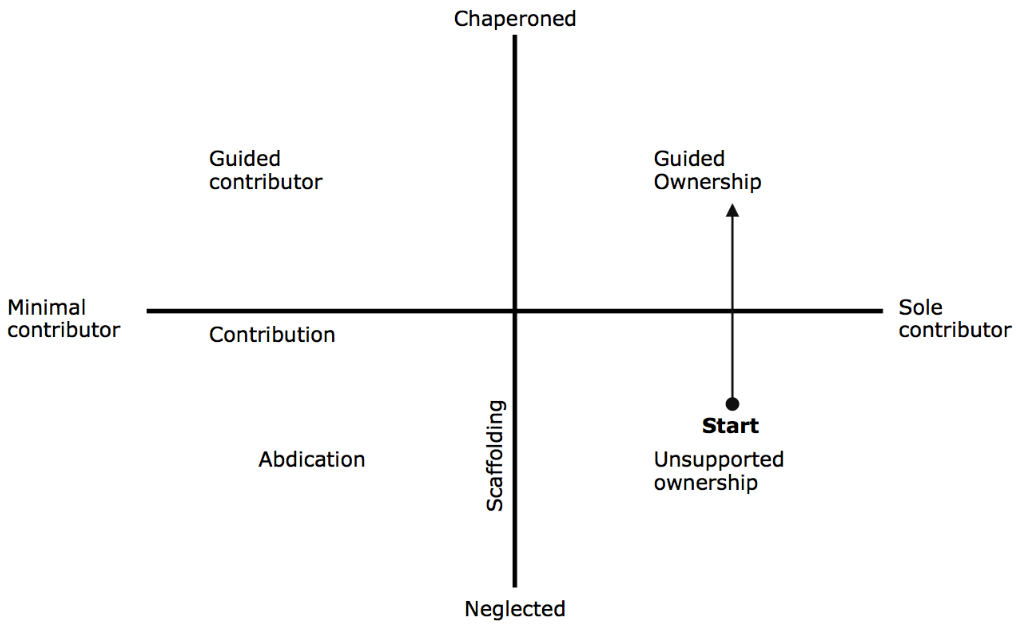


Figure 63. Participant 01 contribution – scaffolding positioning diagram.

The *Scaffolding* axis consists of the PPA (Little et al. 2007) dimensions *Autonomy, Control, Other's View, Outcome/Likelihood of Success, Support* and *Visibility.* The dimensions *Control* and *Outcome/Likelihood of Success* were discussed during explanation of figure 36. *Autonomy* indicated a decrease, beginning with a score of 10, and then steadily reducing first to a score of seven and then to a score of five. *Other's View* rose slightly from the initial measurement to installation of the system, beginning with a rating of four and moving to a rating of six. This dimension remained flat at a value of six between the second and third measure. *Support* demonstrated a similar pattern to *Control* and *Progression,* starting with the rating of 10, dropping sharply to a rating of three at the time of system installation and then rising back up sharply to a rating of eight at the completion of the field test. *Visibility* also remained relatively flat across the three measures, beginning with a rating of eight and then dropping slightly to a rating of six for both the second and third measures.

The *Contribution* axis consists of the PPA (Little et al. 2007) dimensions *Control, Progress, Support* and *Uncertainty.* All dimensional dynamics associated with this axis were discussed during explanations of the *Capability, Project Plan* and *Scaffolding* axes.

The reduction in *Autonomy,* combined with the increase in *Support* suggests a sense of guidance, while increases in *Control* and *Progress* suggested in increase in ownership.

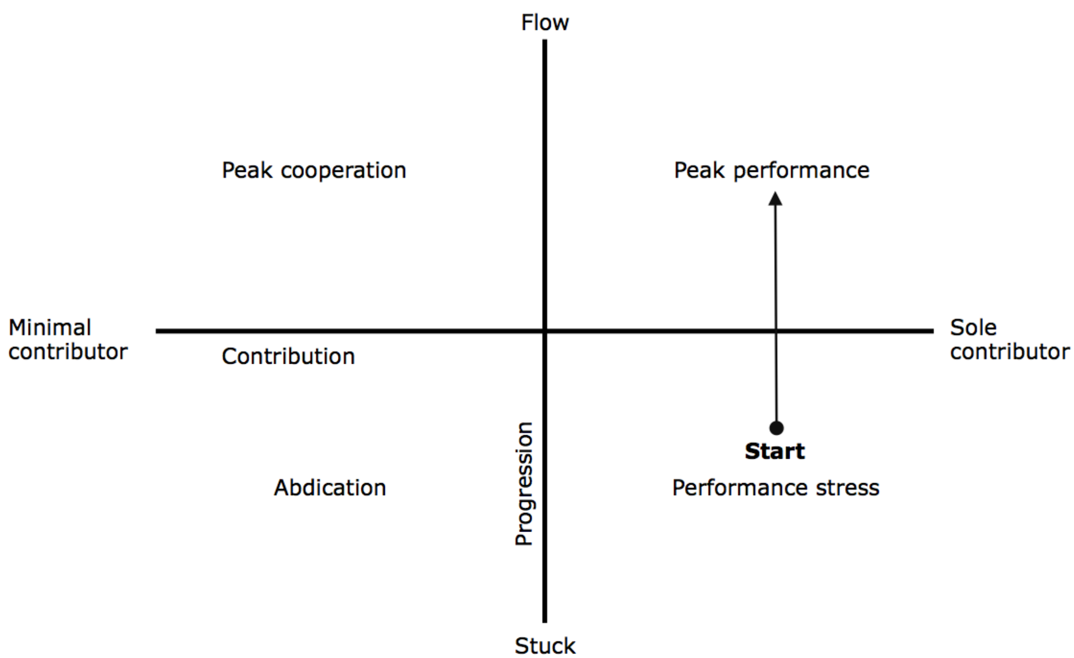


Figure 64. Participant 01 contribution – progression positioning diagram.

Discussion of figure 63, articulated the *Contribution* axis, which consists of the PPA (Little et al. 2007) dimensions *Control, Progress, Support* and *Uncertainty.* The *Progression* axis consists of the PPA (Little et al. 2007) dimensions *Control, Progress, Outcome/Likelihood of Success* and *Uncertainty*, all of these dimensions of which have been previously discussed. The dynamics of all dimensions associated with these axes demonstrate increases in values. With the exception of the

Uncertainty dimension, increases in all other dimensions suggest movement towards peek performance. While *Uncertainty* increases, the maximum value remains small, which suggests that Participant 01 remains relatively confident in her understanding of the project and how to complete it.

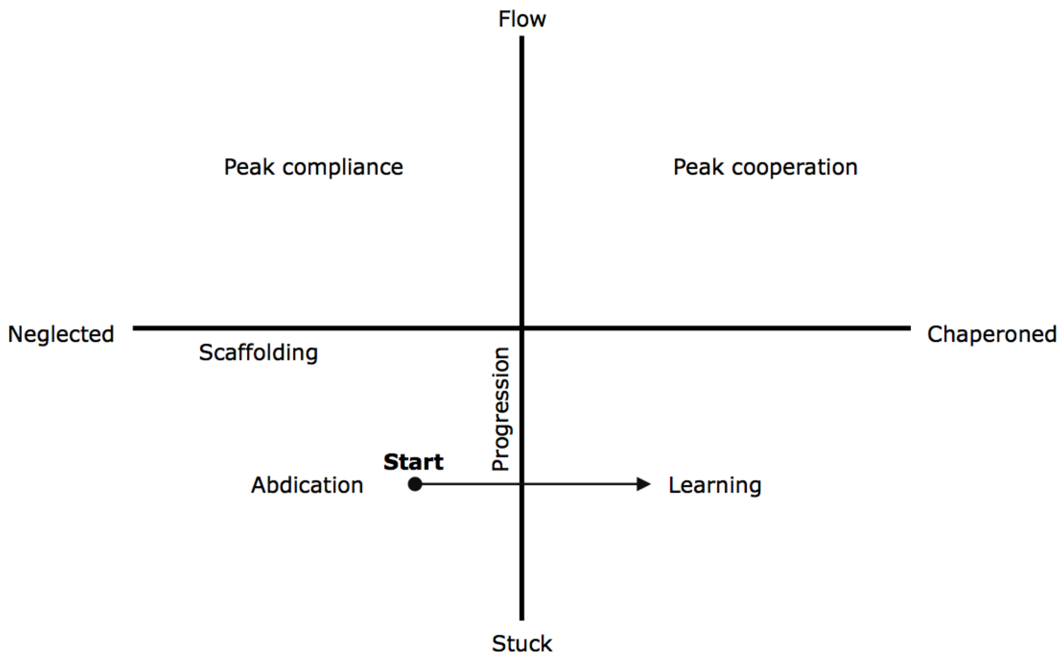


Figure 65. Participant 01 scaffolding – progression positioning diagram.

Discussion of Figures 41 and 42 articulated the *Scaffolding* and *Progression* Axes, respectively. Between both axes, the PPA (Little et al. 2007) dimensions *Autonomy, Control, Other's View, Outcome/Likelihood of Success, Progress, Support*, *Uncertainty* and *Visibility.* The previously discussed changes across these dimensions suggest an increase in scaffolding and increase in effort directed at the project, which, in turn, suggest that Participant 01 has resumed the project and is learning how to play "Blackbird" to approach *Peek Compliance*. System logs indicating that Participant 01 completed three practice sessions over the one-week field test further support this movement towards *Peak Compliance*.

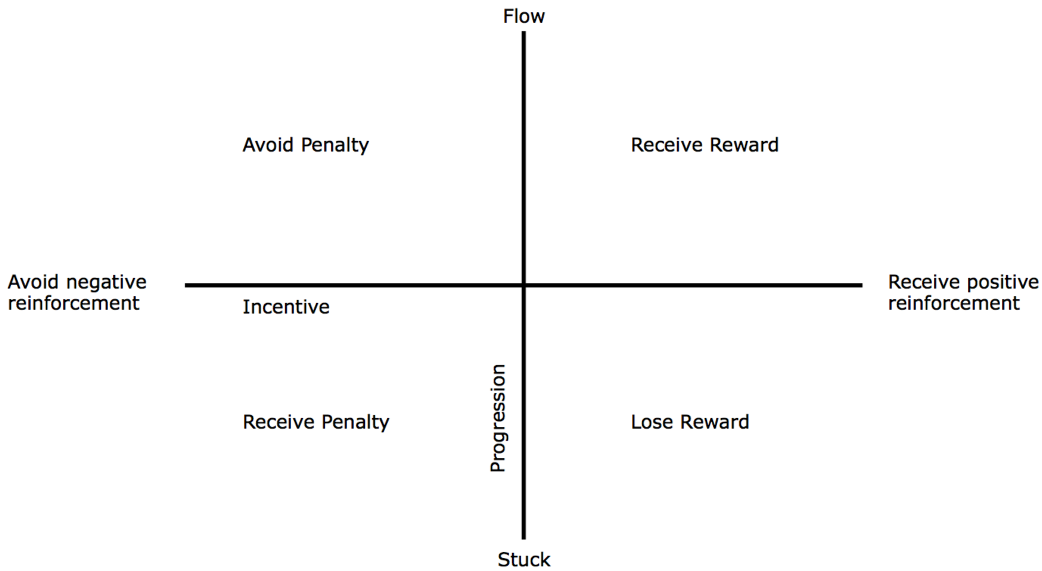


Figure 66. Participant 01 incentive – progression positioning diagram.

Participant 01 perceived learning to play “Blackbird” on her guitar as a hobby. As such this project lacked any penalty for remaining unaccomplished. Conversely, since Participant 01 viewed this project as a leisurely activity, she perceived engagement in the project as reward in itself. From an incentives perspective, there is neither an avoidance of a punishment, or a reception of a reward perceived by Participant 01. Thus, figure 66 does not indicate directionality.

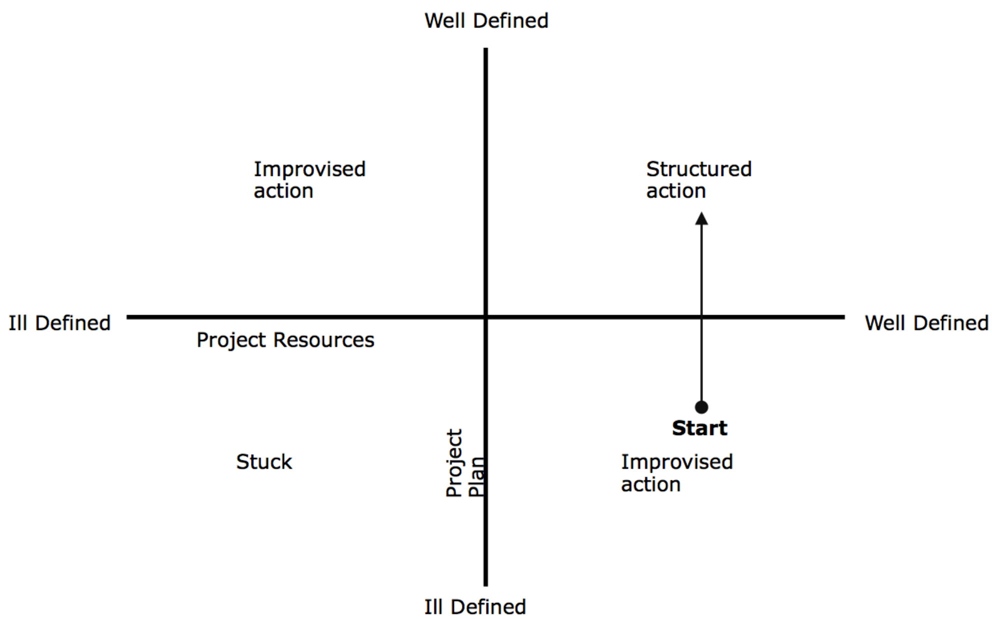


Figure 67. Participant 01 project resources – project plan positioning diagram.

The *Project Plan* axis was previously defined by its PPA (Little et al. 2007) dimensions during discussion of figure 62 and suggests that Participant 01 perceives a stronger sense of a plan related to her project with the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) installed. The *Project Resources* axis consists of the PPA (Little et al. 2007) dimensions *Challenge, Control, Difficulty, Outcome/Likelihood of Success, Progress* and *Uncertainty*. Discussion of figure 67 revealed both *Difficulty* and *Challenge* demonstrated sharp declines. Discussion of figure 67 revealed *Control, Outcome/Likelihood of Success* and *Progress* and *Uncertainty* demonstrated increases, with *Uncertainty* remaining mild. This dynamic combination of movement across the *Project Resource* PPA (Little et al. 2007) dimensions indicates the participant perceives an increase in resources directed at the project. The combination of an increase in perception of a plan and increase in perception of applied resources suggests that the participant engages in structured action.

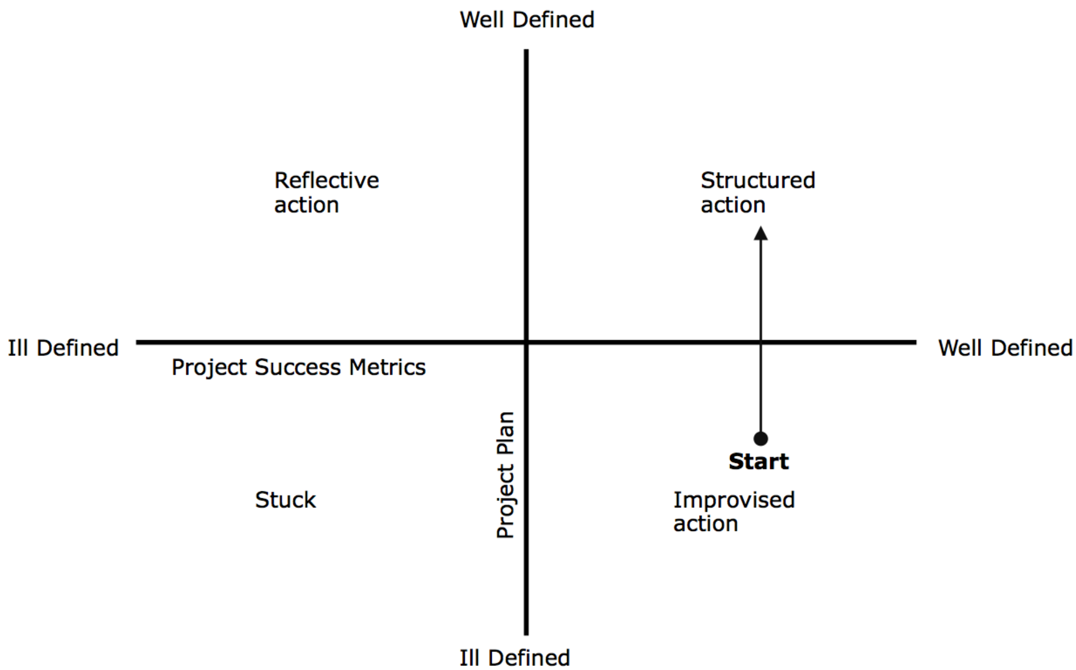


Figure 68. Participant 01 project success metrics – project plan positioning diagram.

The PPA (Little et al. 2007) dimensions *Challenge, Difficulty, Outcome/Likelihood of Success* and *Uncertainty* comprise the *Project Success Metrics* axis. The dynamics of these PPA (Little et al. 2007) dimensions have been discussed during explanations of figure 67. The *Project Plan* axis, and the dynamics of its associated PPA (Little et al. 2007) dimensions have been discussed during explanations of figure 64. The dynamics of the PPA (Little et al. 2007) dimensions further support movement approaching or full engagement in structured action.

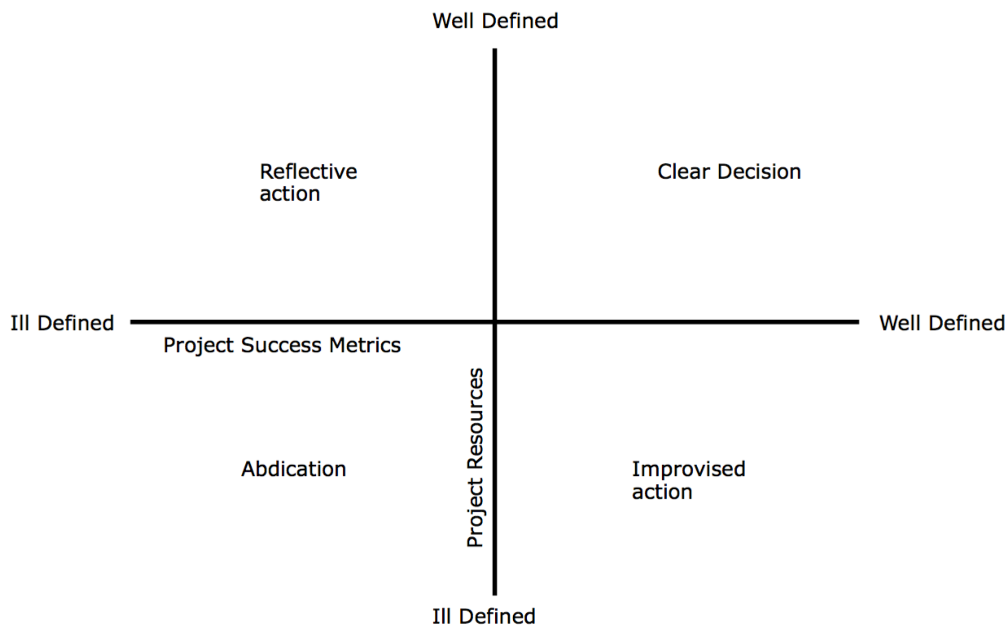


Figure 69. Participant 01 project success metrics – project resources positioning diagram.

Participant 01's decision to engage in the project was resolute from the beginning of her participation in this study. Therefore, no repositioning occurred throughout the course of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) field test.

During her exit interview, Participant 01 stated that she practiced three times during the course of the field test, which was more than she had practiced all of the previous year since starting her internship. She stated that during those practice sessions, she perceived she was getting better at the song. The changes in the axial PPA (Little et al. 2007) dimensions, combined with Participant 01's interview feedback, indicate that the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) succeeded at increasing her focus on the project and made her feel more capable.

Participant 01 also reported that she felt more immersed in the project because the system created multiple points of project engagement throughout her day. Such engagement began with waking up to “Blackbird”, continued with receiving a link to watch a cover of the song at mid-day and then actually practicing the song at night. The final response she reported was that she felt more “pressure” to practice the song because the light shining on her guitar when she returned home from work was exerted a physical presence in her environment and that she knew the only way to turn the light off was to pick up the guitar. This feeling of pressure caused her to create a new PPA (Little et al. 2007) cognitive dimension called *Pressure* on her third and final PCSoP measurement.

During the course of the motivational heuristics study, three models predicting Place attachment, Place Identity and Place Dependency utilizing combinations of PPA (Little et al. 2007) dimensions emerged. Together, these models calculate a participant’s SoP (Jorgensen & Stedman 2001; 2006) related to a personal project (Little 1987; Little et al. 2007), as well as the environmental congruency (Stokols 1977) related to a personal project (Little 1987; Little et al. 2007). These models are:

- Home Attachment = β_0 + (β_1)Fearful + (β_2)Value Congruency
- Home Identity = β_0 + (β_1)Positive Affect + (β_2)Value Congruency + (β_3)Self Identity + (β_4)Autonomy
- Home Dependency = β_0 + (β_1)Difficulty + (β_2)Likelihood of Success

Regression analysis conducted during the motivational heuristics study yielded a set of coefficients. The models with these coefficients applied are as follows:

- Home Attachment = 3.768 + (-.123)FEAR + (.135)Value Congruency

- Home Identity = 2.561 + (.190)Positive Affect + (.242)Value Congruency + (-.094)Self Identity + (.022)Autonomy
- Home Dependency = 7.663 + (-.192)Difficulty + (-.206)Likelihood of Success

Values for each PPA (Little et al. 2007) model dimension were inputted into the models to for each of the three rounds of observations (i.e. Initial completion of the PCSoP survey, PCSoP analysis of the project at installation of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) and PCSoP of the project after completing a one-week field test of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). Figure 70 illustrates changes in these values across the three observations.

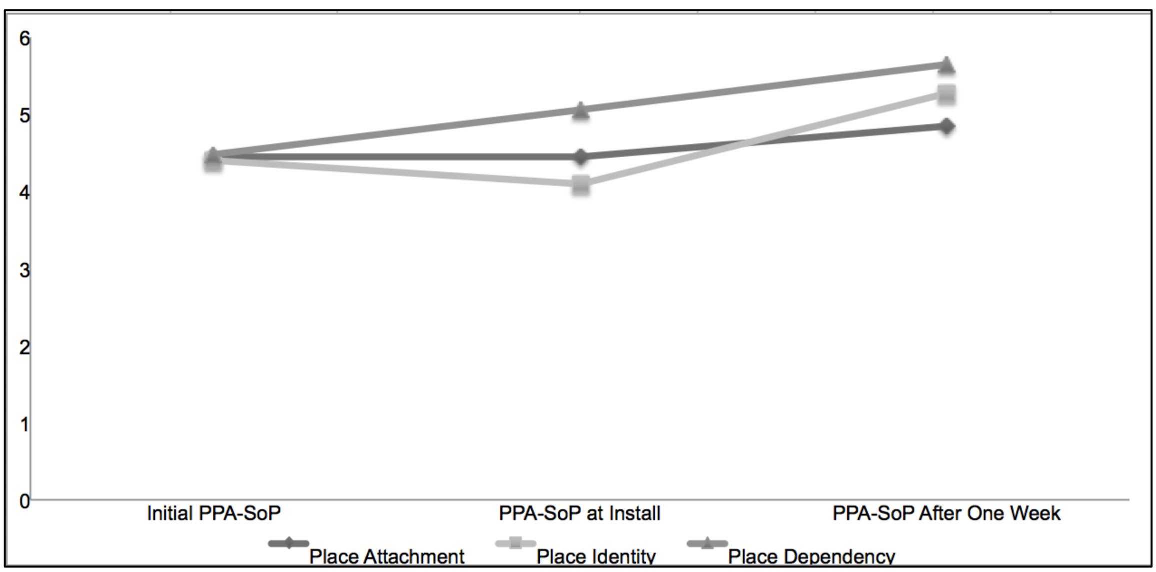


Figure 70. Participant 01 Repeated measures of PPA-SoP factors.

Figure 69 indicates that the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) increased Participant 01’s SoP (Jorgensen & Stedman 2001; 2006) and perceived environmental congruency for learning to play “Blackbird” on her guitar. The escalation, however, is minor, ranging between one and one-and-a-half points on a zero to 10 measurement scale. The results from chapter eight suggest that the personal projects (Little 1987; Little et al. 2007) of young adults possess weak associations with their homes. This small increase is consistent with this finding.

The following section explores a second case study on a SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) supporting the leisurely activities of a young woman. However, whereas this section summarized the case of a participant who desired to set leisure time aside, this second case has no issue setting such time aside. Instead, she desires to repurpose of leisure time from online pursuits to real-world pursuits.

Case Study Two: Spend Less Time Online

Participant 17 chose to design a SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) to assist her in spending less time online during her evenings at home. The project arose during the PCSoP survey, which provided an opportunity to implement a SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) at the inception of a personal project (Little 1987; Little et al. 2007). Participant 17 felt that she spent too much time online during the evening when she could use that time to pursue other leisurely activities that she felt were move valuable. These activities included experimenting with recipes for cooking vegetables, practicing latte art – which is the drawing patterns into latte foam, completing a collage of Arizona to decorate her home, meeting friends outside of her home, visiting the gym to work out and reading.

However, Participant 17 led a vigorous online life, maintaining two blogs, social networking accounts including Facebook, Linkedin and Twitter and was a self-proclaimed avid “window shopper” on Amazon. She stated that she spent much of her time online simply meandering from website-to-website for hours at a time. During this meandering she loses a perception of time, often spending hours online, until she realizes she has spent her entire evening online and her window of opportunity for pursuing other activities has passed.

The SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) she designed begins with the system recognizing she is at home, that it is evening and that she is sitting either at her desk or on the couch and using her laptop. Participant 17 described this feature set as the notable features that describe her evening online behavior. Upon determining that Participant 17 is online, the system notifies her that she has 60 minutes to enjoy her online activities. A second prompt appears on her laptop when she has five minutes remaining to complete any outstanding online activities. At the end of the hour, the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) restricts her access to her blogs, social media sites and online shopping sites.

For the purpose of maintaining a rapid implementation timeline, the capability to restrict the participant’s access to internet service accounts was role played remotely by a researcher. In order to simulate this capability, the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) sent the researcher an email notification that the participant had reached her one-hour time allotment for accessing the previously identified web services. In response, the researcher would manually change the passwords to all of the participant's accounts, effectively restricting her access to those accounts. Rapid implementation of the system was deemed a priority over fully developing all SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) system capabilities based on previous literature showing that a person's project ecosystem can change at any given moment, with a participant either adding, deleting or augmenting personal project (Little 1987; Little et al. 2007) at will (Little et al. 2007). Thus, in order to assure a SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) relevance to a participant, the development team needed to implement the system rapidly.

Prior to beginning the field test, Participant 17 provided her account credentials to these services. To maintain the illusion of a fully functional system, the participant was told the credentials were placed in a system database, where the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) would randomly generate new passwords and change her credentials upon completion of evening 60 minutes of online time.

The SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) then sends Participant 17 a text message prompting her to engage in one of the six, previously described activities. For learning new vegetable recipes, the text message prompts Participant 17 to enter her kitchen and sends texts her a link to recipe website. The SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) recognizes that Participant 17 has engaged in the project when she opens the vegetable crisper in her refrigerator and recognizes that she is cooking by triggering a motion sensor installed on the wall above her cooktop.

For practicing latte art, Participant 17 receives a text message prompting her to go the kitchen. In parallel with the text message prompt, her espresso machine turns on. When she enters her kitchen and approaches the espresso machine, a motion sensor installed on the kitchen wall above the espresso machine recognizes her approach. In order to judge whether or nor the triggering of the motion sensor is a false positive, the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) sets a 10 second timer. When the timer reaches zero, the motion sensor is sampled a second time. If the sensor registers the users presence again, then the espresso machine remains on and ready for use. If the motion sensor registers the participant as absent, then it turns off the espresso machine.

For working on her collage of Arizona, Participant 17 receives a text message to go to the dining room. In a parallel to the text prompt, music from remote audio speakers placed in the dining room stream music from a custom "collage" playlist. The playlist consists of artists that the participant identified as inspiring creative practice during SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) development. The music plays for one hour. The participant has the option to quit the project by pressing a button situated in the dining room that sends a remote signal to the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) to stop playing the music.

For meeting friends outside of the home, the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008;

Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) sends several text messages. First, Participant 17 receives a text message communicating that the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) is contacting a list of her friends on her behalf. The text message indicates her friends' names to identify that the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) is contacting. The SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) then sends an automated text message to each of Participant 17's listed friends asking if they are free to meet somewhere of their choosing. For the purpose of the field test, the system sends a prompt to a researcher, who then role played the part of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) and texted Participant 17's friends using a email-to-texting service. This functionality was role-played in this fashion due to complications with building this system feature and the need to maintain a quick turn around on delivering the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). If friends were available, they responded to the automated text message with place to meet. The SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) recognized if the participant left her home with a sensor that monitored the opening and closing of her front door. When the participant left to meet friends, the sensor captured the door opening and closing and inferred that she left her home.

For working out, the participant received a text message prompting her to go to her bedroom, change into her workout clothes and leave to the gym. The SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) recognized the participant complied with the instructions when she put on her workout shoes. For the purpose of the field test, the participant stored her shoes on top of cloth substrate containing an integrated sensor. This sensor recognized when the participant removed the shoes and inferred that she put them on. This inference, combined with the tracking of exit of the house through the use of the sensor attached to the front door, indicated that the participant left her home to work out.

For reading, the participant received a text message prompt her to find a book and read for 45 minutes. When the 45-minute reading timer reached zero, the system server sent a second text message prompt asking her what book she read and what page she read to. The participant responded back a text message that routed to the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) system server to populate a reading log database.

They system allowed access to the participant's online services at midnight. As with restricting access, a remote researcher role-played this system capability, manually resetting the participant's login credentials to their original state. Figure 71 illustrates the interplay between the participants home space syntax (Hansen & Hillier 1982) and SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) interactions.

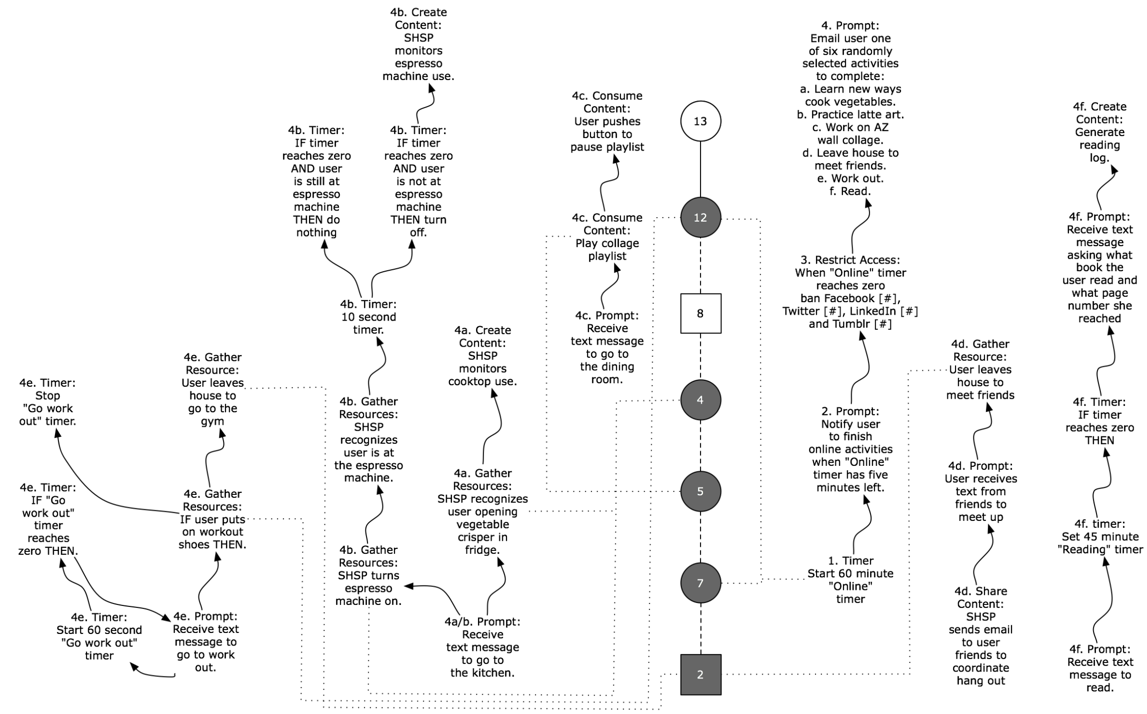


Figure 71. Participant 17 home space syntax (Hansen & Hillier 1982).

During the course of the co-design session, Participant 17 stated that she often did not engage in her many real-world pursuits because by the time she finished her online activities, she was tired and ready to go to bed. This activity pattern supported a cycle of procrastination. One purpose of her SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) was to disrupt this behavior loop. She proposed a two-step process to disrupt her current activity pattern. The first step was limiting her time online. The second step was confronting her with a prompt to engage one of her real-world activities per day. This desired motivational result is illustrated in figure 72 where the arrow representing movement across motivational states starts with Procrastination and ends in Flow (Csikszentmihalyi 2008).

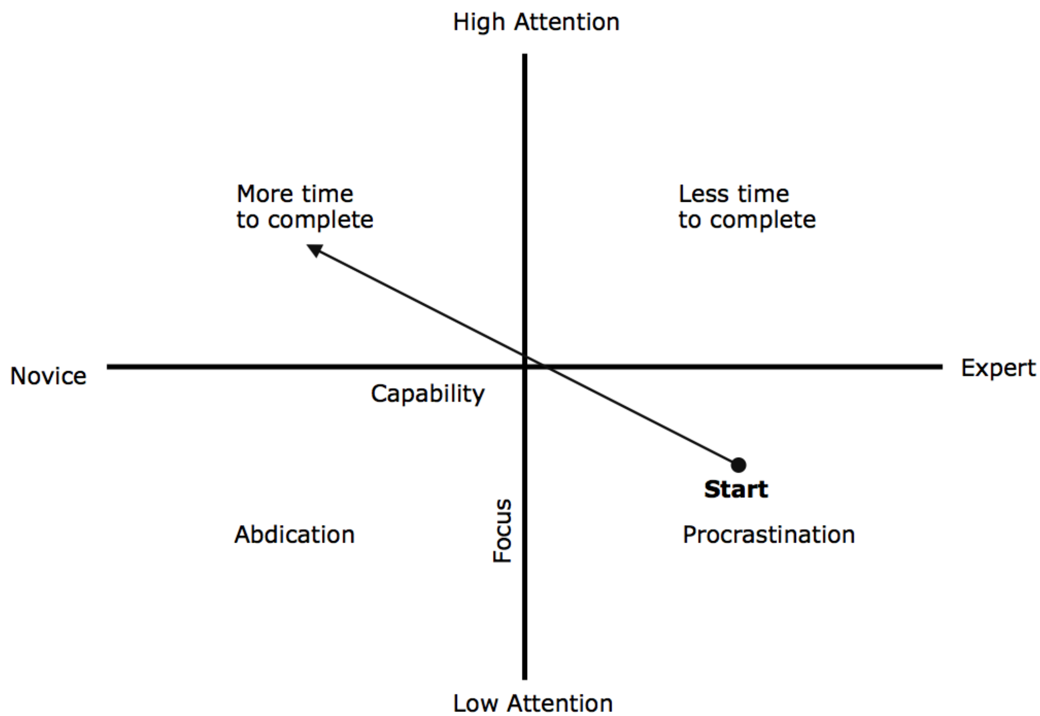


Figure 72. Participant 17 capability – focus positioning diagram.

The *Focus* axis of the positioning diagram consists of the PPA (Little et al. 2007) dimensions *Absorption* and *Difficulty*. The *Capability axis* of the positioning diagram consists of the PPA (Little et al. 2007) dimensions *Challenge, Control*, and *Outcome/Likelihood of Success*.

Participant 17 initially rated *Absorption* as a seven. At the installation of the application, *Absorption* rose to a eight and then rose to a rating of three at the end of the field test. *Difficulty* dropped and then rose back to its original rating, beginning with a rating of three, falling slightly to a rating of one at the time of system installation and then returning to a value of three by the end of the field test. *Challenge* maintained a flat rating score of three across all measures. *Control* and *Outcome/Likelihood of Success* also maintained flat scores of 10 across all three measures.

During the course of the co-design session, Participant 17 stated that she would often start one of her real-world projects, only to become distracted by online activities. She stated that she wanted to instill a sense of consistency in the aforementioned real-world activities in order to feel like she was either improving on acquiring desired skills, completing creative works and maintaining a healthy social life. Figure 73 illustrates her desire to transition from sporadic engagement towards purposeful engagement.

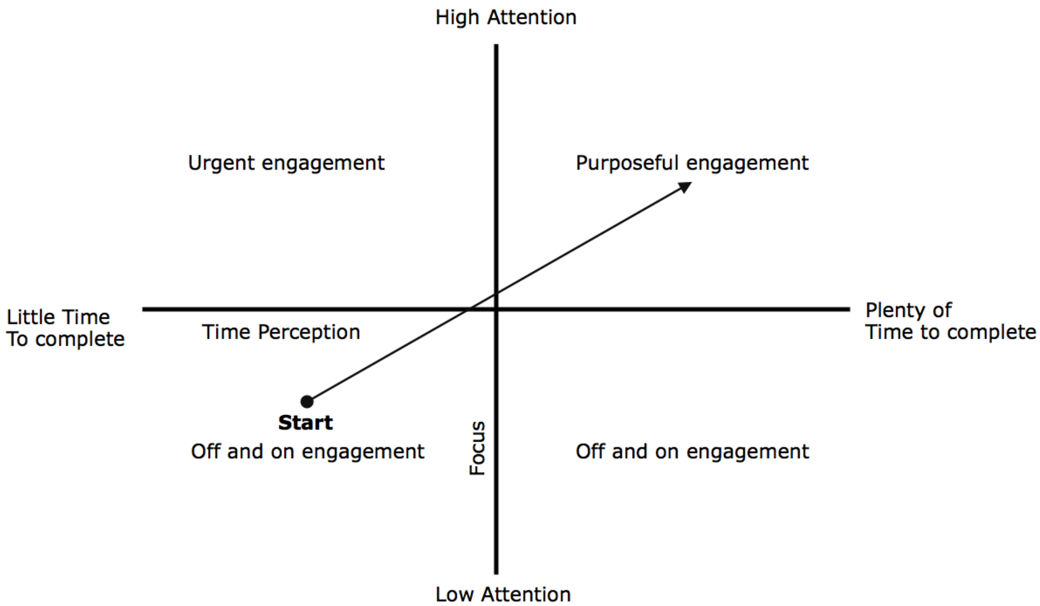


Figure 73. Participant 17 time perception – focus positioning diagram.

The *Time Perception* axis of the positioning diagram consists of the PPA (Little et al. 2007) dimensions *Absorption, Depressed*, and *Difficulty*. The dimensions *Absorption* and *Difficulty* were discussed during explanations of figures 60. The PPA (Little et al. 2007) dimension *Depressed* maintained a consistent score of zero. The increase in *Absorption* as well as the degrees in *Difficulty* and the consistent absence of *Depression* across the three PPA (Little et al. 2007) measures indicates movement towards *Purposeful engagement*.

One design element that emerged during the co-design session with Participant 17 was the random selection of a daily activity from the initial list of six activities she identified to engage in. This random selection led to a feeling of improvisation because she did not know which activity she would be presented with on any given day. This interaction quality is illustrated in figure 74, with movement from the project's current state of *Procrastination* towards a desired state of *Improvisation.*

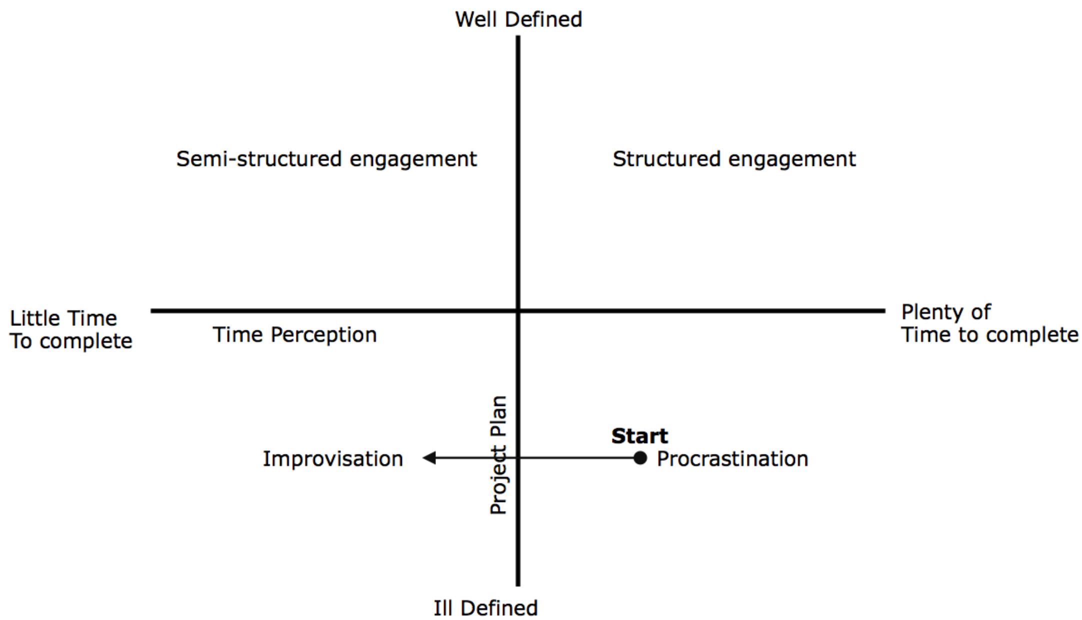


Figure 74. Participant 17 time perception – project plan positioning diagram.

The *Project Plan* axis consists of the PPA (Little et al. 2007) dimensions *Control, Outcome/Likelihood of Success, Progress* and *Uncertainty. Control* and *Outcome/Likelihood of Success* were identical across all measures, yet with a high rating of 10. The *Progress* dimension indicated an increase, beginning with an initial score of one, increasing to a rating of four at the time of application installation and continuing to increase with a rating of six at the end of the one-week field test. *Uncertainty* reduced slightly from the first to second measure from a rating of one to a rating of zero and then increased to a value of two at the conclusion of the field test. The high *Control* and *Outcome/likelihood of Success* combined with an increased perception of *Progress* indicate movement from *Procrastination* towards *Improvisation.*

With the exception of the activity "meet up with friends", the other activities Participant 17 listed as alternatives to spending time online were solitary in nature. The implementation of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) as a disciplinarian that restricts access to her online activity, a provocateur, prompting an engagement in a real-world activity and a provider, delivering support content (recipe websites, music playlists, etc.) during real-world activity engagement scaffold her actions through completion of an activity. The autonomous nature of her activities combined with the additional support provided by the system suggest movement from *Unsupported Ownership* towards *Guided Ownership*, as illustrated in figure 75.

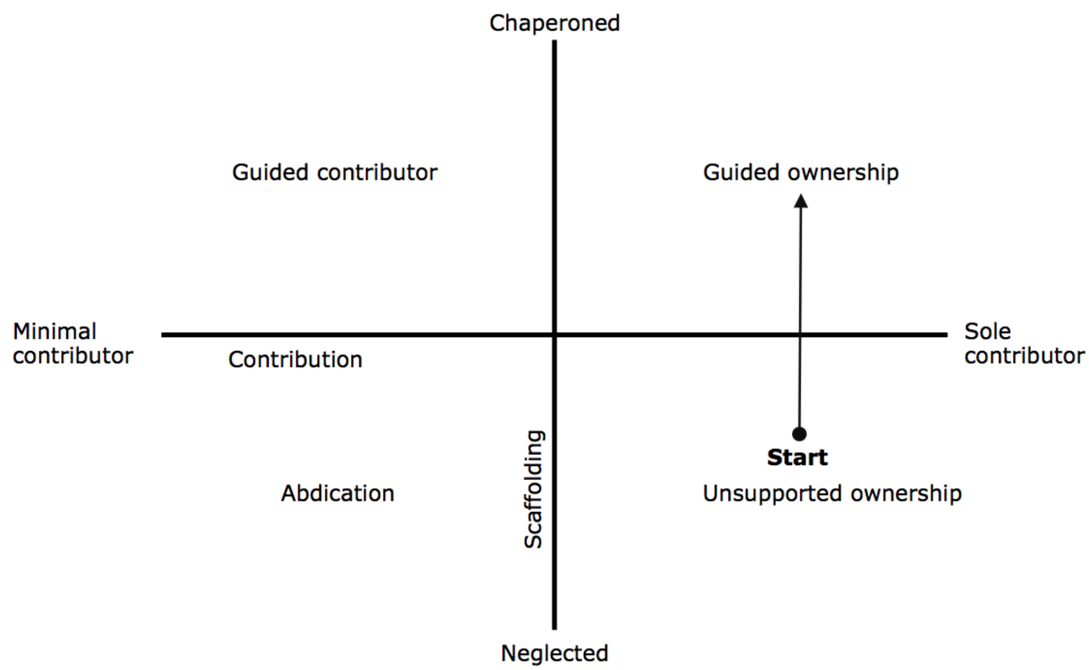


Figure 75. Participant 17 contribution – scaffolding positioning diagram.

The *Scaffolding* axis consists of the PPA (Little et al. 2007) dimensions *Autonomy, Control, Other's View, Outcome/Likelihood of Success, Support* and *Visibility.* The dimensions *Control* and *Outcome/Likelihood of Success* were discussed during explanation of figure 74. The *Autonomy* dimension rating remained static with a value of 10 across all three measures. The *Other's View* dimension rating also remained static with a value of zero across all three measures. *Support* increased consistently across all three measurement samples, beginning with a rating value of two, increasing to rating value of five at the time of system install and further increasing to value of six at the end of the field test. Participant 17 further corroborated her perceived increase in *Support* during her exit interview when she stated that the system felt, "-like a roommate constantly telling me to get out from behind my computer and be active. I think having someone else, or some*thing* else - other than my own free will was really powerful in helping me spend less time online." *Visibility* dimension ratings first reduced in value and then increased. During the initial PCSoP survey completion, the participant reported a rating of five. During the second measure at the time of system install, the participant reported a one. The third measure of *Visibility* increased to a value of three.

The static ratings of *Autonomy* and *Control* at 10 indicate that the participant accepts total ownership of the project. The static ratings of *Other's View* at zero, combined with the reduction in *Visibility* suggest that Participant 17 views this project as a private one with regards to interacting with other people. However, the increase of the *Support* suggests that the system is providing scaffolding, facilitating *Guided Ownership*.

Participant 17 conceptualized this project at the start of this study during completion of the initial PCSoP survey. Since she has no previous experience engaging in this project, it is positioned as *Abdication* as the starting point in figure 76. As previously mentioned during discussion of figure 75, five out of six of her desired activities are autonomous. As the sole contributor to these activities, she seeks to enter a Flow (Csikzentmihalyi 2008) state and perform at her peek capacity. Figure 76 illustrates the desire to move from *Abdication* to *Peek Performance*.

Discussion of figure 75 articulated the *Contribution* axis, which consists of the PPA (Little et al. 2007) dimensions *Control, Progress, Support* and *Uncertainty.* The *Progression* axis consists of the PPA (Little et al. 2007) dimensions *Control, Progress, Outcome/Likelihood of Success* and *Uncertainty*, all of these dimensions of which have been previously discussed. The increase in ratings pertaining to *Progress* and *Support* in conjunction with the decrease in *Uncertainty* over the course of the three measure samples suggests a perceived increase in *Contribution.* The increase in ratings pertaining to *Progress* combined with the decline of ratings pertaining to *Uncertainty* over the course of the three measurement samples suggests *Progression* towards project completion. The indicators imply movement towards *Peek Performance.*

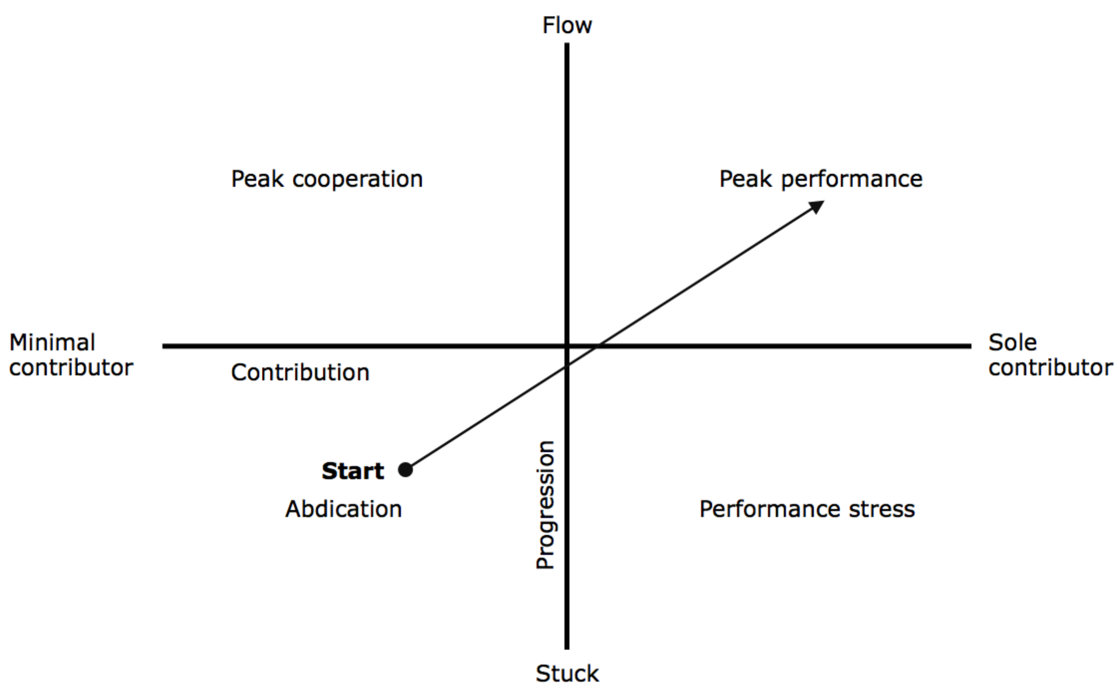


Figure 76. Participant 17 contribution – progression positioning diagram.

Discussion of figures 75 and 77 previously articulated the *Contribution* and *Progression* Axes, respectively. Between both axes, the PPA (Little et al. 2007) dimensions *Autonomy, Control, Other's View, Outcome/Likelihood of Success, Progress, Support*, *Uncertainty* and *Visibility.* The previously discussed changes across these dimensions suggest an increase in scaffolding and increase in effort directed at the project, which, in turn, suggest that Participant 17 has minimized her evening online activity to engage in her desired real-world activities to approach *Peek Compliance*. The dynamics of ratings, combined with exit interview commentary where Participant 17 stated she progressed on a one of her activities every day, provides additional support of the movement towards *Peek Compliance.*

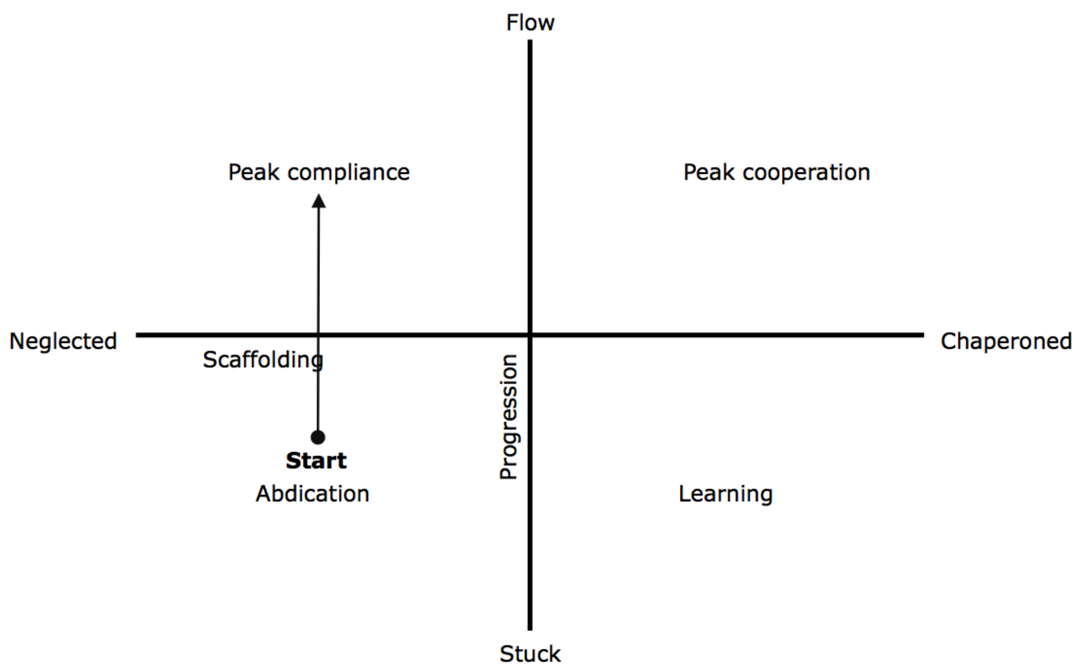


Figure 77. Participant 17 scaffolding – progression positioning diagram.

Participant 17 perceived spending less time online as a means of focusing her efforts on more meaningful, real-world leisurely activities. As with Participant 01's desire to learn "Blackbird" on her guitar, which was also a leisurely activity, the pursuits of Participant 17's project lack both a penalty or reward for accomplishing the project. Thus, figure 78 does not indicate directionality.

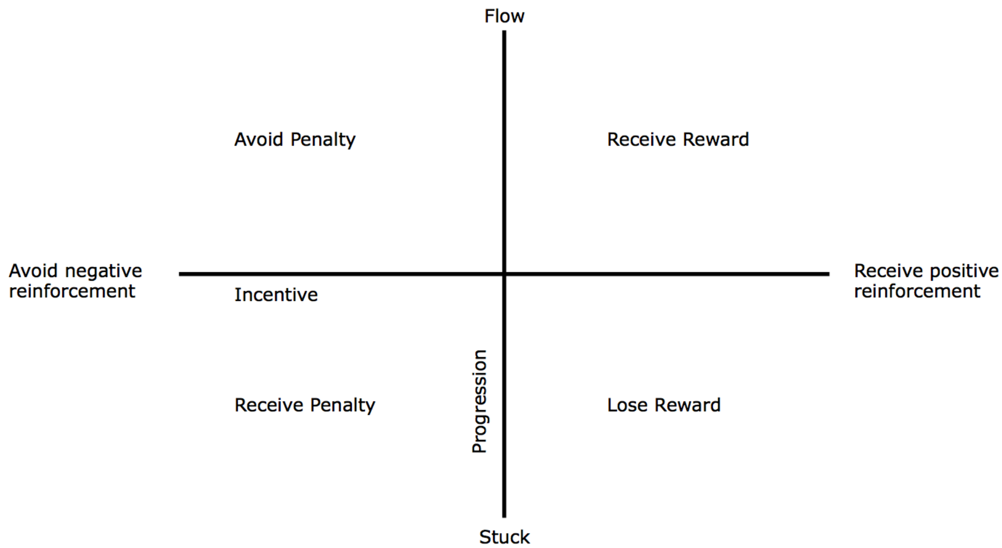


Figure 78. Participant 17 incentive – progression positioning diagram.

During Participant 17's co-design session, the infancy of the project led her to realize that she needed to device a plan for accomplishing her goal and that the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) could support her plan. In contrast, both her online activities and the physical activities were older pursuits of which she understood the resources she possessed to accomplish each objective. The lack of plan, combined with an understanding of available resources generated improvised actions. She reported these actions as typified by a sudden realization that she had spent too much time online, which was either followed by procrastination regarding her real-world projects or improvised, urgent action to try and accomplish something in what little time she perceived she had left in the day. The participant desired the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) to transition her behavior into a *Structured Action* through limiting her time on line, prompting an alternative activity and monitoring the activity's progress. Figure 79 illustrates this desired transition.

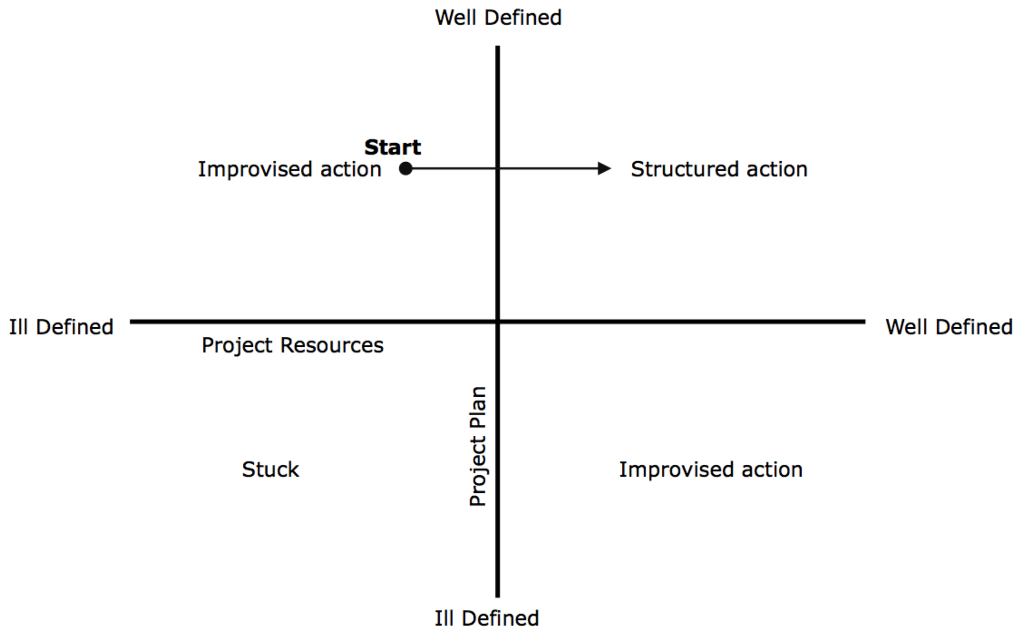


Figure 79. Participant 17 project resources – project plan positioning diagram.

The *Project Plan* axis was previously defined by its PPA (Little et al. 2007) dimensions during discussion of figure 74, suggesting that Participant 17 perceives a stronger sense of a plan related to her project with the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) installed. The *Project Resources* axis consists of the PPA (Little et al. 2007) dimensions *Challenge, Control, Difficulty, Outcome/Likelihood of Success, Progress* and *Uncertainty*. *Uncertainty, Difficulty* and *Challenge* demonstrated relatively static ratings across samples. Values for these three dimensions remained low. *Control, Outcome/Likelihood of Success* also remained static across sampling, but with high value ratings. *Progress* increased sharply. The static, yet low values attributed to negative indicators (*Uncertainty, Difficulty* and *Challenge)* combined with the static, yet high values of positive indicators (*Control* and *Outcome/Likelihood of Success)* and the increase in the positive indicator *Progression* suggest that Participant 17 had a strong understanding of what resources were available to her, and with the assistance of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), was able to more towards accomplishing her goal.

While figure 79, describes Participant 17's desire to structure her newly formed personal project (Little 1987; Little et al. 2007) within an action plan, figure 80 appears to contradict this need by demonstrating a desire to move from *Reflective Action* towards *Improvised Action.*

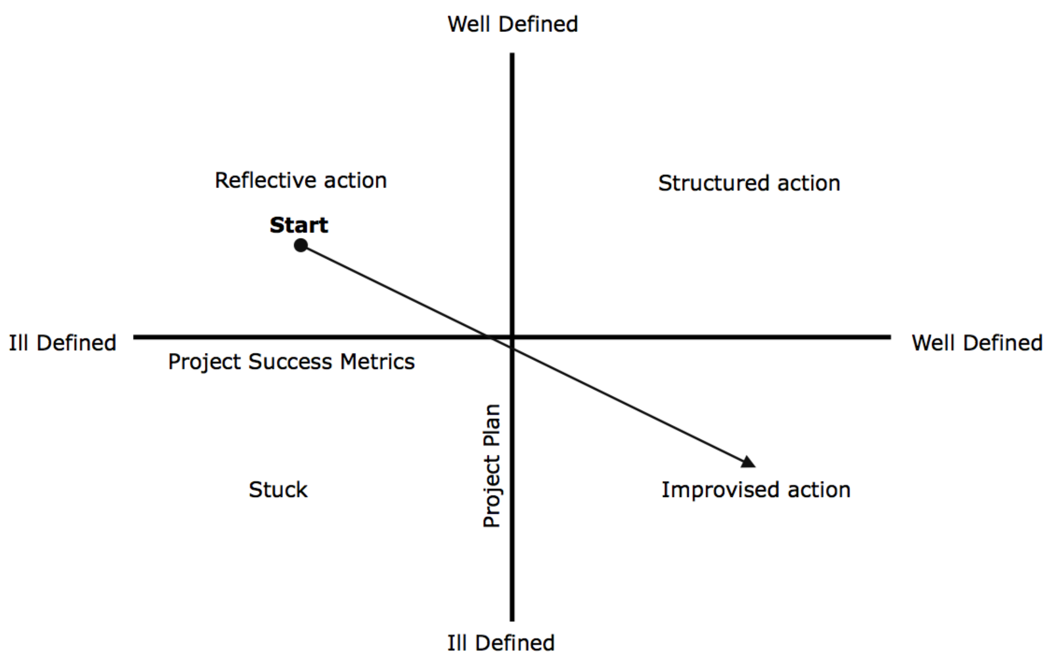


Figure 80. Participant 17 project success metrics – project plan positioning diagram. During her co-design session, Participant 17 discussed her habit to reflect on the current state of the real-world leisurely pursuits, yet would often not act to continue those pursuits after reflection and continue to spend time online. In addition to this admission, she stated that she desired consistent interaction with her real-world leisurely pursuits, yet wanted that consistence embellished with a feeling of newness. In response to this tension, Participant 17 designed her SHSP (Abowd et al.

2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) to select one of her real-world leisurely activities at random. She proposed that the uncertainty associated with which activity the system would present her with would create a sense of urgency and improvisation. In this manner, she structures her actions by eliciting daily engagement, while affording improvisation regarding which project she engages in on a daily basis which, in turn, shift what her given metric of success is on a day-to-day basis.

The PPA (Little et al. 2007) dimensions *Challenge, Difficulty, Outcome/Likelihood of Success* and *Uncertainty* comprise the *Project Success Metrics* axis. The dynamics of these PPA (Little et al. 2007) dimensions have been discussed during explanations of figure 79. The *Project Plan* axis, and the dynamics of its associated PPA (Little et al. 2007) dimensions have been discussed during explanations of figure 74. The dynamics of these dimensions indicate that Participant 17 engaged in consistent, improvised action resulting in an increased understanding of how she defines success on this project.

Indication of her consistent engagement with the personal project (Little 1987; Little et al. 2007) was further supported by the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) log which showed four uses of the system over the course of the one-week field test. An increase in an understanding of what success means to Participant 17 was further supported through her post field test interview commentary.

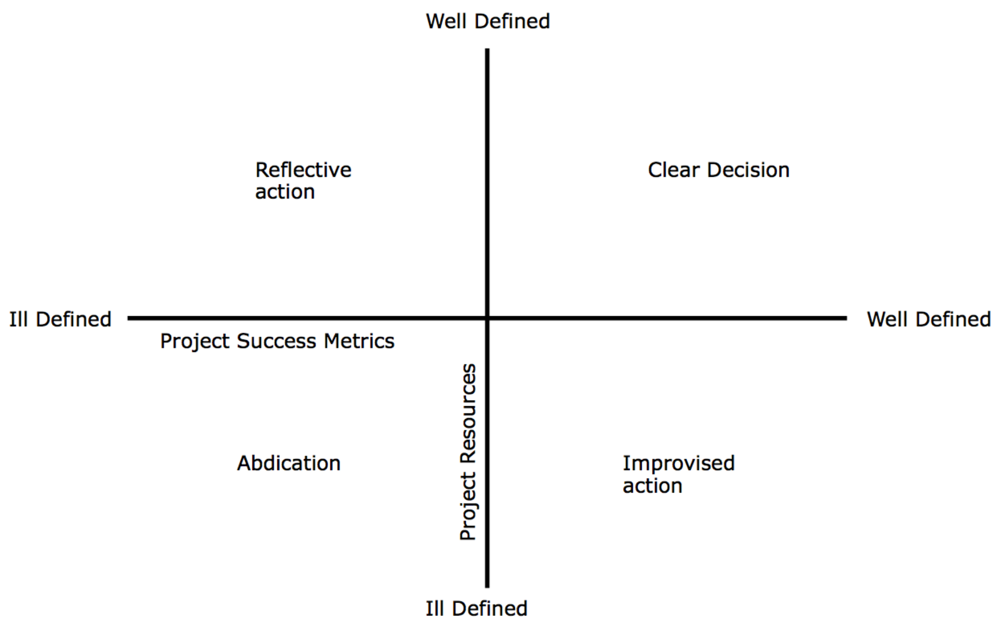


Figure 81. Participant 17 project success metrics – project resources positioning diagram.

Participant 17's decision to engage in the project was resolute from the beginning of her participation in this study. Therefore, no repositioning occurred throughout the course of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) field test.

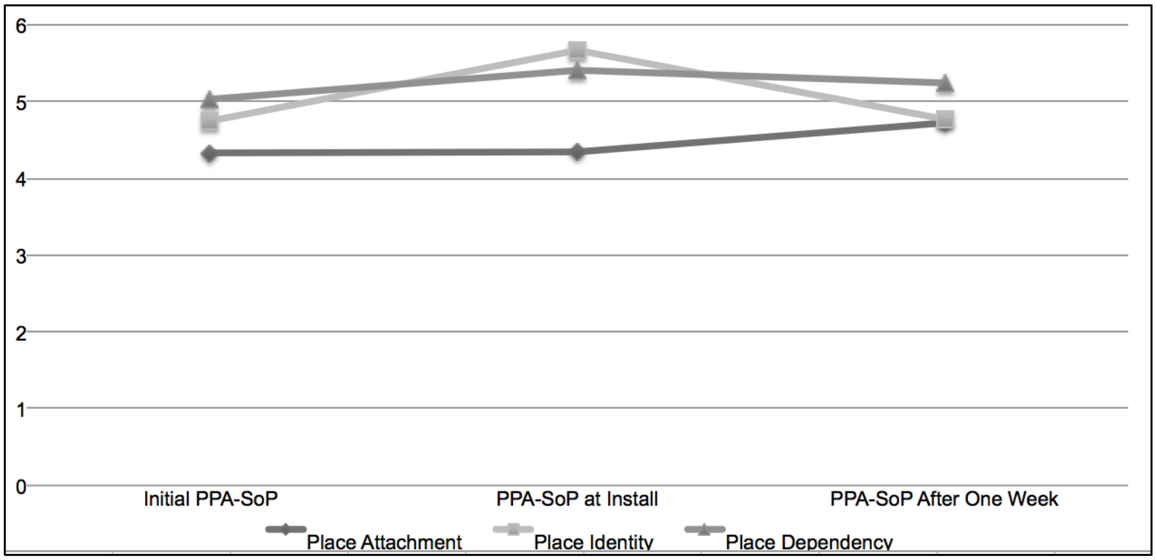


Figure 82. Participant 17 Repeated measures of PPA-SoP factors.

The following section explores a third and final case study on the motivational home. While the previous two case studies described instances of young women applying SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) to leisurely activities, the following case explores the role of a SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) on an academic project that has deep, personal meaning and is in crisis of collapse.

Case Study Three: Write my Autobiography

Participant 20 chose to design a SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) that supports her effort to complete an autobiography. The project began in the fall semester of 2012 as an assignment for one of her courses. However, as she began to pen her personal story, the assignment took on a life of it's own, becoming deeply meaningful to her. This increase in meaning led to a need to make her story perfect, which led to writer's block and incompletion of the assignment. Her instructor gave her an extension on the assignment and she continues to struggle with completing her story. During Participant 20's co-design session, she stated, "I know I should just scribble something down and turn it in and then I can just continue to work on it to perfect it afterwards, but this story is about me, and I've gone through a lot really shitty things and made it through and I'm proud of that. I want what I turn in to reflect all of that stuff, because it what makes me, me."

As with Participant 01, Participant 20 stated that she had an problem with structuring her a time in a manner that allowed her to make consistent gains on writing her autobiography. Additionally, she often preferred to write in public venues, such as coffee shops, because her home was a distraction. The one exception to feeling distracted was in the morning because her roommates were either still asleep or away from home. Participant 20 reported a number of general interests, including extreme sports, electronic music and comedy movies.

In response to these insights regarding Participant 20's chosen project and her life style, she designed a SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) that accounted for both her in-home and away-from-home writing preferences, her need to structure consistent writing time on a daily basis and her media preferences. The SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) consists of two scenarios. One scenario takes place on Friday through Monday Mornings, while the other takes place on Tuesday through Thursday evenings. The Friday through Monday morning scenario begins when she wakes up at 10:00 AM. (11:00 AM on Sundays). At the time her alarm clock wakes her, the system sets a 60-minute timer, allotting her time to complete her morning routine.

When the timer reaches zero, the song "Elephants and Ivory (Vanilla Instrumental Remix)" by the group *Les Loups* plays from a GaLLaG (Burleson et al. 2009) server laptop located in her bedroom. In parallel to the song playing, her desk lamp turns on to prompt her to sit down and a 20-minute timer to sit down to write. The song repeated until the 20-minute timer reached zero. If the timer reached zero, then as a consequence for not complying with the system, the participant's Facebook access was banned for 24 hours.

A digital pressure sensor integrated into an additional seat cushion was installed on her desk chair. Sitting at her desk causes the 20-minute timer to stop and the song to cease play. A second 60-minute timer begins with the intent that the participant sits at her desk and writes for one hour. Once the timer reaches zero, her desk lamp turns off to notify her that she has completed her writing for the day. As a reward, she then receives an email with a link to an extreme sports video.

If the participant leaves her chair prior to the timer reaching zero, then the system assumes she needs a break and will return to the chair. In response to this assumption, the system pauses the 60-minute timer, and starts a new, 15-minute timer to time her break. If the 15-minute timer reaches zero, then the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) bans her Facebook for 24 hours. If she returns to sit down at her desk chair prior to the 15-minute timer reaches zero, then the timer stops and resets and the 60-minute "writing" timer resumes.

On Tuesday through Thursday evenings, the writing scenario transitions to scaffold writing away from home. Upon returning home for the evening, the system recognizes her arrival by first registering a state change on a sensor attached to her front door. The system verifies her return home, as opposed to one of her roommates, by pulling GPS data from her mobile phone and comparing the coordinate data against her home's coordinates. Once her presence is verified, the system sends her a text message asking her to press one of two buttons installed on her front entry wall and starts a 10-minute timer. If she fails to press either button before the timer reaches zero then the system bans her Facebook access for 24 hours. Pressing either of the buttons causes the timer to stop and reset for the next day.

Pressing one button indicates she has already completed her writing for the day and will generate a second email with a link to an extreme sports video. Pressing the other button indicates she has yet to write that day and starts a 40-minute timer to allow her to eat dinner, relax or attend to any other activities. Once the timer reaches zero, audio clips from the movie *Step Brothers* plays from the GaLLaG (Burleson et al. 2009) laptop and she receives a text message with the name and address of a coffee shop within a one-mile radius of her home. A 60-minute timer begins to allot her ample time for travel.

Upon arriving at the coffee shop, she needs to check in with the SHSP by starting a GaLLaG (Burleson et al. 2009) mobile phone application that pulls GPS data from her phone while away from home. If GPS coordinate data collected from the mobile phone matches the GPS coordinate data associated with the coffee shop, then the system registers as "checked-in" and a 60-minute writing timer begins. If she does not arrive at the coffee shop prior to the "travel" timer reaches zero, or the GPS coordinates on her phone due not match those of the location, then the system bans her Facebook access for 24 hours.

When the 60-minute "writing" timer reaches zero, her SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) sends her a text message letting her know she has completed her writing time for the day and provides a link to an extreme sports video. If she leaves the writing location prior to the "writing" timer reaching zero, then the system pauses the timer and generates a 15 minute timer, assuming that she needs to take a respite from writing. If the timer reaches zero, then the system bans her Facebook access for 24 hours. If she returns to the writing location prior to the 15 minute timer reaches zero, then the timer stops and resets and the "writing" timer resumes. Figure 83 visually illustrates the relationship between Participant 20's home space syntax (Hansen & Hillier 1982) and SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) interaction flow.

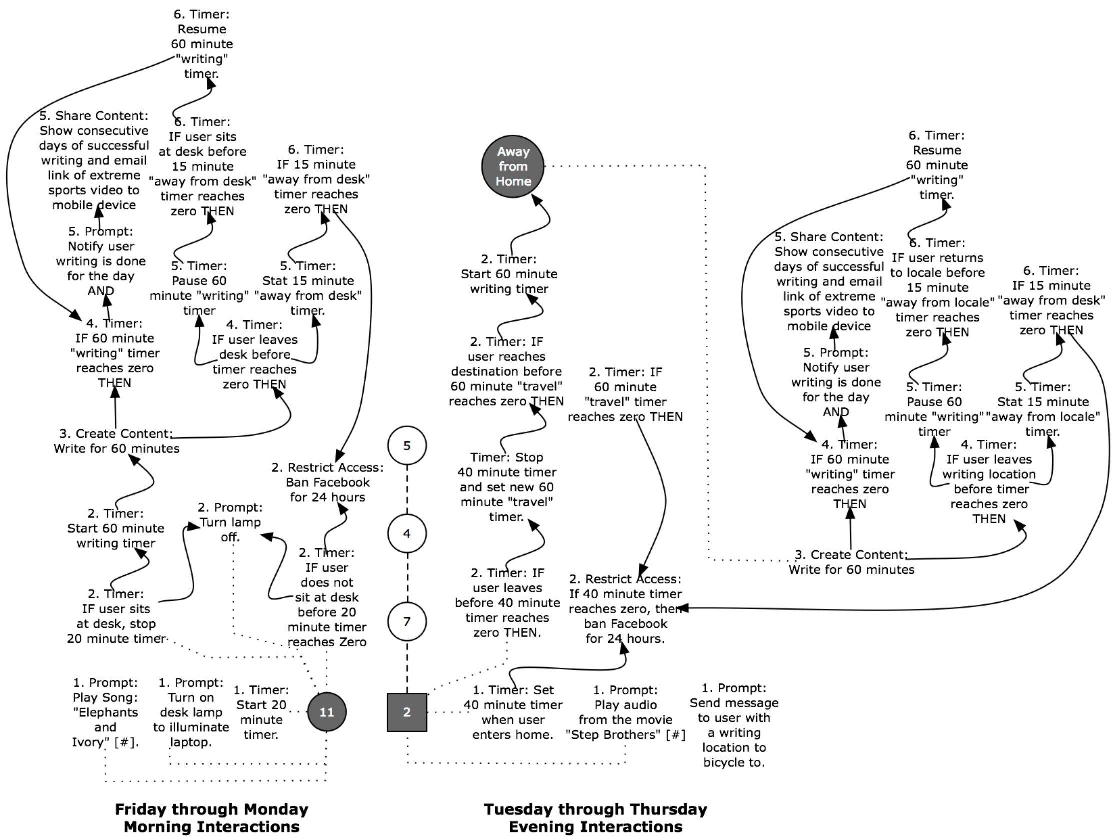


Figure 83. Participant 20 home space syntax (Hansen & Hillier 1982).

Unlike the other two participants, whom field-tested their respective SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) for one week, Participant 20 field-tested her SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) two weeks. This extension of testing was allowed for two reasons. First, the participant requested to continue using the system after the initial first week of testing and data collection was completed. Second, the participant only complied with the system on the first day of implementation, resulting in little progress towards completing her autobiography. Prior to continuing the field test, all data collection protocols associated with ending the field test at the end of one week were completed in order to maintain consistency with the other two case studies. Continuation of the study for the additional week resulted in zero additional instances of compliance with her SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). Participant 20's PCSoP dimension scores, as well as her exit interview responses, reflected this lack of compliance and therefore progression towards completing her autobiography.

During her co-design session, Participant 20 indicated that a major challenge facing her with regards to completing her autobiography was setting time aside to write. Although she designed her SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) to structure her time in a manner that allotted for writing her autobiography, she failed to comply with the system's prompts. These outcomes are reflected in the *Time and Timing* positioning diagrams.

Participant 20 desired perceived herself as an author fully capable of writing a compelling autobiography, stating that what she required was a prompted change in focus, causing her to cease procrastination and allow her to enter a flow state (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). This transition is represented in figure 84.

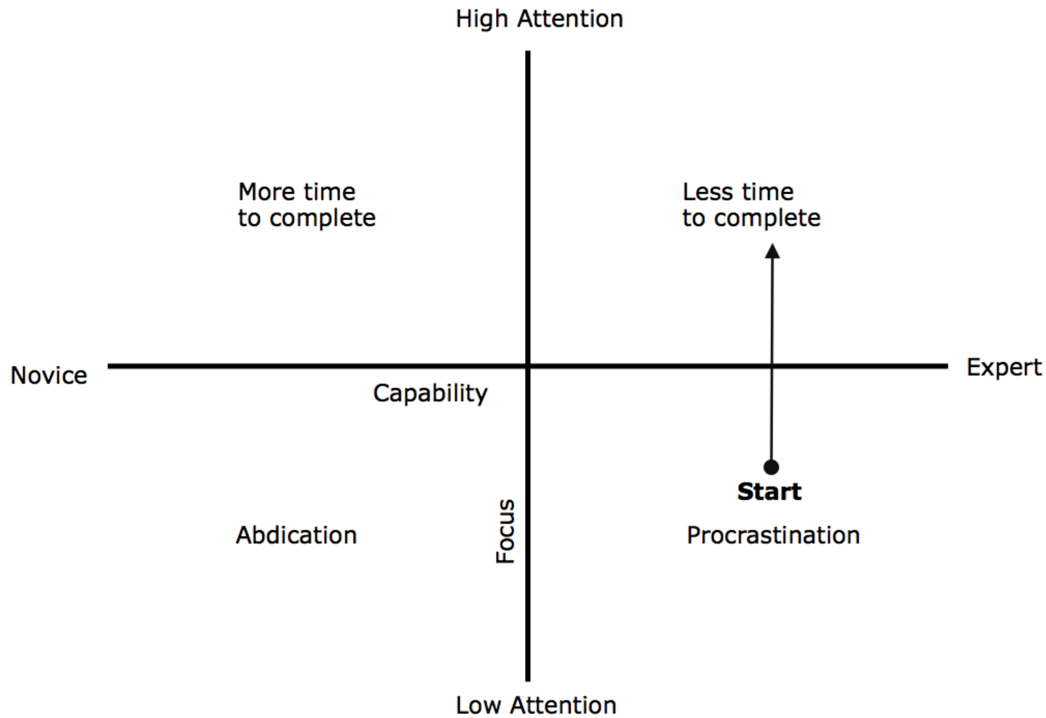


Figure 84. Participant 20 capability – focus positioning diagram.

The *Focus* axis of the positioning diagram consists of the PPA (Little et al. 2007) dimensions *Absorption* and *Difficulty*. The *Capability-axis* of the positioning diagram consists of the PPA (Little et al. 2007) dimensions *Challenge, Control*, and *Outcome/Likelihood of Success*.

Participant 20 initially rated *Absorption* as a 10. At the installation of the application, *Absorption* remained static with a value of 10 and decreased to a rating of six at the end of one week of field-testing. *Difficulty* and *Challenge* remained static with a value of 10 across all three measurements. Control also remained relatively static across all three samples, reporting a value of five for her initial completion of the PCSoP survey and again at the time of system installation and increasing to a value of six after completing one week of field-testing. *Outcome/Likelihood of Success* also maintained static scores of 10 across all three measures. Since she did not comply with the system to change her behavior related to the project, the minimal changes in her PPA (Little et al. 2007) dimensions across samples is expected. The decrease in the values ascribed to the dimension absorption is also expected as she failed to engage with the project for six days, thereby negating opportunities for applying her skills as a writer to enter into a flow state (Csikzentmihalyi 2008).

When describing the current state of her project during the co-design session, Participant 20 reported that she had very little time left to complete the project because the assignment was already late. She also stated that she had not been able to maintain a routine writing schedule, which she desired. These responses led to establishing the need to move from sporadic engagement to urgent engagement, as illustrated in figure 85.

As stated above, PPA (Little et al. 2007) dimensions related to the axis *Focus* suggest that she continued to lack focus at the end of the field test. *Absorption* and *Difficulty,* which also contribute to the *Time Perception* axis, suggest Participant 20 still believed she lacked adequate time to progress on her autobiography. This inference is further supported by a sharp increase in the *Depressed* dimension, which is the remaining PPA (Little et al. 2007) dimensions supporting the *Time Perception* axis. Participant 20's initial value attributed to *Depressed* was three. At the time of system install, Participant 20 rated *Depressed* at four. At the end of the one-week field-test *Depressed* increased to 10. The participant's exit interview qualified the increase in depression related to her project. She states that having the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) installed in her home increased her awareness of the project as well as the actions she needed to take to complete her autobiography and that when she did not comply with the system, it made the project seem more unattainable. Additionally, the restricted access to her

Facebook account reminded her of her failure to make progress, which contributed to feeling depressed.

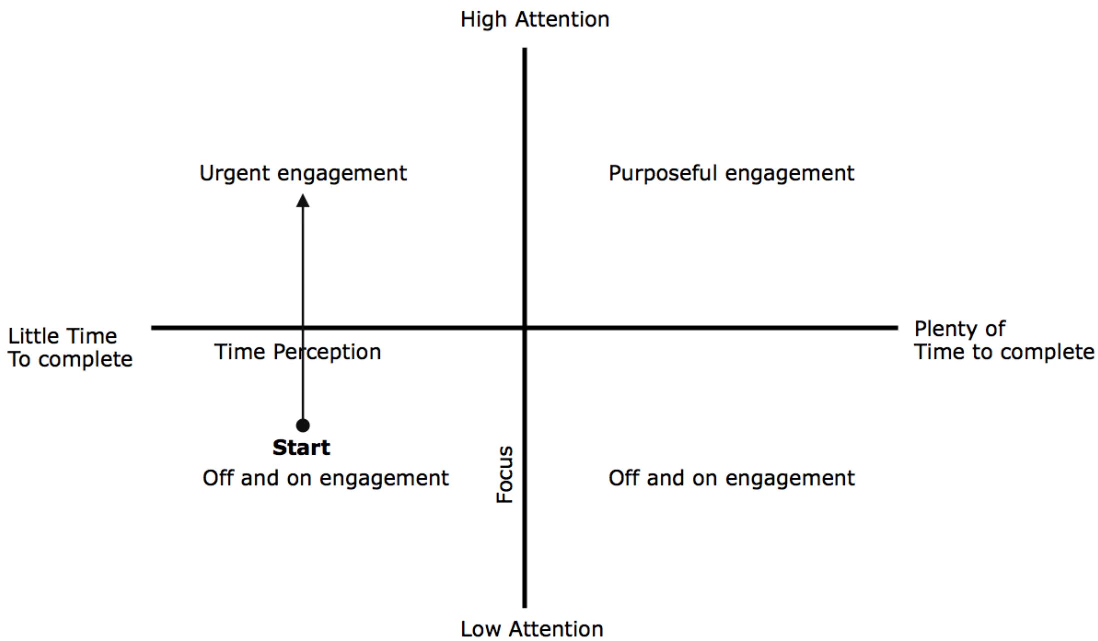


Figure 85. Participant 20 time perception – focus positioning diagram.

The *Time Perception* axis is illustrated perpendicularly against the *Focus* axis, in figure 85. These axes consist of the PPA (Little et al. 2007) dimensions *Control, Outcome/Likelihood of Success, Progress* and *Uncertainty. Control* and *Outcome/Likelihood of Success* were identical across all measures, yet with a high rating of 10. The *Progress* dimension remained static between the initial sampling and the sampling at time of system installation, with the participant reporting a value of seven. The final sampling progress valued *Progress* at a six. Overall, *Uncertainty* decreased over the course of the three samples, beginning at nine, falling to a value of seven at the time of system installation and deceasing further to a value of five at the end of one week of field-testing. When compared with her exit interview transcripts, this reduction in uncertainty is qualified in her responses to two questions. When asked if the system affected her understanding what steps she needed to take to complete the project she replied, "Absolutely. The hours that were scheduled for me to write would have ended in a completed project." Continuing along a similar line of inquiry, she was asked if the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) impacted her understanding of what resources she needed to complete the project, in which she responded, "Yes. I had to ponder places that would be best to write, which places offer Wi-Fi, what I can read to help me write better and so on." These answers suggest that even though she did not comply with the system, the presence of the system in her home instigated additional reflection on the project resulting in less uncertainty. However, the reduction in *Uncertainty*, on its own, failed to persuade Participant 20 to modify her behavior from procrastination into a pattern of structured engagement.

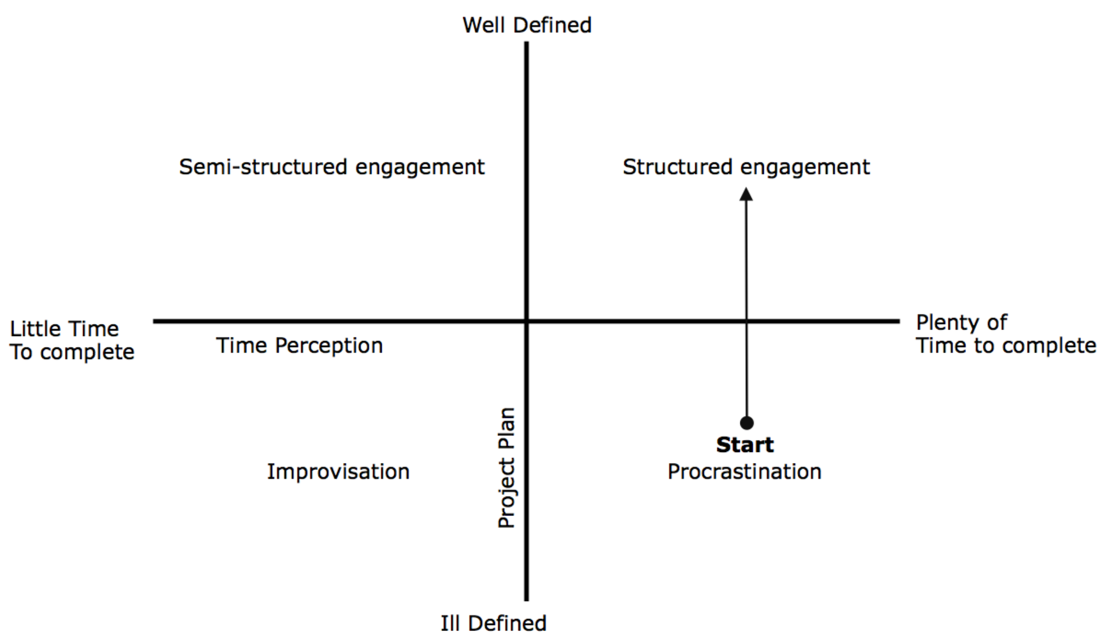


Figure 86. Participant 20 time perception – project plan positioning diagram.

Participant 20 perceived writing her autobiography as an extremely private and intimate activity that relied solely on her to complete. However, the scope of placing her life on paper often made her feel overwhelmed. She viewed the role of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al.

2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) as a work supervisor who managed her time, formalized a space for her to work and regulated consequences and rewards in response to her performance. This view of her project and SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) translated into a need to move form *Unsupported Ownership* to *Guided Ownership* through the use of targeted scaffolding as illustrated in Figure 87.

The *Scaffolding* axis consists of the PPA (Little et al. 2007) dimensions *Autonomy, Control, Other's View, Outcome/Likelihood of Success, Support* and *Visibility.* The dimensions *Control* and *Outcome/Likelihood of Success* were discussed during explanation of figure 85. The *Autonomy* dimension rating remained static with a value of nine across all three measures. The *Other's View* dimension rating also remained static with a value of eight across all three measures. *Support* decreased slightly, with an initial and second sampling value of 10 and ending with value of nine after completion of the first week of field-testing. *Visibility* dimension ratings indicated a sharp reduction. During the initial PCSoP survey completion, the participant reported a rating of nine. During the second measure at the time of system install, the participant reported a value of 10. The third measure of *Visibility* decreased to a value of six.

The static ratings of *Autonomy* at a value of nine along with the minimal changes in values for *Control* from seven, to five and then six, indicate that the scaffolding failed to support guided ownership. If Participant 20 had allowed the scaffolding to lead her through her project related behavior, then a reduction in *Autonomy* was expected because she was relying on the system to structure her actions. Conversely, an increase in *Control* was expected because she would have engaged in regularly schedule writing sessions to make progress on her autobiography. The static ratings of dimensions related to the *Scaffolding* axis, with the exception of *Visibility*, also indicate that the system failed to provide guidance as interaction with system was expected to generate some sort of changes within her dimension ratings. Finally, the reduction in *Visibility* also indicated failure on the part of the system to scaffold the participant's project related behavior as the scaffolding interactions were designed to externalize her need to complete her autobiography within her environment through audio and visual cues.

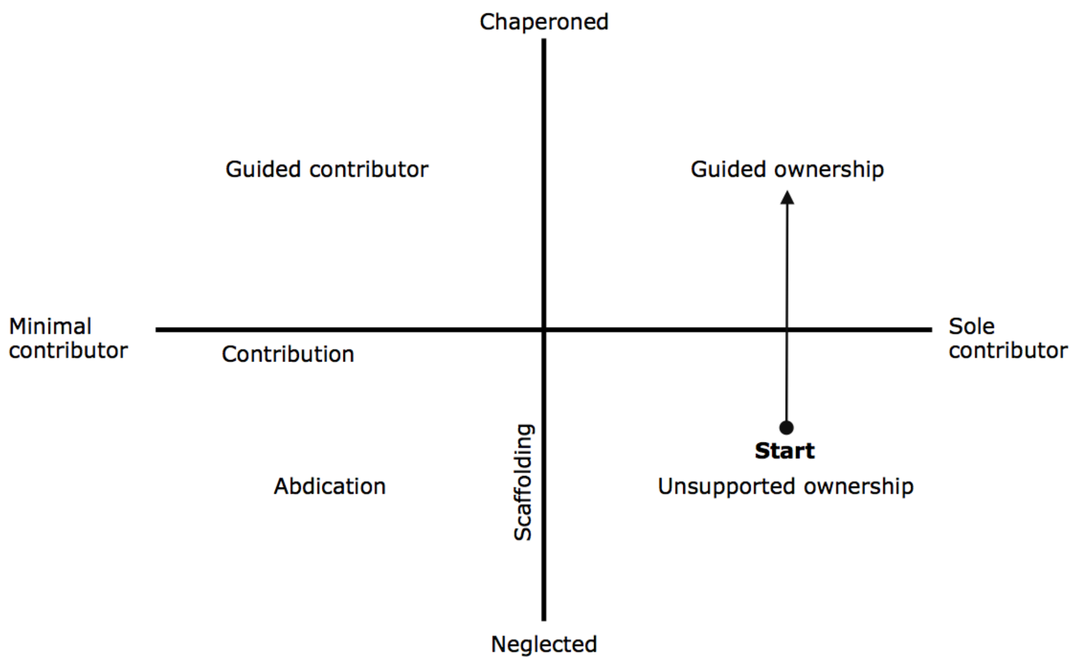


Figure 87. Participant 20 contribution – scaffolding positioning diagram.

At the time of Participant 20 co-designed her SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), she had failed to turn in her autobiography on time and floundered with making progress on the document. She stated that a mélange of stress hovered over her whens he walked around campus for fear of serendipitously meeting the professor that gave her an extension on the assignment. When combined with her perception that this project rested solely on her to complete, these factors cultivated stress when trying to progress on the project. Hence, she hoped the system would relieve some of her stress while promoting generation of new content for her autobiography. This aspiration is illustrated in figure 88.

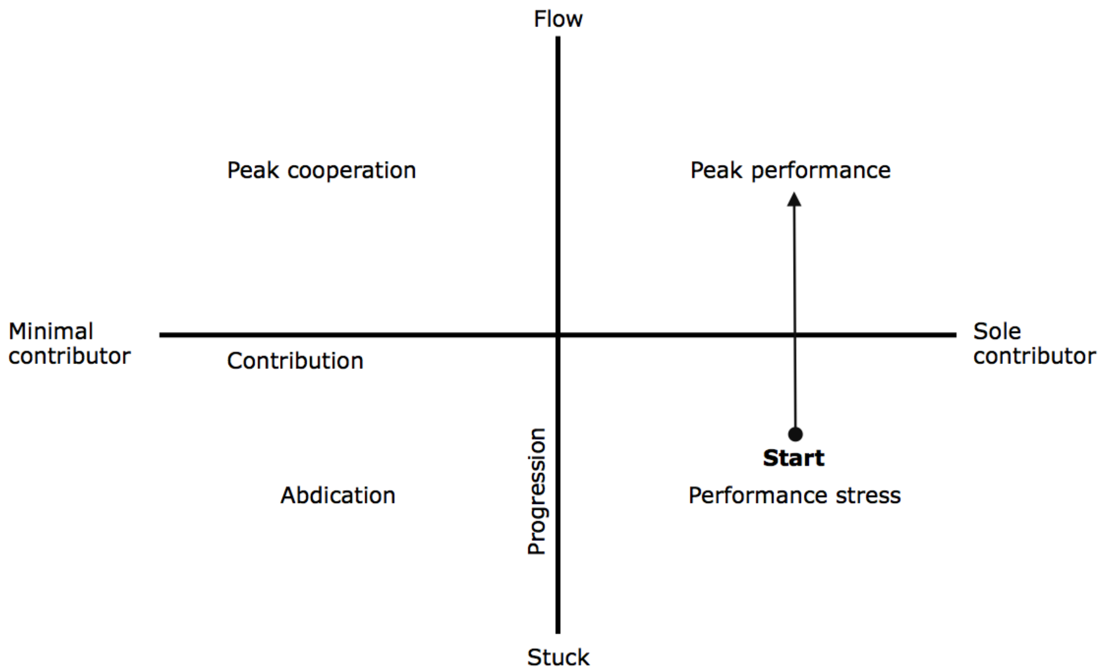


Figure 88. Participant 20 contribution – progression positioning diagram.

Discussion of figures 88, articulated the *Contribution* axis, which consists of the PPA (Little et al. 2007) dimensions *Control, Progress, Support* and *Uncertainty.* The *Progression* axis consists of the PPA (Little et al. 2007) dimensions *Control, Progress, Outcome/Likelihood of Success* and *Uncertainty*, all of these dimensions of which have been previously discussed. All of these dimensions remained relatively unchanged across the three samples, indicating that the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) failed at both reducing Participant's stress related to the project and heightening her project performance. During her exit interview, she stated that during the week of the field test, she was rarely home to engage in the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012;

Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). However, the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) did not take her absence from home into account when monitoring her progress, banning Facebook for the six out of the seven field test days. She stated that the ban on Facebook constantly reminded her that the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) was waiting for her to work on her autobiography. Her awareness that the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) laid in wait for her to engage in the project made her feel worse about the project because she viewed the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) as a squandered resource. This increase in negative affect towards the project reduced her potential for transitioning into *Peek Performance*.

During her co-design session, Participant 20 recognized that her inability to commit to writing her autobiography had led to an abdication of the project because she felt overwhelmed. As stated previously, she felt that if SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) could guide her through a consistent daily routine focused on writing her autobiography, she could complete the project. This desire for guidance led to designing a SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) that sought compliance through the serious of media prompts and the consequence and reward structure. Figure 89 illustrates movement from project abdication towards engagement with the project through compliance with the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011).

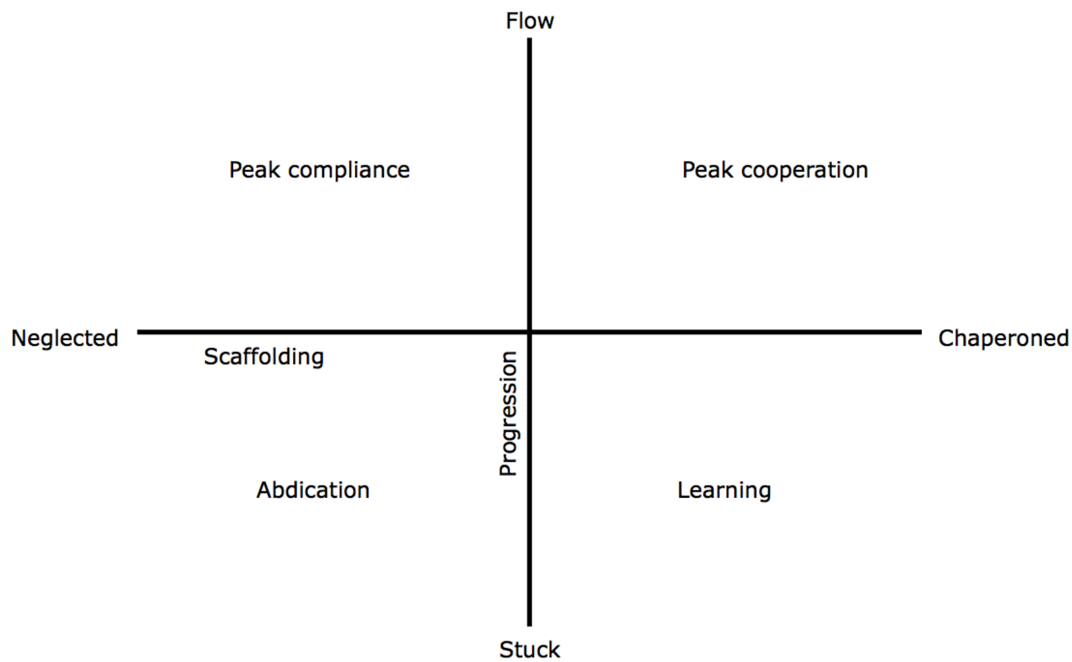


Figure 89. Participant 20 scaffolding – progression positioning diagram.

Discussion of figures 87 and 88 previously articulated the *Scaffolding* and *Progression* Axes, respectively. Between both axes, the PPA (Little et al. 2007) dimensions *Autonomy, Control, Other's View, Outcome/Likelihood of Success, Progress, Support*, *Uncertainty* and *Visibility.* As stated during discussion of other outcomes regarding shifts in project positioning, with the exception of *Visibility*, all other related PPA (Little et al. 2007) dimensions remained relatively static across the three samples, which suggest that Participant 20 continued to abdicate the project upon completing her one-week field test. During her exit interview, Participant 20 confirmed her continued abdication stating that she did not have time to work on her autobiography because of the effort required to succeed at her current courses.

Participant 20's SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier

2011) included both penalties and rewards for complying the system to complete her autobiography. Her penalty for failing to comply with the system was a ban on her Facebook access for 24 hours. Her reward for complying with the system was a text message containing a link to an extreme sports video. In addition to the penalty and reward integrated into the gaming mechanics of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), Participant 20 face an additional penalty external to the system: the potential removal of her passing course grade for the class that assigned the autobiography. Figure 90 illustrates Participant 20's desire to complete her autobiography while avoiding penalties and receiving rewards.

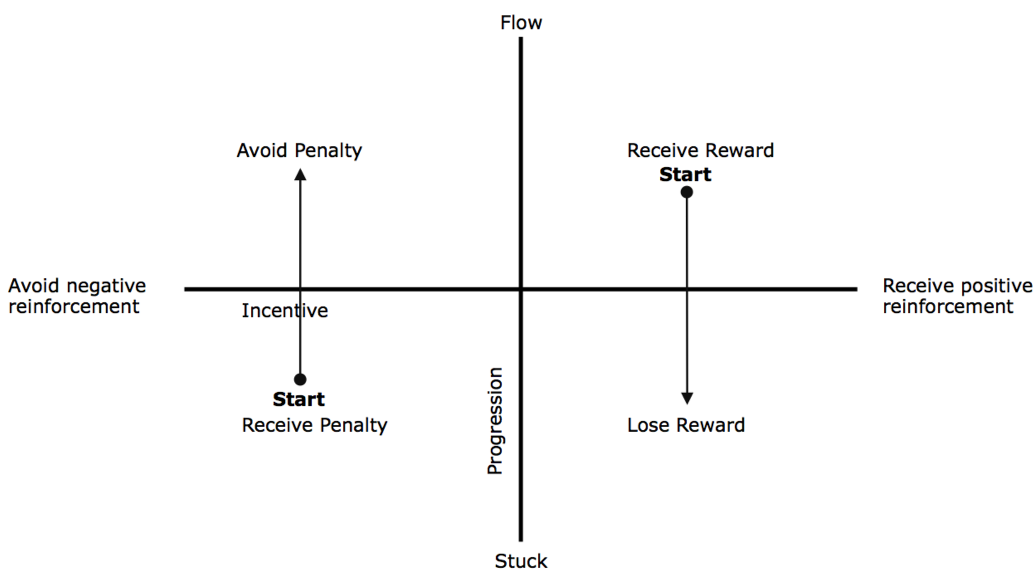


Figure 90. Participant 20 incentive – progression positioning diagram.

Discussion of *Progression* which serves as Figure 90's Y-axis was previously discussed during presentation of figure 89. The incentive axis consists of the PPA (Little et al. 2007) dimensions *Progress, Outcome/Likelihood of Success* and *Uncertainty*. Changes in values across the three measurement samples for Participant 20 were previously discussed during descriptions of figure 89. As with the other position diagrams, outcome measures failed to change over time, which is attributed to a lack of engagement with the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) and progress made towards completing her autobiography during the field test. Because of her lack of engagement with the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), Participant 20 failed to avoid the penalty of her Facebook being banned and failed to receive rewards in the form of extreme sports videos. Her external consequence of receiving a bad grade for the course associated with the autobiography remains outstanding and does not possess a deadline to avoid. The lack of deadline for this external consequence, which has both short-term and long-term consequences to Participant 20's future, may have contributed to her lack of engagement during the field test. Conversely, the incentives utilized in the gaming mechanics may not possess enough persuasive power to motivate behavior change.

As mentioned previously throughout the description of Participant 20's case study, she craved a plan to breathe life back into completing her autobiography. In addition to a plan, Participant 20 needed clarity on the resources at her disposal for completing her project. She was unsure on how she would find the time to write and create a built environment conducive for writing. During her co-design session, she reported that she had written most of her current autobiography content at her ex-boyfriends home. She missed that environment because the space possessed certain aesthetic features, including a fireplace and red brick walls, which she felt created a "cozy" environment conducive for writing. Additionally, her ex-boyfriend was a write and provided guidance during her earlier attempts to write. The end of that relationship removed that environment and social support from her, creating a gap in her current resources. The SHSP (Abowd et al. 2002; Burleson, Brotman & Newman

2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) sought to fill this deficiency in Participant 20's resources by prompting writing sessions at home and at a number of commercial venues close to her home as a means of experimentation to find a new writing environment. Figure 90 illustrates the goal of constructing a plan and defining resources to move from project abdication to structured action.

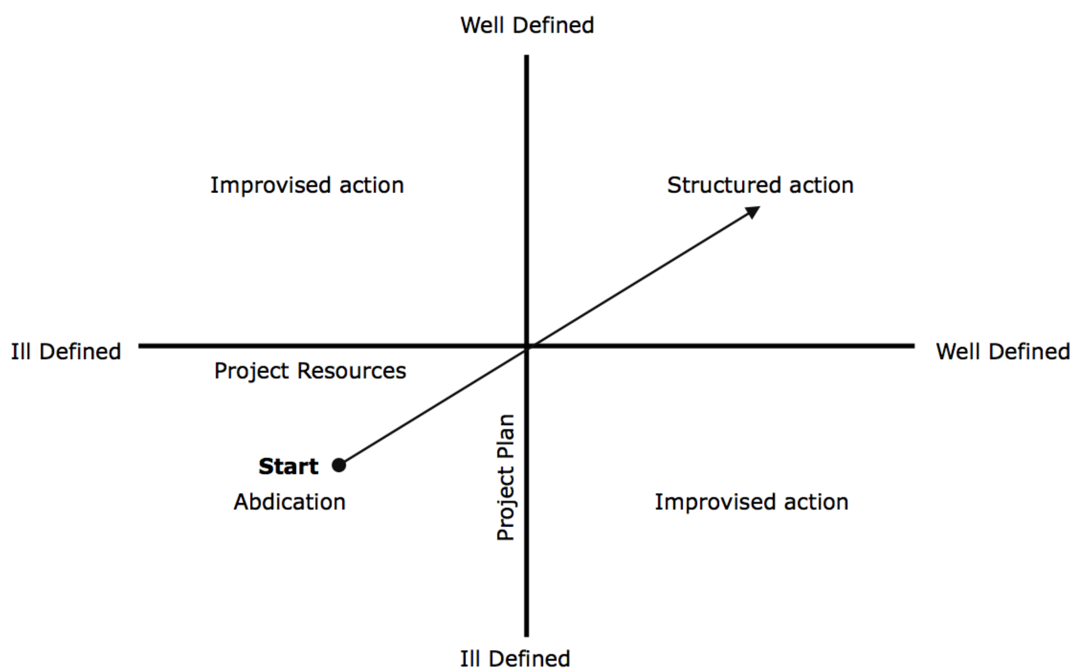


Figure 91. Participant 20 project resources – project plan positioning diagram.

Figure 86 previously described the PPA (Little et al. 2007) dimensions that define *Project Plan.* The *Project Resources* axis consists of the PPA (Little et al. 2007) dimensions *Challenge, Control, Difficulty, Outcome/Likelihood of Success, Progress* and *Uncertainty*. *Uncertainty, Difficulty* and *Challenge* demonstrated relatively static ratings across samples, with both *Difficulty* and *Challenge* retaining values of 10. The resoluteness of all PPA (Little et al. 2007) dimensions associated with the *Project Plan* and *Project Resource* axis suggests that the system failed to engage the participant, which, as previously indicated, she confirmed in her exit interview.

Figure 92, continues to support Participant's need to develop clarity on what her project is about and why she continues to pursue it. During co-design discussions, the participant stated that she knew that success meant finishing a draft of her autobiography to submit to her professor. However, she could not articulate what defined a "finished draft". When asked if her SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) should support defining what a "finished draft" should be, she responded, "No, I don't think I need to know that. I think because the story is about me, I'll know when it is finished when I get there. You know, feel it out." The need for a plan to structure action while leaving success metric vague indicates a desire to transition from *Stuck* (Burleson & Picard 2007) to *Reflective Action* (Schön 1984) where she commits to making progress on the project while simultaneously reflecting on that progress to intuit whether or not she has finished her autobiography. Figure 92 illustrates this transition.

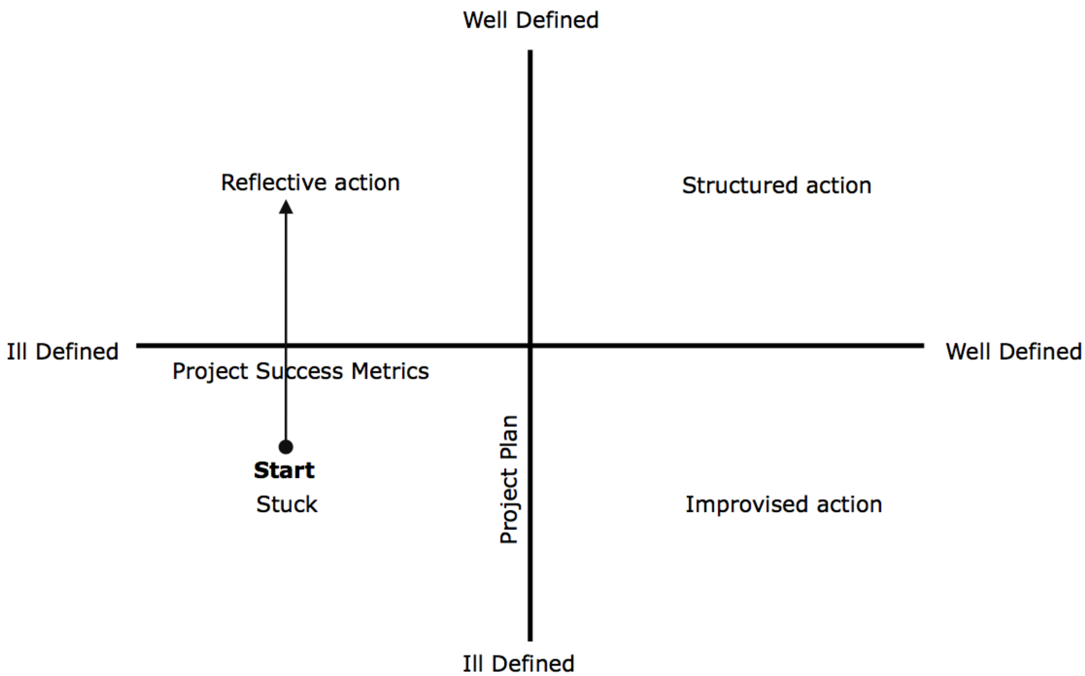


Figure 92. Participant 20 project success metrics – project plan positioning diagram.

Outcome/Likelihood of Success and *Uncertainty* comprise the *Project Success Metrics* axis. The dynamics of these PPA (Little et al. 2007) dimensions have been discussed during explanations of figure 90. The *Project Plan* axis, and the dynamics of its associated PPA (Little et al. 2007) dimensions have been discussed during explanations of figure 91. As previously indicated during discussions of those previous positioning diagrams, the lack of change over time across the PPA (Little et al. 2007) dimensions associated with figure 92's axes, suggest a lack of engagement with the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), which was confirmed during Participant 20's exit interview.

While Participant 20 has struggled to complete her autobiography, she made a clear decision to engage in the project, even if that decision was forced due to the need to pass her class. As such, the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers

2002; Olivier 2011) makes no effort to assist her with reflecting on whether or not to continue moving forward with the project. Rather, it operates under the assumption that she is not allowed to quit the project, because quitting would mean redaction of a passing course grade, which Participant 20 stated was unacceptable during her co-design session. Figure 93 illustrates this lack of position transitions regarding decision making on project engagement with an unmodified position diagram.

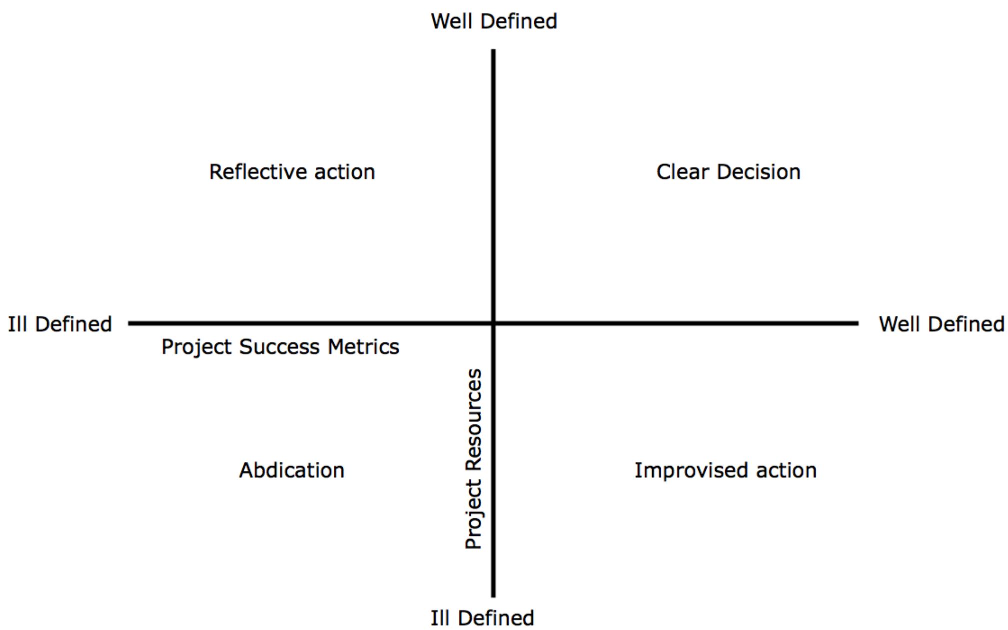


Figure 93. Participant 20 project success metrics – project resources positioning diagram.

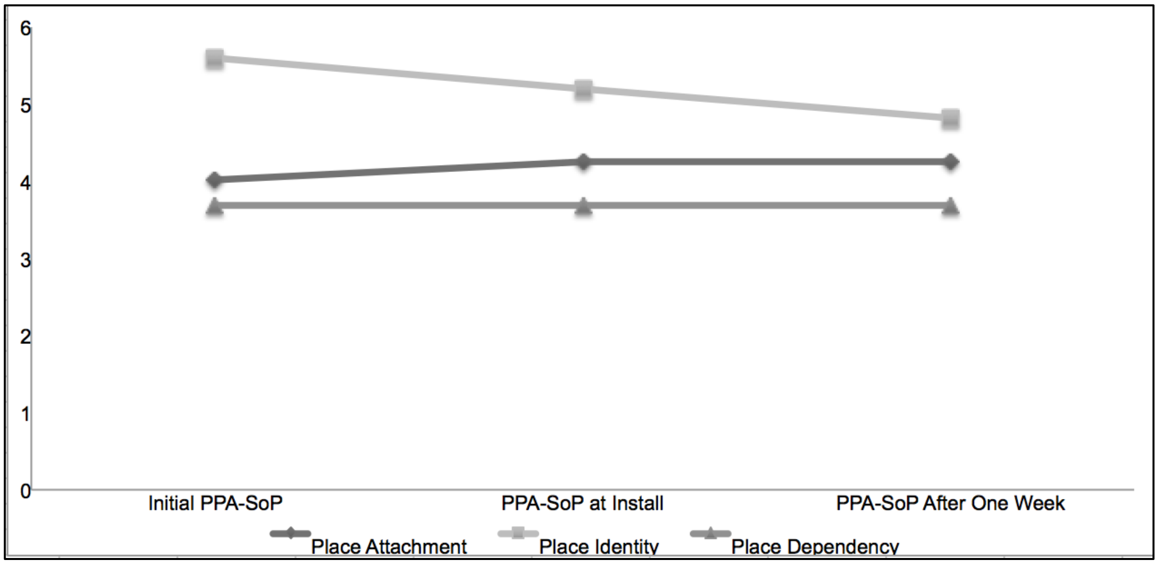


Figure 94. Participant 20 Repeated measures of PPA-SoP factors.

Upon completing Participant 20's first week of field testing, and the evaluation procedures associated with that first week, she requested to keep the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). Two additional weeks of field-testing were completed. Both weeks indicated no compliance with system, resulting in three week of banning Participant 20's Facebook account access. Due to the lack of behavior change, as indicated by the system log, no additional evaluation activities were completed. Appendix F. contains PCSoP repeated measurement data for all survey dimensions across all participants.

Conclusion

This chapter described the development, implementation and evaluation of three SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) for the motivational home. These SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) embodied the motivational needs of three young women with different personal projects (Little 1987; Little et al. 2007). Their case studies demonstrated the use of GaLLaG (Burleson et al. 2009) technologies within the home with the intent of supporting goal attainment. Additionally, their stories served as grounding to test the value of the motivational home design framework in two contexts. First, the design framework positioning diagrams demonstrated value by visualizing the motivational needs each SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) sought to address for each of their respective personal projects (Little 1987; Little et al. 2007). Second, the design framework demonstrated value by functioning as an evaluation toolkit, tracking PPA (Little et al. 2007) dimensions related to each of the positioning diagrams across multiple measurement samples to assess if, how and to what extent the SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) fulfilled their purpose as motivational agents, fostering goal attainment and HF (Fredrickson 2002; Little et al. 2007; Seligman 2004).

The results discussed in these case studies suggest that motivation-centric SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), much like human motivational agents, such as personal confidants, clinicians and life coaches, work only if the user has a clear understanding of their goals (or recognize they need assistance building clarity on what the goals are), the actions they need to take to accomplish those goals and are willing to respond to motivational stimuli to complete those actions. The young woman who practiced “blackbird” on her guitar and the young woman who spent less time meandering online and more time engaged in meaningful real-world activities in response to their SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008;

Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) stimuli reported movement towards desired motivational states and minor increases in environmental congruency as shown through changes in PCSoP dimensions repeatedly measured. The minor increases in environmental congruency aligned with the finding of the motivational heuristics developed in chapter eight that suggested that the personal projects (Little 1987; Little et al. 2007) of young adults do not have strong associations.

In stark contrast, the young woman struggling to finish her autobiography and did not comply with the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) she designed, reported little positive changes in the motivational positioning of her project, no further progression on the project and her PPA (Little et al. 2007) measures indicated an increase in negative affect, such as depression, related to the personal project (Little 1987; Little et al. 2007). These results, suggest an interdependency between the efficacy of a motivational SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) and the willingness of the user to participate in goal-directed behavior to uphold the social contract implicit in the form and function of the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011).

Based on these findings, a number of opportunities for future work in either technology development for SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) or further exploration of SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) for HF (Fredrickson 2002; Little et al. 2007; Seligman 2004).

With regards to technology, more robust interfaces between SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) and web services are needed to support content creation, consumption activities and performance incentives that users become involved in during project completion. Web services that participants repeatedly mentioned fell into to categories: social communication and location-based services. Improving the consistency of remote audio streaming is another area of technical development that needs to be addressed. For all three participants, remote audio playback was an integral part of their SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), yet audio would crash due to weak wireless connectivity between the GaLLaG (Burleson et al. 2009) server and remote speakers. Additionally, when audio would play, latency would occur due to the amount of time it took for the GaLLaG (Burleson et al. 2009) server to recognize an event trigger and then implement the response. A third opportunity for technology development is the creation of a set of end-user friendly tools that allow lay people with minimal technical expertise to define and implement they're own SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). The current process for implementing a SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) with the GaLLaG (Burleson et al. 2009) platform requires a team of technical experts to first work with end users to define what they want to build, then build the SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) for the end user and install them within end user homes. Both Participant 17 and 20 experienced system failures that required technical experts to conduct site visits to troubleshoot the system failures. Developing a suite of user friendly tools that afford end users a what-you-see-is-what-you-get (WYSISWYG) design, implementation and debugging cycle (or another interaction paradigm requiring little technical expertise) would not only reduce development and upkeep overhead, but potentially increase system compliance by increasing an end users perception of investment in their SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) prior to engaging with the system.

With regards to continued exploration of the SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) for HF (Fredrickson 2002; Little et al. 2007; Seligman 2004), a number of interesting opportunities emerge. First, the three case studies discussed in this chapter do not provide enough data to make confirmatory claims regarding the relationships people form with SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) to attain personal goals. Additional case studies, both within the same demographic population, as well as in other populations need to be conducted to formalize a logical argument that definitely shows the value of such technologies implemented in the context of HF (Fredrickson 2002; Little et al. 2007; Seligman 2004). Additionally, the three field tests completed for this study were conducted over a relatively short period of time. Implementing SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) as part of longitudinal research design could generate far different results. For example, if Participant 20 had kept her SHSP (Abowd et al. 2002; Burleson, Brotman & Newman

2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) through her school semester and then into summer when her schedule was less frenetic, perhaps her SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) would have been a more effective motivational agent. Additionally, all three participants remained keenly aware that their SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) were part of research study, which may have biased important behavior, such as adoption and compliance. A longitudinal study may provide more authentic data as participant awareness of the research design framing their interactions can fade, allowing more natural interactions.

Finally, as motivational tools, SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) deployed in this study demonstrated the potential to build similar relationships with participants as human motivational agents do with their confidants. This emerging provokes a number of interesting questions regarding the methods and limitations of SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) to motivate human behavior. First, what relational characteristics of human motivational agents can SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) simulate and what characteristics of human motivational agents should SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) omit from their interactions? Second, what, if any, limitations should researchers develop into SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) with regards to determining and implementing penalties and rewards for behavior? Participant 20 design both penalties and rewards into her SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), yet neither were good motivators for behavior change. Should SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) recognize those failures and decide on new types of consequences and/or rewards and if so, what are the ethical boundaries attached to providing SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) such power.

This chapter described three case studies of SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) for HF (Fredrickson 2002; Little et al. 2007; Seligman 2004). Each case study presented the successes, failures and sensitivities of these systems as agents motivating behavior change in their occupants to attain personal goals. These case studies are also the culmination of larger research agenda that began with bridging PPA (Little et al. 2007) and SoP (Jorgensen & Stedman 2001; 2006) to reveal relationships supporting a set of motivational heuristics which were then used in the context of co-design sessions to produce a series of SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) paper prototypes and the motivational home design framework. The final chapter of this dissertation summarizes the outcomes and implications of this larger agenda to define the motivational home.

Chapter 11

CONCLUSION

This chapter concludes this initial exploration of the motivational home research agenda. It begins with a summary of the major findings, followed by brief discussion on the contributions and implications of the work. The chapter ends with a projection of future work.

Findings Summary

The findings of the three studies detailed in chapters eight through ten of this document demonstrated a new, motivation focused process for design. In chapter eight, initial evidence of PCSoP, a theory positing a person's SoP (Jorgensen & Stedman 2001; 2006) fluxuates depending on the personal project (Little 1987; Little et al. 2007) a person engages in, was shown, yielding two outcomes. First, three models predicting SoP (Jorgensen & Stedman 2001; 2006) factors place attachment, place identity and place dependency using combinations of PPA (Little et al. 2007) affective and cognitive dimensions. Second, the associations proposed in those models were used to develop a set of motivation-sensitive design heuristics to support user-centered design activities for designing new products and services targeted at the home lives of young adults.

During chapter nine, the motiation-sensitive design heuristics scaffolded co-design of SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) supporting completion of personal projects (Little 1987; Little et al. 2007) by young adults. Normative analysis of the paper prototypes produced during this study produced a design framework consisting of design principles, design qualities, positioning diagrams, interaction models and use cases that articulate what young adults need from motivational agents delivered as SHSPs (Abowd et al. 2002;

Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). The design framework also serves as toolkit for ideation and evaluation of SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011).

In chapter 10, three of the paper prototypes were further developed into technology probes (Hutchinson et al. 2003). These probes were field-tested for a period of one-week within the homes of end-users to investigate if SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) could act as motivational agents influencing the completion of personal projects (Little 1987; Little et al. 2007). Use of the design framework to evaluate the effectiveness of the of the probes as motivational agents suggest that if occupants comply with their SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011), then the occupants perceive increased productivity with regards to project completion. Use of the design framework to evaluate the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) suggests that such systems, if designed appropriately, can assist in structuring an occupant’s time, provide meaningful guidance and accountability and reduce ambiguity associated with project completion.

However, the study also demonstrated that as with other motivational agents, such as life coaches, councilors, teachers or fitness instructors, incentivizing compliance remains challenging. Additionally, repeated measures of PCSoP dimensions across the lifespan of the field-tests that were analyzed using the PCSoP attachment, identity and dependency predictive models did not conclusively indicate that SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) improved environmental congruency (Stokols 1977).

Lastly, qualitative assessment between *a priori* and *posteriori* interview data revealed that while participants initially believed the SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) would reduce stress associated with their personal projects (Little 1987; Little et al. 2007) field testing, they reported increases in stress at the end of their field tests. The reasons behind stress ranged from feeling as if the system's presence was exerting a pressure to engage with a personal project (Little 1987; Little et al. 2007), to feeling stress associated with guilt for not complying with the system, to stress associated with system malfunctions that adversely affected their physical and digital environments.

Contributions and Intellectual Merit

When taken as a whole, this document describes a new motivation-sensitive approach to design. Realizing this approach has produced a number of unique contributions spanning multiple disciplines. First, the initial confirmation of PCSoP bridges motivational psychology (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) and place attachment theory (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992) and place attachment theory. In practice PCSoP uses personal projects (Little 1987; Little et al. 2007) as meta carrier unit that allows researchers to describe and evaluate the dynamics of relationships between a person's goals and the congruency a place exhibits to meet those goals. This method of evaluating environmental congruency (Stokols 1977) is novel in that it treats a place as part of a complex, dynamic system that evolves over time. In contrast, current methods of measuring people-place relationships isolate those relationships from external factor such as goals and treat such relationships as unchanging over time. In addition to the implications PCSoP has for the burgeoning psychological fields of motivational psychology (Fredrickson 2002; Little, Salmela-Aro, & Phillips 2007; Peterson 2007; Seligman 2004) and place attachment theory (Cooper Marcus 2006; Jorgensen & Stedman 2001, 2006; Pennartz 1999; Stokols 1977; Tuan & Hoelscher 2001; Williams 1992), PCSoP also provides a new way for designers to collect robust user-centered data on a person's actions, thoughts, feelings and environmental relationships. As demonstrated in chapter nine, the data collected through the use of the PCSoP survey can be used to scaffold design activities that lead to grounded theories on how people, places and artifacts interact with one another.

To date, in the published literature, design tools for conceptualizing and evaluating the qualities of user experiences SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) deliver are non-existent. The motivational home design framework presented in chapter nine delivers a first-of-its-kind toolkit for designers of smart homes to leverage during prototyping cycles. Additionally, the design framework presents the first grounded theory on smart homes as social agents, and based on the current state of published literature, on smart homes in general.

In chapter 10, the installation and evaluation of three technology probes (Hutchinson et al. 2003) exploring motivation-sensitive SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). While the literature on smart home implementation and evaluation has documented similar studies, this work makes a novel contribution in two ways. First, the smart home applications installed in the homes of end-users were designed by the end-users themselves. This differentiator represents a larger proposition of occupant-tailored smart environments, rather than smart environments that are delivered in whole by developers. Second, this study investigated the role of smart homes as motivational agents capable of persuading the social behavior of occupants to increase goal attainment and HF (Fredrickson 2002; Little et al. 2007; Seligman 2004). The role of a smart home as a motivational agent represents a departure from the current literature on smart homes, which focuses on issues of energy consumption, security, automation and occupant health and safety. In the future, this movement towards smart homes as social agents could provide an umbrella for defining issues such as energy consumption, security and automation as such behaviors could be viewed as symptoms of domestic social behavior.

Future Work

This work presents far more questions than answers. The initial findings from the PCSoP study indicate that SoP (Jorgensen & Stedman 2001 & 2006) is dynamic, influenced by a person's goals and related activities at any given time and can be predicted through use of PPA (Little et al. 2007) dimensions. However, this work was conducted within the context of young adults and their homes. In order to confirm the existence PCSoP, as well as its value in describing and evaluating person-place relationships, additional studies across different subject groups needs to occur.

Related to the need for additional studies that define PCSoP relationships between other populations and other places, is the need for additional design frameworks to guide conceptualization and evaluation of smart home user experiences. The framework presented in chapter nine only articulates the design space for young people and their homes related to motivational SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008;

Mykityshyn, Fisk, & Rogers 2002; Olivier 2011). As development teams continue to explore design spaces that include other populations, other places and other purposes for smart homes, new design frameworks will be necessary to capture the design issues idiosyncratic to those spaces.

Implementation of the technology probes (Hutchinson et al. 2003) revealed opportunities for technology development research and HCI research. With regards to technology development, the GaLLaG (Burleson et al. 2009) platform afforded installation of sensor and feedback hardware into the built environment that supported interactions that blended the physical and digital worlds of occupants.

This strength needs to be counterbalanced with soft sensing through accessing web services that are now a linchpin in the lives of many peoples' digital selves. Developing libraries that engage with service APIs to gather, analyze and make data driven decisions that either support existing occupant behavior, or incentivize behavior change is critical to the success of motivational smart homes. Additionally, targeted, context-aware, content delivery requires further development of interstitial technologies, such as firmware and method libraries that increase the interconnectedness of smart home components with mature ecosystem devices such as PCs, phones and television. Very few participants indicated a desire for additional displays in their lives, yet most participants desired to engage visual content on such their current devices.

In contrast, participants desired audio feedback across throughout their home environments. Implementing current wireless audio solutions in people's homes require interacting with wireless networks that possess various capabilities with regards to network security, speed and bandwidth. These variables affect the ease of audio installation as well as the performance of audio streaming as audio file are either collected from web locations or locations on a local server and then routed over the network to the appropriate speakers. Increasing stability of audio throughput to reduce latency, control volume and ensure sound fidelity through development of technologies that manage such variables to ensure consistent audio playback anywhere in the home.

Current low-cost, easily acquirable environmental sensors have narrow bandwidths in terms of the volume of space they react to. For example, X10 sensors respond to use of specific architectural elements such as a door, a window a wall outlet, a specific appliance, or, in more creative instances, non-electronic domestic artifacts they are affixed to. Infrared motion detectors respond changes in heat determined through interaction with a narrow laser. The limitations of these sensor to map activity in the entire domestic space and make sense of that activity requires that current socially-oriented SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) rely on meticulously scripted occupant behavior in which people must open a door at a certain and/or sit in a specific chair to trigger specific interactions from the system. Such modes of interaction are in stark counterpoint to the invisible, ubiquitous computational system SHSPs (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) are envisioned as.

Lastly, the notion of user-tailored smart homes requires a set of development tools that allow users to develop complex systems with minimal technical knowledge. Current tools require technical professionals to translate user desires into interactive systems, install the systems in the homes of users and then return the user's home in instances where tech support is required. In all three field tests, researchers returned to the homes of users multiple times to address technical challenges. Developing integrated hardware-software solutions that democratize the design, development, implementation and testing cycles of SHSP (Abowd et al. 2002; Burleson, Brotman & Newman 2012; Intille et al. 2005; Keintz et al. 2008; Mykityshyn, Fisk, & Rogers 2002; Olivier 2011) is crucial for adoption of smart home user experiences.

These trajectories for future were are both broad in scope and deep in potential richness. Continuing to explore any one, multiple or all of them has the potential to inform how people engage with their environments and vice-versa, how designers can approach development of new design theory, practice and outcomes and how smart technologies can participate in social behavior to support goals of end users.

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APPENDIX A

A SURVEY EXPLORING CONNECTIONS BETWEEN DOMESTIC ACTIVITY, THOUGHTS, FEELINGS AND TECHNOLOGY INSTITUTIONAL REVIEW BOARD APPROVAL DOCUMENTATION

Knowledge Enterprise Development

Office of Research Integrity and Assurance

To:	Winslow Burleson BYENG
From:	Mark Roosa, Chair Soc Beh IRB
Date:	11/29/2011
Committee Action:	**Exemption Granted**
IRB Action Date:	11/29/2011
IRB Protocol #:	1111007123
Study Title:	A Survey Exploring Connections Between Domestic Activity, Thoughts, Feelings, and Technology

The above-referenced protocol is considered exempt after review by the Institutional Review Board pursuant to Federal regulations, 45 CFR Part 46.101(b)(2) .

This part of the federal regulations requires that the information be recorded by investigators in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. It is necessary that the information obtained not be such that if disclosed outside the research, it could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

You should retain a copy of this letter for your records.

Figure 95. A survey exploring connections between domestic activity, thoughts, feelings and technology Arizona State University Institutional Review Board research study approval letter.

APPENDIX B

GAME-AS-LIFE, LIFE-AS-GAME INSTITUTIONAL REVIEW BOARD APPROVAL DOCUMENTATION

Knowledge Enterprise Development

Office of Research Integrity and Assurance

To:	Winslow Burleson BYENG
From:	Mark Roosa, Chair Soc Beh IRB
Date:	02/15/2013
Committee Action:	**Renewal**
Renewal Date:	02/15/2013
Review Type:	Expedited F7
IRB Protocol #:	0902003664
Study Title:	Game as Life - Life as Game
Expiration Date:	02/23/2014

The above-referenced protocol was given renewed approval following Expedited Review by the Institutional Review Board.

It is the Principal Investigator's responsibility to obtain review and continued approval of ongoing research before the expiration noted above. Please allow sufficient time for reapproval. Research activity of any sort may not continue beyond the expiration date without committee approval. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol on the expiration date. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study termination.

This approval by the Soc Beh IRB does not replace or supersede any departmental or oversight committee review that may be required by institutional policy.

Adverse Reactions: If any untoward incidents or severe reactions should develop as a result of this study, you are required to notify the Soc Beh IRB immediately. If necessary a member of the IRB will be assigned to look into the matter. If the problem is serious, approval may be withdrawn pending IRB review.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, or the investigators, please communicate your requested changes to the Soc Beh IRB. The new procedure is not to be initiated until the IRB approval has been given.

Please retain a copy of this letter with your approved protocol.

Figure 96. Game-as-life, Life-as-game Arizona State University Institutional Review Board research study approval letter.

APPENDIX C

PROJECT-CENTERED SENSE OF HOME WORKBOOK

Participant ID #

1

Instructions: We are interested in understanding what sort of personal projects you currently have in your life. A personal project is set of actions you undertake to achieve a personal goal. Some examples of personal projects are "Pass my math class", "Paint my house" and "Loose weight". In addition to understanding what projects you have in your life, we would also like to know how you feel about your projects, what you think about your projects, and how your home relates to your projects. The information you provide will be instumental in designing new interactive technologies for the home. Prior to filling out the questions on your projects, please complete the demographic information below. **Once you have finished the demographics section, use the tabs at the bottom of the screen to navigate the personal projects survey, starting with the "Project Brainstorming" page and finishing with the "Rating Page 3" page.** Once you have completed the survey, save it and email it to ryan.brotman@gmail.com. Your participation is completely voluntary and you may choose to quit at any time. If you have questions, comments or concerns about this study, please email Ryan at ryan.brotman@gmail.com**.** Your identity will remain anonymous, but the data you generate may be used in dissertations, journal publications, conference proceeding publications, and general presentations concerning the research outcomes.

Age

Sex

1, male | 2, female

Relationship Status

1, single | 2, domestic partnership (including

3, widow | 4, divorce

Parent?

1, yes | 2, no

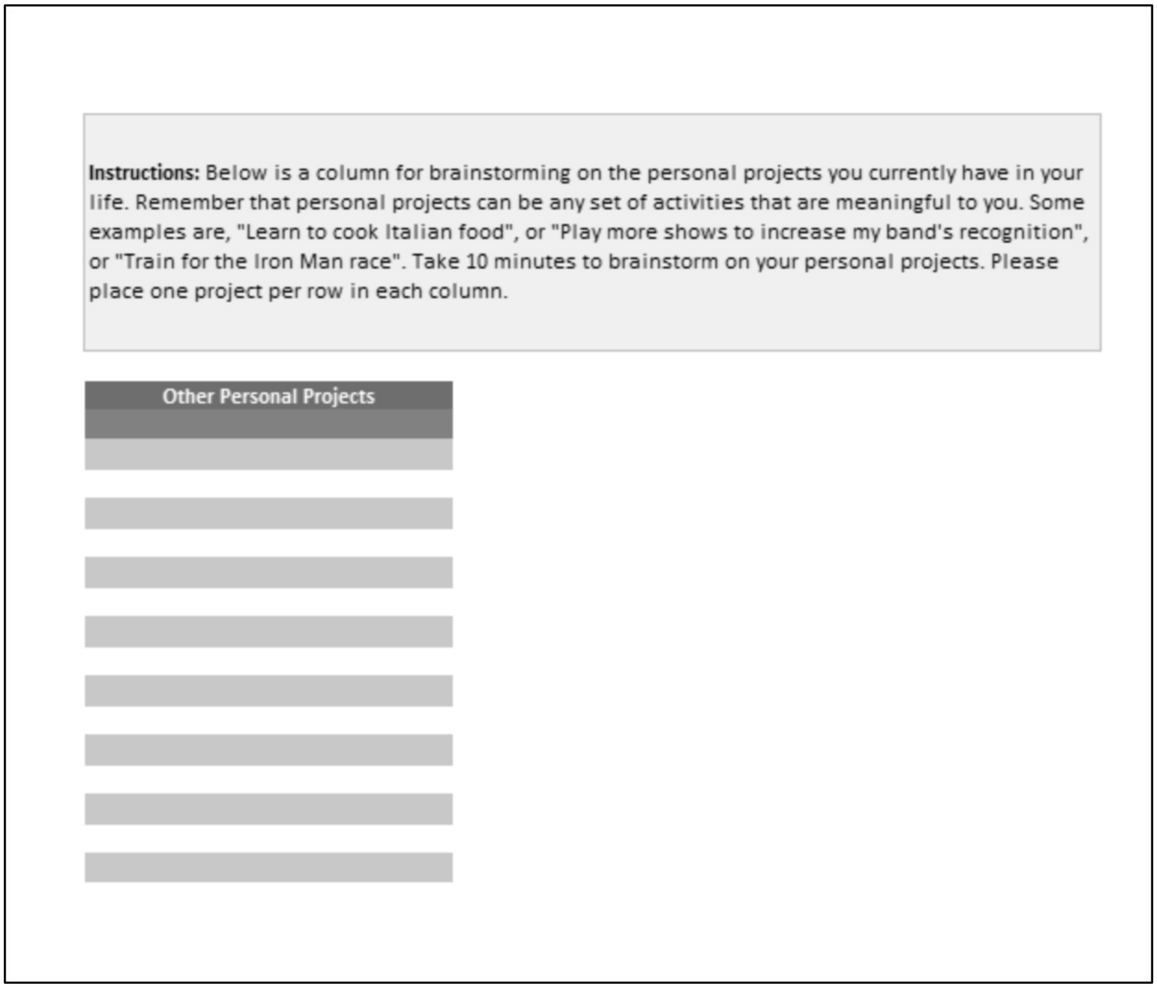
Live Alone? (yes/no)

1, yes | 2, no

Ethnicity

1, white
2, hispanic
3, african american
4, asian
5, native american
6, other

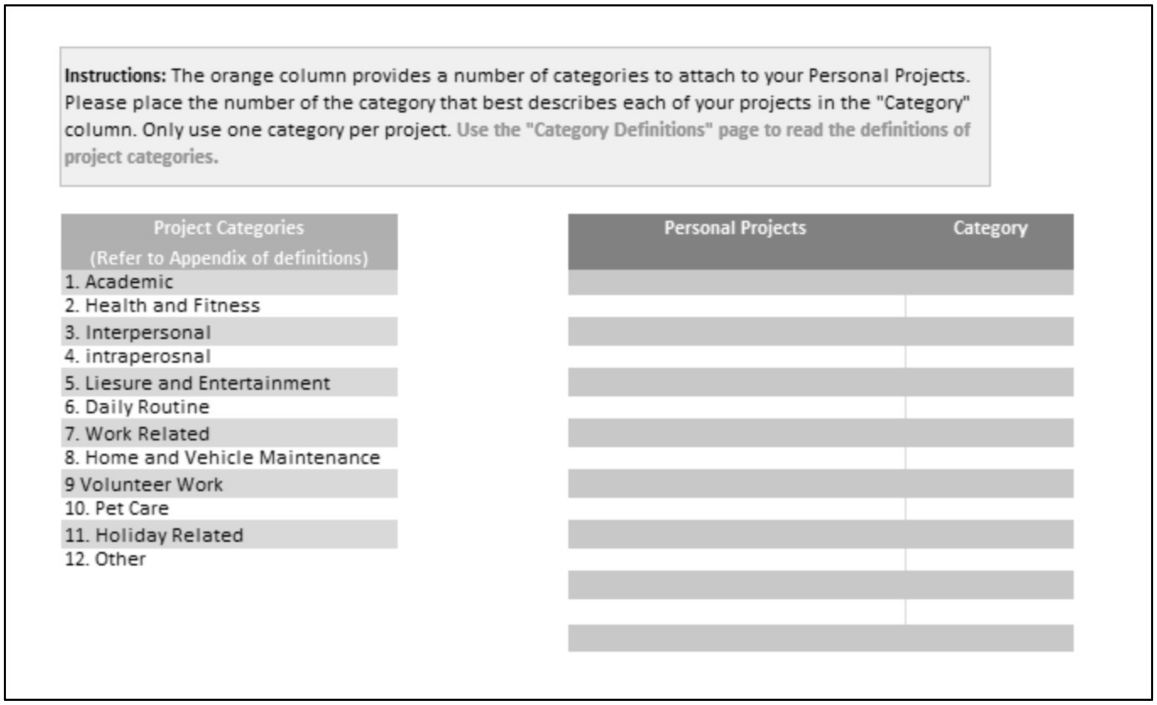
Figure 97. Page one of the project-centered sense of place survey workbook used to collect participant demographic data.



Instructions: Below is a column for brainstorming on the personal projects you currently have in your life. Remember that personal projects can be any set of activities that are meaningful to you. Some examples are, "Learn to cook Italian food", or "Play more shows to increase my band's recognition", or "Train for the Iron Man race". Take 10 minutes to brainstorm on your personal projects. Please place one project per row in each column.

Other Personal Projects

Figure 98. Page two of the project-centered sense of place survey workbook used for participant brainstorming on personal projects.

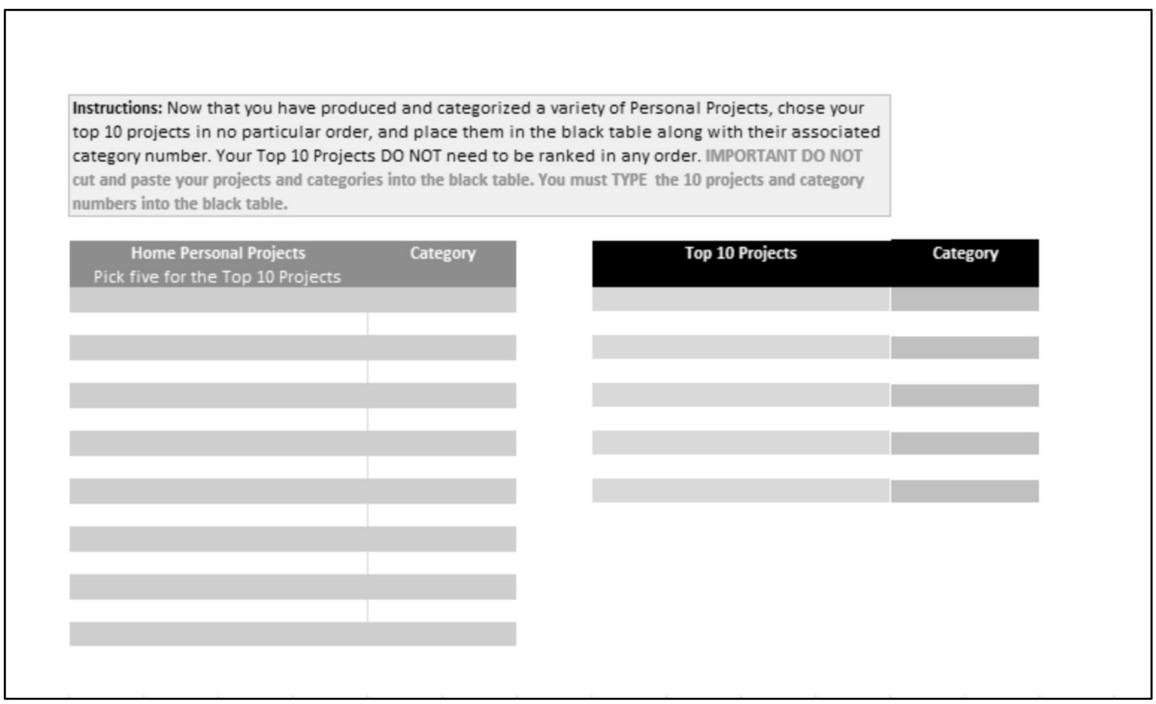


Instructions: The orange column provides a number of categories to attach to your Personal Projects. Please place the number of the category that best describes each of your projects in the "Category" column. Only use one category per project. **Use the "Category Definitions" page to read the definitions of project categories.**

Project Categories (Refer to Appendix of definitions)
1. Academic
2. Health and Fitness
3. Interpersonal
4. intraperosnal
5. Liesure and Entertainment
6. Daily Routine
7. Work Related
8. Home and Vehicle Maintenance
9 Volunteer Work
10. Pet Care
11. Holiday Related
12. Other

Personal Projects	Category

Figure 99. Page three of the project-centered sense of place survey workbook for participants to categorize their personal projects.



Instructions: Now that you have produced and categorized a variety of Personal Projects, chose your top 10 projects in no particular order, and place them in the black table along with their associated category number. Your Top 10 Projects DO NOT need to be ranked in any order. **IMPORTANT DO NOT cut and paste your projects and categories into the black table. You must TYPE the 10 projects and category numbers into the black table.**

Home Personal Projects Pick five for the Top 10 Projects	Category

Top 10 Projects	Category

Figure 100. Page four of the project-centered sense of place survey workbook for

participants to choose up to 10 of their most meaningful personal projects for assessment.

Instructions: The matrix below has your top 10 Personal Projects listed in the rows and a descriptor in each of the columns. Please rate each project by each descriptor using a 0 to 10 scale, with 0 meaning that you do not feel that emotion with regards to the personal project, and 10 meaning that you feel this emotion very strongly about the Personal Project.

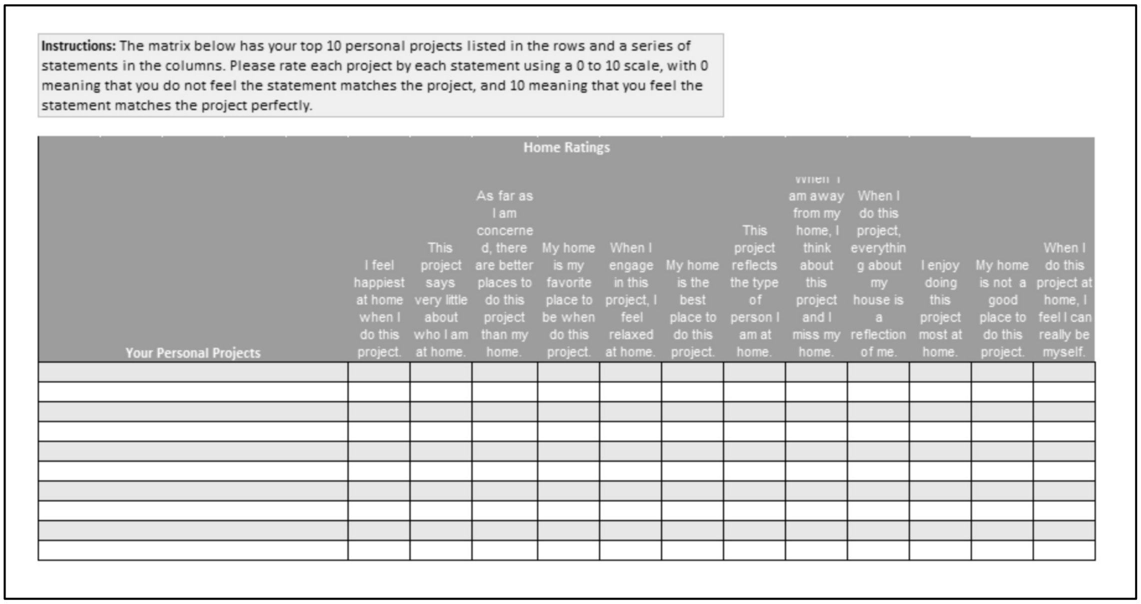
	Emotional Ratings									
Your Personal Projects	Depressed	Fearful/Scared	Hopeful	Stressed	Happy, w/ Enjoyment	Full of Love	Angry	Uncertain	Sad	Other (Delete and write your own)

Figure 101. Page five of the project-centered sense of place survey workbook where participants evaluate up to 10 of their most meaningful personal projects across a set of affective psychometric dimensions.

Instructions: The matrix below has your top 10 personal projects listed in the rows and a descriptor in each column. Please rate each project by each discriptor using a 0 to 10 scale, with 0 meaning that you do not feel the descriptor matches the project, and 10 meaning that you feel the descriptor matches the project perfectly. **Use the "Ratings Definitions" page to read the definitions of rating.**

	Cognitive Ratings																	
Your Personal Projects	Control	Value Congruency	Visibility	Importance	Difficulty	Competence	Outcome/Likelihood of Success	Self Identity	Support	Responsibility	Progress	Challenge	Absorption	Other's View	Time Adequacy	Autonomy	Stage	Other (Delete and write your own)

Figure 102. Page six of the project-centered sense of place survey workbook where participants evaluate up to 10 of their most meaningful personal projects across a set of cognitive psychometric dimensions.



Instructions: The matrix below has your top 10 personal projects listed in the rows and a series of statements in the columns. Please rate each project by each statement using a 0 to 10 scale, with 0 meaning that you do not feel the statement matches the project, and 10 meaning that you feel the statement matches the project perfectly.

	Home Ratings											
Your Personal Projects	I feel happiest at home when I do this project.	This project says very little about who I am at home.	As far as I am concerned, there are better places to do this project than my home.	My home is my favorite place to be when do this project.	When I engage in this project, I feel relaxed at home.	My home is the best place to do this project.	This project reflects the type of person I am at home.	When I am away from my home, I think about this project and I miss my home.	When I do this project, everything about my house is a reflection of me.	I enjoy doing this project most at home.	My home is not a good place to do this project.	When I do this project at home, I feel I can really be myself.

Figure 103. Page seven of the project-centered sense of place survey workbook where participants evaluate up to 10 of their most meaningful personal projects across a set of sense of place psychometric dimensions.

APPENDIX D

MOTIVATIONAL HOME HEURISTICS-BASED CO-DESIGN INTERVIEW GUIDE

- When did you start this project? How did you start this project?
- How will you know when you're done with this project? When do you want to be done with this project?
- Value Congruency [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You reported that this project has LOW/HIGH alignment with your core values? What are some of your core values (give an example)? How does this project relate?
- Full of love [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You reported that you feel NO/LITTLE/A LOT of love towards this project. Why? What about this project do you love? What about this project don't you love?
- Happy with joy [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You reported that you feel NO/LITTLE/A LOT of joy when engaged in this project. What about this project do you enjoy? Why
- Stressed [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You report feeling NO/LITTLE/A LOT of stress when involved in this project? Why do you feel stress about it? What about it makes you stressed out? How could you combat this stress?
- Uncertain [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You report feeling NO/LITTLE/A LOT of uncertainty about this project? What about this project makes you feel uncertain? Why? How could you feel more certain about this project?
- Depressed [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You report feeling a NO/LITTLE/A LOT of depression about project? What about this project makes you feel depressed? Why? What could you do to feel less depressed about this project?

- Difficulty [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You report you feel this project is NOT/MODERATELY/VERY difficulty? What about this project is difficult? Why? What about this project is easy? Why? How could you make it less difficult?
- Visibility [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You report this project has NO/MINIMAL/A LOT of visibility? Who else knows about this project? Why do they know?
- Control [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You feel you have NO/MINIMAL/A LOT/TOTAL control over this project? What about this project do you control? Why do you control it?
- Outcome/Likelihood of Success [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You report a LOW/MODERATE/HIGH likelihood of success? What about this project makes you likely to succeed? What makes you likely to fail? Why?
- Progress [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You report a LOW/MODERATE/HIGH degree of progress. What have you done thus far? What do you have left to do?
- Challenge [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You report you feel this project is NOT/MODERATELY/VERY challenging? What do you find challenging about this project? Why?
- Absorption [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You report that you feel NO/SOME/A LOT of immersion in this project? What about this project immerses you? Why?
- Competence [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You report feeling NOT/MODERATELY/COMPLETELY competent to complete this

project? What skills and experiences support your competence? Why do you think they do?

- Autonomy [INSERT NUMBER FROM PARTICIPANT PCSoP SURVEY]: You report that this project DOES NOT/SOMEWHAT/COMPLETELY depends on you, and you alone? Why?

APPENDIX E

CO-DESIGN WORKSHOP MATERIALS

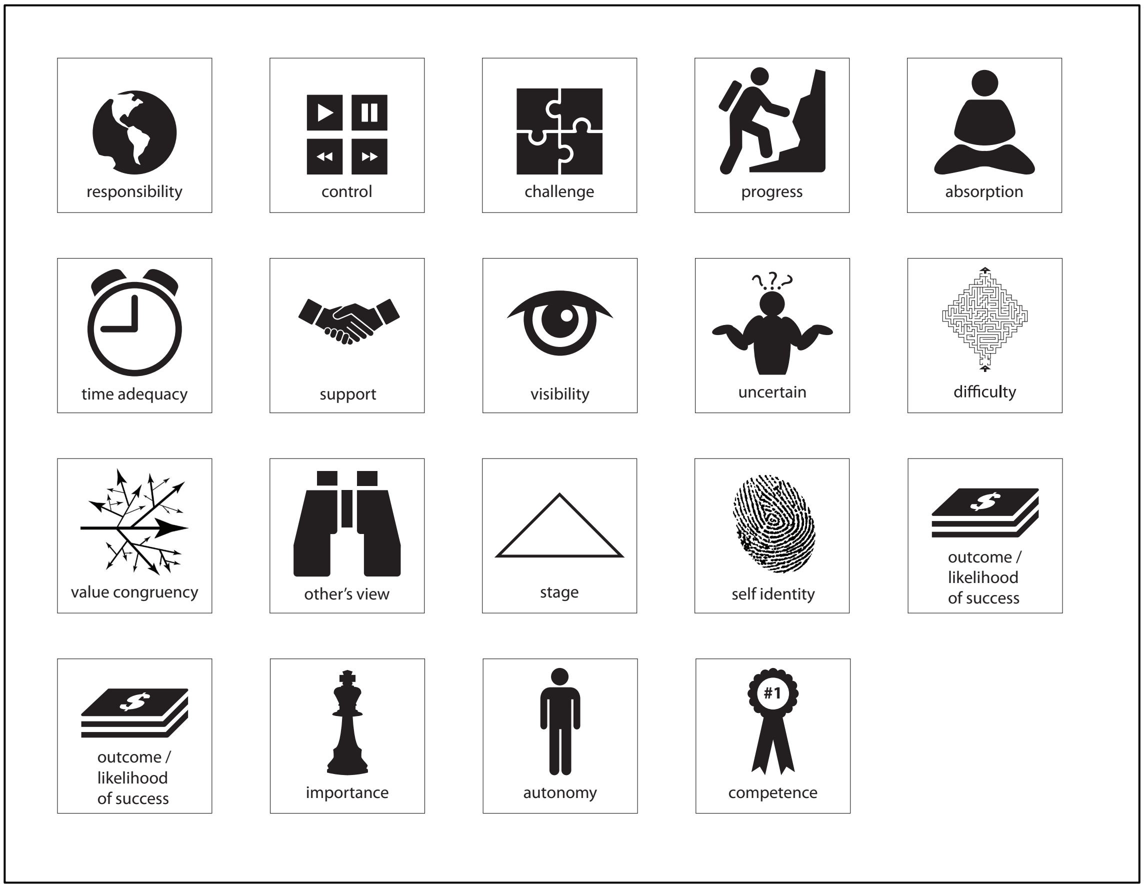


Figure 104. Personal project analysis (Little et al. 2007) cognitive tokens for psycho-cartographic mapping during the co-design collage activity.

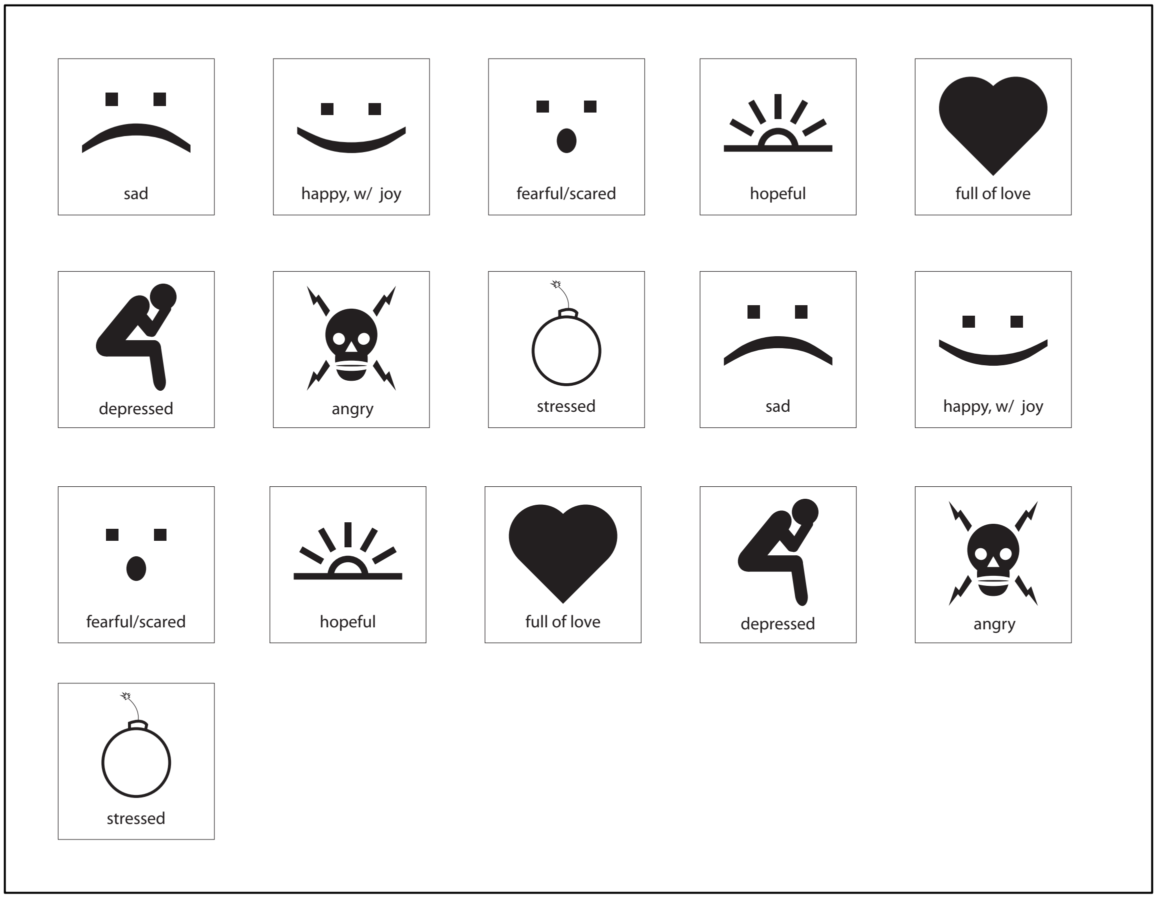


Figure 105. Personal project analysis (Little et al. 2007) affective tokens for psycho-cartographic mapping during the co-design collage activity.

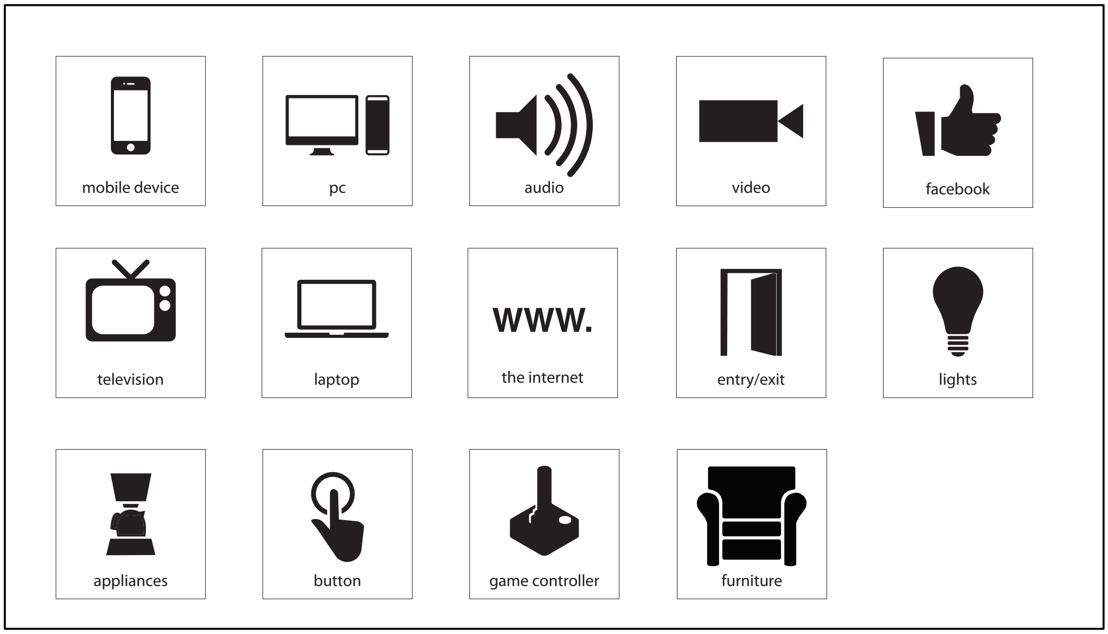


Figure 106. Game-as-life, life-as-game (Burleson et al. 2009) tokens for interaction mapping during the co-design collage activity.

APPENDIX F

GAME-AS-LIFE, LIFE-AS-GAME SMART HOME SERVICE PROVISION FIELD TEST

POST-HOC INTERVIEW GUIDE

- Over the past week, how have you used the system? If so, how and why? If not why?
- Has having the system in your home changed how much time you spend on the related project. If so, how and why? If not, why?
- Has having the system in your home affected your daily schedule? If so, how and why? If not, why?
- Has the system guided you through making progress on your project? If so, how and why? If not, why?
- Has the system made you feel more accountable for the project? If so, how and why? If not, why?
- Has the system affected your understanding of what you need to accomplish to complete your project? If so, how and why? If not, why?
- Has the system affected your understanding of what resources are available to you to get the project done? If so, how and why? If not, why?
- Has the system affected your understanding of what you consider to be success for this project? If so, how and why? If not, why?