# LEARNING, EFFICACY AND ACHIEVEMENT FRAMEWORK FOR OLDER ADULTS: A TECHNOLOGY ACCEPTANCE MODEL APPROACH

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## EXECUTIVE SUMMARY

Smart Assistive Technologies (SMATS) have the potential to improve the lives of older adults by helping them age in place. Many of these emerging technologies provide a range of benefits that assist older adults with activities of daily living, including improved health management, enhanced safety, and increased social connectivity. For instance, smartphone applications can assist elderly individuals with managing their medications independently, or conversational agent technologies can be used to contact emergency services if a telephone cannot be reached. By leveraging these technologies, older adults can enjoy greater autonomy, maintain their daily routines, and engage more actively in their communities. Despite the potential benefits of SMATS, many older adults struggle to adopt and use them.

One potential method to improve the adoption and use of SMATS among older adults is improving the associated instruction and training. From a macroscopic perspective, effective instructional design and training methods could prompt a behavior change that leads to technology adoption, an idea that is supported by the Health Belief Model (HBM; Rosenstock, 1966). This model stands out as one of the foundational health psychology models because it was developed to understand practical problems, such as why people fail to adopt disease prevention measures like tuberculosis screenings (Rosenstock, 1974a).

The systems approach to training (W. Rogers et al., 2001) can be applied to develop instructions and training to meet the needs of older adults. The systems approach to developing instructions and training involves identifying the problem domain, the specific tasks, the trainee population, the cost (in terms of time and money), and the resources available (S. Czaja & Sharit, 2013). The systems approach also involves identifying the best modality of instruction to be employed, given the details and context of an application. However, this approach does not integrate technology adoption literature, leaving a critical research gap. To address this gap constructs from the Unified Theory of Acceptance and Use of Technology 2 (UTAUT 2) and the Health Belief Model (HBM) were integrated into the Learning, Efficacy, and Achievement Framework (LEAF).

The LEAF was then integrated within the systems approach to developing instructions and training, supplementing it to improve outcomes by addressing the unique challenges and barriers older adults face when adopting and using SMATS. Older adults often encounter specific barriers that younger adults do not experience. Therefore, incorporating insights from technology adoption literature, the LEAF provides a comprehensive framework for developing tailored instructions and training targeting these potential problems.

This paper focuses on integrating technology acceptance literature into a framework that can be applied within the systems approach to developing training for older adults. The end goal of using the LEAF within the systems approach is to create an improved instruction and training program that can prompt behavior change, leading to the successful adoption and use of SMATS among older adults. The LEAF has three major components: 1) Learning, 2) Efficacy, and 3) Achievement. Learning incorporates two main principles: providing purpose and meeting learner needs. Providing purpose emphasizes the importance of users understanding their individual health-related needs and how adopting SMATS can address them. By offering clear, balanced information, users can develop outcome expectations crucial for the adoption and sustained use of SMATS. This involves understanding the health-related needs that SMATS can address and fostering a belief in users' abilities to engage with new technology successfully. Meeting learner needs on reducing the effort required to adopt and use SMATS. It highlights the importance of integrating SMATS into daily life and addresses users' abilities to engage effectively with new technology.

Efficacy within the LEAF aims to increase older adults' confidence in using technology by providing hands-on experience. These experiences demonstrate the specific benefits of SMATS and allow the learner to understand the amount of effort necessary to adopt and use the technology successfully. This approach ultimately enhances older adults' readiness to adopt and use technology effectively. Additionally, it focuses on reducing anxiety associated with using a new technology by providing assistance and training appropriate for the user's needs. Lastly, Efficacy in the LEAF emphasizes the role of social support networks. These networks are crucial in shaping attitudes toward technology adoption among older adults. Positive support from family and friends influences attitudes toward technology adoption, while negative influences can hinder adoption efforts.

Lastly, Achievement in the LEAF underlines the importance of reducing cognitive load and breaking tasks into sub-goals to reduce barriers to adoption. Setting clear, achievable goals and celebrating accomplishments can enhance older adults' self-efficacy, encouraging habitual use of SMATS. Moreover, breaking down larger learning goals into smaller, manageable tasks improves learning and self-efficacy by fostering problem-solving skills. Researchers and educators can utilize these strategies to foster greater confidence and proficiency in using technology.

In conclusion, the LEAF represents a pivotal strategy for addressing some of the challenges older adults face that hinder their adoption and use of SMATS. By leveraging insights from technology adoption literature, the LEAF, within the systems approach, enables the development of tailored training programs that cater to older adults' unique needs and circumstances. This, in turn, lowers barriers to adopting and using SMATS in their daily lives. Further research and application of the LEAF framework can continue to refine our understanding and implementation of effective technology training strategies for older adults. If applied, this framework, grounded in both theory and empirical research, has the potential to foster the ability of older adults to age in place using SMATS.

# CHAPTER 1
# INTRODUCTION

## 1.1 Problem and Background

The size of the older adult population in the United States is increasing at an extraordinary rate. There are 54.1 million adults aged 65+, representing 16% of the population. This is expected to grow to 80.8 million by 2040 and 94.7 million by 2060, ultimately making up approximately 25% of the United States population (Centers for Disease Control and Prevention, 2022). Simultaneously, technological innovation has accelerated, and technology has become an integral part of modern society. The proliferation of technology has led to the development of products and systems that have the potential to benefit older adults (Arthanat et al., 2019; Facchinetti et al., 2023; Levy et al., 2020; Trajkova & Martin-Hammond, 2020; Zubatiy et al., 2021). Specifically, emerging technologies offer promising solutions to facilitate aging in place by promoting health monitoring and socialization, in addition to providing improved safety and independence (Arthanat et al., 2019; Facchinetti et al., 2023; Levy et al., 2020; Trajkova & Martin-Hammond, 2020; Zubatiy et al., 2021).

Maintaining independence is crucial for older adults, and aging in place allows them to maintain this independence and self-esteem (Farber et al., 2011). Aging in place is defined as the ability to age safely and independently in one's home, and 77% of adults over 50 would prefer this arrangement (AARP, 2021; Farber et al., 2011; Ratnayake et al., 2022). This overwhelming preference is driven by older adults' desire to maintain their independence and the coupled issues of high cost and low availability of long-term care facilities (Bandura, 2004; Ratnayake et al., 2022; Shuman, 2023). Some estimates have indicated that 3,000 nursing homes must be built in the United States to meet the demand due to the growth of the older adult population (Shuman, 2023). The shortage of appropriate long-term care and the desire to age in the home could be addressed with the help of technological innovations that can assist older adults with activities of daily living (ADLs).

Smart assistive technologies (SMATS), such as wearable fitness, health and sleep trackers, smartphones, and computers, can help older adults complete activities of daily living and proactively monitor their health. Research suggests that older adults are increasingly seeking opportunities to learn how to use SMATS and other technologies (Haase et al., 2021; Mayhorn et al., 2004; Mitzner et al., 2008). The desire to learn to use SMATS grew further during the COVID-19 lockdowns due to these devices being used to combat boredom, learn new skills, and connect with other people (Gleaton, 2023b). In a quantitative study of 1,923 older adults' use of digital technology pre-pandemic (2019) and during the pandemic (2020), Sixsmith et al. (2022) found that that webinar attendance increased by 51%, online social activities increased by 50%, use of wearable health devices increased by 17%, and smartphone use increased by 15%. Moreover, 68% of the participants surveyed indicated they intended to continue using these technologies post-pandemic (Sixsmith et al., 2022, p. 22).

Despite the increase in older adults interest in SMATS, there is abundant literature indicating that most instructions accompanying these technologies do not meet older adult users' needs (S. Czaja & Sharit, 2013; Heinz et al., 2013; Hickman et al., 2007; W. Rogers et al., 2001; Yusif et al., 2016). More specifically, older adults find SMAT instructions insufficient, poorly designed, or difficult to understand (Gleaton, 2023b; Vaportzis et al., 2017). This poor instructional design has been identified as a barrier to the adoption and sustained use of SMATS. It is also one reason for the disuse of these devices among older adults (Gleaton, 2023b). Improved instructional design and training is one potential way to alleviate concerns that lead to disuse and improve adoption of these technologies.

Technology adoption refers to the uptake and integration of a new technology (E. Rogers, 1995). However, technology adoption is the first step in the broader lifespan of technology use. After technology adoption, sustained use must be achieved. Sustained technology use is defined in this paper as ongoing and consistent engagement with a particular technology. The literature supports that sustained engagement with a technology fosters familiarity, proficiency, and, in some cases, mastery (Arthanat et al., 2019; Dahlman & Westphal, 1981; Venkatesh et al., 2003).

Considering the instructional design and training gaps might help reduce or eliminate some of the challenges older adults encounter when trying to use SMATS. However, simply improving the clarity or design of instructions and training might not completely address the barriers that older adults face when adopting SMATS. To better cater to the specific needs of older adults, this work also combines technology adoption literature to inform the creation of instructions and training.

### 1.2 Objectives of This Work

The main objective of this paper is to improve the successful adoption and sustained use of SMATS by older adults by providing a structured yet flexible framework to guide the development of instruction and training materials. This framework will exist within the systems approach for developing instructions and training for older adults. Throughout this paper, "instructions and training" refers to any combination of materials, tutorials, and training programs (in-person and online). Frameworks provide a foundation for iterative improvement based on feedback, evaluation, and emerging research findings. A framework might lead to developing a model to explain or predict a particular outcome. However, developing and testing a predictive or explanatory model for a specific user base or technology is beyond the scope of this paper.

The framework development approach used in this work will be based on the technology acceptance literature and incorporate insights from empirical research and various cognitive, social, and health psychology theories. Traditionally, instructional design literature has focused solely on creating instructions without considering the broader user environment (W. Rogers et al., 2001). Some researchers have concentrated on enhancing instructional and training material design for older adults' technological, cognitive, and perceptual needs by applying a systems approach. A systems approach to developing training for older adults that integrates both theory and practice has been recommended by researchers (Mayhorn et al., 2004; W. Rogers et al., 2001).

However, the literature on technology adoption has not been integrated within the systems approach to developing training for older adults. By addressing this gap and utilizing a framework based on the technology acceptance literature, new instruction and training could be developed for older adults to minimize barriers to adopting and using SMATS. These materials could also prompt a behavior change that improves independence and the ability of older adults to age in place.

A high-level overview of some cognitive and physical age-related changes that older adults experience will be provided in chapter 2. This will serve to provide context for the remainder of this work. Then chapter 3 summarizes the Health Belief Model (HBM; Rosenstock, 1966), an integral model that this work relies on to understand the broader implications of the Learning, Efficacy, and Achievement Framework (LEAF). From a macroscopic approach, the LEAF is applied within the systems approach to training older adults in order to prompt a behavior change (i.e., the adoption and sustained use of SMATS among older adults to improve their ability to age in place). Next, chapter 4 discusses the systems approach to developing training for older adults (W. Rogers et al., 2001). This will provide an overview of the person and task requirements for developing appropriate instructions and training for older adults. In chapter 5, a brief history of the technology acceptance literature will be provided. This will serve as the foundation for developing the LEAF. Chapter 6 draws upon the previous foundational explanations to outline the LEAF. A high-level example of applying the LEAF will be provided in chapter 7. This will be followed by discussing the LEAF's scope, rationale, and limitations in chapter 8. Potential future work is discussed in chapter 9. Concluding remarks are given in chapter 10.

# CHAPTER 2
# UNDERSTANDING OLDER ADULTS

Mayhorn et al. (2004) suggests the design of effective instructions and training goes beyond crafting well-structured materials because it requires a deep understanding of the learners. To this end, the normative age-related physical and cognitive changes older adults undergo will be summarized. Additionally, this chapter will provide an overview of some common misconceptions regarding older adults' attitudes toward SMATS, emphasizing that a one-size-fits-all approach is insufficient for this population. This background material is critical in laying out the foundation for the subsequent developments of this work.

## 2.1 Normative Age-Related Changes in Cognition

The American Psychological Association (2018) defines cognition as "all forms of knowing and awareness, such as perceiving, conceiving, remembering, reasoning, judging, imagining, and problem-solving." Aging people experience a range of changes in cognition. While some cognitive abilities stay the same or improve over time, others can decline (Bugg et al., 2006; Murman, 2015). It is important to note that the extent of these changes is highly variable within groups of older adults (S. Czaja et al., 2019). Discerning empirically supported changes in cognition is integral to understanding older adults' adoption and use of technology. For example, one study of 47 Japanese adults between 60-80 years old ($M = 66.8, SD = 4.8$) Umemuro (2004) assessed the relationship between cognitive abilities and usage of various types of technology. They found that cognitive abilities significantly ($p < 0.05$) correlated with the use of multiple products, including copiers, answering machines, computers, the internet, and email (Umemuro, 2004, p. 73).

### 2.1.1 Memory

Memory is the "the ability to retain information or a representation of experience, based on the mental processes of learning or encoding, retention across some interval of time, and retrieval or reactivation of the memory" (American Psychological Association, 2018). There are multiple types of memory. These can be classified as short-term and long-term. Short-term memory includes working memory, while long-term memory includes semantic, prospective, and procedural memory.

Working memory is used for "the short-term maintenance and manipulation of information necessary for performing complex cognitive tasks such as learning, reasoning, and comprehension" (American Psychological Association, 2018). This form of memory has been well documented to decline with age (S. Czaja et al., 2019; Forsberg et al., 2022; Verhaeghen et al., 2019). Working memory is also associated with language comprehension. Among older adults, working memory limitations can make forming inferences from complex speech difficult (S. Czaja et al., 2019). However, according to Payne et al. (2012), life experience can buffer the effects of working memory declines among older adults, especially when reading information.

Semantic memory is "memory for general factual knowledge and concepts, of the kind that endows information with meaning and ultimately allows people to engage in such complex cognitive processes as recognizing objects and using language" (American Psychological Association, 2018). Research indicates that vocabulary, verbal reasoning, and speech comprehension in normal conversation remain stable among older adults (Murman, 2015). This is because normative age-related changes do not typically impact semantic memory, although information retrieval might be slower for older adults (S. Czaja et al., 2019). The factual knowledge retained in semantic memory overlaps with the concept of crystallized intelligence (Cattell, 1961), which is "the accumulation of knowledge" over the lifespan (Coane et al., 2023, p. 1).

Prospective memory is "remembering to do something in the future, such as taking one's medicine later" (American Psychological Association, 2018). Research indicates that "time-based" prospective memory, which involves remembering to do a task at a certain time, often degrades more than “event-based” prospective memory, which is remembering to do a task sequentially after another task (S. Czaja et al., 2019, p. 25). This type of memory is negatively impacted by age-related changes, although there is a high degree of individual variability (Murman, 2015).

Procedural memory is “long-term memory for the skills involved in particular tasks. Procedural memory is demonstrated by skilled performance and is often separate from the ability to verbalize this knowledge” (American Psychological Association, 2018). Remembering procedural tasks encoded earlier in life, such as playing a musical instrument or riding a bike, is not impacted by aging (Murman, 2015, p. 5). However, older adults might have difficulty or take longer to encode new processes or procedures (S. Czaja et al., 2019; Fisk & Rogers, 2000).

#### 2.1.2 Attention

Attention is defined as “a state in which cognitive resources are focused on certain aspects of the environment rather than on others” (American Psychological Association, 2018). Types of attention include selective, divided, and sustained. Selective attention is “concentration on certain stimuli in the environment and not on others, enabling important stimuli to be distinguished from peripheral or incidental ones” (American Psychological Association, 2018). This form of attention is not directly impacted by aging. Still, research has attributed attentional differences between older and younger adults to the general slowing of information processing (Glisky, 2007).

Next, divided attention is “attention to two or more channels of information simultaneously so that two or more tasks may be performed concurrently. It may involve using just one sense (e.g., hearing) or two or more senses (e.g., hearing and vision)” (American Psychological Association, 2018). According to S. Czaja et al. (2019), most people must divide their attention across multiple sources throughout daily activities. This form of attention has been shown to have age-related decline, particularly when the tasks increase in complexity (S. Czaja et al., 2019; Glisky, 2007). Promising research has shown that aerobic exercise and practice completing tasks involving attention-switching can reduce the impact of age-related decline in these abilities (Glisky, 2007). Lastly, sustained attention is “attentional focus on a task for an extended length of time” (American

Psychological Association, 2018). This form of attention is not impacted by age-related changes (Glisky, 2007).

### 2.1.3 Spatial Cognition

Spatial cognition is defined as "the collection, organization, use, and revision of information about one's environment. Spatial cognition enables people to manage many everyday tasks, such as getting to the breakfast table, taking the subway to work, or using a joystick to move a character in a virtual game. It is a complex phenomenon that often extends beyond immediate perception" (American Psychological Association, 2018). Research indicates that younger adults outperform older adults in tasks that involve spatial cognition (S. Czaja et al., 2019). In particular, declines in spatial cognition tend to increase after the age of 70 (Barrash, 1994; Beaudet et al., 2015).

## 2.2 Normative Age-Related Physical Changes

As people age, they undergo physical changes that shape their health and daily functioning in later life. These age-related physical changes encompass various aspects of the body's structure, function, and overall well-being. Understanding these age-related physical changes is crucial when designing for older adults. Designing instructions that consider these changes can make technology more accessible and user-friendly for older adults, increasing their likelihood of adoption and sustained use.

Interacting with technology often requires physical, perceptual, and cognitive skills that some older adults may struggle with; therefore, technology must be designed with accessibility in mind. For example, hearing impairment can impact an individual's ability to interact with certain audio-based technologies (Rosenberg et al., 2009). Additionally, lacking fine motor skills might make it challenging to operate a computer mouse (Fisk, 1999). The following section overviews some normative age-related physical changes that older adults experience.

### 2.2.1 Vision

Numerous changes to visual abilities occur when aging. Two of the most prominent changes are decreases in visual accommodation and acuity. Decreased visual accommodation is caused by "a reduction in the efficiency of the eye's ability to change focus for objects at different distances" (American Psychological Association, 2018). Changes in visual accommodation occur from decreased elasticity of the lens fibers, ultimately leading to presbyopia, also known as farsightedness (Glasser & Campbell, 1998; Salvi et al., 2006). Visual acuity is "the degree of clarity, or sharpness, of visual perception" (American Psychological Association, 2018). Additionally, older adults often experience a reduced ability to adapt to dark lighting conditions (S. Czaja et al., 2019; Salvi et al., 2006). They might also experience increases in glare and have a more challenging time differentiating between specific colors, mainly yellow and blue (S. Czaja et al., 2019; Salvi et al., 2006; Tamura & Sato, 2020).

### 2.2.2 Hearing

According to National Institutes of Health (2023a), approximately one out of every three adults between the ages of 65-74 have experienced hearing loss, increasing to one in two by age 75. This is caused by long-term degradation of the receptor cells within the ear due to cumulative damage caused by loud noises (National Institutes of Health, 2023a). Hearing loss has many consequences such as making understanding and communicating with others difficult. Research indicates that hearing loss increases the risk for additional cognitive decline (Eshkoor et al., 2015; National Institutes of Health, 2023b).

### 2.2.3 Kinesthetics and Motor Skills

One of the most noticeable changes people experience while aging is the gradual decline in muscle mass, bone density, and strength. This generally results in decreased mobility and movement control. Movement control is defined as "coordination of muscles for action control based on perception or cognition and includes a range of motions, from broader motions like steering a car to more precise motions such as moving a mouse and double-clicking on the desired action" (S. Czaja et al., 2019, p.28). Moreover, some older adults lose their ability to recognize their body position, particularly in motion. The ability to identify body position is known as Kinesthetics, and losing this ability leads to falls and an increase in injuries (S. Czaja et al., 2019).

### 2.3 Common Misconceptions About Older Adults

Considering these cognitive and physical changes is an essential part of designing for older adults, but it is incorrect to assume that all older share the same experience, knowledge, skills, and abilities (S. Czaja et al., 2019). Moreover, there are extensive differences in socioeconomic status and literacy rates among older adults, which might impact their ability to access or interact with technologies (Yusif et al., 2016).

It is often assumed that older adults are computer-phobic. However, a meta-analysis conducted by Rosen and Maguire (1990) found that computerphobia is equally likely to be found in older and younger people. Researchers who study older adults have also indicated that this population is "open to learning and using a wide range of new technology (from apps to computer systems to robots) if training and support are available" (S. Czaja et al., 2019, p. 52). As mentioned in chapter 1, older adults often seek training programs to teach them how to use technologies (Mayhorn et al., 2004; Mitzner et al., 2008).

The desire to learn how to interact with technologies increased during the COVID-19 pandemic, and therefore, many technology support programs for older adults were initiated (Finkelstein et al., 2023). While it is still largely unknown how efficacious these programs were, research indicates that technology use among older adults is at an all-time high. According to PEW research, between 2012 and 2021, among United States adults ages 65 and older, smartphone ownership rose from 13% to 61%, social media use increased from 11% to 45%, and tablet ownership increased from 4% to 44% (Faverio, 2022).

These increases largely disprove sentiment referring to an older adult's unwillingness or inability to try and learn new things. Poor technology adoption rates and high disuse might be due to additional barriers caused by products and instructions not sufficiently designed to meet the needs of older adults. For example, Loos et al. (2021) found that older adults desire technology developers to create usable products that meet their needs. These findings are consistent with the work of Olson et al. (2011), who found that while the "breadth of experience may differ across age groups, there are certain aspects of Internet use within which older adult Internet users will be quite familiar" (p. 142). Their results ultimately indicated that although general technology use among older adults is more domain-specific than among younger adults, older adults are not averse to utilizing new technologies. They further suggested that these effects might be especially true for health-related technologies because older adults need them more (Olson et al., 2011).

# CHAPTER 3
# THE HEALTH BELIEF MODEL

When trying to understand the adoption of health-related behaviors, the Health Belief Model (HBM; Rosenstock, 1966) stands out as one of the foundational models of health psychology. The HBM is an explanatory model theoretically grounded in the cognitive and social psychology work of Kurt Lewin and Edward Tolman (Maiman & Becker, 1974; Rosenstock et al., 1988). The HBM was also heavily influenced by empirical studies conducted by the social psychologists Godfrey Hochbaum, Stephen Kegels, Howard Leventhal, and Irwin Rosenstock, who worked for the United States Public Health Service (Rosenstock, 1974a). The creators of the HBM intended to use it to understand practical problems such as why people fail to adopt disease prevention measures like tuberculosis screenings (Rosenstock, 1974a, 1974b). Since then, the HBM has remained relevant because it explains the factors influencing an individual to adopt various preventative health-related behaviors (Glanz, 2001).

## 3.1 Components and Theoretical Background of the Health Belief Model

The HBM hypothesizes that individuals are more likely to adopt health-related behaviors if they 1) perceive themselves to be susceptible to a health threat or disease, 2) believe the threat to be severe, and 3) see the benefits of adopting the behavior as outweighing the barriers (Rosenstock, 1974a; Rosenstock et al., 1988). According to the HBM, several factors influence an individual's health-related behaviors. These are *perceived susceptibility*, *perceived severity*, *perceived benefits*, *perceived barriers*, and *cues to action*. First, *perceived susceptibility* refers to whether an individual believes that they are susceptible to a health threat or disease (Rosenstock, 1974a, p. 330). The literature indicates that people often underestimate their disease susceptibility (Redding et al., 2000). This is important because perceiving risk or vulnerability to disease is essential to motivating a healthy behavior change (Ferrer & Klein, 2015).

Next, *perceived severity* (sometimes known as "perceived threat") refers to an individual's perception that "the occurrence of the disease would have at least moderate severity on some component of his life" (Rosenstock, 1974b, p. 330). Like perceived susceptibility, perceived severity might be based on medical knowledge or individual beliefs about the difficulties the disease would have on their daily life. However, Bandura et al. (1999) theorizes that perceived severity might not correlate well with health behavior due to avoidance behavior (Munro et al., 2007; Orji et al., 2012).

Third, *perceived benefits* is defined as the perception that "taking a particular action would be beneficial by reducing his susceptibility to the condition, or if the disease occurred, by reducing its severity" (Rosenstock, 1974a, p. 330). More specifically, an individual needs to believe that an intended outcome will occur by performing a specific behavior. Orji et al. (2012, p. 5) provides an example where if an individual does not believe that there is a relationship between excessive eating and obesity, they are unlikely to adopt healthier eating habits to reduce the chances of obesity.

*Perceived barriers* refers to cost, inconvenience, pain, and embarrassment that might occur by partaking in the behavior (Rosenstock, 1974b, p. 330). An individual must do an internal cost-benefit analysis to determine whether the benefits of performing the new behavior outweigh the consequences of continuing the old behavior.

Lastly, *cues to action* are prompts that lead to a health-related action being taken. According to Rosenstock (1974a, p. 332) cues to action can be "internal (e.g., perception of bodily states) or external (e.g., interpersonal interactions, the impact of media of communication, or receiving a postcard from the dentist)." According to the HBM, cues to action can directly influence the perceived severity of disease. Therefore, triggering a new behavior (Orji et al., 2012). Moreover, observing another person successfully perform a health-related change prompts a change in individual behavior. In Social Cognitive Theory (SCT), this is known as *observational learning*, which occurs when an individual sees another person successfully demonstrate behavior and then believes they can do it themselves (LaMorte, 2022b). Ultimately, Rosenstock et al. (1988) attributes the similarities between SCT and the HBM to the author's shared inspiration in the work of Edward Tolman (e.g., Tolman, 1932) and Kurt Lewin (e.g., Lewin, 1935; Lewin, 1951).

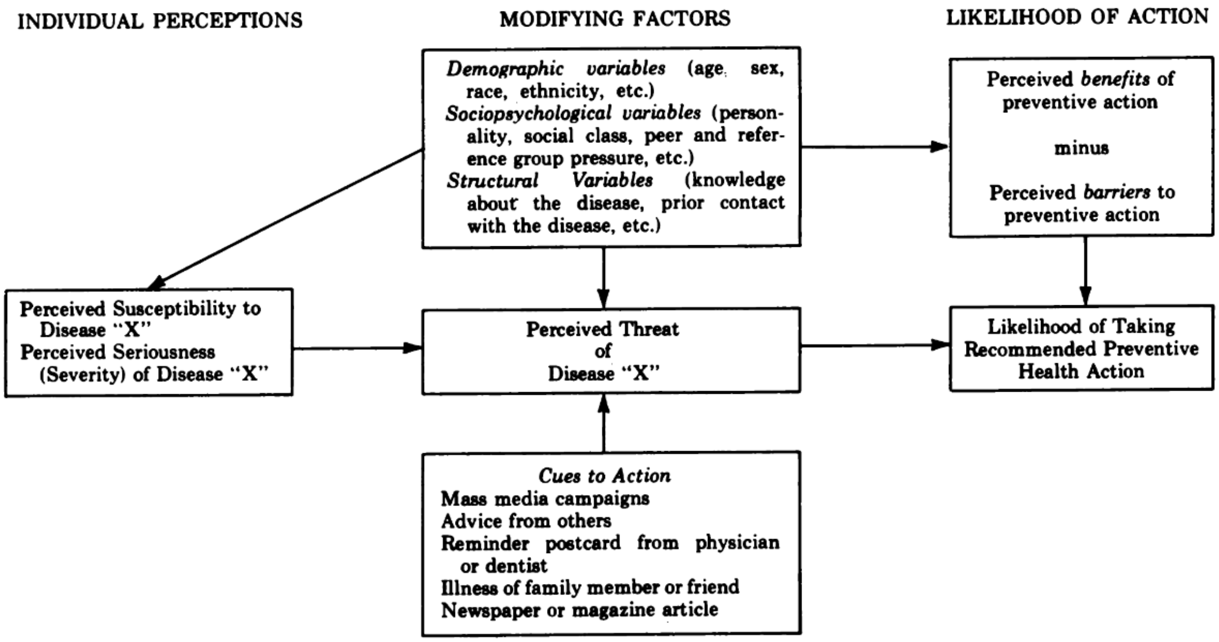


Figure 3.1: The Health Belief Model from Rosenstock (1974b, p. 334)

In 1988, SCT's concept of self-efficacy was added to the HBM as "efficacy expectation". This addition addressed concerns regarding the models' coverage of chronic illness and long-term changes in health status as opposed to its previous focus on short-term preventative measures (Rosenstock et al., 1988). Specifically, efficacy expectation posits that those with higher self-efficacy are more likely to engage in health-promoting behaviors because they believe they can do so successfully and will achieve a positive outcome. Rosenstock et al. (1988) asserts that assessing self-efficacy is integral to planning health education needs. They then provided an example of skill training arranged in terms of increasingly difficult steps to master, with individuals' self-efficacy increasing by achieving success in the earlier exercises, making them more prepared for complex tasks (Rosenstock et al., 1988, p. 181).

## 3.2 Critiques and Limitations of the Health Belief Model

Despite its widespread use, the HBM has faced criticism over its limitations. One criticism is that the HBM was created as an explanatory model, so its predictive validity has been questioned (Orji et al., 2012). Furthermore, the model's focus on individual-level factors might neglect the importance of sociocultural contexts and systemic barriers to health behavior. For example, someone might recognize that smoking is a behavior that will lead to negative health-related outcomes. Yet, they do not stop because the behavior is socially acceptable among their peers. Additionally, the HBM does not consider the influence of habits, including addiction, that might alter the process of making a health-related decision. For example, the behavior of smoking is an addictive habit, which makes quitting extremely difficult (LaMorte, 2022a, para. 4).

One limitation of the HBM that is not often discussed is the location of the efficacy expectation construct. As previously mentioned, efficacy expectation was added to the HBM much later than the other constructs. However, its location and relationships with the other constructs were not clearly defined. The debate on where efficacy expectations should be located has persisted in the literature. Janz and Becker (1984) suggested that it falls within Perceived Barriers; however, Rosenstock et al. (1988) disagreed. Rosenstock explains that "Making self-efficacy explicit in the HBM has two values: it delimits the dimension of the barrier and, more importantly, suggests new and more productive lines for research and practice" (Rosenstock et al., 1988, p. 179). Subsequent research that utilized the HBM placed the construct of efficacy expectations in various locations (see Appendix A).

Another limitation of the HBM, according to Rosenstock (1974a), is that cues to action were not carefully studied before their inclusion in the model. This is a valuable area of research that needs to be explored. A potential cue to action might come in the form of a training program. Training programs can emphasize the potential health benefits of SMATS technologies. Ultimately, by incorporating the HBM into discussions about older adults' adoption of SMATS, instructions and training can be designed to effectively communicate health benefits, address technological barriers, and help users overcome perceived barriers to adoption.

### 3.3 Instructions and Training as a Cue to Action for Behavior Change

The gap in understanding effective cues to action has persisted since Rosenstock (1974a) historical overview of the HBM. According to Orji et al. (2012, p. 6), cues to action are still the least developed and researched variable in the HBM. However, their influence on behavior change has a lot of potential utility. The LEAF is designed to be implemented as a cue to action within W. Rogers et al. (2001) Systems Approach to Training (discussed in chapter 4). Ultimately, the LEAF is comprehensive, theoretically grounded, and used to guide the development of training and instructional materials that address the complex issue of technology adoption for health promotion among older adults. More specifically, it is a framework to guide the development of instruction and training that can be applied to diverse groups of older adults who might use a variety of SMATS.

# CHAPTER 4
# THE SYSTEMS APPROACH TO TRAINING

## 4.1 The Role of Human Factors

Researchers and designers need to consider physical and cognitive changes when developing products for older adults. Human Factors play a key role in this analysis by drawing upon psychological theory to inform design decisions that improve user outcomes. While Human Factors is important for product design, the instructions and training to use the product are equally critical in setting up the older adult learner up for success from the beginning (W. Rogers et al., 2001). Historically, there is a disconnect between the developers and end-users of instructional and training materials (W. Rogers et al., 2001). This is problematic because studies have found that current training and instructions are not being designed based on the needs and capabilities of older adults (S. Czaja & Sharit, 2013; Gleaton, 2023b; Heinz et al., 2013; Hickman et al., 2007; W. Rogers et al., 2001; Yusif et al., 2016). To address these concerns, researchers in the field of Human Factors have dedicated their careers to improving instructions and training for the older adult population (e.g., S. Czaja & Sharit, 2013; S. Czaja et al., 2019; Fisk, 1999; Mitzner et al., 2008). Some recommendations include reducing working memory load by avoiding the use of technical jargon (Mayhorn et al., 2004), allowing for self-paced learning (Zandri & Charness, 1989), introducing procedural instructions (Mayhorn et al., 2004; Mead & Fisk, 1998; Mitzner et al., 2008), and employing scaffolding methods to allow for the structured increase in difficulty of practice tasks (S. Czaja & Sharit, 2013).

It is beyond the scope of the present paper to provide a detailed summary of the various physical design recommendations that have been derived over the years. However, prominent Human Factors and design literature for older adults is compiled in S. Czaja and Sharit (2013), S. Czaja et al. (2019), and Fisk (1999). Additionally, Duffy and Waller (1985) provides theoretical and practical guidelines for designing general texts for all age groups (e.g., document preparation, editing, figure placement, graphics). Lastly, Evans (2017) provides an overview of how to align user-centered design with psychological theory. The implications of this work and its relation to the physical design of SMATS and their interfaces will be discussed in more detail in chapter 8.

For example, David Evans, a social psychologist and senior manager of customer research at Microsoft, presented a salient example of applying Human Factors principles to the design of technology in his book "Bottlenecks: Aligning UX Design with User Psychology" (Evans, 2017). He explained that in 2007, Microsoft transitioned from installing Microsoft Office as a CD to downloading it online. Unfortunately, the download button for the software was not positioned well, and many users incorrectly clicked a more salient large green button instead of the correct "download now" button (depicted in Figure 4.1). He goes on to explain that it makes sense that even attentive users often make this mistake and click the wrong button. Gestalt psychology posits that color, size, and shape are more influential in drawing the user's attention to click a button than the words on the button itself (Evans, 2017, ch. 4). Microsoft subsequently updated its interface based on recommendations derived from Gestalt Theory, leading to an improved design, fewer user errors, and fewer calls to their customer support (Evans, 2017, p. 40).

While these recommendations are important, their implementation requires trade-offs. For example, procedure-based instructions might help users accomplish their tasks quickly and easily with minimal effort. However, they might also lead to sub-par learning and transfer of skills (Eiriksdottir & Catrambone, 2011; Hickman et al., 2007). A more detailed review of this literature can be found in S. Czaja et al. (2019). An analysis of these trade offs is where a systems approach to training provides value. The systems approach utilizes Human Factors principles to improve technology design and training based on the user's needs, capabilities, and limitations. This approach considers the interplay between different training program elements, including the learners, content, delivery methods, and assessment techniques.


Figure 4.1: Download Dialog Box for Office 2007. Buttons enlarged for clarity. *Reprinted with permission* from Evans, 2017, p.39

### 4.1.1 The Systems Approach to Developing Instructions and Training for Older Adults

According to W. Rogers et al. (2001), the systems approach to developing a training program is described as including a *needs assessment* to understand what information is required to inform the training development. Within the needs assessment are the *task analysis* and *person analysis*. A task analysis is used to identify the elements of the desired tasks and their order (W. Rogers et al., 2001, p. 189). While a person analysis focuses on user-specific variables such as age, gender, competence, self-efficacy, and experience (W. Rogers et al., 2001, p. 189). The information from the needs assessment is used to inform the development of the training. Lastly, the systems approach calls for the *evaluation* of the training program to determine "whether or which training programs are successful" (W. Rogers et al., 2001, p. 189). According to Rogers, evaluation includes usability testing, information retention, and measures of transfer of training. These results can lead to decisions about modifying the existing training to improve outcomes for the learner. This iterative process is outlined in figure Figure 4.2.

Ultimately, the systems approach to developing instructions and training involves identifying the problem domain, the specific tasks, the trainee population, the cost (in terms of both time and money), and the resources available (S. Czaja & Sharit, 2013). Additionally, the modality of instruction employed is important when considering both the goals of the training and learner outcomes. W. Rogers et al. (2001) emphasized that the systems approach to training "must consider the user of the technology, the environment in which the technology will be used, and the characteristics of the technology itself." According to W. Rogers et al. (2001), the systems approach is very common in Human Factors literature. However, until her 2001 paper, it had not been used to develop of training and instructional materials for older adults. By understanding the user, Human Factors best practices can be leveraged to reduce barriers to adoption by improving the design of instructions and training for older adults. The literature is clear that lowering barriers will improve the adoption of technology and foster the behavior of sustained use.

### 4.1.2 Limitations of the Systems Approach

The systems approach focuses on the structure, design, implementation, and evaluation of instructions and training rather than the psychological factors influencing technology adoption. It does not currently integrate the technology adoption literature, which leaves a critical research gap. The literature on technology adoption attempts to predict or explain how and why users adopt and use technology. Several well-established theories and models of technology adoption have been developed, such as the Diffusion of Innovation (DOI; E. Rogers, 2003) theory, the Technology Acceptance Model (TAM; Davis, 1989), the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003), and the Unified Theory of Acceptance and Use of Technology 2 model (UTAUT 2; Venkatesh et al., 2012), which provide robust frameworks for understanding technology adoption. Similarly, the Health Belief Model (HBM; Rosenstock, 1966) attempts to explain how people make preventative health-related decisions (such as adopting a new healthy behavior or preventative treatment for a disease). These models and their underlying theories identify vital factors influencing adoption, and they will be discussed in more detail in chapter 5.

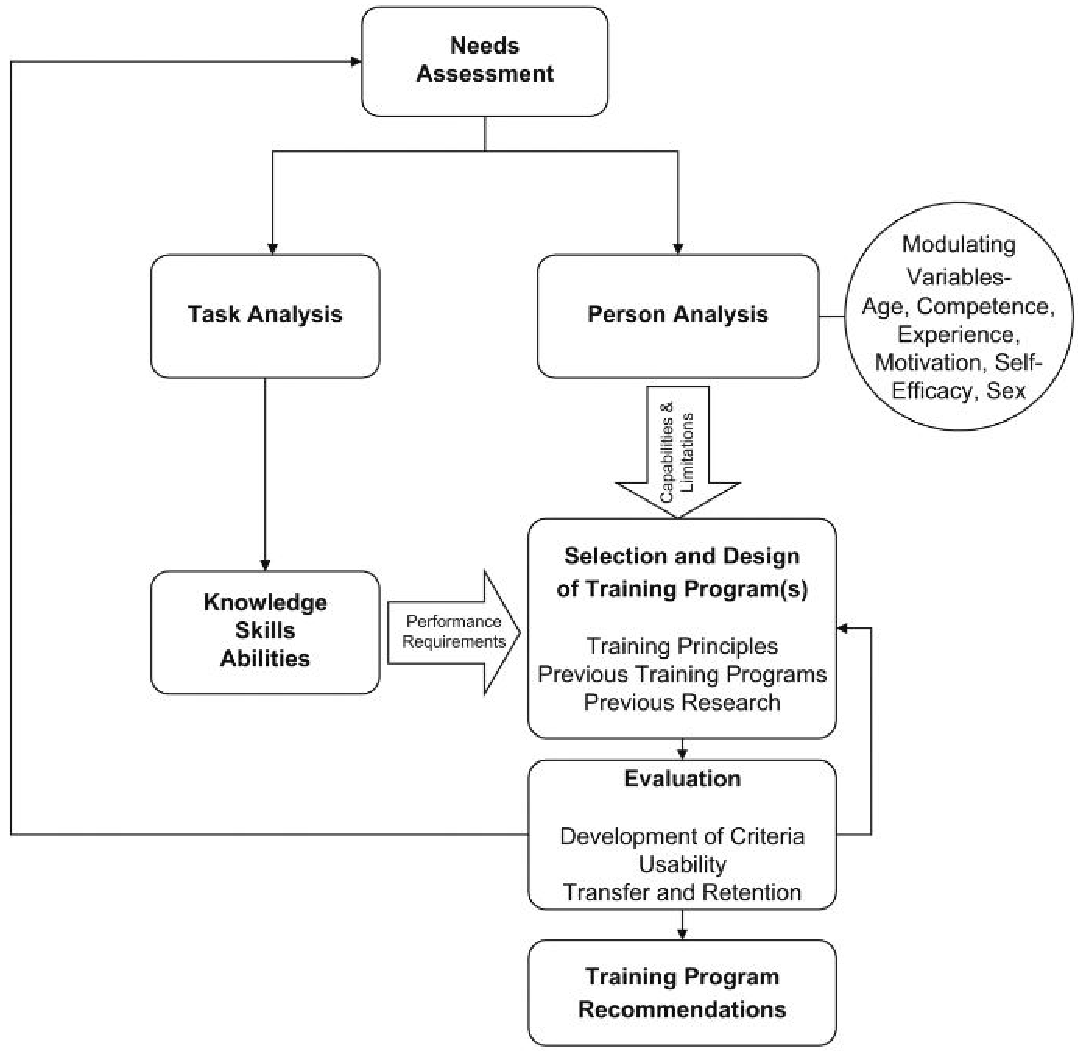


Figure 4.2: A Systems Approach to Training *Reprinted with permission* from W. Rogers et al. (2001, p.190)

Incorporating insights from the technology adoption literature into the systems approach for developing instructions and training is crucial to this work. This integration addresses a critical gap in existing methodologies. By merging the constructs and principles of technology acceptance with a comprehensive systems approach, this work provides a robust framework that can significantly improve older adults' instruction and training outcomes. This combination ensures that instruction and training programs are evidence-based and grounded in psychological theory. This combination is also anticipated to serve as a cue to action to foster a lasting behavior change.

## 4.2 The Learning Efficacy and Achievement Framework (LEAF)

The technology adoption literature attributes adoption to factors such as the benefits and barriers of use, social influences, whether it is fun, and what habits are formed around using it. The LEAF integrates these constructs and empirical evidence from studies assessing technology adoption, use, and disuse among older adults with the systems approach to training. The LEAF is a comprehensive, theoretically grounded framework designed to guide the development of training and instructional materials that can address the complex issue of technology adoption and use. The resulting instructions and training form a cue to action, as defined by the HBM, to foster behavior change. This integration is demonstrated in Figure 4.3. The behavior change goal of the LEAF is the adoption and use of SMATS to improve older adults' ability to age in place.

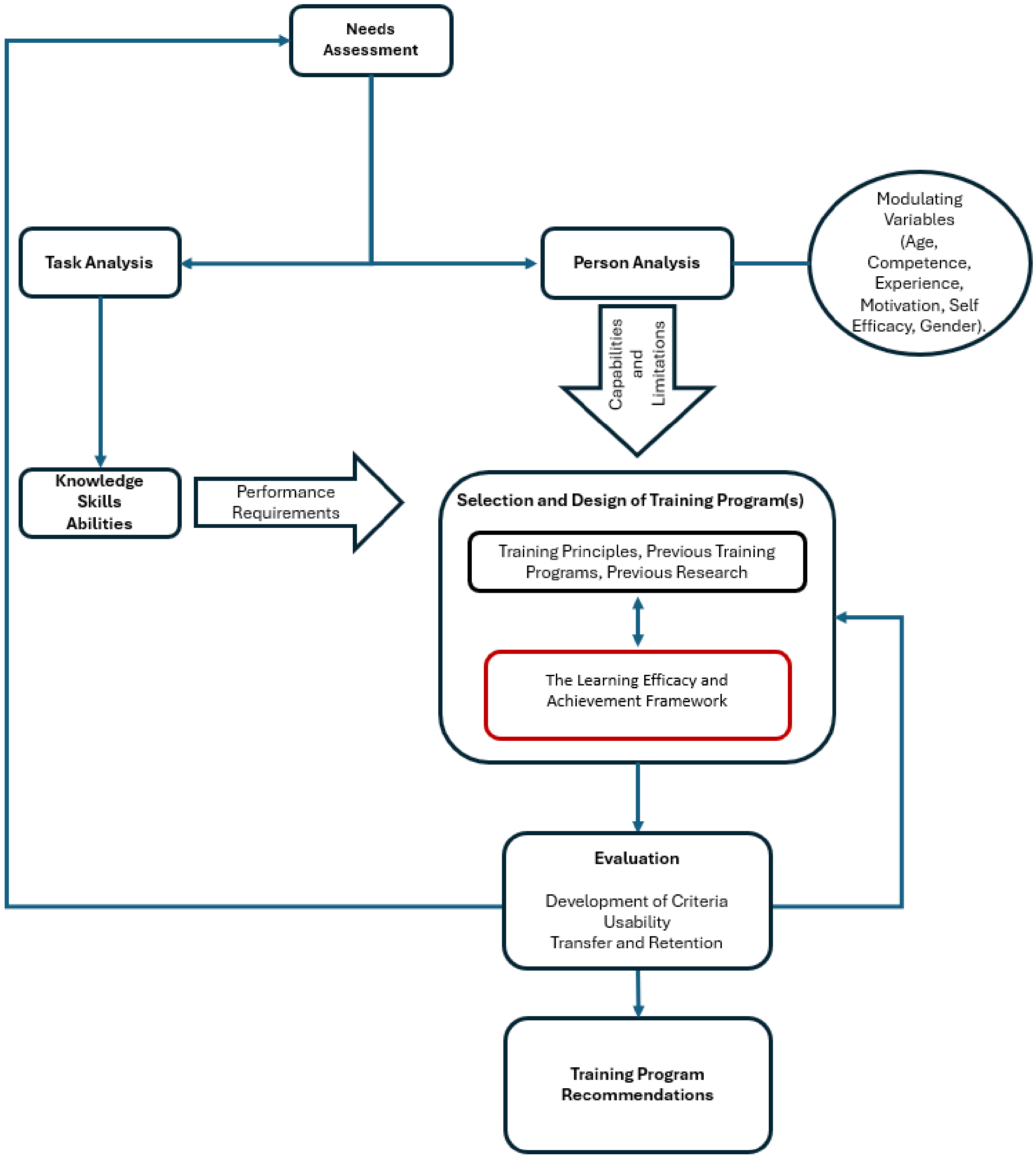


Figure 4.3: The Learning, Efficacy, and Achievement Framework (LEAF) within W. Rogers et al. (2001) Systems Approach to Training

# CHAPTER 5

# TECHNOLOGY ACCEPTANCE: BACKGROUND AND THEORY

The LEAF is theoretically grounded in models of technology acceptance. Research on technology acceptance indicates that for a technology to be adopted, the user must identify a need that the technology will meet (also known as perceived usefulness or PU). The user must also find the technology relatively effortless (perceived ease of use or PEOY). Together, these constructs determine behavioral intention to adopt the technology (Davis, 1989). These findings also extend to older adults. In an assessment of older adults' willingness to adopt digital tools, Liesa-Orús et al. (2023) found that "perceived ease of use of the technology has a positive effect on the perceived usefulness" and that "perceived usefulness of technology on the intention to use these resources is observed through the manifestation of positive attitudes towards the use of digital tools".

Additionally, Sugawara et al. (2018) assessed 643 adults about assistive technology that was adopted and then abandoned. Their results indicated that "the users' perception about the importance of using these devices is shown to be significant in explaining abandonment" (p. 716). This result highlights the importance of older adults' comprehension and perception of the usefulness and usability of technology in sustaining the use of the technology. (Mitzner et al., 2010) suggests that enhanced training and education on the outcome-of-use benefits might lead to improved adoption of these technologies among older adults. Integrating technology adoption literature and its underlying theory into the training development framework will be crucial in fostering older adults' adoption and sustained use of SMATS.

The UTAUT 2 model (Venkatesh et al., 2012) is the decedent of the UTAUT model (Venkatesh et al., 2003). With over 17,000 citations, it is one of the most dominant models of technology adoption that occurs outside of the workplace. This chapter provides an overview of the history and theory of technology adoption and the models that contributed to the development of the UTAUT 2. First, the Diffusion of Innovation Theory (E. Rogers, 1995) is described. Next, this chapter provides a historical overview of the development of the UTAUT 2 and the underlying theories and models that contributed to its development. Lastly, this chapter describes how the UTAUT 2 model and HBM share an underlying theory and complement each other.

## 5.1 Diffusion of Innovations Theory

Dr. Everett Rogers' 1962 book, *Diffusion of Innovations* explains how innovations are communicated in society. Now in its fifth edition (E. Rogers, 2003), Diffusion of Innovations has been widely applied in sociology, psychology, economics, anthropology, political science, management, and ecology (Greenhalgh et al., 2005). Diffusion of Innovation (DOI) theory describes a macro-level approach to adopting innovations. *Innovations* are defined as "an idea, practice, or object that is perceived as new by the individual or other unit of adoption" (E. Rogers, 2003, p. 12). Core concepts of DOI theory include *communication channels*, *adopter categories*, and *perceived attributes of innovation*. The following sections provide an overview of the core components of DOI theory. Lastly, subsection 5.1.4 discusses the theory's critiques and limitations.

### 5.1.1 Communication Channels

Communication channels are "the means by which messages get from one individual to another" (E. Rogers, 2003, p. 18). These channels range from mass media to interpersonal communications. Rogers declares that most investigations of DOI show that the adoption of innovation depends on the experiences of peers who have already adopted it (E. Rogers, 2003, p.19). Therefore, within the context of communication channels, the involvement of other people becomes crucial. Engaging in interpersonal discussions about innovations that peers have adopted can influence individuals' desire to adopt the innovation. Ultimately, communication channels serve as the path through which information about innovations travels. Individuals rely on the experiences and behaviors of others communicated through these channels to decide whether they want to adopt an innovation.

### 5.1.2 Adopter Categories

Rogers defines five different categories of adopters: innovators, early adopters, early majority, late majority, and laggards. It should be noted that these adopter categories represent “ideal types” and are abstractions based on empirical investigations (E. Rogers, 2003, p. 282). These investigations suggest that each group’s population percentage is based on the average timespan of innovation adoption (Figure 4.2).

*Innovators*

Innovators are the first type of adopters, and they comprise approximately 2.5% of the population. They are adventurous risk-takers who can handle uncertainty and setbacks. They also have a high degree of technical knowledge that can readily be applied. Rogers also explains that innovators “control of substantial financial resources helps absorb the possible losses from an unprofitable innovation” (E. Rogers, 2003, p. 282). This suggests that innovators are generally more wealthy and can afford to adopt innovations that might not be successful. Innovators socialize with innovators while acting as gatekeepers between innovations and society (E. Rogers, 2003, p.283).

*Early Adopters*

Early adopters are the next category, and they represent approximately 13.5% of the population. This category tends to advise other adopter categories, serving as role models in using innovations. While innovators are not always respected, peers often respect the judgment of early adopters. According to Rogers, “The early adopter knows that to continue to earn this esteem of colleagues and to maintain a central position in the communication of networks of the system, he or she must make judicious innovation-decisions” (E. Rogers, 2003, p.283). Ultimately, the role of the early adopter is to reduce the uncertainty about utilizing innovations, thereby furthering the diffusion of innovations into society.

*Early Majority*

The early majority represents 34% of the population, and they provide “interconnectedness to the systems personal networks” (E. Rogers, 2003, p. 284). Adoption takes longer for the early majority than the first two groups, but they play a critical role in disseminating innovations to the broader population (Figure 5.1). Rogers explains that this slower adoption is due to a more deliberative thought process (E. Rogers, 2003, p. 284).

*Late Majority*

The late majority represents another 34% of the population. They tend to adopt innovations slightly later than other adopters (Figure 5.1). Adopting innovations might be out of necessity for the late majority due to changing social norms or increased societal reliance on new technology. It might also be due to pressure from peers or family members. Rogers also indicates that these individuals might have fewer resources than those in the previous adopter categories, and therefore “most of the uncertainty about the new idea must be removed before the late majority feel safe to adopt” (E. Rogers, 2003, p. 284). For example, a survey of 1,167 adults (220 of which were age 65 and above) indicated that over 50% of participants age 65 and older were late adopters of Internet banking systems (Mattila et al., 2003). Their study revealed that improved education for older customers to use Internet banking alleviated concerns that hindered adoption (Mattila et al., 2003, p. 524).

*Laggards*

Lastly, laggards represent 16% of the population. Rogers explains that these individuals do not possess opinion leadership, are socially isolated, and interact with those who have relatively traditional values. Moreover, they are suspicious of change agents and often resist innovation. Laggards are also hindered by limited resources, meaning that they are not willing to entertain the idea of failure of the innovation. Despite the negative connotation, Rogers indicates that this description of bias away from innovations is not meant to be derogatory. Specifically, he states that “...it is a mistake to imply that laggards are somehow at fault for being relatively late to adopt. System blame might more accurately describe the reality of the laggards' situation" (E. Rogers, 2003, p. 285).

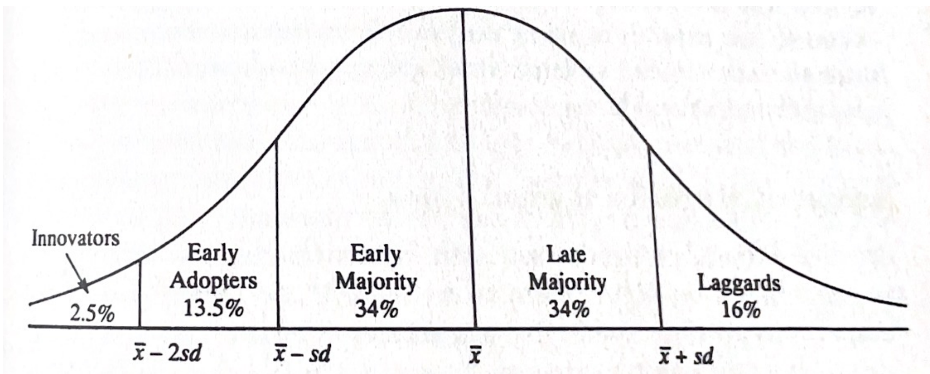


Figure 5.1: Adopter Categories on the Basis of Innovativeness from E. Rogers (2003, p. 281)

### 5.1.3 Perceived Attributes of Innovation

DOI theory describes five factors contributing to the adoption of innovations. Rogers acknowledges that these are a "gross oversimplification" because of the time variable, with some innovations being rapidly adopted and others taking decades (E. Rogers, 2003, p.15).

*Relative Advantage*

Relative advantage is defined as "The degree to which an innovation is perceived as better than the idea it supersedes" (E. Rogers, 2003, p. 15). Rogers indicates that advantage is not necessarily based on productivity or economic advantage but also on social advantage or prestige. Advantage also does not necessarily have to be objective. Ultimately, what matters is the user's subjective perspective on whether or not the innovations are advantageous.

*Compatibility*

Compatibility is "the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters"(E. Rogers, 2003, p. 15). This attribute of innovations depends on associated social values and societal norms. Innovations that are not compatible with these norms will not be readily adopted. In his book, Rogers provides an example of contraception not being adopted in countries that have religious beliefs discouraging its use (E. Rogers, 2003, p. 15)

*Complexity*

Complexity is “the degree to which an innovation is perceived as difficult to understand and use”(E. Rogers, 2003, p. 16). Rogers defines complexity at the societal rather than the individual level. He provided an example of researchers attempting to teach germ theory to a rural Peruvian village. He explained that not all members of the society were willing to accept this idea because they could not understand something they could not see (E. Rogers, 2003, p. 1-2).

*Trialability*

Trialability “is the degree to which an innovation may be experimented with on a limited basis” (E. Rogers, 2003, p. 16). Trialability gives prospective users additional certainty when adopting innovations because they have gained experience with them during a small-scale test. Rogers provides an illustrative example of a farmer testing a new hybrid seed in a small plot of land before changing their entire crop over in the future (E. Rogers, 2003, p. 16). A trial period allows for the uncertainty around innovations to be mitigated before adoption occurs.

*Observability*

Observability is “the degree to which the results of an innovation are visible to others. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it” (E. Rogers, 2003, p.16). Rogers claims that an individual’s immediate social network fosters peer discussion and evaluation. He then provides another illustrative example of solar water heaters being more likely to be found in neighborhood clusters due to peer observability. Other innovations, such as home computers, diffuse more slowly because they have relatively low external visibility (E.

Rogers, 2003, p. 16). The 2003 publication date should be considered when reviewing the home computer example.

### 5.1.4 DOI Theory Limitations

DOI theory has demonstrated incredible value in explaining how innovations are adopted within society (Greenhalgh et al., 2005). However, it is limited in some aspects. One limitation is that it does not account for an individual's social or financial resources or lack thereof (LaMorte, 2019). For example, an individual might want to adopt an electric vehicle but cannot because they cannot afford it. Another major critique is that conducting participatory research on a large enough scale to capture and model these constructs is both challenging and resource-intensive. The term "innovations" is also broad and encompasses wide-ranging new ideas and technologies. Therefore, predictively modeling the adoption of innovations in general might be infeasible. To address these limitations, Moore and Benbasat (1991) simplified DOI theory. Their work was then used by Venkatesh et al. (2003) to create a predictive technology acceptance model called the Unified Theory of Adoption and Use of Technology (UTAUT). This will be discussed further in section 5.2.

## 5.2 Informing Models of Technology Adoption: From DOI Theory to the UTAUT 2 Model

Venkatesh et al. (2012) developed the Unified Theory of Acceptance and Use of Technology 2 (UTAUT 2). The UTAUT 2 represents a substantial advancement in understanding the dynamics of technology adoption. It is built upon its predecessors, the Technology Acceptance Model (TAM; Davis, 1989) and the original UTAUT model (Venkatesh et al., 2003). Subsection 5.2.1 will overview the empirical research and theory that contributed to the development of the UTAUT 2 model.

### 5.2.1 Origins of UTAUT 2: The TAM

The TAM model was first introduced in Fred Davis' dissertation (Davis, 1986) and subsequently published (Davis, 1989). This work quickly demonstrated practical value by becoming one of the most widely acknowledged models of technology acceptance, having influenced psychology, education, computer science, and engineering (Davis, 1986, 1989; Kim et al., 2016; King & He, 2006; Lee et al., 2003). According to Davis (1989), two main components determine an individual's behavioral intention to adopt a technology. They are *perceived usefulness*, and "perceived ease of use". Perceived usefulness is the intention to use a technology based on a need. Perceived ease of use is an individual's belief that it would not take much effort to use a system (Davis, 1989).

The TAM is heavily grounded in the Theory of Reasoned Action (TRA; Fishbein & Ajzen, 1975). According to TRA *attitudes* and *subjective norms* determine specific behavior (see Figure 5.2). Attitudes "refer to the degree to which a person has a favorable evaluation or appraisal of the behavior in question" (Ajzen, 1991, p. 188). Subjective norms "refers to the perceived social pressure to perform or not to perform the behavior" (Ajzen, 1991, p. 188). Together, these constructs lead to the formation of *intention*, which is the likelihood of a behavior occurring in the form of how much effort it takes to perform a behavior (Ajzen, 1991, p. 181).

Despite its popularity, the overarching criticism of TAM is its simplicity and lack of predictive power (Benbasat & Barki, 2007; Shachak et al., 2019). Critics believe that the shortcomings of TAM are due to the limited consideration of the dynamic relationship among individual differences, social influences, and device design that shapes technological needs (Benbasat & Barki, 2007; Burton-Jones & Hubona, 2005; Chuttur, 2009; S.-C. Lin et al., 2014; Malatji et al., 2020).

### 5.2.2 The Evolution of TRA to TPB

In 1985, the same year that Davis defended his dissertation on the TAM, a new construct, *Perceived Behavioral Control*, was added to TRA (Ajzen, 1985). This change prompted the evolution of TRA to the Theory of Planned Behavior (TPB). The additional construct, Perceived Behavioral Control "refers to the perceived ease or difficulty of performing the behavior, and it is assumed to reflect experience as well as anticipated impediments and obstacles" (Ajzen, 1991, p. 188). While this addition was not included in the TAM, subsequent research incorporated this update. The addition of this construct can be seen in Figure 5.2.

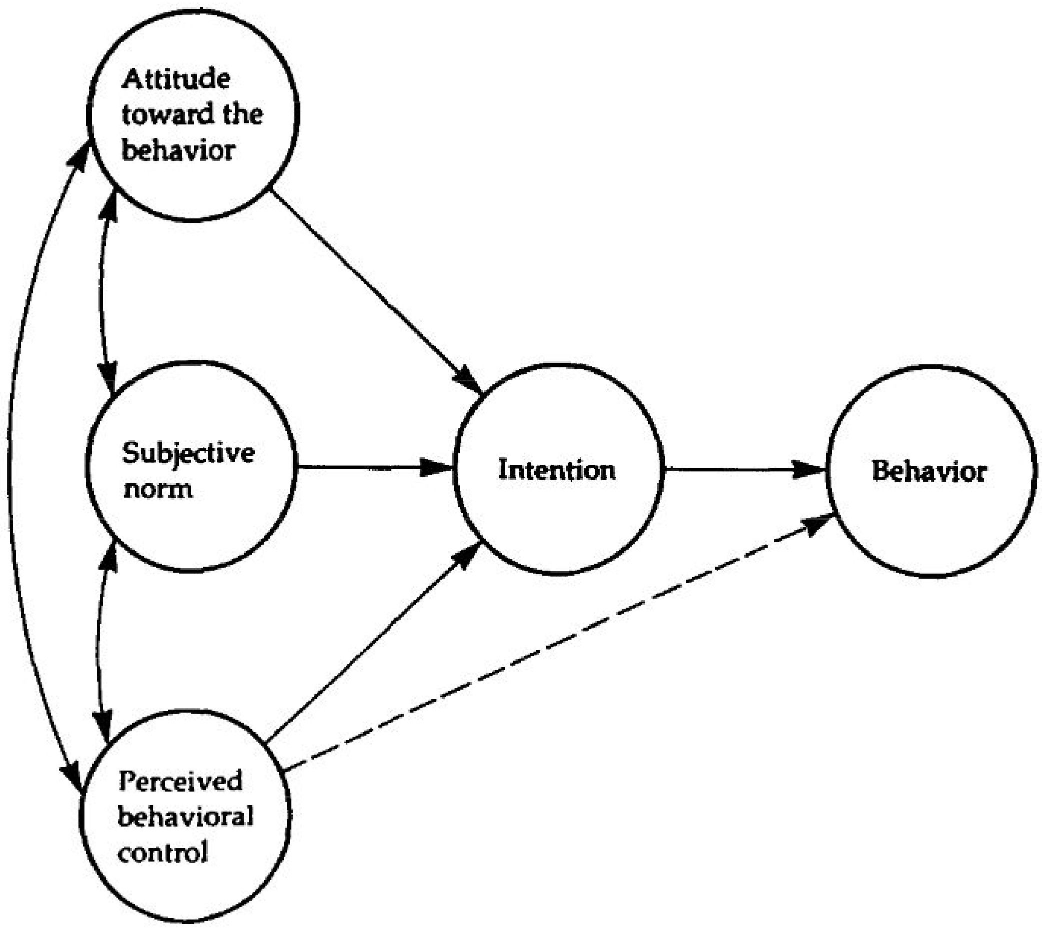

Figure 5.2: The Theory of Planned Behavior from Ajzen (1991, p. 191)

### 5.2.3 From the TAM to the UTAUT Model

To address the criticisms about the TAM and to consolidate other theories and models of technology acceptance, Venkatesh et al. (2003) integrated technology acceptance constructs from across the literature into the UTAUT. These include the TAM (Davis, 1989), DOI theory (E. Rogers, 1995), Social Cognitive Theory (SCT; Bandura, 1986), the Theory of Planned Behavior (TPB; Ajzen, 1985) and others.

In their study, Venkatesh and colleagues compared constructs from technology acceptance models and psychological theories to determine the variance in user intention toward using a new computer system in the workplace. This was done by collecting longitudinal data every two months from four organizations with employees being introduced to the new computer system in the workplace. The total data collection time was six months. Using this data, they created the UTAUT (depicted in Figure 5.3).

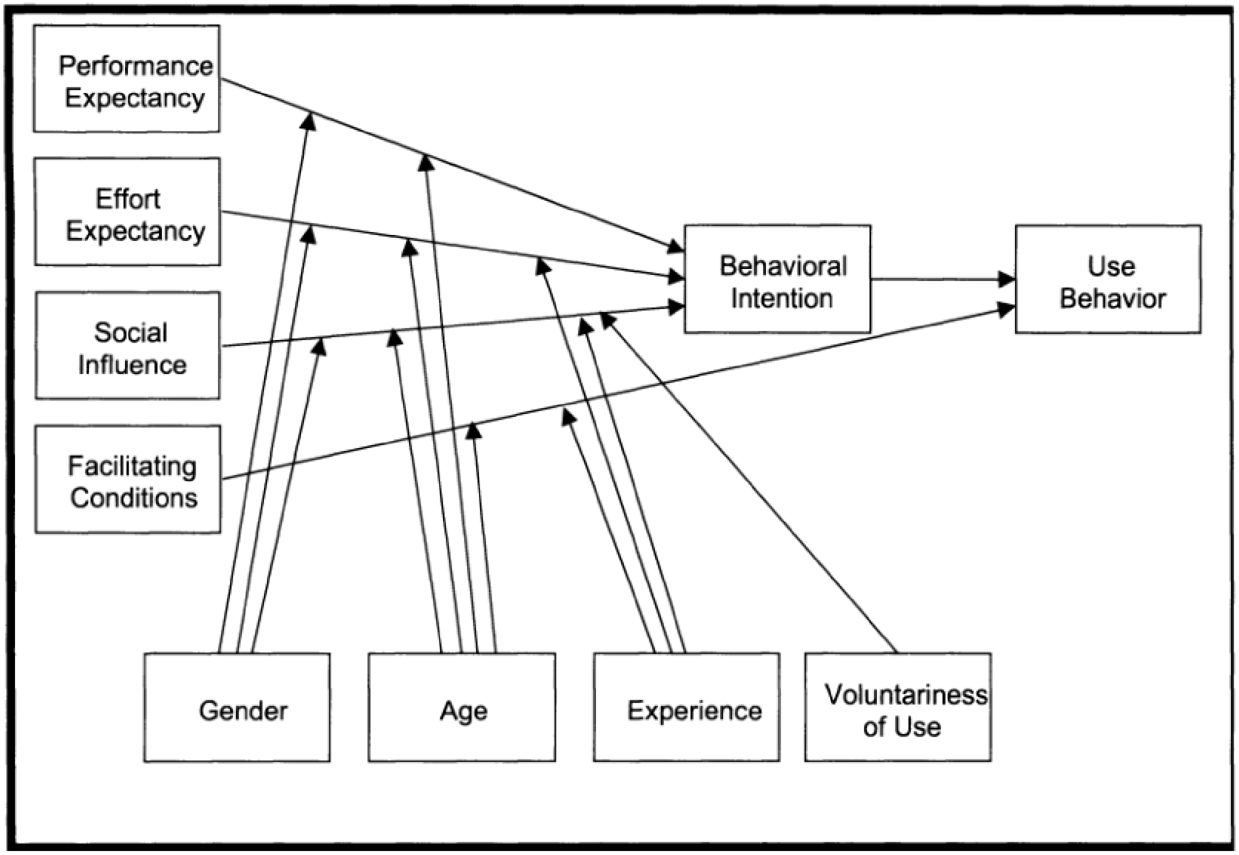


Figure 5.3: UTAUT Model from Venkatesh et al. (2003, p. 447)

The UTAUT model comprises four key constructs: *performance expectancy*, *effort expectancy*, *social influence*, and *facilitating conditions* (Figure 5.3). The first two, performance expectancy and effort expectancy, resemble the TAM constructs perceived usefulness and perceived ease of use, respectively. Performance expectancy is defined as “the degree to which an individual believes that using the system will help him or her attain gains in job performance” (Venkatesh et al., 2012, p. 447). This construct is also theoretically grounded in the relative advantage portion of DOI theory (subsection 5.1.3) and Social Cognitive Theory’s (SCT) construct of self-efficacy (section 3.1).

Effort expectancy is defined as “the degree of ease associated with the use of the system” (Venkatesh et al., 2012, p. 450). In addition to being derived from TAM, this construct is theoretically grounded in the perceived behavioral control portion of TPB, emphasizing the role of difficulty in performing behavior (Ajzen, 1985). Effort expectancy also integrates the complexity measures of DOI theory (subsection 5.1.3). Next, Venkatesh et al. (2003) defines social influence as "the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh et al., 2003, p. 451). Social influence is theoretically grounded in DOI theory, TPB, and SCT. DOI theory describes the influence of opinion leaders and communication channels on adoption (subsection 5.1.1-subsection 5.1.2). TPB explains the role of subjective norms (subsection 5.2.1). SCT posits that behavior is influenced by the interaction between personal factors, environmental factors, and behavior itself (Bandura, 1994).

Venkatesh et al. (2003) defines facilitating conditions in the UTAUT model as "the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system" (p. 483). Facilitating conditions are informed by TPB's construct of perceived behavioral control (subsection 5.2.2) and DOI theory's construct of compatibility (subsection 5.1.3). According to TPB, perceived behavioral control can directly influence behavior, as individuals are more likely to engage in a behavior if they perceive that they have the necessary resources and opportunities to do so (Fishbein & Ajzen, 1975). In DOI theory, compatibility includes the support that can accelerate adoption by reducing perceived barriers (E. Rogers, 2003).

Lastly, gender, age, experience, and voluntariness of use were added as moderators of the UTAUT model (Figure 5.3). The previous theories make no claims regarding these moderators, but Venkatesh et al. (2003) references numerous empirical studies that informed the decision to include these variables as moderators in their hypotheses. For example, they referenced a meta-analysis conducted by Rhodes (1983) showing that older workers are more likely to place increased value on social influences than younger workers (Venkatesh et al., 2012, p. 253).

#### 5.2.4 Validity of the UTAUT Model

After creating the UTAUT model, Venkatesh et al. (2003) aimed to test it. They had six major hypotheses, shown in Table 5.1. These hypotheses were generated based on previous empirical research suggesting the relevance of each construct and moderator. Results of their study indicated that the UTAUT model accounted for 70% of usage intention variance (Venkatesh et al., 2003, p. 467). The moderators, age, gender, voluntariness, and experience were also found to be significant. Ultimately, all hypotheses were supported, demonstrating the overall predictive power and validity of the UTAUT model.

| **UTAUT Hypothesis** | **Independent Variables** | **Result** |
|---|---|---|
| ***H1:*** *The influence of performance expectancy on behavioral intention will be moderated by gender and age, such that the effect will be stronger for men and particularly for younger men.* | Performance Expectancy | Supported |
| ***H2:*** *The influence of effort expectancy on behavioral intention will be moderated by gender, age, and experience, such that the effect will be stronger for women, particularly younger women, and particularly at the early stages of experience.* | Effort Expectancy | Supported |
| ***H3:*** *The influence of social influence on behavioral intention will be moderated by gender, age, voluntariness, and experience, such that the effect will be stronger for women, particularly older women, particularly in mandatory settings in the early stages of experience.* | Social Influence | Supported |
| ***H4(a):*** *Facilitating conditions will not have a significant influence on behavioral intention* | Facilitating Conditions | Supported |
| ***H4(b):*** *The influence of facilitating conditions on usage will be moderated by age and experience, such that the effect will be stronger for older workers, particularly with increasing experience.* | Facilitating Conditions | Supported |
| ***H5(a):*** *Computer self-efficacy will not have a significant influence on behavioral intention* | Computer-self efficacy | Supported |
| ***H5(b):*** *computer anxiety will not have a significant influence on behavioral intention* | Computer anxiety | Supported |
| ***H5(c):*** *Attitude toward using technology will not have a significant influence on behavioral intention* | Attitude toward using technology | Supported |
| ***H6:*** *Behavioral intention will have a significant positive influence on usage* | Behavioral Intention | Supported |

Table 5.1: UTAUT Model Hypotheses Summary (Venkatesh et al., 2003)

While their study did not exclusively assess older adults or SMATS in voluntary use contexts, the results provide an additional understanding of technology adoption. The results of Hypothesis 2, Hypothesis 3, and Hypothesis 4b are particularly relevant in this work because they directly assessed the moderating effects of age on behavioral intention (Hypotheses 2 and 3) and actual usage (Hypothesis H4b) of the computer system.

The results of Hypothesis 2 indicated that the effect of effort expectancy on behavioral intention was particularly strong "for women, older workers, and those with limited experience" (Venkatesh et al., 2012, p. 468). This result shows that effort expectancy is important when users form usage intentions.

The results of Hypothesis 3 indicated that the effect of social influence on behavioral intention to adopt technology also was stronger among "women, older workers, in conditions of mandatory use, and among those with limited experience" (Venkatesh et al., 2012, p. 468). This result indicates that other people influence a user's behavioral intention to adopt a technology.

Lastly, the results of Hypothesis 4b indicated that the effect of facilitating conditions on actual usage of the computer systems was stronger among older workers with increasing experience (Venkatesh et al., 2012, p. 468). This result emphasizes the role of organizational support when individuals determine their usage intention. However, the UTAUT study is specific to the organizational workplace context and does not address voluntary use.

### 5.2.5 The Creation of the UTAUT 2 Model

The major shortcoming of the UTAUT model is that it was created and evaluated in an organizational workplace context and might not accurately reflect the voluntary adoption of technologies. To address this concern, Venkatesh et al. (2012) used empirical results of research conducted on the UTAUT to add *Hedonic Motivation*, *Cost*, and *Habit* into the UTAUT model. These additions created the UTAUT 2 (Figure 5.4). Similar to the original UTAUT model, age, gender, and experience were included as moderators.

Hedonic motivation is defined as "the fun or pleasure derived from using technology" (Venkatesh et al., 2012, p. 161). This construct was added because Venkatesh and colleagues found empirical evidence suggesting it would contribute to the model's ability to predict the product's utility in voluntary use contexts. For example, Brown and Venkatesh (2005) hypothesized that "age will

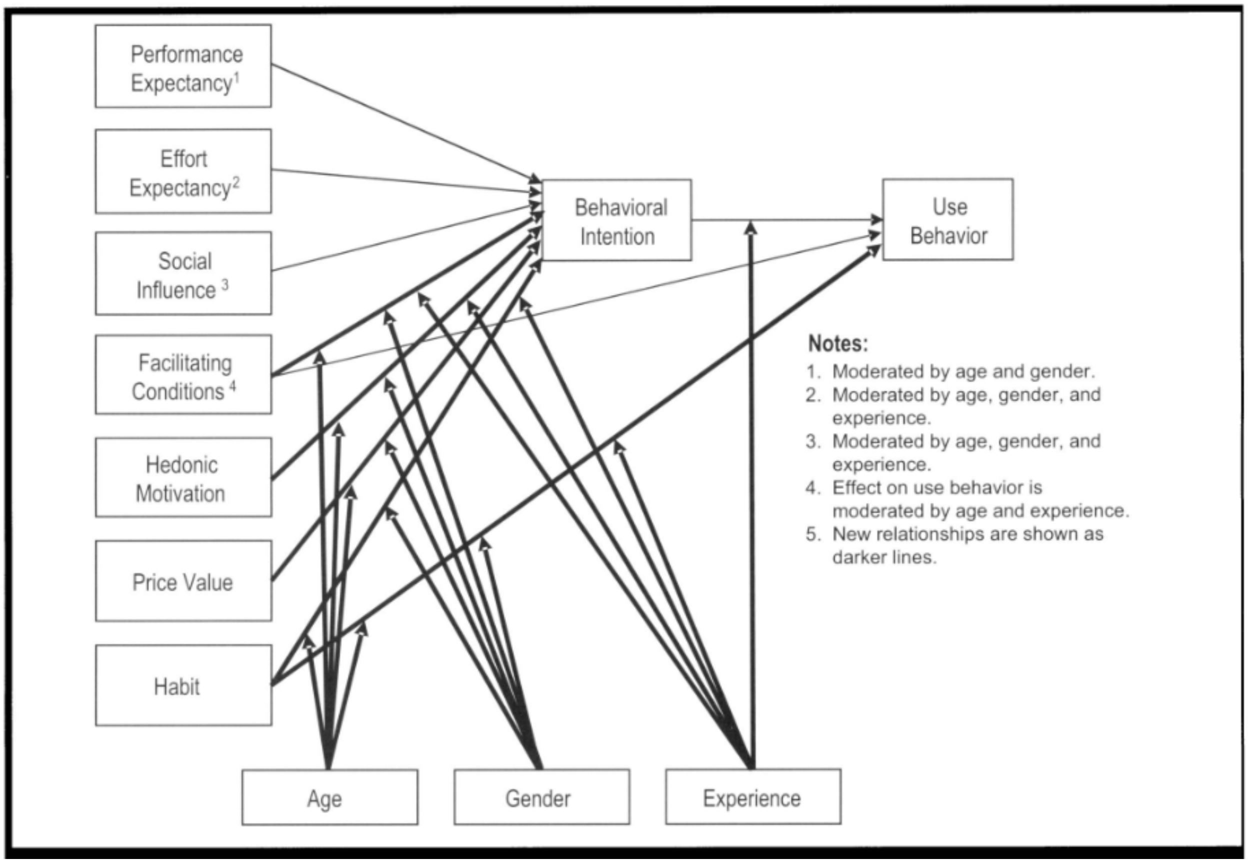


Figure 5.4: UTAUT 2 Model from Venkatesh et al. (2012, p. 160)

moderate the relationship between applications for fun and intention to adopt a personal computer (PC) for household use, such that applications for fun decrease in importance as age increases" (Brown & Venkatesh, 2005, p. 406). To test this, Brown and Venkatesh (2005) recruited 1,247 participants to respond to a survey that assessed intentions to use a home PC. Results indicated that hedonic motivation became less important as age increased, although the authors suggested that additional research was needed to understand these changes in belief structure over time (Brown & Venkatesh, 2005).

Price value is defined as "consumer's cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them" (Venkatesh et al., 2012, p. 161). The inclusion of this construct was based on marketing research that assessed how consumers determine the value of a product. For example, Dodds et al. (1991) assessed the effects of price, brand, and store information on whether a buyer will be willing to purchase a product. Dodds et al. (1991) results found that favorable brand and store information influenced buyers' perceptions of the product's quality and value. These perceptions increased the buyer's intent on purchasing the product (Dodds et al., 1991, p. 307).

Lastly, the UTAUT 2 defines habit as the "extent to which people tend to perform a behavior automatically because of learning " (Venkatesh et al., 2012, p. 161). In the context of their work, Venkatesh et al. (2012, p. 161) state that "habit is a perceptual construct that reflects the results of prior experiences." It is important to acknowledge that habit is different from experience. Experience "reflects an opportunity to use a target technology and is typically operationalized as the passage of time from the initial use of technology by an individual" (Venkatesh et al., 2012, p. 161).

#### 5.2.6 Validity of the UTAUT 2 Model

The UTAUT 2 model was validated by having 1,512 participants complete an online questionnaire that assessed the use of six different types of popular mobile internet applications. The results revealed that the UTAUT 2 model could explain 74% of the variance in behavioral intention to use mobile applications. They then analyzed these data using the original UTAUT model. Results showed that the UTAUT explained only 53% of the variance in intention to use the mobile applications. This comparison revealed that for voluntary use, the UTAUT 2 is a more valid model than the UTAUT.

Hypothesis development for the UTAUT 2 was also largely inspired by the results of empirical studies rather than traditional psychological theory. Results found that most of the specific hypotheses for the UTAUT 2 were supported. While the UTAUT 2 validation work did not specifically assess older adults, age was a moderating variable in hypotheses 1-4. These results are summarized in Table 5.2.

| **UTAUT 2 Hypothesis** | **Result** |
|---|---|
| ***H1:*** *Age, gender, and experience will moderate the effect of facilitating conditions on behavioral intention, such that the effect will be stronger among older women in the early stages of experience with technology.* | Partially Supported |
| ***H2:*** *Age, gender, and experience will moderate the effect of hedonic motivation on behavioral intention, such that the effect will be stronger among younger men in the early stages of experience with technology.* | Supported |
| ***H3:*** *Age and gender will moderate the effect of price value on behavioral intention, such that the effect will be stronger among women, particularly older women.* | Supported |
| ***H4(a):*** *Age, gender, and experience will moderate the effect of habit on behavioral intention, such that the effect will be stronger for older men with high levels of experience with the technology.* | Supported |
| ***H4(b):*** *Age, gender, and experience will moderate the effect of habit on technology use, such that the effect will be stronger for older men with high experience with the technology.* | Supported |
| ***H5:*** *Experience will moderate the effect of behavioral intention on use, such that the effect will be stronger for consumers with less experience.* | Supported |

Table 5.2: UTAUT 2 Model Hypotheses Summary (Venkatesh et al., 2012, p. 163-166)

*Hypothesis 1*

Hypothesis one included age as a moderator. This was motivated by empirical work conducted by other researchers suggesting that "older consumers tend to face more difficulty in processing new or complex information, thus affecting their learning of new technologies" (Venkatesh et al., 2012, p. 162). Venkatesh and colleagues attributed this difficulty to a potential decline in cognitive and memory capabilities. Moreover, they hypothesized that older women are more impacted by facilitating conditions because "as people become older, particularly from teenagers to adults, the differentiation of their gender roles will be more significant. Thus, women will place more of an emphasis on facilitating conditions."

Of the five hypotheses, only Hypothesis 1 was not fully supported. Results found that gender and age were significant moderators of usage intention, but experience was not. Venkatesh and colleagues speculated that this might be due to some overlap between the constructs of experience and facilitating conditions, with facilitating conditions potentially capturing the factors that are important to forming behavioral intention regardless of experience (Venkatesh et al., 2012, p. 171).

Despite being significant, Venkatesh et al. (2012)'s age-related conclusions from hypothesis one are flawed. The participants in the UTAUT 2 study do not represent older adults, with an average survey respondent age of 34.68 years ($SD = 6.94$). There was also no participant age range provided. Venkatesh and colleagues acknowledge the potential limitation of these findings for significantly older demographics (Venkatesh et al., 2012, p. 173). Given the relatively young demographic, it's plausible that other factors might have confounded the results.

*Hypothesis 2*

Hypothesis two, which was supported, suggests that age moderates the effect of hedonic motivation on behavioral intention. However, this specific hypothesis focused on younger men. While age and gender are moderators, Venkatesh et al. (2012) explains this hypothesis mainly in the context of experience. Specifically that "As experience increases, the attractiveness of the novelty that contributes to the effect of hedonic motivation on technology use will diminish, and consumers will use the technology for more pragmatic purposes, such as gains in efficiency or effectiveness." This hypothesis was supported, and similar results have been found in other literature that studied hedonic motivation among older adults (e.g., Trajkova & Martin-Hammond, 2020). Specifically, older adults might find utility more important than a device's novelty. The novelty might initially attract them to use a device, but it is not enough to foster sustained use without sufficient utility.

*Hypothesis 3*

Hypothesis three suggests that price value (moderated by gender and age) will impact behavioral intention to adopt technology. Venkatesh and colleagues hypothesize that this effect will be stronger among older women. Hypothesis three is supported by literature that suggests women are more price-conscious and that as they age, they are more likely to engage in care activities (e.g., Bakan, 1966; Deaux & Kite, 1987; Deaux & Lewis, 1984). The results of the UTAUT 2 study supported this hypothesis, and the authors attributed the finding to older women's views regarding the availability of resources, knowledge, and support. They also ascribed some of the results to the social role of women (Venkatesh et al., 2012, p. 163). However, this hypothesis is limited in that the average age of participants was 34.68, meaning that the result might not represent older adults as defined in this work.

*Hypothesis 4 (A-B)*

Hypotheses four, A and B, suggest that age, gender, and experience will moderate the effect of habit on behavioral intention (A) and actual use (B). Venkatesh and colleagues also expect this effect to be stronger in older men with more technology experience. These hypotheses were informed by previous researchers who suggested that the environment can trigger certain behaviors (e.g., Ajzen & Fishbein, 2000). Venkatesh then provides the example that "...after an extended period of repeated checking of email on mobile devices during commuting, a consumer may have developed a positive view toward mobile internet technology... This intention is thus stored in the conscious mind of the consumer. When entering a car or taxi, the environment or context can spontaneously trigger the positive view and intention that, in turn, results in the behavior" (Venkatesh et al., 2012, p. 165).

It was found that individual experience, a learned outcome, impacts the strength and association between the cues that lead to habit formation and the behavior itself. Moreover, Venkatesh asserts that age and gender impact how habits might guide behavior. Specifically, Venkatesh references empirical studies that discuss how older adults rely on automatic information processing, thereby suppressing new learning and habit formation (Hasher & Zacks, 1979; Jennings & Jacoby, 1993; Lustig et al., 2004).

Hypotheses four, A and B, were supported; however, they have the same age-related limitations as the previous hypotheses. The relatively young sample is potentially a flaw in the motivation for hypothesis four because normative age-related cognitive changes in information processing are unlikely to impact adults in their 30s in the same manner as adults ages 65 and older. Therefore, understanding the importance of habit formation in older adults is an understudied and important consideration when developing the LEAF.

*Hypothesis 5*

Hypothesis five suggests that experience will moderate the effect of behavioral intention on actual use. It also suggests that this effect would be stronger among consumers with less experience. Venkatesh and colleagues supported the creation of this hypothesis with other literature suggesting that experience provides opportunities to reinforce habits (Venkatesh et al., 2012, p. 166). They reference Verplanken et al. (1998)'s empirical study, which found that when behavior becomes habitual, other influences determining behavior intention are less relevant (Verplanken et al., 1998, p. 124). It was speculated that these habitual behaviors were once treated as the others were, with individuals considering the cost, benefits, and outcomes. However, habitual pro-behavior involves routine choices rather than "automatic associations" (Verplanken et al., 1998, p. 123).

Hypothesis five was supported, with the effect of experience significantly moderating behavioral intention. This has important implications when considering developing a training program for older adults because, in many cases, older adults might have additional experience with a variety of technologies.

#### 5.2.7 Limitations of the UTAUT 2

The UTAUT 2 model builds upon other technology adoption literature, empirical studies, and psychological theories to create a predictive model for the voluntary adoption of technology. However, it fails to consider the health-related motivations that could contribute to this adoption, a limitation that the HBM addresses. The HBM (chapter 3) provides valuable insight for understanding these additional factors. Specifically, the HBM highlights how perceptions of susceptibility to health issues, the severity of these issues, benefits of adopting, and barriers play crucial roles when individuals decide to perform a behavior such as adopting a technology.

## 5.3 Understanding the Shared History of the UTAUT 2 and HBM

There is substantial conceptual overlap between the UTAUT 2 and the HBM. The UTAUT 2 and the HBM emphasize the importance of individual perceptions, attitudes, beliefs, and social influences in shaping behavior. They also both highlight perceived benefits and barriers that drive behavior change. The HBM and UTAUT 2 address each other's limitations while attempting to predict or explain a similar phenomenon, adopting a technology or behavior. The HBM provides a complementary perspective on individual perceptions and beliefs about health behavior.

### 5.3.1 The Theory of Planned Behavior and Social Cognitive Theory

As previously mentioned, the UTAUT 2 is grounded in numerous theories, including the TPB. Ajzen (1991) explains that perceived behavioral control in the TPB is very similar to Bandura's construct of self-efficacy, which is a part of SCT. Recall from chapter 3 that self-efficacy is defined as "the level of a person's confidence in his or her ability to perform a behavior successfully" (LaMorte, 2022b, para. 4). Additionally, as mentioned in chapter 3, self-efficacy was added to the HBM in 1988 as *efficacy expectation*. These self-beliefs are influenced by *outcome expectations*, which, according to SCT, are courses of action that are adopted based on estimates surrounding whether performing a behavior will lead to an associated outcome (Rosenstock et al., 1988, p. 178). Ultimately, efficacy expectations influence whether a behavior will occur (Rosenstock et al., 1988). This is demonstrated in Figure 5.5

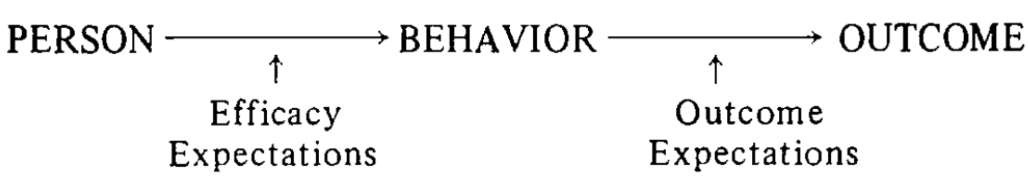


Figure 5.5: Relationship between Efficacy Expectations and Outcome Expectations in SCT and HBM from Rosenstock et al. (1988, p. 178), adopted from Bandura and Adams (1977).

In summary, despite being developed for various purposes and at different times, the UTAUT 2 and HBM share considerable similarities that ultimately can be traced back to their underlying theory. First, both focus on understanding and predicting behavior. Second, they consider the individual's perception of the cost and benefit of performing the behavior. In the UTAUT 2, this is operationalized as effort expectancy, performance expectancy, and facilitating conditions, while in the HBM, this is operationalized as perceived susceptibility, severity, benefits, and barriers. Third, they both consider external social influences. In the UTAUT 2, this is the social influence construct derived from the social norms construct of TPB. In the HBM model, this includes interpersonal relationships, communications from healthcare providers, and media campaigns. Lastly, while the UTAUT 2 does not explicitly include self-efficacy, the underlying theories that informed its development suggest that efficacy is essential in determining behavioral intention to adopt a technology.

# CHAPTER 6

# INTEGRATING THE UNDERLYING PSYCHOLOGICAL THEORY: CREATING THE LEARNING, EFFICACY, AND ACHIEVEMENT FRAMEWORK (LEAF)

The Learning Efficacy and Achievement Framework (LEAF) is intended to exist within W. Rogers et al. (2001) systems approach (chapter 4). This is because the systems approach encourages the identification of the learner's needs through person and task analyses. Understanding the learner's needs can be leveraged to foster the development of training that appropriately guides older adults. However, the systems approach does not integrate the literature on technology acceptance.

The LEAF addresses this gap by integrating UTAUT 2 and HBM constructs. The goal of the LEAF is to guide the development of appropriately tailored instructions and training that 1) educate older adults about the benefits of SMATS, 2) improve their self-efficacy when using SMATS, and 3) help them achieve positive long-term outcomes with SMATS.

The instructions and training developed from utilizing the LEAF within the systems approach can serve as a cue to action that will reduce barriers associated with adopting and using SMATS. The following sections will describe the LEAF, its core components, and how they relate to the existing literature. A summary of the HBM and UTAUT 2 model constructs integrated into the LEAF can be found in Table 6.1.

## 6.1 Learning

Learning in the LEAF encompasses two ideas: 1) providing purpose and 2) meeting learner needs. Providing purpose emphasizes understanding the benefits and use outcomes of the SMATS in the context of the health-related need that the product will meet. Second, meeting learner needs can foster empowerment. Ultimately, Learning in the LEAF provides the user with a baseline of knowledge about the potential health-related needs the SMATS can address and how the user can effectively learn to meet their needs with this new technology.

| Model | Constructs | LEAF | | |
|---|---|---|---|---|
| | | **Learning** | **Efficacy** | **Achievement** |
| ***UTAUT 2 Model*** | Performance Expectancy | X | | |
| | Effort Expectancy | X | | X |
| | Social Influence | | X | X |
| | Facilitating Conditions | X | X | X |
| | Hedonic Motivation | | X | |
| | Habit | | X | X |
| ***Health Belief Model*** | Perceived Susceptibility | X | | |
| | Perceived Severity | X | | |
| | Perceived Benefits | X | | |
| | Perceived Barriers | X | X | X |
| | Efficacy Expectations | X | X | X |

Table 6.1: The UTAUT 2 and HBM Constructs are integrated into the LEAF. *Note:* The construct of price value from the UTAUT 2 is not included in this table. This is discussed in detail in chapter 8.

### 6.1.1 Providing Purpose

According to the HBM, perceived susceptibility and severity contribute to the likelihood of an individual taking a recommended health-related action. Drawing upon these constructs, the learner should be provided with relevant health-related information that will foster beliefs about the susceptibility and severity of their condition. This can appropriately be done by using the information uncovered during the needs assessment portion of the systems approach. This is not intended to scare the learner but should serve as a cue to action to change behavior.

Providing this information is supported by S. Czaja and Sharit (2013). In her book, Czaja explains that older adults should be provided with a balance of information about their health and the reason for adopting technology. Providing health information can foster a sense of purpose without overwhelming and causing anxiety.

After presenting this health background information, a learner will be shown how SMAT can meet their specific needs. The explanation for how the SMAT will meet a particular need integrates the performance expectancy construct from the UTAUT 2 model, which is essential for adoption and sustained use. This also integrates the benefits construct from the HBM. Benefits emphasize the positive outcome anticipated by performing the health-related behavior change.

Understanding how SMATS will address health-related needs is essential when fostering adoption and sustained use. Hence, ensuring comprehension is vital because the improper understanding of how SMATS will address health needs might lead to the disuse of the product. For example, a systematic literature review on adopting mobility assistive products emphasized the importance of healthcare providers clearly explaining how mobility assistive products will meet user needs (Gleaton et al., 2024). The review discussed a study by Andringa et al. (2013) who tested the efficacy of a dynamic hand-wrist orthosis to prevent wrist contractures post-stroke. In this study, six adults who experienced a stroke that resulted in an upper limb disability were recruited to test a new upper limb orthotic device. Results found that one of the six participants abandoned the orthosis due to misunderstanding its purpose. The user expected the device to improve their condition by reducing the spasticity of their upper arm. Instead, the orthosis worked to prevent contractures by maintaining the length of the wrist and finger flexor muscles.

While this example was not part of a large-scale clinical trial, it is an illustrative case study. This case emphasizes the importance of users understanding the health-related need for adoption and how utilizing the device will improve outcomes. Notably, the authors of the study stated that "It is important to explain what a patient can expect and monitor if the possible effects meet the expectations of the patient" (Andringa et al., 2013, p. 230). Moreover, if the user fails to understand the consequences of abandoning the product, it might lead to disuse and poor health outcomes. In this user's case, the preventable health outcomes in Andringa et al. (2013) might include the worsening of the wrist contracture and loss of movement in the limb.

### 6.1.2 Meeting Learner Needs

Training materials should explicitly contextualize the use of SMATS within daily life. This will help the learner develop beliefs about the effort required to use the SMAT successfully, thereby integrating the effort expectancy construct from the UTAUT 2 model. Assisting the learner in understanding the effort needed to use a SMAT successfully is an integral part of adoption and sustained use. According to Venkatesh et al. (2012), effort expectancy heavily moderates performance expectancy. Therefore, if the expected effort is too high, it might add additional barriers to adopting and using the technology that outweigh the benefits. Effort expectancy in the UTAUT 2 model describes how the user perceptions about the amount of effort it will take to use technology influence the behavior intention to adopt it. Therefore, a training intervention for older adults should be designed to reduce as many barriers to using the technology as possible by providing appropriate instruction. Recall from chapter 3 that barriers in the HBM can include the amount of effort required to perform the health-related behavior change.

Additionally, as discussed in chapter 2, older adults face several normative age-related cognitive changes. These normative age-related changes introduce new barriers to adoption for older adults. For example, S. J. Czaja et al. (2006) studied 1,204 adults (ages 18-91, $M = 46.91, SD = 21.91$). Their study found that cognitive abilities, specifically fluid and crystallized intelligence, played a role in computer use. More specifically, their study found that crystalized intelligence was related to the breadth of computer use. For users with lower fluid intelligence, self-efficacy was more influential to computer use (S. J. Czaja et al., 2006).

To combat these age-related barriers, instructions and training should emphasize integrating concepts familiar to the user and building upon the knowledge they have already accumulated. Thereby, the perceived barriers related to SMAT adoption efforts would be reduced. Building upon previously learned information strengthens the relationship to the new content domain until mastery is achieved (S. Czaja & Sharit, 2013). This is known in SCT as *enactive mastery* (Bandura, 1997). Enactive mastery "allows an individual to acquire cognitive, affective, and behavioral tools that lead to a belief that one can accomplish one's goals" (Gerhardt & Brown, 2006). Providing this infrastructure to learners is a facilitating condition. Recall from chapter 5 that facilitating conditions refer to whether the user believes there is underlying support for adopting and using the technology (Venkatesh et al., 2012).

Lastly, barriers that hinder self-beliefs about the ability to learn need to be addressed. Research has found that the perception of individual cognitive abilities influences technology adoption among older adults (S. J. Czaja et al., 2006; Mitzner et al., 2008). For example, in a sample of

52 older adults ($M = 77.19, SD = 6.85$), Berkowsky et al. (2018) had participants self-assess their physical and cognitive abilities and intention to adopt certain technologies. Participants completed a questionnaire that asked them about "vocabulary, comprehension, numeric ability, memory, learning ability, problem solving/reasoning, detection, and grasping/manipulative skill" (Berkowsky et al., 2018, p. 4). They were also asked about the technology they would be willing to adopt. Berkowsky's results were mixed. Significant correlations were found between certain technologies and skill sets, but no particular cognitive or physical abilities significantly correlated with willingness to adopt technology generally. For example, better memory was associated with a higher desire to adopt Instagram ($r = 0.36, p < 0.05$). At the same time, a stronger numeric ability was correlated with a higher willingness to adopt Xbox ($r = 0.36, p < 0.1$) and Quicken ($r = 0.43, p < 0.01$). Specifically, it was emphasized that "older adults may not want to use a technology that places demands on abilities they perceive as declining" (Berkowsky et al., 2018, p. 9).

This is also an essential consideration for the LEAF. If users do not believe they have the knowledge, skills, or ability to adopt and use a SMAT successfully, their perception of how much effort the product will be to use might outweigh the benefits of use. Understanding the users' beliefs on whether or not they can complete the behavior is a form of Efficacy Expectation, a construct from the HBM. However, people often struggle with accurately estimating their cognitive skills. According to a 2010 meta-analysis, "people are somewhat capable of giving valid self-estimates, especially under favorable conditions, although the degree of accuracy is limited" (Freund & Kasten, 2012, p. 21). This meta-analysis did not exclusively assess the literature on older adults. However, its conclusions might still be applicable. This presents a unique opportunity for improved instructional design that both 1) meets the needs of older adults and 2) fosters feelings of self-efficacy, thereby reducing barriers to learning.

#### 6.1.3 Learning: Conclusion

Learning in the LEAF framework integrates two core ideas: providing purpose and meeting learner needs. Providing purpose emphasizes the importance of users understanding the health-related needs and benefits of SMATS. By offering clear, balanced information, learners can develop outcome expectations (i.e., benefits and performance expectations) crucial for adoption and sustained use. Meeting learner needs focuses on reducing perceptions of effort expectancy and lowering barriers. These principles highlight the necessity of understanding the health-related needs SMATS can address, contextualizing these tools within daily life, and fostering a belief in the users' abilities to successfully engage with these new technologies.

### 6.2 Efficacy

Individuals have preconceived notions about their capability to adopt a technology or behavior. However, these beliefs can be changed. Self-efficacy is a core concept in SCT and is relevant to the UTAUT 2 and the HBM. An abundance of literature has investigated the role of self-efficacy in technology adoption. For example, in a study of 478 older adults ($M = 70.1$ years), Jokisch et al. (2022) found that self-efficacy influenced the perceived usefulness ($p < 0.001$) and intention to use technology ($p < 0.001$). Jokisch also found that informal support ($p < 0.05$) and prior knowledge ($p < 0.001$) significantly influenced beliefs about self-efficacy.

Efficacy in the LEAF comprises three ideas that play a crucial role in fostering confidence and capability in users. First, it includes mastery experiences, which occur through completing tasks and overcoming challenges. The second is reducing anxiety. Older adults might experience technological barriers, such as stigmas and lack of experience, that cause anxiety (S. Czaja & Sharit, 2013). The UTAUT 2 and HBM suggest that barriers inhibit the behavioral intention to adopt and use technology. Technology-related anxiety can be reduced by incorporating gradual exposure, supportive feedback, a positive environment, or offering self-paced opportunities (S. Czaja & Sharit, 2013). The last major Efficacy component in the LEAF is Leveraging Observational

Learning and Social Support. In the UTAUT 2 and HBM, other people's opinions and actions are crucial in fostering technology adoption.

### 6.2.1 Mastery Experiences

According to Gerhardt and Brown (2006) numerous studies have utilized training interventions as a form of enactive Mastery experience. Recall that enactive mastery "allows an individual to acquire cognitive, affective, and behavioral tools that lead to a belief that one can accomplish one's goals" (Gerhardt & Brown, 2006). For example, Gist et al. (1989) assessed how the perception of individual self-efficacy influenced mastery during training to use computer software. This was done using modeling and success cues to build the learner's confidence that mastery of all training components was attainable (Gist et al., 1989, p. 885).

These mastery experiences are an essential component of the LEAF because, according to the HBM, efficacy expectations play a crucial role in forming an intention to perform a health-related behavior. Additionally, Venkatesh et al. (2012) found that experience moderated the behavioral intention to use technology. This was because increasing experience can lead to habit formation. Habit is a construct from the UTAUT 2 model, and its formation is essential when considering how to successfully utilize SMATS on a daily basis to address health-related needs that foster the ability to age in place. Gaining experiences that can lead to habit formation is essential because mastery experiences are associated with increased self-efficacy (Bandura & Adams, 1977). It should be noted that the existing body of research in this area primarily focuses on technology adoption in the workplace. Research exploring the role of enactive mastery in SMAT adoption and use among older adults through targeted training programs is limited.

### 6.2.2 Reducing Anxiety

Anxiety is defined as "evoking anxious or emotional reactions when it comes to performing a behavior" (Venkatesh et al., 2003, p. 432). The literature suggests that anxiety might deter older adults from attempting to use SMATS even if they recognize the potential health benefits (W.-Y.

Lin et al., 2016). Anxiety is a crucial component of SCT because it can undermine perceptions of self-efficacy due to concerns about making mistakes or being unable to overcome challenges (Bandura, 1986). It is also an essential component of the HBM because it contributes to an individual's efficacy expectations regarding whether or not they can successfully perform the behavior. Similarly, effort expectancy in the UTAUT 2 model is influenced by whether the user believes they have the knowledge, skills, and abilities to use the technology successfully.

Older adults often have lower technology self-efficacy than the younger population (Chung et al., 2010; S. J. Czaja et al., 2006). This is usually attributed to the rapid integration of technology into everyday society (Chung et al., 2010; S. J. Czaja et al., 2006). As discussed in chapter 2, older adults might also experience physiological changes that make learning to use new technology more difficult. The limitations on processing speeds and increased demand for perceptual and cognitive resources in older adults might exacerbate feelings of anxiety and lead to reduced performance. As described in S. Czaja and Sharit (2013, p. 98), "older adults in learning situations will be more likely to experience anxiety and be more vulnerable to the possibility of being over-aroused and thus subject to some degree of cognitive impairment deriving from this anxiety."

Lastly, social stigmas surround the use of many assistive technologies. For example, walkers, canes, and hearing aids are often abandoned due to fears of being perceived as having a disability (Jimenez-Arberas & Ordonez-Fernandez, 2021; Mcneill & Coventry, 2015). Additionally, research shows that many older adults value their autonomy and independence (Yusif et al., 2016). In some cases, this emphasis on maintaining independence can lead to the disuse of assistive technologies due to fears of being perceived as dependent on the technology. For example, a qualitative survey of older adults' disuse of conversational agents found that for some older adults, disuse was attributed to the perception that the technology negatively impacted the user's perception of autonomy (Gleaton, 2023c).

When considering how perceptions of abilities influence an individual's willingness to utilize technology, it is clear that reducing anxiety is essential in fostering improved self-efficacy. "Performance desensitization" is one way to enhance mastery experiences and reduce or eliminate feelings of anxiety. These feelings are often caused by concerns about making mistakes or fears about the inability to overcome challenges (Bandura, 1977, p. 196). When used in a training context, exposure to technology must be designed appropriately to avoid adding negative stimuli and increasing anxiety. This can be done through positive reinforcement and effective integration of Human Factors design principles identified through the systems approach. For example, many older adults express that current text-based instructional materials are often difficult to comfortably use due to small font sizes and age-related visual decline (S. Czaja & Sharit, 2013). The inability to read the instructions can lead to frustration and feelings of lower self-efficacy. This is supported by existing literature showing that difficult-to-use technologies require extensive assistance. This can make older adults feel like they have diminished autonomy due to relying on others to utilize the technology successfully (Lorenzen-Huber et al., 2011; Yusif et al., 2016).

Reducing anxiety is an essential component of the LEAF because addressing these barriers should improve the adoption and use of SMATS. The literature recommends additional methods to reduce anxiety, such as gradually introducing technology, starting with simple tasks and progressively increasing complexity as confidence builds (Mayhorn et al., 2004). Creating a safe, non-judgmental space for practice, where mistakes are seen as learning opportunities, is supported in the literature as an effective approach as well (S. Czaja & Sharit, 2013). Lastly, celebrating small successes builds confidence and reduces anxiety associated with making mistakes (Bandura & Adams, 1977; Matteson, 1989; West & Thorn, 2001). These recommendations act as facilitating conditions to help lower the barriers that hinder the adoption of SMATS.

#### 6.2.3 Leveraging Observational Learning and Social Support

The UTAUT 2 indicates that the social influence construct can impact technology adoption. Similarly, the HBM suggests social support facilitates health-related behavior changes. These social influences can be leveraged by integrating SCT's observational learning construct (discussed in chapter 3). Observational learning occurs through witnessing other people perform a behavior (Bandura, 1986). The LEAF can leverage SCT principles to encourage behavior adoption by providing opportunities for older adults to witness the positive health-related outcomes of others who adopted SMATS.

Few peer-reviewed studies have tested the effectiveness of such an intervention. Despite this hole in the literature, two dissertations focused on this topic. One focuses on high school students and another on older adults in nursing homes. In a study of 119 high school students, Bullock (2014) found that observational learning could significantly ($p < 0.1$) increase exercise-related self-efficacy. This result is evidence that observing peer and instructor models improves self-efficacy beliefs. The improved self-efficacy beliefs also positively correlated with increased self-reported physical activity ($p < 0.01$).

In the second dissertation, Story (2010) assessed observational learning in 17 older adults living in a nursing home (ages 73-103). In this study, the older adults watched another individual perform certain behaviors: designing a doorknob hanger, baking bread, and searching for a topic on the Internet. Performing these behaviors is a type of *modeling*, which can be used to study observational learning. This type of modeling is one suggested method that can improve self-efficacy through enactive mastery experiences (Bandura, 1986). The older adult's task performance was assessed 24 hours after it was modeled to the participants. The study showed that observational learning led to behavior change and increased performance in all three modeled tasks ($p < 0.05$).

Despite the lack of peer-reviewed research on this topic, much literature suggests that social influence is crucial in technology adoption among older adults. For example, Lian and Yen (2014, p. 136) hypothesized that "Social influence will positively affect older adult's intentions to shop online." They measured Social Influence with a modified version of the UTAUT Social Influences Scale (Appendix B). The results indicated social influence significantly affected behavioral intention among older adults ($p < 0.01$).

Strong social support networks, including family, friends, and peers, can support self-efficacy (Chu, 2010). A systematic review of effective strategies to increase older adults' self-efficacy and physical activity found that encouragement, validation, and assistance from others can boost older adults' confidence (French et al., 2014). Establishing peer support networks where older adults can exchange knowledge, share experiences, and provide mutual encouragement might also improve outcomes by acting as a form of hedonic motivation. These social interactions enhance the excitement and fun of using the technology. Recall from chapter 5 that hedonic motivation is a construct from the UTAUT 2 model. However, social influences can also be harmful, as older adults are susceptible to criticism, skepticism, and lack of encouragement from family members or healthcare providers. Negative Social Influences can diminish older adults' self-efficacy (Yusif et al., 2016). Similarly, some technologies perceived as too fun might be rejected due to feelings of it being more of a toy than a practical solution to meet a need (Trajkova & Martin-Hammond, 2020).

#### 6.2.4 Efficacy: Conclusion

The effectiveness of a technology influences its adoption, so the LEAF aims to boost self-efficacy by providing mastery experiences, reducing anxiety, and leveraging social norms. Providing opportunities to gain mastery experiences and addressing anxiety through strategic instructional design can significantly improve self-efficacy, a crucial factor for successful technology use. Moreover, integrating social support is crucial for promoting positive behavior change among older adults. Strong social networks can provide encouragement and validation, boosting confidence and facilitating technology use.

### 6.3 Achievement

Achievement in the LEAF comprises two parts that focus on how older adults can set and attain goals effectively. First, goal setting involves deliberate steps and strategies that utilize cognitive resources. Related to goal setting is problem-solving, because unforeseen or novel challenges are highly likely to occur. To use SMATS successfully, problem-solving is essential. Emphasizing the importance of breaking complex tasks into manageable steps when unforeseen or novel challenges arise is a crucial component of achievement. Overcoming unforeseen challenges is another way to enhance efficacy beliefs.

#### 6.3.1 Goal Setting

Goals are the plans people set for themselves and the strategies they will use to realize them (Bandura, 2004, p. 144). Research on goal setting among older adults is abundant, especially concerning physical health (e.g., French et al., 2014), exercise (e.g., McAuley et al., 2011), and rehabilitation (e.g., Geohagen et al., 2022). These studies have repeatedly demonstrated that effective goal-setting improves self-efficacy and performance. Goal setting is a powerful strategy to help older adults navigate the learning curve associated with developing habits around using SMATS. *Habit* is one of the constructs of the UTAUT 2 model. According to Venkatesh et al. (2012), habits can significantly contribute to the formation of behavioral intention ($p < 0.001$) and actual use of technology ($p < 0.001$). Repeatedly engaging in behavior such as using a technology leads to routine formation (Venkatesh et al., 2012).

Setting clear, achievable goals can provide structure and direction for repeatedly engaging in a particular behavior. This ensures that progress is measurable and can be celebrated. Researchers and educators can create a supportive environment through appropriate goal setting that encourages continual learning, ultimately fostering a greater sense of self-efficacy. One recurring theme in the literature is that goal-setting can be challenging for older adults (Lynch et al., 2022). Some researchers have theorized that difficulty with goal setting can be attributed to age-related declines in cognitive abilities that contribute to executive functioning (Brandt et al., 2020; Carlson et al., 2013; Duarte et al., 2006; Williamson, 2023). Executive functioning is defined as "the set of neurocognitive skills involved in goal-directed problem solving, including working memory, inhibitory control, and set-shifting/flexibility" (Carlson et al., 2013, p. 1). Moreover, executive functioning is involved in "situations that require planning, decision making, error correction or troubleshooting, initiation of novel action sequences, overcoming a habitual response, or pursuing goals" (Carlson et al., 2016, p. 1).

Literature on goal setting among older adults generally focuses on making behavioral changes to improve health outcomes. Most of the literature suggests that setting specific, measurable, achievable, and time-targeted (SMART) goals is an effective strategy for behavior change (Hynes et al., 2021; Lynch et al., 2022). Additionally, SCT posits that positive outcome expectations are pivotal in motivating individuals to engage in behaviors that they believe will lead to desirable outcomes. For example, Burke et al. (2008) created and disseminated a booklet to 114 older adults to help them better understand their physical activity and nutritional needs. Moreover, this booklet encouraged older adults to set goals aligned with the national health standards. The program lasted approximately five weeks, and results indicated that 76% of participants reported feeling more aware of their health and fitness, 75% of participants reported that they would continue to be more active when the program ended, and 79% reported that they felt they would still maintain a healthy diet in 6 months (Burke et al., 2008, p.5 ). Ultimately, by setting clear, achievable goals, older adults can repeatedly engage in a behavior, forming routines that lead to habitual use of technology and improved self-efficacy.

### 6.3.2 Problem Solving

*Action training* is one method of training older adults to use technology. Action training typically focuses on the repetitive practice of specific tasks until proficiency is achieved (Fisk & Rogers, 2000). It is particularly effective for tasks that are consistent and require little variation. For example, Mead and Fisk (1998) found that action-based training, such as prompts to target attention to the next step, led to significantly faster ($p < 0.001$) and more accurate ($p < 0.05$) outcomes than concept-based training for older adults. Concept-based training is when factual information identifies the next step to be utilized (Fisk & Rogers, 2000).

The action training approach has limitations when applied to broader, more complex, or less consistent tasks. Utilizing SMATS will involve various tasks, such as performing specific actions and understanding why they are important, troubleshooting issues, and adapting to new updates or changes. The variability and complexity of the tasks involved make a purely action-based approach to instruction and training insufficient. To address this, problem-solving skills must be integrated into SMATS training. Introducing problem-solving skills into instruction and training is another way to reduce barriers to SMATS adoption. This is done by providing users with additional knowledge and skills that can be utilized to solve problems that might occur when using the new technology. Additionally, allowing users to learn these skills is another way to help them form effort and efficacy expectations to use the technology successfully.

American Psychological Association (2018) defines *problem-solving* as “the process by which individuals attempt to overcome difficulties, achieve plans that move them from a starting situation to a desired goal, or reach conclusions through the use of higher mental functions, such as reasoning and creative thinking.” Problem-solving is extremely important when using technologies and critical to instructional design and training. This is because unforeseen issues or difficulties often emerge when attempting to meet goals. When adopting and using technologies, these unforeseen difficulties frequently lead to disuse when troubleshooting and navigating a challenge is perceived as too difficult (Gleaton, 2023b).

The literature on problem-solving among older adults is multi-faceted due to the variety of problems they encounter. Researchers have found that studies that assess familiar problem-solving tasks are less likely to find differences between older and younger adults. This is because experience acts as a confound (Fisk & Rogers, 2000, p. 374). In everyday life, older adults encounter problems that can be solved using familiar tools they have already mastered. However, when a novel problem arises when using a new technology to perform a new task, new skills must be learned to solve it. For example, Gleaton (2023c) assessed the usability of a commercially available wearable device to monitor health and sleep among older adults with mild cognitive impairment (MCI). Their results found that despite each participant receiving individualized training, after 60 days, 73.33% of participants experienced an error of missing data that they could not resolve independently within four days.

Upon investigating the reason for the missing data error, researchers found that the errors were caused mainly by a lack of foundational understanding of the underlying technology. For example, the wearable device must be connected to a smartphone or tablet via Bluetooth, and the smartphone or tablet must also be connected to the internet. When participants realized that the data was not transferred from the wearable to their smart device, they could not identify the source of the problem or what steps must be taken to remediate the issue without additional support from the researchers. Participants struggled to understand novel technological concepts like how Bluetooth differed from wireless internet.

These difficulties are hypothesized to have occurred due to the original training implementation. In the initial training, participants received physical paper instructions (content type instructions) and a demonstration of connecting the wearable to their smart device and using its features (action-based instruction). However, they did not receive training on what steps to take to troubleshoot a problem, nor did they recognize how to transfer skills from similar technologies to the wearable.

Similar results have also been demonstrated in laboratory-controlled settings. When presented with novel tasks, older adults experienced difficulty due to the normative age-related decreases in fluid abilities (S. Czaja & Sharit, 2013; Fisk & Rogers, 2000). Implementing subgoal learning methods is one potential way to reduce difficulty when completing novel tasks. Subgoals are defined as task structures "to be learned for solving problems in a particular domain" (Catrambone, 1994, p. 606). They can reduce cognitive load when properly applied because the learner has less information stored in their working memory (Margulieux et al., 2012). Subgoals might make it easier for older adults to process and understand new information without becoming overwhelmed. This strategy might also help learners build confidence and gradually integrate new skills by focusing on one subgoal at a time.

Very little research exists about using subgoal-labeled instructional materials for older adults. However, this method yields promising results when teaching cognitively demanding skills to younger adults. For example, Margulieux et al. (2012) assessed whether subgoal-labeled instructional materials would improve performance and transfer of computer science skills. In their study, 40 undergraduates were taught to build a mobile application using a drag-and-drop programming language. Half of the students received subgoal-labeled instructional materials, while the other half received conventional ones.

The results of Margulieux's study indicated that participants in the subgoal group could more correctly complete the tasks involved with app development ($M = 28.10, SD = 7.22$) than those in the conventional group ($M = 20.63, SD = 6.72$), $F(1, 38) = 11.16, MSE = 48.71, p = .002, \omega^2 = .23, f = .53$ (Margulieux et al., 2012, p. 75). The subgoal group was also faster at completing the tasks ($M = 40.64$ min., $SD = 7.48$ min) than the conventional group ($M = 45.45$ min., $SD = 5.11$ min). The authors suggested that the subgoal-labeled instructions might have helped the learners develop mental models during the learning process. These models could be used to better conceptualize problems and work through attainable steps to reach the solution (Margulieux et al., 2012, p. 71). Developing mental models might benefit older adults when learning to utilize and troubleshoot problems with novel technologies.

By breaking down larger learning goals into smaller, manageable tasks, older adults might experience a sense of achievement and progress toward mastery, thereby improving learning and self-efficacy. The reduced cognitive load due to subgoals might help foster learning by compensating for this population's age-related attention and working memory declines. Furthermore, subgoals also help highlight the logical sequence of events required to complete a task, reducing frustration and increasing the likelihood of successful completion (Kurby & Zacks, 2019). This would bolster the user's sense of achievement and self-efficacy, lowering barriers caused by high effort expectancy and low efficacy expectations.

### 6.3.3 Achievement: Conclusion

The goal-setting strategy plays a crucial role in forming habits, a fundamental construct in the UTAUT 2 model. By setting clear, achievable goals, older adults can repeatedly engage in the behavior, thus forming routines that lead to habitual use of a technology. This continuous engagement, supported by measurable progress and celebrated achievements, enhances self-efficacy, a critical component of both the UTAUT 2 model and the HBM. Breaking down larger learning goals into smaller, manageable tasks improves learning and self-efficacy by reducing cognitive load and highlighting the logical sequence of events required to complete a task. Ultimately, breaking down tasks and setting goals creates a supportive environment that reduces perceived barriers by acting as facilitating conditions for adopting and using SMATS. Researchers and educators can leverage these strategies to improve learning and self-efficacy, fostering greater confidence and proficiency when using SMATS.

## 6.4 Final Insights: The Dynamic Interdependence of the LEAF

The LEAF aims to reduce barriers to the adoption of SMATS by integrating constructs from psychological theory and technology acceptance models. Notably, the components of the LEAF are not presented in any particular order and should be considered interdependent (see Figure 6.1). For example, learning influences efficacy because as individuals acquire new skills, their confidence to perform tasks increases. Learning will also influence achievement because learning new skills can positively improve performance on tasks. Conversely, efficacy beliefs also impact learning and achievement because high self-efficacy can improve motivation to learn new skills and complete challenging tasks (Locke & Latham, 2002). Achievement provides a positive reinforcement mechanism to strengthen self-efficacy when learning and reduce anxiety around SMAT use. This interdependence highlights the dynamic and interconnected nature of the framework, emphasizing that enhancing one component can positively affect the others, leading to a more holistic improvement in SMAT adoption and outcomes.

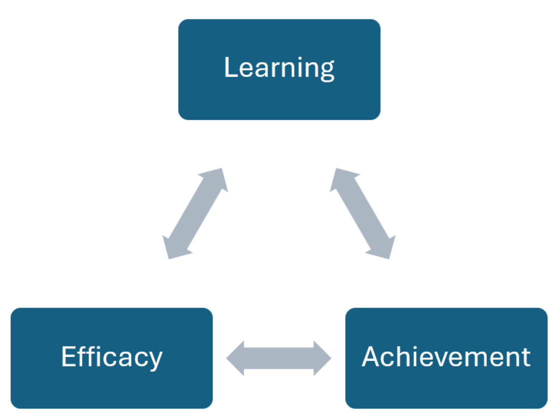


Figure 6.1: The Learning, Efficacy, and Achievement Framework

# CHAPTER 7
# UTILIZING THE LEAF

The purpose of this chapter is to provide an illustrative example of how the LEAF could be implemented. This example is based upon work conducted by Gleaton (2023c). Her research aimed to implement a health promotion intervention in which older adults with mild cognitive impairment (MCI) were trained to use a commercially available wearable sleep-tracking device. Improving sleep health has many benefits, particularly in that improved sleep quality has been shown to slow the progression of MCI to Alzheimer's disease (Torossian et al., 2021). Through regular monitoring, participants could better understand their sleep habits and identify areas for improvement. Gleaton and colleagues' ongoing research aims to foster a behavior change in which older adults use their wearable devices to monitor sleep habits daily and change their behavior accordingly. Utilizing the wearable device allows participants to identify negative behaviors impacting their sleep quality and provides them with resources to help correct the problem.

If the LEAF were applied to Gleaton's ongoing work, the first step would be to apply the systems approach. According to W. Rogers et al. (2001), the systems approach to developing a training program includes a needs assessment to understand what information is required to inform the training development. Within the needs assessment are the task analysis and person analysis. Recall that a task analysis is used to identify the elements of the desired tasks and their order (W. Rogers et al., 2001, p. 189). In this example, a task analysis would be beneficial to help list all of the tasks that older adults need to perform with the wearable device. Those include how to set up the device, synchronize the device with a smartphone or tablet, interpret the health data, charge and maintain the device, and troubleshoot common issues. A thorough task analysis would provide valuable insights into how older adults interact with the wearable and would allow researchers to better understand and develop strategies that can be used to improve user experience.

The person analysis is done to better understand user-specific variables such as age, gender, competence, self-efficacy, and experience (W. Rogers et al., 2001, p. 189). This could include an assessment of physical abilities such as fine motor skills, vision and hearing, and physical comfort. In the case of this work, that could include identifying the prevalence of relevant age-related conditions that affect older adults. These could include the use of diuretics that lead to rapid changes in fluid retention, thereby impacting the fit of the wearable device based on the amount of swelling that the user experiences on a daily basis. Additionally, the person analysis could be useful when identifying the prevalence of osteoarthritis among participants. Osteoarthritis can cause pain and bony prominence at the finger joints, which might also impact the comfort and fit of the wearable device. A thorough understanding of the cognitive abilities of the learner is also critical. This can include memory and attention, problem-solving, and, most importantly, the severity of the participant's diagnosis of MCI. Once all of this information is identified, the appropriate instructions and training material can be created utilizing the LEAF.

To apply the LEAF's construct of Learning, the learner would first acknowledge the importance of sleep health after attending a health promotion class. During this class, participants would learn about sleep health and the risks associated with poor sleep habits. The function of the health promotion class is to inform the learner about the health-related need for a behavior change, thereby addressing the HBM's construct of perceived severity. Subsequently, learners would be presented with information about how the SMAT can be leveraged to improve sleep health. By providing information about how the technology can address a need, users form beliefs about the outcomes that might occur if they use the technology. This integrates the benefits construct from the HBM and the performance expectancy construct of the UTAUT 2 model.

To address the Efficacy portion of the LEAF, researchers could present the testimonials of those who utilized the device. They could also demonstrate how health outcomes can change based on the adoption of the device. This form of social influence is a construct from the UTAUT 2 model. Social influence can also be leveraged by involving care partners of participants with MCI. Care partners have been demonstrated to be valuable resources for participants by providing emotional support and assistance to their loved ones. This inclusion of care partners has led to improved confidence and feelings of self-efficacy among older adult users due to the additional support from their loved ones (Gleaton, 2023c). Additionally, providing demonstrations and opportunities for learners to interact with the product can help them develop efficacy and effort expectations. These constructs are critical components of the HBM and UTAUT 2 models. Next, researchers could provide appropriately designed instructions and training materials curated to the learner's needs by utilizing the information gathered from the systems approach (W. Rogers et al., 2001). Providing appropriately designed instructions and training reduces barriers caused by low self-efficacy or beliefs about the high effort required to utilize the SMAT successfully. Well-designed instructions that meet the needs of the learner are essential. Additionally, offering support to learners should help to reduce anxiety about the technology and create a comfortable learning environment that encourages the development of new skills. Recall that facilitating conditions are a construct from the UTAUT 2 model that reduces barriers by reducing the effort required to adopt and use the SMAT independently.

Lastly, to integrate the Achievement portion of the LEAF, assisting users in setting achievable goals will motivate older adult learners to incorporate technology into their daily routines. These routines can lead to habit formation, a construct from the UTAUT 2 model. Habit can also be fostered when positive feedback is provided. This positive feedback can be a form of hedonic motivation, a construct from the UTAUT 2 model. One way to reinforce feelings of achievement is by providing instructions that reduce cognitive load. Successfully overcoming challenges increases the learner's confidence and autonomy due to having mastered the skills to resolve issues independently. This can be achieved by including subgoal-labeled instructions that are informed by the task analysis.

In conclusion, the instructions and training developed by applying the LEAF within the systems approach serve as a cue to action for a health behavior change. By setting and achieving technology-related goals to meet health-related needs, older adults experience the benefits of using the SMAT. Experiencing the benefit of the health behavior change of adopting SMATS will positively reinforce their continued use. As older adult learners build confidence and self-efficacy through troubleshooting and overcoming challenges, their successes become internal motivators that prompt continued engagement with technology. The interrelated components of the LEAF foster the intrinsic motivation to use technology, aligning with the HBM's emphasis on cues to action that prompt health-related behavior changes.

# CHAPTER 8
# SCOPE AND RATIONAL

## 8.1 Relationship to the Systems Approach

Rather than focusing solely on individual-level factors, a systems approach acknowledges the interconnectedness of individual, interpersonal, and environmental elements. The LEAF itself does not account for individual and group differences in knowledge, skills, and abilities; however, it fits within W. Rogers et al. (2001) systems approach to training. The systems approach uncovers individual and group differences because it emphasizes understanding the user's needs before developing the training program.

The systems approach is robust to different user needs and technology types. Due to how the LEAF is integrated within the systems approach to training, affixing the LEAF to a specific technology or training modality would limit the breadth of its implications. This framework extends W. Rogers et al. (2001) systems approach by integrating constructs from technology acceptance models into a framework that exists within the systems approach. Integrating the LEAF within the systems approach provides a new methodology that can be used to inform and develop instructions and training to improve the adoption of SMATS. Additionally, The iterative nature of the systems approach allows modification of the instructions and training as necessary. This can include utilizing different techniques or strategies based on the learner's needs and limitations.

## 8.2 Limitations

The price value construct from the UTAUT 2 was not included within the LEAF. Recall from chapter 5 that the price value in the UTAUT 2 model is determined by the user's belief of whether the financial cost of adopting the technology is worth the benefit (Venkatesh et al., 2012, p. 161). The financial cost of adopting SMATS can be interpreted as a barrier to adoption. Providing users with SMATS free of charge would be one way to lower or remove this barrier. However, this might not be feasible in all situations. Cost should also be considered when developing the final product using the LEAF within the systems approach because its iterative nature is often constrained by real-world resource limitations (W. Rogers et al., 2001, p. 190). The systems approach accounts for the economic components of developing instructions and training.

The LEAF does not account for individual motivation, which is another of its limitations. Some users might lack the motivation to engage with the SMAT even when health-related needs are communicated and barriers are minimized. Individual motivation plays a crucial role in the adoption and sustained use of technology. Without the individual motivation to engage, even the most well-designed instructions and training might fail to achieve their intended impact. Researchers who study health promotion initiatives suggest behavior change can be accomplished within a system that is structured appropriately. Otherwise, "those who need the guidance most will use this tool least" (Bandura, 2004, p. 151). The HBM and UTAUT 2 make sufficient effort to address motivation; however, motivation is a complex and multifaceted construct that is not fully understood. It might be the case that even if all barriers are removed, a learner might simply not be interested. Their decision to not utilize SMATS must be respected.

A final limitation of the LEAF is the physical design of the device and its user interface are outside the scope of instructional design. Existing research suggests that technologies that are difficult to use, invasive, and require considerable assistance are unlikely to be adopted and are more likely to be disused (Arthanat et al., 2019; Gleaton, 2023b; Sun, 2013). Even with carefully crafted instructions and training, the design of the physical device and its user interface is crucial for the technology to be adopted and used in daily life. A device that is not user-friendly can hinder adoption and use regardless of the quality of its instructions and training. Therefore, for training programs to succeed, the devices and interfaces they support must be designed with the end user in mind. Design itself is a process, and this process, if done correctly, ensures ease of use, accessibility, and a positive user experience that encourages ongoing engagement and utilization. As mentioned in chapter 4, physical device design is beyond the scope of the present work; however, Human Factors research is abundant on how to design products and systems for human use (e.g., S. Czaja & Sharit, 2013; S. Czaja et al., 2019; Evans, 2017; W. A. Rogers et al., 2023; Wickens et al., 1997).

### 8.3 Justifying the Emphasis on Older Adults

This paper introduces the LEAF framework, designed to promote the adoption and use of SMATS among older adults. As discussed in chapter 1, older adults are a group that could benefit from adopting SMATS. However, they struggle to do so and have a high rate of disuse. Improving instructions and training for these devices is one way to improve adoption and foster sustained use. The LEAF provides a structured yet flexible approach to enhancing education and training for older adults using SMATS by integrating technology adoption literature into the systems approach for training older adults.

This framework mainly benefits older adults because they often face unique barriers to technology adoption, such as limited digital literacy, lower technology self-efficacy, and age-related physical or cognitive difficulties. While the integration of LEAF within the systems approach might enhance instructions and training for SMATS across all users, it is expected that the impact of incorporating the LEAF will be more effective among older adults. This is because the literature suggests that older adults might have more difficulty using a novel tool (i.e., SMATS) to solve a problem (Fisk, 1999). This is primarily due to older adults having less experience with emerging technologies than younger adults, making relying on prior knowledge more challenging.

Furthermore, SMATS offer a promising solution to assist older adults with daily activities that might become more challenging due to age-related physical and cognitive changes (Trajkova & Martin-Hammond, 2020). When these changes become too difficult to manage, they can lead to the inability to complete essential daily activities required for independent living, presenting a unique opportunity for integrating SMATS into the lives of older adults. The ability to maintain autonomy and independence while aging has been demonstrated to be highly valued by older adults and is an integral part of aging in place (Moilanen et al., 2021; Sánchez-García et al., 2019). The

LEAF was designed to specifically address difficulties with technology adoption that are unique to the older adult population. Its interventions are tailored to alleviate the particular challenges this group has with novel tools such as SMATS.

## 8.4 PRISMA Guidelines: Scoping

The present work aimed to integrate ideas from different areas of literature and develop a framework that could address theoretical and empirical gaps, not to systematically review or meta-analyze the data in the referenced studies. Therefore, many items in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklists do not apply. For the complete PRISMA checklist by Page et al. (2021), see Appendix C. The following section describes and addresses items in the PRISMA checklist.

### 8.4.1 Presentation of Methods

The PRISMA checklist requires the discussion of study eligibility criteria, information sources, search strategy, selection process, and data collection methods when determining the eligibility of included articles for a systematic review or meta-analysis. Deciding which studies are eligible for a systematic review or meta-analysis is essential. This process includes defining search-key terms, determining a boolean search phrase, tabulating study intervention characteristics, and comparing them against planned groups. The checklist also involves strict inclusion and exclusion criteria to ensure that only studies meeting specific methodological standards are included. PRISMA also emphasizes disclosing how bias was controlled, whether the article identification was conducted independently, or whether automation tools were used.

For the present work, items in the reading list were identified between 2020 and 2024. These include dissertations, peer-reviewed journal articles, books, book chapters, conference proceedings papers, and presentations. No formal boolean search phrase was used to identify these articles. This was due to the wide range of time and the circumstances in which the articles were initially identified (e.g., graduate classwork, literature reviews, peer/faculty recommendations, other research publications, etc.). Throughout January - April 2024, the reading list that informed this work was refined, curated, and approved by a committee of five subject matter experts.

The external review of the reading list by subject matter experts is one way to eliminate bias and ensure that the literature that informed the development of this framework was comprehensive. Moreover, this work is the culmination of the knowledge gained from the author's experience (e.g., Gleaton, 2023a, 2023b; Gleaton & Catrambone, 2024a, 2024b; Gleaton et al., 2022). It should be noted that this effort was conducted independently. Therefore, inter-rater reliability statistics for article inclusion are not applicable. Automation tools were not used to systematically develop the reading list that informed the present work.

PRISMA also emphasizes the importance of disclosing how data was prepared for synthesis, how missing data and summary statistics were handled, and how data was converted to a standard format. These methods ensure that data from different studies can be compared and combined meaningfully. Once results are synthesized, methods are used to tabulate or visually display the results of individual studies. Additionally, synthesizing results in meta-analyses involves specific statistical models and methods to identify the presence and extent of statistical heterogeneity among study results, such as subgroup analysis and meta-regression. However, the present work does not involve quantitatively synthesizing empirical data.

Lastly, meta-analyses employ sensitivity analyses, which test the robustness of findings and are conducted to assess how results change with different assumptions or inclusion criteria. Conducting a sensitivity analysis was beyond the scope of the present work. Ultimately, the robustness of the present work is evaluated through coherence and the ability to address identified gaps in the literature rather than through statistical analyses of empirical data.

#### 8.4.2 Presentation of Results

The PRISMA checklist for systematic review and meta-analysis has specific items regarding the presentation of results. The present work does not have a formal result; instead, it presents a framework that aims to integrate the technology acceptance models into the systems approach for training older adults. The final product of the LEAF within the systems approach ultimately serves as a cue to action that will foster the adoption and use of SMATS among older adults. This section will discuss the PRISMA checklist results section items in the context of the present work.

Systematic reviews and meta-analyses require the demonstration of the selection of articles with a flow diagram. For an example of this diagram, see Gleaton et al. (2024) in Appendix D. This flow diagram demonstrates the search strategy used to identify articles and visually display how inclusion/exclusion was handled. The present work did not systematically identify the included articles; therefore, a flow diagram is not applicable.

According to PRISMA, a checklist citing each included study and its characteristics should be included. Additionally, studies that appear to meet the inclusion criteria but were excluded should be presented. This is done to ensure transparency and reputability in the selection process. PRISMA also states that the presentation of summary estimates, effect sizes, their precision, measures of statistical heterogeneity, the causes of the heterogeneity, sensitivity, and certainty analysis is necessary for all included literature. Since the present work does not involve quantitatively synthesizing empirical results from studies, providing this detailed catalog is beyond the scope of the present work.

#### 8.4.3 Presentation of Other Information

The PRISMA checklist indicates that registration information (register name and number) or a statement that the review was not registered should be provided. Funding sources, analytic code, and other materials should also be available to the reader. The present work was not pre-registered as a systematic review or meta-analysis. Additionally, this work was not funded. There are no competing interests. There is no additional analytic code or other materials available. Author notes on the included articles can be requested.

In summary, the methodologies and processes associated with systematic reviews and meta-analyses are designed for empirical synthesis and detailed evaluation of study results. While valuable and relevant, the present work is neither a synthesis of the literature nor quantifying and statistically analyzing results. Ultimately, the LEAF integrates theoretical constructs to develop a comprehensive framework and does not require these empirical synthesis processes.

# CHAPTER 9
# RECOMMENDATIONS FOR FUTURE WORK

## 9.1 Future Work: The UTAUT 2 and HBM

When discussing the UTAUT 2 model (chapter 5), it was found that many of the hypotheses assessed differences between older and younger adults. However, the mean age of participants in their study was 34.68 years old ($SD = 6.94$). It would be a substantial contribution to the literature on technology adoption if this study could be repeated with adults aged 65 and older. Additionally, as noted in chapter 3, the HBM was developed as an explanatory rather than a predictive model of health behavior. Little research has been conducted to improve the predictive power of the HBM. Lastly, according to Rosenstock (1974a), cues to action are the least studied part of the HBM. Future research should be conducted to improve the predictive power of the HBM. More specifically, focus should be placed on cues to action to address the concerns about a lack of empirical studies on this construct.

## 9.2 Future Work: the LEAF

Within the LEAF, there are numerous areas where additional research could be conducted. First, as discussed in chapter 6, few peer-reviewed studies have tested the effectiveness of a training intervention that leverages Bandura's concept of observational learning among older adults. Therefore, this might be a promising area for future investigations. Next, investigating the role of social support networks, including family, friends, and community groups, in older adults' goal-setting processes could uncover additional factors that enhance or act as barriers to SMAT adoption. Understanding the dynamics of these factors could inform the design of more comprehensive and supportive training and instructions.

Next, when considering the role of mastery experiences and how they relate to skill building, the literature is relatively sparse about what exactly "mastery" entails. While Gleaton et al. (2023) aimed to operationalize this construct, more investigation is necessary to better understand how mastery experiences influence technology adoption.

Lastly, it should be noted that the novel problem-solving methods described in chapter 6 have not been empirically studied among older adults. Existing literature on the utilization of subgoal learning has primarily focused on collegiate-level education. However, the underlying psychological theory suggests that these strategies might benefit older adults more than younger adults. Specifically, instructions that utilize subgoals might help reduce cognitive load when teaching new skills to older adults by compensating for normative age-related declines in working memory and attention. By pursuing these areas of future work, researchers and practitioners can continue advancing psychological theory, improving instructional design and training, and ultimately, enhancing outcomes for older adults by fostering their ability to age in place.

# CHAPTER 10
# CONCLUSION

Adopting and using SMATS could significantly enhance older adults' ability to age in place. Despite these potential benefits, technology adoption rates among older adults remain low, and frequent disuse is common. This paper outlines a comprehensive framework, the LEAF, designed to improve the adoption of SMATS by serving as a cue to action for health behavior change. Grounded in the literature on technology acceptance, the LEAF framework fits within the systems approach to improve SMATS instruction and training for older adults. Ultimately, the LEAF within the systems approach can be leveraged to reduce barriers to adopting SMATS by better addressing older adults' technology adoption needs. The literature clearly shows that lowering barriers will improve technology adoption and sustained use. The adoption of SMATS by older adults comprises health behavior changes that can improve health and well-being, long-term independence, and the ability to age in place.

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# Appendices

## APPENDIX A

## LOCATION OF THE EFFICACY CONSTRUCT IN THE HBM

The following figures all demonstrate versions of the HBM found in the literature. However, there is disagreement on where the construct of self-efficacy should lie. This disagreement highlights the need for additional research to better understand the relationship between this model's constructs and how that relationship might change depending on the situation in which the model is applied. In Figure A.1, Adom-Fynn et al. (2019) was interested in understanding religious coping behaviors among women living with cervical cancer in Ghana. Their work hypothesized that women with higher self-efficacy and positive cues to action would have higher medication compliance and attendance for chemotherapy sessions (Adom-Fynn et al., 2019). Next, in Figure A.2, Chuang et al. (2013) was interested in applying the HBM to understand the adoption of telecare among elderly people in Taiwan. In their model, they hypothesized that people with higher self-efficacy would believe that continual use of telemedicine would lead to fewer health threats. Ultimately, both figures depict the self-efficacy construct in different locations with different relationships to the other constructs.

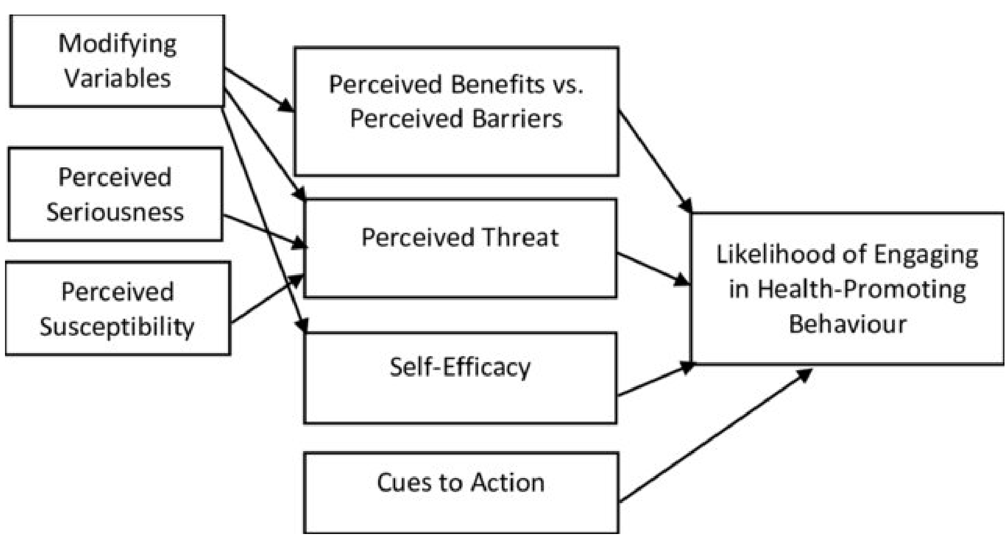


Figure A.1: The Health Belief Model (Adom-Fynn et al., 2019)

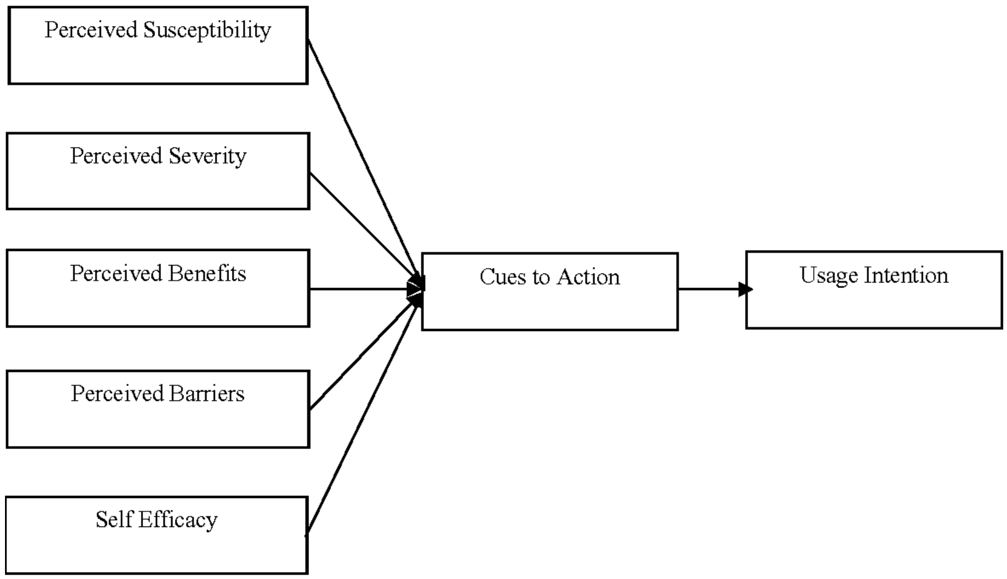


Figure A.2: The Proposed Health Belief Model used in Chuang et al. (2013)

Lastly, as discussed in chapter 3, the terminology used in Rosenstock et al. (1988) is explicit in that self-efficacy as a construct is integrated into the HBM as "efficacy-expectation." This terminology is rarely used in practice.

## APPENDIX B

## MODIFIED SOCIAL INFLUENCE SCALE ITEMS

**Modified Social Influences Scale Items**

- **SI1.** My friends think that I should shop online.
- **SI2.** A person who is very important to me believes that I should shop online.
- **SI3.** Overall, many of my friends shop online.

Figure B.1: Modified UTAUT Social Influences Scale Items (Lian & Yen, 2014, p. 142)

## APPENDIX C

## PRISMA 2020 CHECKLIST

# PRISMA 2020 Checklist

June 3, 2024

Table 1: PRISMA 2020 Checklist

| Section and Topic | Item | Checklist Item | Location where item is reported |
|---|---|---|---|
| TITLE | | | |
| Title | 1 | Identify the report as a systematic review. | |
| ABSTRACT | | | |
| Abstract | 2 | See the PRISMA 2020 for Abstracts Checklist. | |
| INTRODUCTION | | | |
| Rationale | 3 | Describe the rationale for the review in the context of existing knowledge. | |
| Objectives | 4 | Provide an explicit statement of the objective(s) or question(s) the review addresses. | |
| METHODS | | | |
| Eligibility Criteria | 5 | Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses | |
| Information sources | 6 | Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted. | |
| Search strategy | 7 | Present the full search strategies for all databases, registers and websites, including any filters and limits used. | |
| Selection process | 8 | Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process. | |
| Data collection process | 9 | Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process. | |
| Data items | 10a | List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect. | |
| | 10b | List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information. | |
| Study risk of bias assessment | 11 | Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process. | |
| Effect measures | 12 | Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results | |
| Synthesis methods | 13a | Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)). | |
| | 13b | Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions. | |
| | 13c | Describe any methods used to tabulate or visually display results of individual studies and syntheses. | |
| | 13d | Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used. | |
| | 13e | Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression). | |
| | 13f | Describe any sensitivity analyses conducted to assess robustness of the synthesized results. | |
| Reporting bias assessment | 14 | Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases). | |
| Certainty assessment | 15 | Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome. | |

Table 2: PRISMA 2020 Checklist, Cont'd.

| Section and Topic | Item | Checklist Item | Location where item is reported |
|---|---|---|---|
| RESULTS | | | |
| Study selection | 16a | Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram. | |
| | 16b | Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded. | |
| Study Characteristics | 17 | Cite each included study and present its characteristics. | |
| Risk of bias in studies | 18 | Present assessments of risk of bias for each included study. | |
| Results of individual studies | 19 | For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots. | |
| Results of syntheses | 20a | For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies | |
| | 20b | Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect. | |
| | 20c | Present results of all investigations of possible causes of heterogeneity among study results. | |
| | 20d | Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results. | |
| Reporting biases | 21 | Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed. | |
| Certainty of evidence | 22 | Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed. | |
| DISCUSSION | | | |
| Discussion | 23a | Provide a general interpretation of the results in the context of other evidence. | |
| | 23b | Discuss any limitations of the evidence included in the review. | |
| | 23c | Discuss any limitations of the review processes used. | |
| | 23d | Discuss implications of the results for practice, policy, and future research. | |
| OTHER INFORMATION | | | |
| Registration and protocol | 24a | Provide registration information for the review, including register name and registration number, or state that the review was not registered. | |
| | 24b | Indicate where the review protocol can be accessed, or state that a protocol was not prepared. | |
| | 24c | Describe and explain any amendments to information provided at registration or in the protocol. | |
| Support | 25 | Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review. | |
| Competing interests | 26 | Declare any competing interests of review authors. | |
| Availability of data, code and other materials | 27 | Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review. | |

Table 3: PRISMA 2020 Abstract Checklist

| Section and Topic | Item | Checklist Item | Reported (Yes/No) |
|---|---|---|---|
| TITLE | | | |
| Title | 1 | Identify the report as a systematic review. | |
| BACKGROUND | | | |
| Objectives | 2 | Provide an explicit statement of the main objective(s) or question(s) the review addresses. | |
| METHODS | | | |
| Eligibility criteria | 3 | Specify the inclusion and exclusion criteria for the review. | |
| Information sources | 4 | Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched. | |
| Risk of bias | 5 | Specify the methods used to assess risk of bias in the included studies. | |
| Synthesis of results | 6 | Specify the methods used to present and synthesise results. | |
| RESULTS | | | |
| Included studies | 7 | Give the total number of included studies and participants and summarise relevant characteristics of studies. | |
| Synthesis of results | 8 | Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured). | |
| DISCUSSION | | | |
| Limitations of evidence | 9 | Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision). | |
| Interpretation | 10 | Provide a general interpretation of the results and important implications. | |
| OTHER | | | |
| Funding | 11 | Specify the primary source of funding for the review. | |
| Registration | 12 | Provide the register name and registration number. | |

## APPENDIX D

## FLOW DIAGRAM EXAMPLE

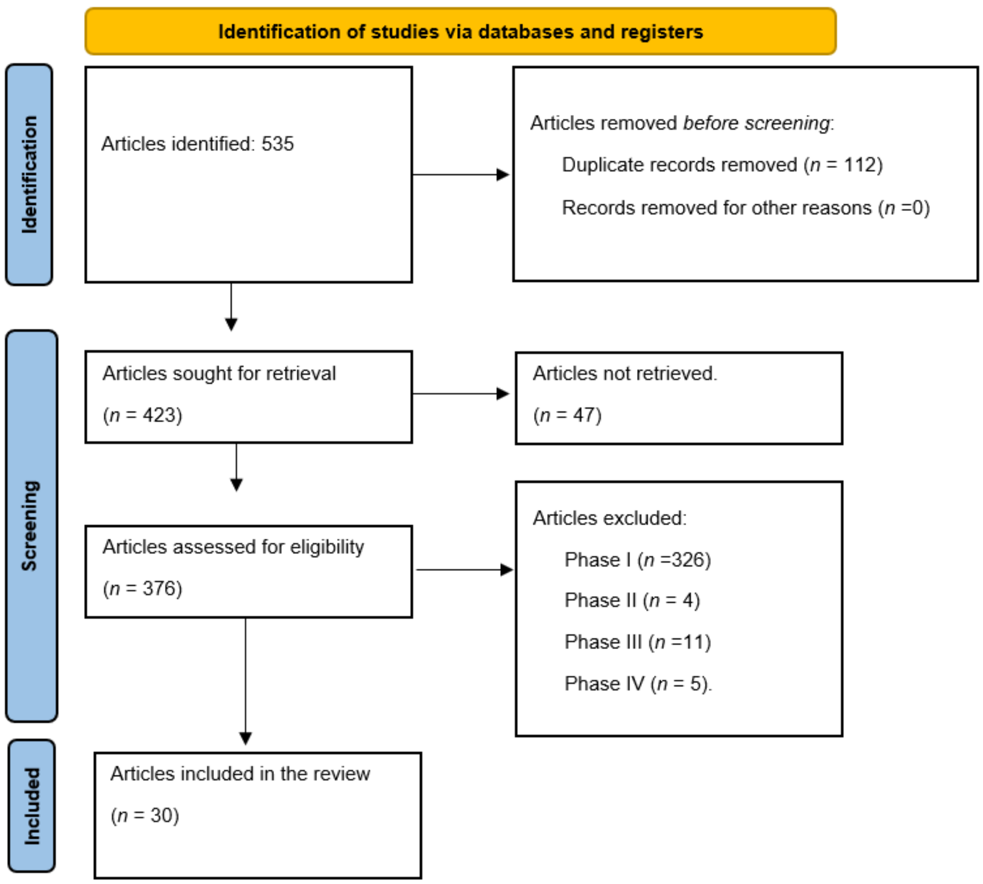


Figure D.1: An example of a flow diagram that adheres to PRISMA guidelines (Gleaton et al., 2024, p. 7)