Design of an Augmented Reality Health Activity Platform for Older Adults Living in Long-Term Care

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ABSTRACT

As the Canadian population continues to age efforts have been focussed on finding innovative strategies to promote active aging throughout the aging process and well into long-term care (LTC). The increased use of innovative technologies has been identified as a leading strategy to promote participation in health activities among older adults in LTC. However, technology use by older adults remains a challenge and participatory design (PD) frameworks must be used to design user-centered technologies with favourable acceptance and uptake. Hence, this thesis aimed to identify design requirements for an augmented reality health activity gaming platform for use in LTC. A participatory design framework was used with the objectives of (1) exploring the current attitudes, usage, benefits and challenges regarding the use of technology, (2) gathering preliminary data on the attitudes of older adults and staff in LTC regarding the inclusion of an augmented reality health activity platform and (3) reflecting on the process of employing a PD approach with older adults and other stakeholders in the context of LTC. Focus group data was used to perform qualitative inductive thematic analysis on older adult and staff discussions. The findings of the research included a current understanding of technological needs and uses within LTC, facilitators and barriers to technology uptake as well as the integration process of technology in LTC. In addition, findings included pragmatic design requirements for the augmented reality health activity platform at the selected LTC facility. This thesis research addresses the need to engage in PD activities to create a platform anchored in person-driven design rather than technology-driven design. This research ultimately builds the foundation for which future technology design teams should involve relevant stakeholders in the ideation, prototyping and evaluation of novel technologies for LTC.

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CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

In response to the global aging population, there has been increased interest in strategies to help older adults live longer and healthier lives, commonly referred to as active aging. Many definitions of active aging exist; however, the World Health Organization's (WHO) defines active aging as:

> "*the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age" (WHO, 2002).*

The emergence of active aging marked the start of a new era in the care of older adults globally, as mindsets shifted from traditional disease management to active prevention and engagement. The importance of active aging to support living longer, healthier lives was first emphasized in the WHO's (2002) *Active Ageing A Policy Framework*, which intended to inform discussion and the formulation of action plans to promote healthy and active aging (WHO, 2002). In this framework, researchers and decisionmakers are urged to focus their efforts on finding innovative ways to promote health, participation and security in older adults (WHO, 2002). The shift in ideologies was facilitated once the research community began to move away from the ageist belief it was impossible or too late to promote health in older adults (Swift et al., 2017). Rather older adults became a priority population in health promotion initiatives. The WHO and its active aging framework laid the foundation to identify opportunities for improved health and promote innovation in the creation of new and effective strategies to disseminate active aging outputs.

Health promotion initiatives have become front and center in the context of promoting active aging throughout the lifespan. However, this has not always been the case; historically older adults have been neglected in the design and implementation of health education and promotion activities (Golinowska et al., 2016). Whether stemming from ageist stereotypes, believing it is too late to improve the lifestyle of an older adult, or the challenges arising from the increased prevalence of physical and cognitive morbidities, older adults have historically been perceived as poor targets for health education and promotion (Golinowska et al., 2016). Of course, this belief has evolved, and older adults have increasingly been targeted in initiatives to promote their health throughout the aging process (Lima et al., 2017). In addition to the historical shortcomings in older adult health promotion there still remain challenges in the creation and delivery of health activities in LTC. Notably, physical and cognitive constraints can complicate the success of these programs through poor reported health status, decreased mood and fear of falling (Galík 2009; Guerin 2008). In addition, health programming can be perceived as

uninteresting for many older adults and considered as more of a chore than an enjoyable activity (Molina et al., 2014). Finally, organizational constraints in the form of low staffing and concurrent activities and priorities can make the implementation of health programs a challenge (Benjamin et al., 2009).

Disruptive innovation is the economic term used to define the streamlining of expensive and complex services and products to simpler more affordable alternatives (Hwang, 2008). In the context of healthcare, disruptive innovation looks to provide better healthcare outcomes while alleviating burdens on the healthcare system. In this regard, technological advances are considered a leading strategy to promote innovative active aging initiatives in older adults (Sixsmith & Gutman, 2013). Specifically, simulated experience technologies such as virtual reality (VR) and augmented reality (AR) present innovative and exciting ways to promote health behaviours, such as physical activity and social interaction, among older adults (Roberts, 2019). These technologies can be purposed to enhance —or even replace— the environment of the end-user and create immersive user-specific experiences with clear health benefit outputs. Technology offers the unique opportunity to tailor a system to meet the unique needs and interests of individual users and resources of organizations and may improve overall health impacts.

Of course, the design and implementation of novel technologies in older adult populations is a challenge. Older adults have vastly different perceptions regarding technology compared to younger populations, and its uptake remains a challenge in this population (Peek et al, 2014). The current generation of older adults have not lived with technology their entire lives, representing a generational gap or divide compared with younger generations. Given the complexity of technology, and the WHO recommendations to involve older adults in active aging initiatives, Participatory Design (PD) is gaining greater traction in the development of novel technologies. PD is the process of involving end-users in technology design and can be defined using Velden's (2014) definition:

> "a collection of design practices for involving the future users of the design as co-designers in the design process. PD's methodology is based on the genuine decision-making power of the co-designers and the incorporation of their values in the design process and its outcome, which is often a high-fidelity prototype for a product or service, or a new way to organise a work practice" (Velden & Mortberg, 2014)

Participatory design can be conducted using single or a combination of methods such as surveys, interviews, focus group discussions and design workshops. Past research has shown that PD in health sciences can provide unique technological innovations ranging from increased creativity with discussion and collaboration of end-users, stakeholders and technology designers (Clemensen et al., 2007). Given the WHO recommendation for increased involvement of older adults in active aging and the hard-to-reach

nature of older adults regarding technology, PD is an important tool to bridge the gap from innovation to effective implementation of technologies to promote active aging.

Another important tool in understanding the technology acceptance of older adults is the use of technology acceptance models. The Unified Theory of Acceptance and Use of technology (UTAUT) predicts up to 70% of the attitude formation process by considering important factors such as effort expectancy, ease of use, previous experience, social influence and other relevant factors (Venkatesh et al., 2003). The UTAUT theory has since been characterized as a powerful and robust model having been used by researchers to design and understand the acceptance of technology design in older populations (Dai et al., 2020; Lai., 2018; Peek et al., 2014; Nagle & Schmidt, 2012). The purpose of PD is to align the design with the needs and preferences of the target population to positively impact the technology acceptance process and ultimate success and integration of technology.

This thesis research builds upon the ongoing Mixed Reality Aspiration not Rehabilitation (Magic Mirror) project within the Metrics lab at the University of Ottawa. This long-term project focuses on utilizing innovative technologies such as mixed reality and augmented reality to promote health activity in older adults. Such an example of the work of the Metrics lab is the *Magic Mirror* an augmented reality platform to promote physical activity and social engagement in older adults. This project was designed to extend the work of the Metrics lab by determining the unique situation and needs of an Ottawa long-term care (LTC) facility, to be incorporated in the design considerations of a Magic Mirror prototype. This thesis is based upon the PD work which was conducted to understand technology use in LTC to help inform future prototypes of the Magic Mirror platform. This research acts as the foundational work for future user-studies and eventual implementation of augmented reality health activity platforms in older adult populations.

1.2 RATIONALE:

The Canadian population is rapidly aging; it is estimated that by 2030 1 in 4 Canadians will be over 65 years of age (GoC, 2016). This has myriad implications for health care systems, including increased demands on the Canadian long-term care system and the healthcare service delivery on Canadian older adults (PHAC, 2014). Given the pressures of an older population on a healthcare system, a new focus is to enable older adults to not only live longer, but to live healthier lives. Older adults living in LTC represent a unique sub-population of Canadian older adults with different needs than community dwelling older adults. Health Canada define LTC facilities as “providing living accommodations for people who require on-site delivery of 24 hour, 7 days a week supervised care including professional health services and other services such as personal care” (Health Canada, 2004). Residents living in LTC

require varying levels and types of support in day-to-day activities and include a large proportion of Canada's most vulnerable and frail older adults.

There continues to be a need to find new and potentially disruptive innovations to keep LTC residents engaged physically, cognitively and socially (SIC, 2018). Through health education and promotion older adults may actively participate in their own active aging process and curb the negative health impacts associated with cognitive and physical decline (Golinowska et al., 2016). Advancing on the WHO's 2002 recommendation to maximise opportunities for older adult engagement in active aging initiatives (WHO, 2002). Persuasive technologies are regarded as a leading strategy to create interactive, user-specific and engaging health education delivery platforms in LTC (Khosravi et al., 2016). Technologies such as augmented reality (AR) provide a unique opportunity to create semi-immersive health promoting environments without the challenges of full immersion such as physical discomfort and cumbersome equipment in virtual reality (VR) (Kujawska et al., 2019).

Technology design and acceptance in older adults remains a challenge (Peek, 2014). Given the generational gaps and limitations associated with aging, technological interventions that have not adapted to user needs and preferences are unlikely to attract sufficient interest for acceptance in a LTC setting (Jarvis et al., 2020). This urges technology designers to involve older adults and other relevant stakeholders in the ideation, design and implementation process of technology development through participatory design (PD) in LTC settings.

1.3 PURPOSE STATEMENT

The purpose of this thesis research was to generate the preliminary data for the design and development of a potentially disruptive health technology capable of challenging traditional methods of disseminating health activities to older adults residing in LTC. Specific objectives included:

1) Explore the current attitudes, usage, benefits and challenges regarding the use of technology in LTC;
2) Gather preliminary data on the attitudes of older adults and LTC staff on the inclusion of an augmented reality health activity platform in an Ottawa LTC setting;
3) Reflect on the process of employing a participatory design approach with older adults and other relevant stakeholders in the context of long-term care.

These data provide the foundational work in a long technological innovation process to create a user-specific platform to meet the needs of its older adult end-users and to ultimately promote better quality of life in residents. All while advancing the field of augmented reality in the context of older adult care.

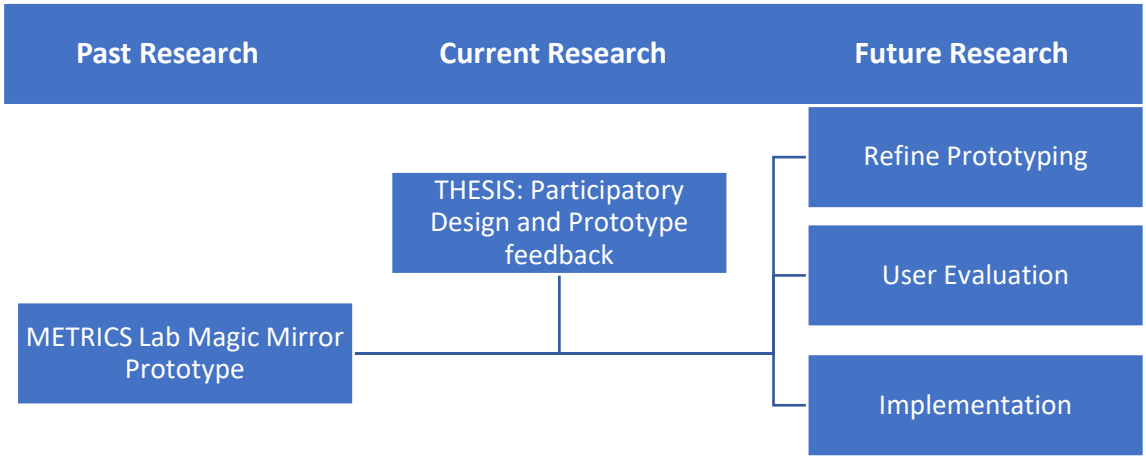

Figure 1.1: Visual representation of the current research project in relation to past research within the METRICS lab at the University of Ottawa and proposed future research.

1.4 POSITIONALITY STATEMENT

I am a white male who was born in Canada and remains a Canadian citizen. I have an undergraduate degree in Interdisciplinary Health Sciences and am working on completing my master's thesis in Interdisciplinary Health Sciences. I consider myself an early adopter of novel technologies. I am comfortable with several applications of technologies, having been exposed to technology my entire life. I consider the current and future applications of technologies as highly beneficial to the whole of society. I am an avid physical activity enthusiast including activities such as running, biking and hiking and I believe technology enhancing physical activity experiences to be an important application of technology.

1.5 THESIS STRUCTURE

This thesis is structured into 7 chapters, including two articles intended for submission to peer reviewed journals. Chapter 2 provides an overview of the scientific literature which has guided this thesis, considering past research findings and current knowledge gaps. Chapter 3 presents the methods employed in this thesis research and explains the manner in which a PD approach was applied with older adults and LTC staff. Chapter 4 presents the results from the focus groups which were used for the participatory design process. Chapter 5 is a reflection of the PD approach in the context of LTC and the compounding impact of research with older adults in the midst of the COVID-19 pandemic. Chapter 6 provides a discussion for this thesis reflecting on lessons learned, and how this research fits within the broader

literature. Chapter 7 is a conclusion to the thesis project followed by references and appendices containing other relevant materials to support this thesis.

1.6 DEFINITIONS

The definitions below establish the scope for terms that will be used throughout the thesis. These definitions have been gathered from a variety of peer-reviewed and government sources and references are provided.

Active Aging: Health concept defined as the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age. (WHO, 2002).

Age-friendly environment: Adaptation of structures and services to be accessible to and inclusive of older people with varying needs and capacities. (WHO, 2007).

Augmented reality (AR): A technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view. A user will always remain aware of their physical surroundings when using augmented reality. (Oxford Dictionary)

Community dwelling older adults: Older adults aged 65+ living independently in the community outside of long-term care or retirement homes.

Frail older adults: "A clinically recognizable state of increased vulnerability resulting from aging-associated decline in reserve and function across multiple physiologic systems such that the ability to cope with everyday or acute stressors is comprised" (Li Xue 2011, pg.1)

Health Technology: Application of organized knowledge and skills in the forms of devices and systems developed to solve health problems and improve quality of life. (WHO, 2007)

Loneliness: "A subjective, negative feeling related to the deficient social relations." (Tiwari, 2013 p. 1)

Long-term care (LTC): A facility offering residential care for older adults requiring medical and non-medical supports. The residents of these facilities are not considered independent and have varying degrees of needs and supports.

Older adults: Adults aged over 65 years of age. (GoC, 2016)

Persuasive technology: Technology harnessed in pursuit of persuading people and motivating them toward various individually and collectively beneficial behaviors. (Hamari et al., 2014)

Retirement home: A facility composed of individual apartment style dwellings for older adults requiring little to no medical supports considered as independent. The tenants of these facilities will not require

daily support and care. These facilities will typically share commonalities with long-term care facilities such as common eating and activity areas.

Social Isolation: Social isolation is also defined as the absence of relationships with family or friends on an individual level, and with society on a broader level. (Alspach 2013 pg.1)

Technology: The application of scientific knowledge for practical purposes in the specific branch dealing with computer and software engineering. (Oxford dictionary)

Virtual reality: the computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors. (Oxford dictionary)

CHAPTER 2: LITERATURE REVIEW

2.1 AGING IN CANADA: A FOCUS ON LONG-TERM CARE

With the global aging population, it is estimated that by 2050, 1.6 billion or 17% of the world population will be aged 65 or older (NIH, 2016). In Canada, the reality of an aging population is quite clear —in fact by 2030, 1 in 4 Canadians will be estimated to be aged 65 or over (GoC, 2016). As Canadians continue to live longer, the repercussions of this advancement pose significant challenges moving forward. The increase in the proportion of older adults ensures a greater need for health services and supports. Similarly, older Canadians in LTC and retirement homes are also an increasing population. Indeed, in Canada, 1 out of every 10 Canadians aged 65 or older currently lives in a LTC or community setting, with this number increasing to 3 out of 10 for those aged 80 or over (GoC, 2018). As this population continues to increase, so do the needs for improved LTC infrastructure; it is estimated that in Canada the demand for LTC beds will increase by 199,000 beds by 2035 (Gibbard, 2017).

Long-term Care

Long-term care (LTC) residents represent a unique sub-population of older adults in Canada. In fact, older adult residents have needs and circumstances which differ from those of community dwelling older adults, in research it is important to distinguish between these particular needs, and to not assume the needs of all older adults are identical. LTC facilities provide a variety of services that offer 24-hour health services and personal support to their residents. LTC residents reside in centers commonly referred to as *nursing homes* or *homes,* given physical and/or cognitive limitations which hinder their ability to live independently, such as community-dwelling older adults (Mlinac & Feng, 2016). The high variation in care needs is one of the challenges faced by LTC facilities in the development and implementation of advanced care programming (Mcglade et al., 2017). As Canadians continue to live longer there has been a recent trend to enter LTC at an older age than in the past, and as a result with a greater variety of medical limitations inhibiting the activities of daily living (Yu-Hin Siu et al., 2019). However, it is important to note that older adults in LTC can present with any combination of cognitive and physical capability, resulting in the existence of a spectrum of needs. For example, one resident may have perfect cognition with some physical limitations, while another may have more serious cognitive impairment, yet maintain a high physical capacity. Understanding the difference between both residents and the level and type of support and care they would individually require is very important to understand the complexity of a LTC home. However, some older adults in LTC face increased challenges arising from increased physical and cognitive limitations. These older adults are commonly referred to as frail older adults; they face

increased vulnerability to adverse health outcomes (Bethell et al., 2019). Frail older adults are considered a challenging population in research given a majority will not self-identify as frail and, in many cases, frail older adults, caregivers, family members and other care providers will not be involved in the research process (Bethell et al., 2019). As LTC homes continue to see increasing numbers of frail residents, their inclusion in health research is paramount to the successful implementation of care programs. For example, diminished capacity of some residents, difficulties communicating, inadequate staff training, low availability and time constraints are all present challenges to the delivery of effective care programs in LTC (Triaphat et al., 2017). Paired with the unique characteristics of individual residents, the type of LTC facility and the preferences of residents, the design and delivery of care programs is unique to individual centers.

In addition, the unique Canadian situation of LTC, specifically its funding model characterized by partitioned contribution from public, private for-profit, private not for-profit and religious-based providers, creates differences in the delivery of care and experiences of residents from one center to another (Mazurkewich, 2010). In Canada, this has led to differences in the set priorities and target populations of residents in certain centers. As a result of the myriad of care options available, questions such as paying for better out of pocket services and finding culturally and linguistically appropriate centers has become top of mind for many older adults and their families when deciding to enter LTC (CMA, 2016). The choice of a LTC center is a complex decision moving beyond simple geographical location and availability. The variability in funding and available resources is a key determinant in the variety of services and care offered in different centers (CHC, 2018). Compounded with the challenges in navigating regulations and standards across the mixed model and provinces and territories, LTC centers are not all created equal (CHC, 2018). One can imagine not only significant differences between centers across the country but even between two centers in the same city. In fact, LTC residences are complex, context-specific, facilities where differences between publicly funded, non-profit and for-profit residences vary in care and ultimately health outcomes, such as resident hospital admissions (Poss et al., 2020). Similarly, it is individual center characteristics which can determine overall health and quality of life in older adult residents (Kehyayan et al.,2016).

Finally, research has shown that older adults entering LTC today are exhibiting stronger preferences for autonomy in the choice of services they receive (OLTCA, 2019). Historically, older adults in LTC would face inevitable reductions in the range of options available to them by virtue of the "institutionalized" nature of LTC centers (Sherwin & Winsby, 2011). Now, considering the increasing expectation to provide person-centered care, emphasis must be placed on assisting residents to maintain individual control, by fostering a culture marked by increased resident options and care models (Sherwin

& Winsby, 2011).This creates the opportunity to implement innovative care options and to involve older adults in the design and choice of new modalities to best meet their changing needs. Understanding the unique challenges and the position of older adults in a specific LTC facility must act as the preliminary work to any intervention aiming for implementation in long-term care.

LTC centers must be designed to meet the varying needs of their residents and with the best interest of all residents in mind (Kehyayan et al., 2016). Given the potential vulnerabilities of this population, maintaining a high quality of care in LTC centres is critically important to residents, family members and the whole of society (Wilkinson & Cornish, 2018). As this thesis is written in the midst of the ongoing COVID-19 public health crisis, the need to invest in LTC has been reaffirmed as older adults have faced unprecedented challenges during the pandemic. The harsh reality of Canadian LTC must further entice decisionmakers to consider strategies to provide this population with the highest quality of care possible. In fact, data as of June 25, 2020 provided by the Canadian Institute of Health Information (CIHI, 2020) showed that 81% of COVID-19 cases in Canada were in LTC settings, and that the case mortality rate was approximately 35% in LTC homes (CIHI, 2020). The direct health impacts of the pandemic have been significant, reinforcing the need to create resilient and healthy environments enabling older adults to be resilient and healthy.

The pandemic has also been responsible for a plethora of indirect health impacts on older adults. For example, the WHO highlights that widespread isolation from loved ones and social services has placed older adults —specifically in LTC— at increased risk of mental health repercussions, such as loneliness and depression (WHO, 2020). Weaknesses within Canadian LTC facilities in light of a serious health crisis has highlighted the presence of pre-existing and systemic issues (Hsu & Lane, 2020). Given the impacts of the pandemic in LTC, provincial authorities in provinces such as Ontario and Quebec have initiated investigations into the systemic issues and the design and delivery of services and care for older adults in LTC settings. This pandemic has in many placed researchers in the unique position of refocussing their efforts on caring for older adults and finding new and innovative strategies to promote active aging, anchored in better quality of life and health.

2.2 ACTIVE AGING:

The WHO states that healthy aging initiatives can support health care system capacity for managing the ever-increasing health care needs of an aging population (WHO, 2002). The concept of active aging has been guided by the three major pillars defined by the WHO as participation, health and security (WHO, 2002). Since the early iterations of active aging frameworks, the paradigm of active aging moved into the realm of focussing on participation and emphasized the importance of improving

the environments and interventions which are available throughout the aging process (Lopez & Sanchez, 2020). This understanding of the active aging paradigm encompasses the vastness of active aging, and why active aging should be viewed as more of an ecosystem rather than a single action.

Viewing active aging as a broad ecosystem however creates the particular challenge, stemming from the voluminous body of information on active aging (Lak et al., 2020). Frameworks are regularly designed and updated to guide active aging activities in different contexts such as policy, built environments, social environments and economics (Lak et al., 2020). No matter what model or framework is used, there exists a consensus regarding some domains of active aging; decreased disability, physical fitness, cognitive functioning, positive mood and social inclusion to name a few (Fernandez-Ballesteros et al., 2008). It is these domains which transcend from one model to the next, and are commonly markers to determine the success of one's aging process . From a research point of view, it is in these domains that researchers must innovate to increase accessibility to desirable outcomes such as physical activity ans social inclusion. Keeping in mind the notion of the ecosystem of active aging, it is through the physical environment that older adults have the possibility to interact favourably or less favourably to promote or not active aging in their personal lives (Kerr et al., 2012). Indeed, academic interest in the role of environmental factors on aging has been explored and in a state of constant evolution (Greenfield et al., 2019). Since the 2000s increasing research has focussed on the role of environmental factors on the modulation of short and long-term vulnerability and frailty in older adults (Di Ciaula 2020). No matter the environmental lens that is applied in understanding active aging, it is clear the environment has a direct impact on active aging be it social, physical or cultural (Lak et al., 2020). In relation to the WHO framework of active aging this supports the importance of physical environments, social support and health and social services be made available for active aging at all stages of life including residents in LTC.

Enabling Environments

To further understand the role of the physical environment on health, Lawton and Nahemow set the foundational work to understand the ecological perspective of the aging process (Lawtonet al., 1973). Lawton and Nahemow explain the critical process of aging being heavily influenced by one's physical environment (Lawtonet al., 1973). Since then there has been growing evidence highlighting the importance of the physical environment and health (Baar et al., 2016). The relationship between the built environment and health has been extensively studied demonstrating how one's environment can influence health domains such as physical activity, mental health and morbidity (Cunningham & Michael, 2004; Kerr et al., 2012).

The clear role of the environment on health has given rise to the practice of interweaving health promotion into people's daily environments. This process focusses primarily on two key notions for one's physical environment: facilitation and shared use (Springer et al., 2017). Facilitation requires the creation of environments to enable actions and reduce barriers , while shared use is the establishment of formal or informal agreements with entities to create opportunities to share property or facilities to promote health (Springer et al., 2017). This presses decision-makers to maximize opportunities to provide health promotion opportunities to residents in LTC by creating diverse, enabling environments axed upon shared use and low barriers to access. This has led to a paradigm shift in the study of aging to the creation of "age-friendly" environments; environments where social and physical attributes have direct impacts on the health and wellbeing of older adults (Nieboer & Cramm, 2018).

The creation of an age-friendly environment requires a "person-environment fit" considering the unique characteristics of individual older adults and the need for environments to be more nuanced toward these particular needs (Keating et al., 2013). This concept has been further defined, and it is now well-known that personal attributes are dominantly involved with the environment to age actively, this reflects on the complex transaction between an individual and their environment (Constanca, 2012). In fact, ecological approaches to age-friendly communities are necessary as domains such as the physical and social environment can never be completely isolated from interpersonal factors such as age, gender income etc. (Menec, 2011). To improve the health and wellbeing of a specific population is to understand their environment and how this environment will impact them on an individual level and strategically embedding opportunities for heath education and promotion. It is also recommended that special attention be given to more vulnerable groups of the population such as older adults in LTC and frail older adults , to ensure equity in access to greater quality of life through the years (da Silva Sousa & de Azevedo Barros, 2020). For researchers attempting to improve built environments, the WHO has provided a policy framework axing on three major pillars for decision-makers; understanding from a scientific perspective can be considered as an umbrella concept embracing a space where healthy, successful and productive aging are all closely related (Fernandez-Ballesteros et al., 2008).

2.3 HEALTH PROMOTION:

Health is determined by many different factors, including individual lifestyle factors, social networks and socioeconomic, cultural and environmental conditions. The well-known behaviours of proper eating, exercise and social interactions are commonly referred to as essential habits to achieving good overall health. A healthy lifestyle can be promoted by focussing on these behaviours and enabled with educational and counseling programs (Golinowska et al., 2016). However, it is now clear that older adults have historically been neglected in the design and implementation of health promotion activities

(Golinowska et al., 2016). Whether stemming from ageist stereotypes, believing it is too late to improve the lifestyle of an older adult, or the challenges from the increased prevalence of physical and cognitive morbidities, older adults have been perceived as poor targets for health education (Golinowska et al., 2016). Through the years, this belief has evolved, and older adults have increasingly been targeted in initiatives to promote their health throughout the entire aging process (Lima et al., 2017). In the context of older adults in LTC there are three basic aims to health promotion activities, maintaining or improving functional capacity, maintaining or improving self-care and increasing social integration and networks (Golinowska et al., 2016). It is by targeting these three areas that older adults may be enabled to live longer more self-sufficient lives, ultimately decreasing their need for supports and years lived with a poor quality of life.

Physical Activity

Physical activity is one of the greatest and most widely recognised practices to maintain health throughout the aging process. There is consistent evidence stemming from longitudinal observational studies that physical activity is positively associated with healthy aging regardless of differences in measurement and definitions (Daskalopoulou et al., 2017). Physical activity remains the single best strategy to maintain physical capacity, decrease pre-mature mortality and avoid frailty (McPhee et al., 2016). In frail older adults physical activity can contribute to improved body composition, improved muscle function, increased upper and lower body flexibility as well as decreased rates of depression (Theou et al., 2011). While in the context of LTC tailored physical activity programs have been shown to contribute to falls prevention, improved sleeping patterns and improved muscular strength (Shakeel et al., 2015).

Beyond the physical benefits of remaining active, after admission into LTC there are several indirect motivators to participating in physical activity. For example, LTC physical activity programs are an opportunity to remain independent, improve mood state, fill empty time and cultivate healthy habits contributing to more than physical benefits such as mental wellbeing (Chen & Li, 2014). However, despite the wide abundance of physical activity programs available in LTC, physical inactivity remains a common reality in Canadian LTC (Chen, 2010). Studies have shown that functional decline can actually increase as a result of admission into LTC facilities where increased access to services and supports can create more dependant residents, less likely motivated to attempt certain tasks and to meet physical activity guidelines (Czaplijski et al., 2014). There are many other challenges contributing to why older adults in LTC do not take advantage of the available physical activity programs. For example, LTC

physical activity programs can sometimes be perceived as uninteresting or inadequately challenging to residents (Chen & Li, 2014). Given Canada's mixed model LTC system, and the lack of standardized regulations, different centers may choose to prioritize different areas of resident care (CHC, 2018), as such, physical activity is not always seen as a priority. Herein lies the opportunity to create new and exciting ways for older adults to participate in appropriate and adapted LTC physical activity programs all while considering the capacities of LTC facilities in delivering these programs.

Social Isolation

In addition to physical inactivity, social isolation and loneliness are major health concerns in older adult populations, with research showing the health impacts of isolation being comparable to well-known determinants of poor health, such as smoking and obesity (House, 2001). The actual physical separation of individuals is an important contributing factor to social isolation, by which individuals spend a significant amount of time alone. A consequence of social isolation is the feeling of distress and psychological turmoil which is characterized as loneliness. In Canada, this has been a pressing issue faced by increasingly larger populations of older adults. As a matter of fact, the government report on the social isolation of seniors in 2016 highlighted that over 50% of Canadians aged 80 or older report feeling lonely as a result of their social isolation (GoC, 2016). The negative health impacts of loneliness and social isolation are increasingly being recognised. One large systematic review identified the most common consequences of isolation as increased depression and poor cardiovascular health, identifying over a dozen other reported adverse health outcomes (Courtin & Knapp, 2017). Other deleterious effects of isolation include aggressive behaviours, suicidal thoughts, anxiety and substance abuse (Simard & Volicier, 2020). As a result, the government of Canada report makes stern recommendations to include loneliness in older adults as a leading research area to find new and innovative strategies to overcome social isolation in seniors (GoC, 2016).

Social isolation is common in the context of LTC, where residents face unparalleled loneliness and depression, greatly limiting their overall wellbeing (Simard & Volicier, 2020; Jansson et al., 2017; Theurer et al., 2015). Transitions in care are recognized as a leading risk to facing social isolation and loneliness; transitions such as retirement, the death of a spouse or losing a driver's license are all transitions in care. Entering LTC is considered a significant transition in care where an individual may face unprecedented loss in the sense of community, independence and personal self-worth (GoC, 2016). Given, the drastic changes in day-to-day living after entering LTC efforts must be made to ease the transition in care and provide opportunities and supports to foster strong social networks from initial admission and throughout the LTC aging process. In LTC, residents face other risk factors which can

contribute to poor social integration placing them at higher risk of isolation compared to community dwelling older adults. For example, a resident receiving passive care from staff can have feelings of low self-worth and may further inhibit social relationships (Theurer et al., 2015). Furthermore, the symptoms of cognitive impairment can inhibit the ability of a resident to communicate; if this is paired with inadequate involvement from peers, family and LTC staff it may lead to superficial social interactions leading to feelings of loneliness (Theurer et al., 2015). Given the prevalence of social isolation and loneliness and the magnitude of its impacts this domain is a priority area of improvement in LTC to promote favourable health outcomes in older adults.

Challenges of Implementing Health Education

A revitalized Canadian older adult care system must consider including health education and health promotion initiatives to encourage engagement in healthy habits throughout the lifespan. Health education programs offering opportunities for physical activity, social engagement and education are essential services to maintain a high quality of resident care (Krajic et al., 2015). However, the unique situation of LTC settings can pose certain challenges to the efficient incorporation of health promotion initiatives; this reality has been a contributing factor to LTC being heavily neglected in past health promotion initiatives (Krajic et al., 2015). Barriers to the implementation of health promotion programs in LTC, such as physical activity programs for example, can be categorized into broad categories. Firstly, barriers can exist at a resident level, such barriers can include poor health status reported by the residents themselves, staff and family members (Galík et al., 2009; Guerin et al., 2008; Phillips & Flesner, 2013). Poor reported health status can manifest as a resident lacking the physical capabilities to participate in an activity program. The inability to participate can be a direct result of low energy, pain or morbidity which can all negatively influence the motivation to participate in LTC programs. A related barrier that has been identified in LTC is the fear of falling (Chen, 2010; Galik et al., 2009; Guerin et al., 2008); older adults and staff alike may be reluctant to involve certain residents in LTC activities if mobility issues, medications or past fall history increase the chance of a potential injury when participating in an activity. Aside from the physical or cognitive inability to participate, physical and cognitive health training can be uninteresting for many older adults and perceived as more of a chore than an enjoyable activity (Molina et al., 2014). This attitude can have significant impacts on both the motivation to participate and the results of the health promotion activity (Molina, 2014).

Aside from resident-based barriers, there are organizational barriers that impede the successful implementation of health programming. One of the single greatest barriers to health promotion interventions is that of low staffing in LTC settings (Benjamin et al., 2009); increased pressure on staff to focus primarily on essential care, leaves little time to engage in promotion or restorative care activities

(Resnick et al., 2009). The opportunities for improvement in LTC staffing and resource allocation is one which has come front and center in the midst of the COVID-19 pandemic. It can be difficult to imagine centers undertaking health activities, when basic services can be a challenge in certain locations. As previously discussed, in Canada, the quality of labor, conditions of work, access to resources and staffing levels vary significantly from one facility to another (Armstrong et al., 2020). Unique contexts make it that individual center priorities and culture may impact programming, where health activities may not always be seen as a priority by administrators (Kalinowski et al., 2012). Finally, environmental barriers can pose an important challenge to the implementation of LTC programs including; the lack of a designated space to host the activities, a lack of equipment, the lack of signposting for the visually impaired or the lack of seating for residents (Benjamin et al., 2009; Chen, 2010, Kalinowski et al., 2012; Phillips & Flesner, 2013). As most current education programs in LTC are group programs consisting between 4-14 residents (Lima et al., 2017), one can expect the need for common areas, staff and equipment to effectively deliver this type of program. The staffing, financing and individual resident constraints in LTC creates a need to incorporate highly individualized and specific programs to create a perfect program-institution fit considering the unique circumstances of each LTC facility.

In conclusion, health promotion in LTC is essential to promote resident health. However, the implementation of such initiatives does remain a challenge. As a result, general criteria for the establishment of feasible LTC health programs have been established. These criteria include a demonstrated positive outcome of the program, minimal investment of equipment and staff, easily implemented in the current LTC structure, in line with the needs and priorities of individual centers and typically occurring three-times per week in a small to medium group setting or structure (Shakeel et al., 2015).

2.4 ACTIVE AGING THE CASE FOR TECHNOLOGY

There is growing evidence from evaluation research that technology can benefit older adults, while improving the effectiveness and cost-benefits of health services (Sixsmith & Gutman, 2013). As a result, technological applications are a leading contributor to the innovation process of Canadian LTC. To date the LTC system in Canada has had difficulty managing the demand of services, but the utility of the current infrastructure is rapidly declining in face of the increasing number of residents and the evolving nature of resident priorities (OLTCA, 2019). At this time there is a widespread call on researchers to promote innovation in the context of LTC (SIC report, 2020). Innovation is the process of adding social value and delivering better outcomes be it more efficient, appealing, enjoyable or useful services for a similar or lower cost (Vaughan, 2013). In a healthcare setting, innovation is synonymous with progress (SIC report, 2020). In the context of LTC, innovative uses of technology result in more effective and

higher quality of care for residents either by providing more timely or personalized services. Recently, LTC homes have been integrating emerging innovations to adapt their homes to the growing pressures of digitizing healthcare (Schoville, 2017). This process of internal innovation is key to ensure a facility is equipped and organized to offer a service encouraging a complete state of mental, physical and social health in its residents.

Technology in LTC

Novel applications of technology in LTC have varied over the years and include: medication management, fall prevention, safety and behaviour monitoring and smart home technologies (Stanley, 2015). These technologies offer new and improved ways to enhance patient care and create integrated care plans for older adults, enabling them to live healthier more active lives. Technologies which are specifically designed to support the aging in place process, through the facilitation of daily activities are typically referred to as smart home technologies (Peek et al., 2016). While technologies designed to aid healthcare staff in the delivery of health services and supportive care are referred to as e-health innovations (Peek 2016). It is within these two categories that the majority of technology designed for use in LTC belong. As a matter of fact, in Canada, smart home technologies and e-health technologies are routinely being introduced in LTC settings (Krick et al., 2019; Mileski et al., 2019; Tak et al., 2010; Wang et al., 2019). The introduction of these technologies has led to a revolutionization of care and better health outcomes for residents. For example, the integration of electronic health records in LTC has been marked with positive outcomes such as greater resident health, decreased medical errors and overall staff satisfaction (Jiang et al., 2017, Kruger et al., 2011; Meehan, 2017). Additionally, technology also benefit residents in the form of technologically-driven health interventions. Using technology to deliver health care and extracurricular health activities provides residents with effective person-centered care with the added benefit of improved personal health (Daly Lynn et al., 2019). Generally, speaking the field of healthcare technologies for older adults has been quickly mobilizing to improve the healthcare system and to deliver on the WHO's recommendations to promote active aging through innovation.

Aside from the organizational delivery of care technologies, there is an opportunity for older adults to benefit from the personal use technology such as computers, smartphones, tablets and artificial intelligence technologies. In the current time and age of digitization, more pressure is placed on older adults to adapt to the changing norms of society and to interact with different technologies. As a matter of fact, despite the lower use of technology in older adults compared to other generations, they are still the most digitally connected older generation to date (Andersen & Perrin 2017; Jarvis et al., 2020). The actual use of technology on a personal level can offer several benefits including a greater quality of life, and the facilitation of independent living all while helping to bridge the technological gap across generations

(Vaportzis et al., 2017). For example, playing games on a smartphone or tablet can provide an additional source of pleasure and joy to the day-to-day life of a resident. While the use of a smartphone, laptop or tablet can enable meaningful and efficient discussions with family and friends, helping older adults to remain socially engaged. Finally, using tools such as online banking, emails and search engines, older adults are provided with ways to stay connected with the world around them and to conduct daily business. In the context of LTC, there is emerging evidence that residents living with cognitive impairment are able to independently use touch screen technologies for leisurely activities and socialization (Joddrell & Astell, 2016). Incorporation of such technologies can act as a source of pride and continued motivation, as residents learn new skills and continue to feel connected with the world and younger relatives (Ostensen, 2017). These personal technologies can also act as sources of information and entertainment. When given an opportunity to do so, older adults in long-term care utilized a simplified version of the iPad to pursue a variety of personal interests including entertainment, research and social communications (Ostensen, 2017). This acts as motivation to use everyday technology design principles to create simplified and adapted strategies for older adults, and fully take advantage of what these technologies offer.

Persuasive Technologies

Advances in innovative technology are recognized as a leading research priority to promoting and disseminating health information to older populations (Khosarvi et al., 2016). New and exciting advances in technological innovations offer an opportunity to reinvent traditional health interventions harnessing the best attributes technology has to offer. Traditional health programs can be replaced with new and improved programs focussing on user-specific experiences and continual health improvements. Countless pilot projects have put technological advances to the test, to determine the potential for its application in active aging. Projects such as Enable, safe@home and Action have shown promise in creating enabling environments to improve independence, wellbeing and quality of life (Cabrita et al., 2018; Briggs & de Carvalho, 2018; Orji &Moffatt, 2018).

Technologies designed to change the attitudes or behaviour of its end-user are commonly referred to as a persuasive technologies (Kukkonen, 2013). Persuasive health technologies are typically designed to communicate the health messaging of major health promotion strategies such as physical activity and nutrition. In active aging these persuasive technologies can be specifically designed to alleviate burden on traditional healthcare services, by supporting healthy behaviours, which in turn can delay or even reverse some age-related functional decline (Kukkonen, 2013). In doing so persuasive technologies can play an integral role in the successful aging process.

Technology acts as a strong candidate for the challenge of promoting health in older adults. Novel technologies offer both the ability to provide renewed excitement in traditional activities while remaining customizable to meet different levels of physical and cognitive capability. This phenomenon has been shown in rehabilitation programs where augmented and virtual reality technologies have increased adherence to program participation compared to more traditional programs (Lee, 2017). In terms of use in older adults a large review of exergames, video games promoting physical activity, showed that older adults experienced beneficial changes in GAIT, posture control, mobility and self-efficacy for falls, with overall better physical health outcomes compared to controls (Molina et al., 2014).

In addition, technology is increasingly used in combatting older adult isolation (Garattini, 2012; Neves BB et al., 2017; Vosner, 2016). However, the majority of technologies to prevent isolation have been touch-screen technologies utilizing typical social network services (Baker et al., 2018). These outlets are designed with a heavy focus on communications and content sharing capacities. This does, however, create the opportunity to broaden techniques to use new and emerging technologies such as virtual or augmented reality technologies to redress social isolation (Baker et al., 2018). This work has already begun in the field of gerontology for example, Lin et al were able to demonstrate that their virtual reality experience improved perceived overall health and perceived social wellbeing in residents residing in assisted living communities (Lin et al., 2018). In fact, a comprehensive review of 28 studies examining VR in older adults has shown that the impacts of VR on social benefits are promising, however remain poorly studied, with the emphasis placed on the cognitive and physical effects (McMaster University, 2019). This represents an opportunity to design these technologies with social interaction in mind and to evaluate the impacts on social well-being. Furthermore, AR technologies remain virtually never studied in the context of improving social wellbeing in older adults residing assisted living settings.

Challenges with Technology in LTC

Attention must be drawn to potential challenges of LTC. Firstly, despite the considerable research, development and identified benefits of technology, the uptake and long-term impacts of technology in LTC have remained low in several instances (Sixsmith & Gutman, 2013). This highlights certain shortcomings in the process of designing and implementing technologies for aging. A common explanation to this lack of fruition in results is the *technology-push* approach which has been taken in the development of technologies (Sixsmith & Gutman, 2013). In other words, the primary focus of technology development for aging has been taken through the lens of pure technology design, without considering the implications and impact of integrating these technologies in the daily lives of older adults. This has resulted in poorly conceived technologies which are not always capable of meeting the needs, desires and interests of older adults. In fact, the rapidly expanding field of gerontechnology; a

combination of gerontology and technology is still establishing itself (Sixsmith & Gutman, 2013). The LTC sector remains deeply invested on emphasizing personal relationships in the delivery of personalized care and services (Klesper & Zelth, 2019). In LTC, the perceived quality of healthcare may decrease with the digitization of health as face-to-face interactions may be impacted, as a result precautions must be taken as to ensure the acceptability and evolution of digital care in the sector (Klesper & Zelth, 2019). A failure to identify that technological interventions can be perceived as poor care in older adults, would lead to the poor uptake of a technology pushing for this type of care. In fact, in one study with professional stakeholder's including care providers, family members and older adult residents, found all groups were optimistic and understood the value of digital technologies in LTC settings so long as this did not impede current face-to-face contact and associated quality of care (Deusdad & Ricco, 2018).

Additionally, barriers such as a lack of information about technologies, lack of financial resources and lack of knowledge among staff regarding how to use and implement new technological interventions present a challenge to the implementation of technology in LTC (Freedman, 2005). This reality urges researchers to understand the needs of individual facilities to integrate adequate innovation and supports.

2.5 MIXED REALITIES

Most persuasive technologies used to promote health among older adults are the mobile application/handheld type of technologies followed by online web applications, these simple technologies enable the ctreation of simple yet efficient health education platforms (Orji & Moffatt 2018). However, these application type technologies are primarily used by active younger older adults with experience using technology and an interest in new health applications, prompting uncertainty about the generalizability of the benefits these technologies offer in LTC (Laufer et al., 2014).

Virtual Reality

Contrary to application type technologies, virtual realities (VR) or augmented realities (AR) offer an outlet to develop immersive and exciting experiences, with the possibility of positively influencing a user's motivation to try new technology (Roberts, 2019). Virtual reality (VR) is a simulated experience in which a user wears a stereoscopic display tracking head and body movements, paired with a computer software, it submerses a user in a completely virtual world with which they can interact (Dermody et al., 2020). These technologies can be appealing given their ability to accurately reproduce nearly any environment, allowing them to cater to the individual interests of any target population. When VR is paired with gaming elements, such as objective based exploration or problem solving, truly engaging experiences can be created and promoted through the use of the technology. These types of VR technologies have some proof of concept in older adult populations. One study evaluating the

effectiveness of VR applications to promote activities such as physical activity found that a large number of older adults found VR to be useful, easy to use, and a generally enjoyable experience, implying generally positive attitudes to the platform (Roberts, 2019). Exergames using VR were also found to be a source of motivation to incorporate daily physical activity among older adults (Molina et al., 2014). Other applications of VR in older adults have been extensive; this technology has been applied in persuasive forms to promote health parameters such as better balance (Fordell, 2017), cognitive therapy (Pedroli, 2020), motion rehabilitation (Trombetta et al., 2017) and memory training (Plechata, 2020) among others. There is emerging evidence that that the usability and wide-range applications of VR are favourable, well-accepted and effective, whereas the initial skepticism of older adults can be broken after the actual use of a VR device (Tuena et al., 2020).

However, VR is not always an ideal platform for the purposes of health promotion with older adults. Firstly, VR is an expensive apparatus, which can be a barrier for its widespread uptake in already resource-limited LTC facilities (Syed Abdul et al., 2019). Second, VR programs are known to cause side effects from its use, notably up to 60-70% of older adults using VR for extended periods experience symptoms such as dizziness, nausea, oculomotor issues and a loss of balance increasing the risk of falls (Sharples, 2008). VR is usually recommended for use by younger older adults with greater physical and cognitive capacity for the safety and well-being of the user. Finally, VR technologies require a user to wear a cumbersome headset, which may be heavy and uncomfortable on frail older adults and can lead to physical discomfort in some individuals (Kujawska et al., 2019). Again, this side effect is more pronounced with age as skin becomes increasingly thinner causing fragility and sensitivity (Dyer & Miller, 2018). For these reasons, VR applications should be carefully considered to ensure the LTC facilities and its population are well suited to benefit from this technology.

Augmented Reality

The shortcomings of VR technologies for use by older adults' present opportunities for other platforms— such as augmented reality (AR). AR's are considered real-world experiences where objects in the physical environment are enhanced by computer generated perceptual information (Malik et al., 2013). Examples of this include a camera filming and displaying a user in a room on a television screen, where virtual objects can be added to the screen display. An AR setup is nearly endless in possibilities; from smart glasses, to mobile applications and full body tracking; these are all ways to enhance one's physical environment. However, the defining factor of AR is that it does not fully immerse a user into a virtual world. VR is designed to replace the environment while AR is designed to enhance the environment. The lack of full immersion eliminates the largest risks posed by VR in older adults— such as falls, dizziness and uncomfortable equipment. In addition, the novel nature of the technology, and its

vast potential of applications, present a new and exciting avenue for older adults to engage in health education.

Despite the potential for AR technologies to benefit older adults, their use remains seldom (D'Cunha et al., 2019). Currently the majority of projects opt for fully immersive experiences utilizing the previously discussed VR platforms (D'Cunha et al., 2019). In instances where AR is used, these are typically mobile type augmented realities or mobile AR (Abd Malik et al., 2013). Mobile AR are enhanced mobile applications employing the superimposition principles of typical AR using the camera on a mobile device. Examples of such mobile type applications has been for example, a mobile AR technology acting as a one-stop-shop to assist older adults in daily activities with reminders and guides appearing on the screen of their mobile devices (Saracchini et al., 2015). This unique application received positive feedback as not only a useful tool, but an exciting alternative providing renewed enthusiasm to completing certain daily tasks (Saracchini et al., 2015). Another application was inserting AR in the windscreen of vehicles driven by older adults, which served as a useful and accepted application to demonstrate route navigation —offering fewer distractions than typical navigation devices (Kim & Dey 2009). Finally, AR has been used with older adults to create holographic displays using wearable lenses to practice cognitive games in older adults with Alzheimer's Disease (Aruano & Garzotto 2019). However, an extensive scan of literature showed that AR remains an understudied platform in older adults and LTC. Even more so as it pertains to health education, taking the form of serious gaming; games that are designed with a persuasive purpose other than entertainment. Additionally, applications of "full scale" AR in the form of full body tracking and large display have yet to be studied with older adults living in LTC. Given the varied applications of AR and its improved acceptance profile —compared to VR— it remains an avenue warranting further investigation as a potentially highly beneficial technology for active aging.

2.6 CONSIDERATIONS OF DESIGNING TECHNOLOGY FOR OLDER ADULTS

Despite the benefits of technology, and its potential use in promoting health in older adults, there still exists the challenge of incorporating it within the difficult to reach population of LTC residents. Given the explicit right of older adults to decide how and when to use technology, many technologies remain underused for a variety of reasons (Peek et al., 2014). Generally speaking, older adults have different perspectives regarding technology when compared to millennials —or even to middle-aged adults (Peek et al., 2017). This has led to the creation of a generational gap, where younger generations are more interested and savvier with technology compared to older generations (Nominet, 2017). Several reasons explain this generational gap; however, the simplest explanation may be the most appropriate: the digitization of the world systems has forced younger generations to adopt and use emerging technologies

at a significantly younger age than older generations. In a situation where a young person is learning a new task facilitated by technology, an older adult is likely replacing the way in which that task was previously performed.

Roger's Theory of Diffusion of Innovations classifies individuals within a social system based on their adoption of innovations based on personal needs and social pressures (Rogers, 1962) Older adults, especially oldest-old older adults are often classified as laggards, rather than adopters, and have more negative views on innovations; leading this group to adopt new technologies and innovations later when compared to younger generations, possibly on the premise of social pressures (Heinz et al, 2013). Different factors must be considered to explain the potential lack of interest of older adults in face of these new emerging technologies.

The natural aging process is responsible for the gradual degradation of sensory and motor systems such as the voluntary movements, hearing and vision; these systems are important for using most modern technologies (Czaja et al., 2013). The loss in sensory capability represents a large barrier for some older adults where small text, low volume and pain can be predominant reasons explaining low enthusiasm for the use of new technologies (Vaporitz et al., 2017). Technology designers typically assume perfect dexterity, sensory and cognitive capacities. Unadapted technology— not capable of meeting the unique physical and cognitive needs of older adults— may impact perceptions towards these technologies and ultimately their acceptance and adoption (Jarvis et al., 2020). Another important factor is consideration of the rapid and evolving technological world we currently live in. Modern life is heavily driven by the motivation to replace daily tasks and activities with potentially more efficient and cost-effective processes. However, this is a prospect which may inherently challenge the beliefs of older adults, with the replacement of systems which have historically worked, and favoring technology over person-person interactions (Currie et al., 2015). This clash in ideologies has contributed to the creation of a digital divide between generations, as the rapidly evolving nature of the field can be overwhelming to older generations (Wu & Tsai, 2018). Feelings of being overwhelmed can even lead to anxiety, low self-confidence and technophobia in older adults (Di Giacamo et al., 2019). In fact, the reluctance to use novel technologies can actually be related to the willingness of individuals to take on risk. Generally, older consumers tend to avoid risk and prefer accuracy over speed when making decisions; in situations of technology use older adults may decide not to act if there is a fear of product misuse (Jia, 2015). Finally, other factors such as the accessibility to technology, cost of technology and availability of support can all be diminished in older adults, contributing to decreased interest in novel technologies (Jarvis, 2020).

For many of the previously discussed challenges, there are opportunities for technology developers to adapt and overcome common failures of technology in older populations. With the

introduction of any technology, the target population will formulate attitudes and a willingness to use the technology (Peek et al., 2016). Positive attitude formation process is multifaceted and complex, and can be unsuccessful if initial attitudes to a technology are unfavourable, given a poor technology design (Taherdoost, 2018). This underlies the importance of understanding the technology acceptance of older adults in LTC and how to create a suitable final product. The concept of attitude formation and technology acceptance is defined as the antagonism to the term refusal and means the positive decision to use an innovation (Simon, 2001). Technology designers must understand the issues which influence users' decision to use a particular technology so these can be considered during the development phase (Taherdosst, 2018).

Technology Acceptance

The most widely used framework pertaining to technology acceptance is Davis's (1989) Technology Acceptance Model (TAM). The TAM theorizes that potential users of a new technology formulate their opinions and willingness toward use based on perceived ease of use (PEU) and usefulness (PU) of the technology (Davis, 1989). The PEU refers to the amount of effort expected by a user in the pre-implementation phase, while the PU is the pre-implementation perception of the advantages of using the technology. Combined, the PEU and PU are considered to predict 40% of the pre-implementation attitude formation process (Venkatesh & Bala, 2008). However, in older adults this model has certain limitations; Mitzner et al have expressed that the TAM is oversimplified and does not consider important factors such as abilities, health status, previous use of technology and social influences which vary from the younger generations (Mitzner et al., 2018). Furthermore, there are inherent issues with application of the TAM, in that it does not consider the experiences and attitudes towards technology past the pre-implementation stage, focuses on two parameters, and older adults are unlikely to perceive technology as useful or easy to use, therefore they may be quick to dismiss it (Peek et al., 2017). These findings indicate that more research on technology acceptance is necessary, with the use of a more encompassing model considering other relevant factors.

In 2003, additions to the TAM were made to remediate some of the previously identified concerns of the TAM, with the creation of the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003). The UTAUT expands on the TAM with the inclusion of performance expectancy, effort expectancy, social influence and facilitating conditions to the construction of attitudes. In fact, the UTAUT is capable of predicting up to 70 percent of intention to use, with the addition of social influence and facilitating conditions in addition to the moderating factors of age, gender, experience and voluntariness of use (Venkatesh et al., 2003). In relation to older populations, the UTAUT incorporates key factors such as age, gender and previous experience with technology as deterministic

factors in forming opinions towards a new technology; factors especially relevant in older adults. In fact, the UTAUT theory has been used by researchers to design and understand the acceptance of technology design in older populations (Dai, 2019; Lai, 2018; Nagle, 2014; Peek et al., 2014). The UTAUT has since been characterized as a powerful and robust model to understand the acceptance of technology in older adults (Peek, 2017). Identifying the factors which determine the acceptance of technology in a target population is of paramount importance in the technology design process. With technology acceptance models, decisionmakers, technology designers and caregivers are enabled to design stimulating technology for active aging (Peek, 2017). With elaborate outreach and consultation these models can guide the identification of factors that will promote favourable technology outcomes in older adults.

2.7 PARTICIPATORY DESIGN (PD)

To better understand adoption and attitude formation, a needs assessment involving end-users and other important stakeholders must be conducted throughout the entire design process (Cahill et al., 2018, Peeket al., 2016, Varwijk et al., 2016). This type of approach can broadly be described as participatory design (PD). As the name participatory design suggests, it is a methodology which encourages the maximum involvement of future end-users and other relevant stakeholders throughout the entire innovation process (Merkel & Khukarski, 2019). PD holds the potential to address several of the previously discussed limitations in the field of gerontechnology and technology acceptance in older adults. Historically, PD was first introduced in 70s and 80s in Scandinavian countries, with an objective to empower workers in the building of relationships with employers for the implementation of new technologies and equipment in the workplace (Spinuzzi, 2005). Since then, PD has greatly evolved and morphed into a scientific methodological approach to the innovation and design of technology in scientific research (Halskov & Hanson, 2015). The field of health sciences have increasingly been using PD approaches to meet the goal of greater alignment between theory, research and practice (Clemensen et al., 2007).

Early work on defining the methodology of PD was first conducted by Spinuzzi in 2005, where PD was for the first time defined as a scientific methodology. Theoretically the methodology was based on constructivism, attempting to understand the implicit knowledge of end-users (Spinuzzi,2005). When employing PD, it is assumed that researchers and designers are not ideally positioned to understand the unique needs of their target population. In fact, the PD approach attempts to examine the tacit or invisible components of human activity through a close researcher-designer-participant relationship (Spinuzzi, 2005). Tacit knowledge can be defined as knowledge which is implicit rather than explicit; knowledge which can be well known but cannot necessarily be easily articulated (Spinuzzi, 2005). The paradigm of constructivism suggests that it is through regular interactions that tacit knowledge can be found. It is in

this sense that users are generally referred to as experts by experience. Given their unique experiences, they are the only ones to completely understand their own reality, and must be regarded as important in the design process as other collaborators such as content experts, developers and researchers (Beimborn et al., 2016). Through mutual interactions and discussion, tacit knowledge may be uncovered and preserved, so that the technology can align with the existing reality and activities of the user rather than work against them.

Given the need to understand daily activities of end-users, failure to include them and other relevant stakeholders in the design process can lead to inadequate designs and the poor uptake of a final product (Hakobyan et al., 2015; Lindsay et al., 2012; Merkel & Kucharski, 2019). In fact, it is estimated that nearly 40% of technology information systems do not meet user requirements, a large portion which can be attributed to a lack of participatory design activities (Johnson et al., 2005). Unsuccessful designs opting to not include end-users can often be attributed to a lack of understanding of the end user's individual needs and motivation to using technology (Wilkinson & Cornish, 2018). This urges technology designers to carefully consider the needs and motivations of their target population in the innovation and design of technology.

The diverse definitions of PD have contributed to significant differences regarding the actual rationale for PD approaches, the level of participation, methods of participation, and the outcomes of PD approaches (Halksov & Hansen, 2015). Halksov et al. suggested that overall, three levels of PD participation can be achieved; implicit, users' point of view and mutual learning (Halksov & Hansen, 2015). Implicit participation is a scenario where user participation is unclear as it is inadequately defined and rarely goes beyond the affirmation that users were consulted (Halksov & Hansen, 2015) Users' point of view and mutual learning both expand on participation through clear definitions of participation roles and outcomes. In users' point of view, the user is seen as best positioned to make design decisions whereas mutual learning acts as a middle ground, where in consultation with the point of view of users' design decisions are made (Halskov & Hansen, 2015). The users' point of view and mutual learning type of approaches both rely heavily on the gathering of personal experiences and attitudes. To gather this type of preliminary data, PD heavily relies on qualitative data collection to gain deep understandings of individual contexts (Bergold & Thomas, 2012). This type of data gathering will typically include interviews, focus groups, workshops and to a lesser extent quantitative surveys and questionnaires.

The techniques employed during the PD consultation will depend greatly on the stage of the design process. For example, in the earlier stages of a design relationship a research team will typically look to familiarize themselves with participants with ethnographic methods (Halskov & Hansen, 2015). Examples of such ethnographic methods can include interviews, observations and setting walkthroughs, at

this stage user participation remains limited and the work is very exploratory in nature (Spinuzzi, 2005). By understanding basic characteristics of the population, the later stages of the process can be further refined and directed as to better meet their needs. In subsequent stages of prototyping, users' will be increasingly involved in the process. For example, in early prototyping processes when no working prototype has been created, users' may be involved in "mock-up" sessions. These sessions are early brainstorming sessions where tools such as paper, cardboard and other "hands-on" accessories are used to begin the early process of building an early prototype or idea (Clemensen, 2017; Spinuzzi, 2005). Inclusion of participants at this stage allows researchers and participants to focus efforts and to narrow down towards one consolidated model. In instances where development is more advanced and early prototypes are available, activities such as focus groups and workshops take precedence to elaborate and refine design prototypes. In fact, focus groups in health technology design have been shown to create rich ideas and concepts from the interaction of different participants (Tremblay et al., 2010; Van velsen et al., 2015). Ideas can be harder to uncover in one-on-one prototyping interviews which lack the component of interactive conversations between diverse members with varied experiences and beliefs. Other examples of mobilization can include design workshops which aim to create hands-on experiences with predetermined activities and scenarios eliciting greater participation from users. Examples include workshops such as the Give&Take project, which created a design laboratory utilizing various platforms to create co-design events with embedded activities promoting mutual experimentation between end-users, stakeholders and designers (Malmborg et al., 2016). Despite the greater involvement from these initiatives, these are complex and time-consuming strategies eliciting consideration of time and resources. From the standpoint of a research team, a careful exercise of mapping objectives, the population, and the stage of design is necessary to create a strong PD plan. In the coming section PD will be discussed in the context of older adults and LTC.

2.8 OLDER ADULTS AND PARTICIPATORY DESIGN

For a variety of reasons older adults have unfortunately been excluded from technology PD projects (Iacono & Marti, 2014). As previously discussed, the degenerative physical and cognitive impairments some older adults live with are typically perceived in technology design as difficult barriers in the development of wide-reaching and effective technologies (Hakobyan et al., 2015; Merkel & Khukarski, 2019). In an effort to expedite the design process, these considerations will not always be prioritized by design teams, often resulting from poor stakeholder outreach and consultation. Relating back to Spinuzzi's understanding of tacit knowledge, the knowledge held by older adults regarding technology has remained largely unnoticed and arguably invisible to young designers. However, with increasingly successful projects encouraging PD, there has been a renewed interest in involving older

adults in PD (Brandt, 2006; Lindsay et al, 2012; Muller & Druin, 2002; Merkel & Khukarski, 2019). The consensus has been that assistive technologies have great potential to improve quality of life and independence, however, to do so technologies must meet the real needs and capabilities of older adults (Hakobyan et al., 2015). Poorly designed technologies will not only fail to meet its expected outputs, but can also be regarded as a greater nuisance than a solution. As noted by Lindsay et al. when referencing the social model of disability, impaired health or cognitive ability will only translate into disability through barriers; in the case of technology design, it is an explicit failure in design which can cause disability in the end-user (Lindsay et al., 2012). If a technology fails to be accessible for the target population, its implementation will directly negatively impact the lives of the intended users. In this lies the necessary motivation to apply additional efforts to inclusively design technology in an already difficult to reach population.

The need for PD in the ideation and creation of technology is only exacerbated in older adults, when compared to other populations. In fact, Drury and colleagues highlight the clear gap between young and avid technology designers— and often more technology dismissive older adults (Drury et al., 2016). This generation gap between both groups can make it difficult for technology designers to understand not only the needs of older adults but also their comfort level with technology. The tech industry today is dominated by software engineers in their twenties and thirties who naturally view and understand technology in a different way compared to older adults. Particular attention must be placed considering this generation of older adults having not been raised with modern technologies (Peek et al., 2014). This generational effect refers to the simple notion that younger individuals are capable of interacting more effectively with new technologies, even after receiving no type of formal training (Freudenthal et al., 2011). This phenomenon is increasingly recognized as younger children are interacting with complex technologies without significant input from adults. In LTC, this is in addition to the fact that most older adults are in the oldest-old category and therefore can have different perceptions and experiences with technology than a 65 year old. This urges young designers to consider the fundamental differences in attitudes and experiences with technology and most importantly how these differences will influence the technology at hand. The failure to perform such an exercise and to actively involve older adults in the design process can lead to ageist technologies. In fact, Joyce and Loe (2010) make a case that the majority of technologies are designed with a youthful body in mind, by which nearly all considerations and opinions of older adults are entirely ignored in the design process. On the other side of the spectrum, technologies may result from abiding to the stereotypical understanding of older adult technology use. Young designers in an attempt to cater to the needs of older adults can create an ageist technology only considering common stereotypes rather than designing a technology meeting specific needs. Such stereotypes will assume loud volume, large text and big buttons and completely overlook other important

design considerations. These realities highlight the involuntary nature of poorly designed technologies for older adults. Technology designers must be aware of their own personal biases and how these can influence their design decisions and whether these decisions will for or against the targeted user.

However, despite the need to utilize PD techniques with older adults, it is important to consider how PD must be adapted to cater to the particularities of LTC. Firstly, in projects with older adult end-users, it is common to promote greater involvement from other relevant stakeholders such as caregivers or relatives compared to other groups (Muller & Druin, 2002, Merkel & Khukarski, 2019). The inclusion of such stakeholders is especially relevant in LTC settings where older adults will not interact with technology in isolation but rather with the support from staff, relatives and other residents. In a systematic review of PD methodologies with older adults the majority of projects involved secondary users such as caregivers and relatives in the data collection process (Merkel & Khukarski, 2019). Failure to involve staff members in a LTC project runs the risk of staff not knowing how to operate the system or the system unable of respecting location specific constraints such as resources and staffing. As previously discussed, the methods used for PD projects can be varied, and older adults can be involved using a variety of strategies including but not limited to surveys, interviews, focus groups and design workshops (Iacono et al., 2014). The level of involvement in PD will greatly depend on the nature of the project, the stage of development and the resources of the research team. Though it may seem ideal to involve older adults as equal partners in PD, this is rarely the case given specific resource and time limitations preventing complete mobilization and outreach (Merkel & Khukarski, 2019).

Despite the benefits of the inclusion of a PD approach with older adults, it is in and of itself a significant challenge and a large time commitment (Hakobyan et al., 2015, Lindsay et al., 2012). In fact, challenges such as difficult recruitment, engaging participants with impairments and discussing subject matter on which participants have limited experience, represents some of the challenges of embarking on a PD project (Hakobyan et al., 2015). As a result of these considerations, adaptations must be made to ensure a certain level of flexibility on the part of the research team. Older adults may struggle with technical language or when trying to hypothesize abstract technologies and can even struggle to focus during unclear design sessions (Lindsay et al., 2012). Researcher awareness of this population's experience is important to ensure the project remains accessible and enjoyable for older adults. In planning, researchers must be aware that to successfully implement PD is to commit more time than necessary if to obtain a representative sample of the needs of their population and to not merely address the immediate and obvious functional impairments typically associated with aging (Lindsay et al., 2012). A current gap and missed opportunity in PD of technology in older adults is the failure to include older adults in a positive way, and in more than one stage of technology development; this failure can create the

illusion of involvement and be counterintuitive to the research and design team (Merkel & Kucharski, 2019).

2.9 SUMMARY

The aging Canadian population will lead to significant increase in demands on LTC health systems. Given this demand, there exists a constant need for LTC facilities to find new ways to deliver important physical, cognitive and social health promotion to LTC residents. Given unique limitations, health programming can be a challenge in LTC, and particular attention must be paid to individual center characteristics for successful implementation.

Innovative technologies are viewed as a promising alternative to traditional health programming, where technologies can be modified to meet the needs of LTC centers and individual residents. Furthermore, technologies such as AR and VR offer immersive and exciting opportunities potentially promoting better program adherence. However, there are challenges to the implementation of technology with older adult populations. The physical and cognitive limitations associated with aging, and the difference in perceptions and attitudes to technology can make its uptake difficult in older adults. To date, significant research has been invested in LTC technologies to promote health, however challenges have persisted in long-term implementation and general advances in the field of Gerontechnology. In fact, Gerontechnology remains in a stage of relative infancy with little research and practices in place to support technological development in older adults

To overcome past challenges with technology uptake and impacts, research teams are urged to employ PD approaches. PD approaches enable research teams to involve end-users and relevant stakeholders in the design of a product to meet their unique needs. Older adults are a group which has historically been neglected in PD approaches, resulting in unadapted products incapable of meeting their needs and desires. Specifically, technology designed for use in LTC rarely employs PD approaches or fails to involve older adults in a meaningful manner. This project builds upon the identified gaps in the literature. By employing PD to the design of an AR technology for health education and to understand the unique technological needs of older adults, this thesis is contributing to unique and scarcely explored areas of research. This project provides evidence-based requirements not only to the design of the Magic Mirror and older adult technology use but also to the design and implementation of PD in LTC settings.

Key Messages from Literature Review

- Older Adults are a rapidly increasing population in Canada. The sub-population of older adults requiring LTC is also increasing , adding additional strain on Canada's LTC system.
- In 2002 the WHO endorsed the strategy of active aging, aiming to enable older adults to seize opportunities for health and wellbeing throughout the lifespan.
- Novel technologies are an emerging strategy to act upon the WHO's recommendation to involve older adults in their own health and to promote active aging.
- Mixed realities are an important subtype of technology providing immersive and personalised health activity experiences.
- AR provides several of the similar benefits as VR, while eliminating some common limitations of VR. Yet AR remains understudied in the context of older adults and LTC.
- To date advances in gerontechnology have been extensive. However, the field has failed to fully establish itself in scientific research. The lack of methodology and clear frameworks has led to issues with long-term implementation and success of technological innovations in LTC.
- PD methodologies and technology acceptance models are important tools for the design and eventual implementation of technology in LTC, harnessing the input from older adults and other relevant stakeholders.
- To date older adult populations have been historically neglected in PD of novel technologies.

CHAPTER 3: RESEARCH METHODS

This chapter presents the methods used to answer the research questions for this project. It details how the qualitative data of the participatory design approach was collected and analyzed, as well as how rigour was ensured throughout the process.

3.1 ASPIRATION NOT REHABILITATION

This thesis is one phase in the design of a potentially disruptive innovation known as '*The Magic Mirror*' developed by the Metrics Lab at the University of Ottawa. The current prototype consists of one Kinect sensor, a TV display and a custom in-situ visualization software creating a low-cost mixed-reality technology. The current Magic Mirror allows for the visualization of real-time body motion on the display with a gesture-based user interface (UI). Previous validation of this technology in a previous project (MirrARbilitation) was confirmed in a large user study where end-users worked closely with designers while using a working prototype to provide reflections on its use to determine its learning potential and acceptability in the realm of medical education (Kugelmann et al., 2018; Da Gama et., 2016). The favourable learning outcomes and high fidelity of the operating system and UI have validated the use of this type of technology in health programming. In the current study, the MirrARbilitation platform is to be re-imagined as *The Magic Mirror* for its use as a health activity platform to promote older adult physical activity and social engagement. Major principles had been identified to guide the re-imagination process for its application with older adult populations. Firstly, The Magic Mirror has been enhanced to integrate smart sensors to capture real-time motion and physiological data. Furthermore, the platform is now enriched to monitor progress and provide real-time feedback to the user during the healthy habit formation, such as doing physical activity. Finally, the augmentation and visualization will eventually have the possibility to be personalized (user-specific). The initial prototype of *The Magic-Mirror* is currently harnessing these principles. In summary the Magic Mirror features:

1. Body Movement tracking in real-time to provide immediate visual feedback to the end-user.
2. Personalized content and difficulty to meet the unique needs and interest of different end-users.
3. Mechanisms to provide feedback to end-users during health activity training.

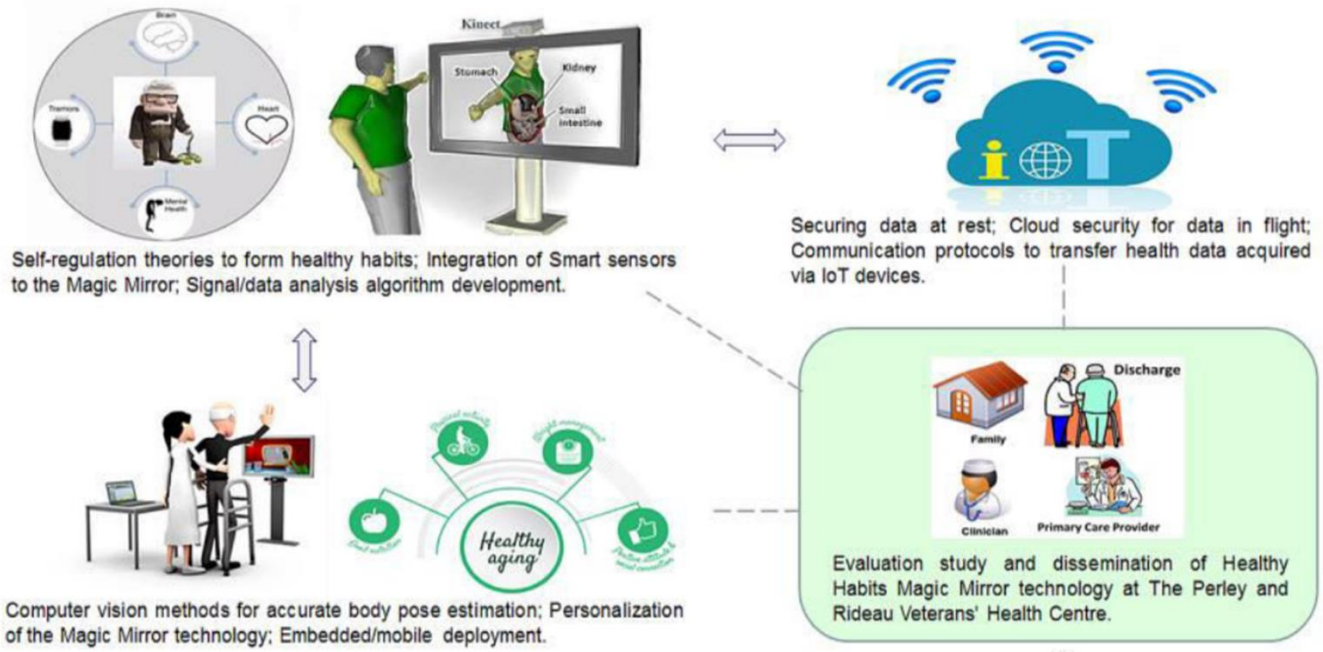

Figure 1: The METRICS lab representation of the MAGIC MIRROR prototype. Reprinted with Permission.

3.2 RECRUITMENT AT THE PERLEY-RIDEAU VETERANS HEALTH CENTER

Recruitment for this study took place at the Perley and Rideau Veterans' Health Centre located in Ottawa, Ontario. This facility is large, with over 450 long-term care beds and 139 apartments for senior's housing for independent seniors. The centre has historically served retired members of the Canadian Armed Forces and continues to be a regional hub for these services. The centre is renowned as a leader in active aging and creating enabling environments to promote health and independence in its residents and tenants. In fact, each resident at Perley-Rideau is offered a specialized care plan designed to maximize individual residents' quality of life. The center offers a variety of services ranging from exercise and meditation to music therapy and arts and crafts. The centre has extensive partnerships in health research, and the centre's dedication to excellence in continuing to seek innovation, and continual improvement made this centre an ideal candidate for the current study. The Perley and Rideau Centre of excellence lives up to a longstanding commitment towards research and knowledge translation to advance the care of older adults. This type of openness to research and innovation aligned well with this Magic Mirror project with a focus on technological innovation. Early establishment of a relationship with the research coordinators allowed for the creation of a partnership for this research, granting access to the facilities and residents for the conduct of this thesis project.

3.3 RESEARCH DESIGN

The study used a qualitative participatory design, achieved with focus groups engaging key stakeholders at the Perley-Rideau Veterans' Health Centre. The research team applied for and was granted approval by the University of Ottawa research ethics board on 27-07-2019 (to review the ethics certificate, please see Appendix A). Informed and signed consent was required from all participants to participate in this study. All participants were reminded of the voluntary nature of this study and their right to withdraw from the study at any time. Furthermore, prospective participants were informed that participation or lack of participation in the study would not change the services and treatment received from the Perley-Rideau Veterans' Health Centre. Following data collection, rigorous measures were taken to ensure that the confidentiality of all participants was maintained. This included the anonymization of data, safe storage of data and responsible storage practices.

In the early stages of this project, older adult LTC residents and LTC staff members were identified as important participants for involvement in focus group consultations about the design of *The Magic Mirror platform*. The residents were invited to attend 2 focus groups, while the staff were asked to attend one. The rationale for two older adult groups was to gather more direct end-user feedback, maintaining short 1-hour sessions to accommodate residents. In addition, given the challenges of organizing several staff discussions during re-enumerated hours, it was optimal to meet with staff once.

3.4 DATA SOURCES FROM OLDER ADULT MEETINGS

Participants for this study were identified using a purposive sampling technique. Potential participants were identified and recruited by this research team with the support of center research coordinators if they met certain inclusion criteria. Older adults were eligible to participate if they were a full-time resident or tenant of the Perley-Rideau Veterans' Health Centre and did not have a diagnosis of a cognitive impairment limiting their ability to participate in the focus group discussions (determined by a cognitive performance scale (CPS) score of 3 or lower). Participants were not obliged to have previous technology interest or experience; participants with or without interest or experience with technology were encouraged to patriciate to gather diverse end-user perspectives. The recruitment of older adults was facilitated with the help of the facility research coordinators. Given, their involvement with the center they were well positioned to identify candidates who might be interested in participating in our study. With the outreach of research coordinators, potential participants were approached following activities at the center and in common areas. When an older adult expressed interest in the project, with their permission, their name was shared with the research team. Potential participants were then met one-on-one by a member of the research team and the facility research coordinator to establish the initial contact.

These meetings were an opportunity to further discuss the project, answer any questions, and to obtain informed consent from participants willing to participate.

The focus groups had between 3-5 participants, to accommodate for certain challenges of conducting focus groups in older adults. Notably, the smaller than usual group size was to ensure all participants could comfortably hear all participants at the table and to diminish any potentially perceived pressure of rapidly responding to questions. Furthermore, the smaller groups allowed for the research team to better assist the participants into the room and help them settle-in comfortably for the meeting. The smaller groups also made it possible to assist residents back to their rooms following the meeting if necessary. An additional benefit to the smaller size of the focus groups was the immediate ability for the groups to familiarize themselves with other participants and moderators prior to the start of the meeting. It was agreed that by creating small teams, a certain level of comfort would be established and would allow for better engagement on behalf of participants. The older adult focus group meetings were scheduled to be approximately 45 minutes with a maximum time limit of 60 minutes and occurring in the early afternoon. This duration and time of day were suitable to ensure participants could remain engaged throughout the meeting, and to minimize disruptions to the schedules of the participants. In discussions with research coordinators, this was highlighted as an important consideration to not prevent participants from attending other activities and commitments at the center. All meetings were held in a conference room at the Perley-Rideau Veterans' Health Centre, allowing participants to easily join the meeting and return to their personal homes after the meetings.

Prior to the focus groups, semi-structured interview guides were prepared to gather information about technology use, acceptance and augmented reality perception data; to guide the design of the Magic Mirror platform. This interview guide was designed by our research team and was revisited in an iterative process to refine the questions for greater output and quality of participant data. The interview guide for the older adult focus groups emphasized two major topics: 1) Previous and current technology use, and 2) initial perceptions of a video demonstration of *The Magic Mirror* prototype. The meetings included a brief introduction and icebreaker activity to familiarize participants with the study and other participants prior to the question period. The first portion of the meeting was designed to understand the needs and the motivations behind the use of technology in older adults. The purpose was to identify similarities in motivation towards technology use which could be incorporated into the design of *The Magic Mirror*. The second portion of the meeting focussed on perceptions of a short video demonstration of the Magic Mirror platform in use. The video presentations were short examples of how the technology could be applied in a LTC setting and were representations of an early prototype version of *The Magic Mirror*. The first game presented was a mild dancing game where a participant would be prompted to mimic the

simple dance movements (lifting body parts and clapping) of a generated “mini Elvis” on the television screen, with the audio playback of popular Elvis music. As a participant correctly moved in unison with Elvis, they were rewarded with points in an attempt to generate a high score and continually improve on subsequent attempts. The second presented mini game prompted users to categorize food items falling from the sky into its corresponding food group. As virtually generated food items fell from parachutes users were to grab these by clasping their hands on them and to drop them above baskets corresponding the correct food group. This exercise also granted points and showed how basic minigames could be enhanced with health messaging. The purpose of showing these videos to the older adults was to remove the obscurity of discussing technology without concrete examples. By providing a video demonstration it was intended to be easier for participants to understand the goals of the technology and their potential role in helping the design team better meet their needs and interests. However, we explained to participants that these were early examples for visualization purposes only, and were not final products. This portion was strategically kept open-ended where participants were asked to provide their initial feelings regarding the technology and to naturally stimulate a dialogue in whichever direction the participants decided to move towards. We felt this approach would allow for the most accurate representation of their perceptions and generate the most accurate and useful data for design purposes.

3.5 DATA SOURCES FROM STAFF MEETING

Participants for the staff focus groups were also identified with the help of the Perley-Rideau Veterans’ Health Centre research coordinators. For this project we were particularly interested in staff who played a role in the day-to-day activity programming at the center. This could include anyone from personal support workers, activity programmers to physical and arts therapists. Purposive sampling was employed to obtain representation from different categories of staff members in an effort to gather a broad representation of the different needs. All interested staff members were asked to identify potential meeting times, and this was coordinated with the research team to organize a discussion. All participating staff members provided informed consent prior to the focus group discussion.

For the staff focus groups, we aimed to have n= 6-10 participants. The larger focus group size was deliberately chosen to promote richer discussions as representation from different staff types would provide insightful data. Prior to the staff focus group meeting, a semi-structured interview guide was designed and revised to specifically tailor questions for the staff. The LTC staff were asked to identify the opportunities and challenges of incorporating technology into healthy activity programming at the facility. The focus group discussion was designed to be split into three sections. In the first staff were asked to provide the current state of health promotion activities in LTC. This included discussing current programs and personal experiences with these programs. The next section of the discussion looked to

gather the perspectives of staff on incorporating technology as a tool to enhance health promotion in LTC. Specifically, asking the benefits and anticipated shortfalls of technological approaches. While the third and final portion of the meeting was to gather initial attitudes and perceptions to the same two Magic Mirror prototypes videos previously shared with older adult participants. This section would determine preliminary design principles to refine the prototypes based on their personal experiences at the facility. This focus group organization was intended to gather a solid representation of LTC health promotion from the viewpoint of staff by identifying current opportunities and gaps.

3.6 DATA ANALYSIS

The selected worldview for this study was that of social constructionism by which there exists neither one truth or reality to be found within a dataset (Crotty, 1998). Rather meaning is constructed through the lens of the researcher considering their unique points of view and experiences (Crotty, 1998). Data analysis for this project followed an inductive thematic analysis framework. Thematic analysis is a method for identifying, analyzing, organizing, and reporting themes which are found within a dataset (Braun & Clarke, 2006). This data reporting framework is the product of deep and prolonged immersion with a dataset, tools such as thoughtfulness and reflection are used throughout to generate meaning (Braun & Calrke, 2019). This type of framework moves away from the school of thought that within data lies a hidden truth which can be found, rather thematic analysis is the process of telling stories and creating an understanding from the interpreted stories (Braun & Clarke, 2019).

For this project each focus group meeting was facilitated by two people: the master's thesis student and a supporting facilitator. All meetings were audio recorded for later verbatim transcription of the data. The transcripts were then used in the data coding process using the data management software Nvivo version 12. For the data coding process of this study two unique codebooks— one corresponding to older adults and the other for staff— were developed to initially organize the collected data. The codebooks were designed with an iterative process. The construction of codebooks followed the process outlined in grounded theory with the early fracturing of data (Chun Tie et al., 2019), initial ideas were developed in the margins of the original transcripts to first guide the codebook design. This process allowed for generation of early themes for later grouping into categories. From this point, ideas were grouped together and branched into codes and categories of codes to account for all data in the transcripts referred in the process of intermediate and advanced coding. Initial ideas, codes and themes were discussed as a team, with my supervisors, to generate new ideas and to refine the codebook. Given the nature of qualitative data analysis it was decided to keep the codebook open to emerging ideas and themes during the coding exercises of the data. This technique aligns with inductive thematic analysis, which intends for qualitative research to remain creative and reflexive allowing for greater flexibility in the

presentation of data following deep immersion in the data (Braun & Clarke, 2019). Further an open code book aligns with the complexity of deeply reflecting on patterns and meaning of human experiences and discussion, and to ensure the constant construction of themes throughout the research process (Saldana, 2008). The audio transcripts were systematically coded by the master's thesis student. However, despite the fluid nature of the codebook creation, the coding of the data as a whole remained rigorous and structured where the process of generating initial themes, searching for themes and reviewing and refining themes throughout was followed to ensure themes were accounted for and fully established (Nowell et al., 2017).

CHAPTER 4: RESULTS – ARTICLE 1

Participatory Design of an Augmented Reality Platform for Promoting Health Activity in Long-Term Care

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Abstract

With the global aging population, there continues to be a need to find new and potentially disruptive innovations to keep long-term care (LTC) residents engaged physically, cognitively and socially. These innovations can not only promote active aging lifestyles in older adults but can also increase the effectiveness and sustainability of LTC systems. However, technology designers have historically faced challenges designing technologies which meet the unique needs of older adults in LTC. As a result, Participatory design (PD) projects have increasingly gained traction to design user-centered innovations. Hence, this project aimed to identify the design requirements for the design of an augmented reality health activity gaming platform for use in LTC. A participatory design framework was used with the objectives of (1) exploring the current attitudes, usage, benefits and challenges regarding the use of technology and (2) gathering preliminary data on the attitudes of older adults and staff in LTC regarding the integration of an augmented reality health activity platform. We conclude with a collection of usability and accessibility findings to help guide the design of our platform and promote favourable integration in a LTC setting.

Keywords

Participatory design, Active aging, Long-term care, Health technology, Older adults, Gerontechnology, Augmented reality

Introduction

1.1 Introduction

The Canadian population is rapidly aging; it is estimated that by 2030 1 in 4 Canadians will be aged over 65 years (GoC, 2016). Despite the societal benefits of living longer there are particular pressures of an older population on a healthcare system, such as a greater need for health services and supports. As a result, a new focus has been placed on enabling older adults to not only live longer, but to live healthier lives. Specifically, the World Health Organization recommends active aging: “the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age” (WHO, 2002). Older adults living in long-term care (LTC) represent a unique sub-population of Canadian older adults. Their varying needs and the particularities of LTC facilities, have led to a increased demand on researchers to find new and innovative strategies to keep older adults in LTC engaged physically, cognitively and socially (SIC Report). Furthermore, innovations must consider constraints which exist in LTC, given that low staffing and limited resources remain challenges in this sector (Triaphat et al., 2017). Technological innovations are important in providing higher quality services to residents, while achieving better value for money by realizing system efficiencies (OLTCA,

2019). Specifically, persuasive technologies to influence individual health behaviours are a leading strategy to create interactive, user-specific and engaging health education delivery platforms in LTC (Khosravi et al., 2016).

Technologies, such as augmented reality (AR), provide a unique opportunity to create semi-immersive health promoting environments, without the challenges of fully immersive virtual reality (VR) experiences, which can include physical discomfort and cumbersome equipment (Kujawska et al., 2019). In fact, up to 60-70% of older adults using VR for extended periods experience symptoms such as dizziness, nausea, oculomotor issues and a loss of balance increasing the risk of falls (Sharples et al., 2008). AR, on the other hand, harnesses similar simulation principles as VR by enhancing the physical environment of a user with computer generated perceptual information, but without a complete loss of one's physical environment (Malik et al., 2013). AR technologies have increasingly been used with older adults in contexts such as facilitating daily tasks, aiding in the communication of navigation information, while driving and playing cognitive games in older adults with Alzheimer's, to name a few (Arruano & Garzotto, 2019; Saracchini et al., 2015). Despite the potential for AR technologies to support active aging in LTC, their use is limited (D'Cunha et al., 2019). As a result, AR remains an avenue warranting further investigation in the context of LTC to promote physical activity and social interaction.

1.2 Introduction to the Study Problem

The purpose of this study is to further understand technology use in LTC and inform the requirements for the design of an Augmented Reality (AR) health activity platform, which is intended to promote behaviours such as physical activity, social interaction and nutrition in older adults residing in LTC. However, technology acceptance and uptake in older adults remains a challenge given their different perspectives and experiences with technology (Peek et al., 2014). Furthermore, technology for older adults is often maladapted to meet their unique needs compared to younger generations; greatly impeding its uptake and success. This is a challenging problem requiring the input and involvement of relevant stakeholders in the implementation of such a platform in the unique particularities of LTC. Participatory Design (PD) is the gold standard methodology for the design of novel technologies in various populations. As the name suggests, PD encourages maximum involvement of future end-users and other relevant stakeholders throughout the entire innovation process (Merkel & Kucharski, 2019). Historically, older adults have been excluded in PD projects, leading to poorly designed and maladapted technologies (Iacono et al., 2014). PD can remediate limitations and shortcomings of previous projects by uncovering the true needs and capabilities of older adults in the context of their environments (Hakobyan et al., 2015). In doing so, technologies can be designed to complement care in older adult residents and facilitate active aging activities.

2 Materials and Methods

2.1 Design and Technology

This study was a qualitative PD project achieved through outreach to LTC residents and staff. This study was carried out as a complement to a longer-term study of designing and implementing a user-centered AR gaming platform in LTC. The technology being designed harnesses the functionalities of AR paired with real-time movement tracking, gesture-based user interface and gaming design principles. The technology is comprised of a single motion sensor, a television display and a custom in-situ visualization software. As a result, on the television an end-user is able to visually see themselves in the room in which they stand with superimposed elements added to their environment. Through customized "mini-games" users are exposed to active aging health activities such as physical activity and social interaction. For example in one mini-game a mini Elvis Presley appears at the bottom of the display for end users to mimic his dance movement and to accumulate a high score. The overarching goal of this platform is to provide additional opportunities for residents in LTC to remain physically, socially and cognitively engaged, with longer-term outcomes being improvements in functionality and autonomy.

2.2 Recruitment

Three focus group meetings were organized at a local retirement community located in Ottawa, Ontario, Canada, to explore the attitudes and perceptions of LTC residents and staff towards general technology and a preliminary prototype of an AR health activity platform. The selected center is a large 450 long-term care bed center with 139 apartments for independent seniors, however the focus of this study was the LTC residents. The center is regionally renowned as a leader in active aging and creating enabling environments to promote health and independence. For example, the center designs individualized care plans for all residents and offers a variety of care and recreation services. In total, three focus groups were hosted with two groups of older adults and one staff group. All participants for the three focus group discussions were recruited in Fall 2019 and meetings were held in Fall 2019/Winter 2020. Ethics approval for this study was provided by the university research ethics committee.

The LTC center research coordinators were involved in the distribution of flyers to individual residents, as well as posting flyers for information in the common eating and recreation areas at the center. Research coordinators also shared information about the research project and its objectives throughout the center to staff and team members to identify potentially interested participants. To participate in the project, older adults had to be full-time residents in the LTC part of the center and they needed to be cognitively capable of attending and participating in a focus group discussion (determined by a cognitive performance scale (CPS) score of 3 or lower). No particular limitations were placed on

self-disclosed interest in technology or previous experience with technology. The names of interested residents requiring more information on the project were shared with this research team. Subsequently, residents were met one-on-one to discuss the project and offer clarifications as necessary, when participants agreed to participate, signed informed consent was acquired. Following the recruitment process, time slots were determined for the two older adult meetings. Research coordinators were available to remind participants the day before the meeting if requested and assistance was offered to escort participants to and from the focus group meeting at the LTC center.

Staff were recruited with outreach support from the research coordinators at the center. Specifically, staff involved in the care of residents, delivery of physical activity programming and recreational services were identified as key stakeholders of interest. Research coordinators reached out to managers of individual units at the center to identify interested staff who could participate in a one-hour focus group meeting during working hours, without interrupting services at the center. A suggested time slot was recommended by the research coordinators to maximize attendance. At the meeting, staff were asked to provide informed consent prior to the start of the focus group meeting.

2.3 Data Collection

The data for this study were collected via three facilitated focus groups, designed to achieve the following goals: (1) understanding the current attitudes, motivations and past experiences with technology among older adults; and (2) explore initial perceptions regarding a video demonstrated AR prototype. For the staff focus groups, the protocol was designed to: (1) gather data on the state of health progamming in LTC; (2) identify the opportunities and risks of using technology to complement health activities in this setting; and (3) explore initial perceptions regarding the same video demonstrated examples of the AR prototype. The focus group guides were designed iteratively; the questions were open-ended in nature and promoted dynamic and open discussions. Sample questions for older adults included:

1. What is technology for you? What does the word bring to mind?
2. What technology do you use, or have you used before?
3. What role would you say does technology have on your daily life?
4. With your experience using different technologies what do you find most difficult when trying to use a new technology?

Sample questions for staff included:

1. What do you perceive as the greatest challenge to offering health education activities to the residents/tenants of this facility?
2. What are your opinions on the prospect of using technology for the purposes of health education in older adults? What do you perceive as the pros/cons in doing so?

3. From an organizational standpoint what kind of resources do you believe are necessary to have this technology implemented and used in a long-term care setting? What facilitators do you think should be in place?

Both older adult focus group meetings and the staff meeting were held in a conference room on-site to enhance accessibility and occurred in the early afternoon. Prior to the meetings participants were asked to complete a short demographics questionnaire. Each meeting was designed to last approximately one hour, with a maximum allocated time of 75 minutes. The meetings were led by the first author and a co-facilitator, to aid in note taking and manage the logistics of the meeting. All focus group discussions were audio recorded and transcribed to prepare for coding.

2.4 Data Analysis

Data analysis for this project followed an inductive thematic analysis framework, with all data coded and grouped around codes in the process of constructing an interpretation of the data. A coding matrix was developed for the coding of the data including a priori codes based on the focus group questions. The coding matrix was subject to iterative editions after consultations and discussions between the research team. Major themes were identified and discussed, and sub themes were developed for the creation of a final coding matrix, which was revised to capture all information portrayed in the focus group discussions.

3 Results

The participants in this study included n=7 older adults between the ages of 86-95 years old (mean=90 years); all participants were male, full-time residents of the LTC center. The first focus group had n=3 participants, while the second focus group had n=4 participants. The demographic survey asked residents to disclose initial interest in new technology. Four participants disclosed that they generally enjoy trying new technologies, one participant considered themself someone who disliked trying new technology, and one participant considered themself neutral. The survey also established the baseline usage of technologies in these participants. All participating residents owned a television, four owned a computer or laptop, two owned smartphones, two residents owned tablets, and one owned home assistant technologies. One participant did not complete the demographic survey.

For the staff focus group, n=7 LTC staff members participated. The staff represented a broad range of professionals from the center, specifically a personal support worker, physiotherapy assistant, music therapist, recreational specialist, occupational therapist, patient liaison officer and a recreation program worker.

Inductive thematic analysis revealed several important considerations to technology use in LTC. Notably, it established the most common motivations to the use of technology, important facilitators and barriers towards technology use by older adults in LTC, and initial perceptions to the early AR prototype, further informing its integration in LTC. Each theme is discussed in detail below and supported by examples of participant comments.

3.1 Current Use and Motivations to the Use of Technology

The first theme pertains to the types and patterns of technology use among this group of older adults residing in LTC. The commonalities in their motivations to use a technology provide insight into their general attitudes towards technology use. They also provide guidance into ideal design practices to take advantage of familiarity in the design of future technologies to promote uptake and long-term use.

Technology for communications

Communication was the most cited reason or motivation to use technology in LTC. All residents cited communication technologies such as cellphones, laptops and tablets as something they use on a near daily basis to communicate with family and friends, both living near and abroad. Below a resident shares one of his two important daily technology uses.

> *"On a daily basis for me there are 2 important things. First is my cellphone it helps me to keep in touch with friends and relatives who are far you know far away in this country or the United States…I use my cellphone for relatives and friends."*

The need to stay connected with family and friends was discussed extensively and perceived as important especially when living away from family.

Technology as a source of information

Technology was also cited by residents as a great tool to gather information on a variety of topics. Notably, television, radio and the internet were common sources of information, such as the news and weather. For these residents, technology acted as a way to stay connected to the world outside of their LTC residence. While this research focuses on health behaviours, health information was not discussed as a primary topic of interest to gather information. Below a resident explains how the television has become his primary news source as he shifted away from computer usage.

> *"I keep current on the news, the world with the TV. I have a computer at home, but I only go home on Sunday. And I'm getting slower to use it now, since I haven't used it for about 2 years."*

This reference to using technology to gather information was common among other residents who discussed the importance of staying up-to-date on world events and the opportunities technology have brought in this domain.

Health technology

Health technologies were also broadly discussed by the older adults in LTC, these technologies predominantly revolved around biomedical applications of technology in the form of extending life and aiding in mobility and sensory support. These technologies were not discussed in the context of health promotion or active aging contexts. Specifically, they discussed hearing aids, pacemakers, and electric wheelchairs. A common feature of these technologies was the clear purpose and benefit these technologies had to offer; a theme which recurred throughout the discussions. One resident discussed his amazement with a new pacemaker, something he considered true scientific innovation.

> *"You touched upon prolonging life a minute ago. Six months I guess ago I got a pacemaker my heartbeat was like 35, they say you're going to die you need a pacemaker… To me that's technology! It prolongs my life I wouldn't be here today without that."*

The clear link between the technology and the outcome was highlighted in this example and during several discussions.

Technology for entertainment

To a much smaller extent, technology was cited as a source of personal entertainment— as a tool to spend time other than socializing and staying informed. However, this purpose was less important than expected whereas even television use was mostly geared to watching the news. Below one resident discusses the use of an artificial intelligence personal assistant for pleasure.

> *"I don't do it as much as I used to, but I would get some of the PSWs in my room and I'd have it to play Jamaican music or something and they'd dance."*

On rare occasions technology was discussed in the manner of providing entertainment value aside from watching of movies; videogames and application type games were not discussed by the older adults.

Changing motivations and evolution of technology

Significant discussions revolved around the evolutionary nature of technology. For example, 6 of 7 residents discussed their military backgrounds requiring continued technology use throughout their careers. A recurring theme was the diminished need to engage with technology throughout the years. As technology use shifted from a practical career-oriented use to a more personal use, technology use and

interest generally seemed to decrease. Several residents cited lack of need as a reason not to try new technologies. However, the evolutionary nature and rapid advancements of technology was described as exciting to watch and for the greater good of society, even if the personal interest to use this technology was not always present. One resident shares his perspectives on technological progress.

> *"Technology is always in development there's always something that comes along, and you say oh that's the best it'll ever be but 2 years from then somebody else has developed something else. So, its always developing its never reached its, I don't think its reached its level yet its still piling on top."*

3.2 Attitudes Towards Technology

This theme refers to the self-disclosed perception regarding technology or the anticipated use of technology as it relates to the attitude formation process outlined by technology acceptance models.

Positive perceptions of technology

In several instances' residents had favourable perceptions regarding technology and its value in day to day activities and health promotion. One of the hallmarks of this theme were discussions regarding the progress of technology and the positive outcomes these advances have had at all levels of society. One resident discusses the importance of this progress after being asked if a rapid progression of technology was difficult to keep up with.

> *"No, I think technology is used to develop the things for the world and it works fine. Technology has helped every field that I know of somewhere along the line."*

Another resident adds to this theme discussing his career in the military as a communications officer, where advances in communications technology continue to amaze him.

> *"When I got first in the communications there was no such things as communication satellites. Because that allows you to do all kinds of things that you otherwise couldn't do and its amazing, I'm amazed everyday when I look at the advancements in that area."*

The optimism towards progress was truly felt during these discussions. Residents portrayed a certain level of openness to the ways in which modern technologies can be applied to improve different areas of daily life and on a commercial level. Even as the discussions moved into difficulties with technology, residents were able to identify a "greater good" component despite some personal struggles with technology. One resident explained his personal struggle with technology, expressed in good faith and humour.

*"Well I can't deny the fact that its very useful and its very time saving as opposed to again the analog the quill pen we start writing things and we can copy and its there its done boom! Yes of course its useful I'm not against it. I'm just saying I'm too bloody ignorant and dense *laughing* to catch on because its new to me still."*

Negative perceptions of technology

Some negative perceptions of technology were also discussed by the residents in the focus groups. Specifically, certain residents believed the increased use of technology can sometimes be considered a steps backward in relation to society as a whole. Below a resident expresses his concerns with the increasing presence of technology in day-to-day life and the caution we should exercise to not overly use technology.

"Well you know the old saying, people get carried away, and I would be afraid with this thing, too much of this in the wrong person could cause all kinds of problems…That's something you have to think about a lot."

While another resident discusses the challenge with the conversion of traditional ways of doing things to technological methods.

"What scares me…any means of communications commercial industry telephone blah, blah… they force you to go you know on the internet as opposed to a paper copy of your invoice… I refuse to do this!"

Finally, discussions with older adults revealed a certain fear with how technology is being used in younger generations. Specifically, residents voiced concerns with the amount of screen time children are now getting and changes to how they are educated in school such as learning to write and count without the support of technology.

"I think we've taken a step backwards whether or not teaching writing in schools."

3.3 Technology Usability

Technology usability for the residents in the focus groups was defined as accessibility to a technology. Sub-themes were directed towards facilitators which make technology more accessible and barriers which make the access to a technology a greater challenge.

Barriers

Barriers to technology use were defined as directly decreasing the accessibility of a novel technology in LTC. Our findings suggested barriers could occur at an individual resident level and a broader organizational LTC level.

Physical/cognitive limitations

One of the most commonly cited barriers to the use of technology were physical and cognitive limitations. Notably, physical limitations such as decreased mobility and dexterity, decreased visual acuity and hearing were common challenges. One participant discussed the challenges of watching television with hearing aids.

> *"I don't know what the TV is but it's not like you talking, if there's background noise or anything. Yeah, I have trouble with TV hearing with my hearing aids."*

Another participant reacted to the prototype video of a person reaching their arm upwards above the head to grab an item as part of a game, highlighting the challenges of this type of movement.

> *"Like that one you were showing of dropping the banana into the right container and stuff like that. There's a lot of people in here who just can't do that. So, the program is no good for them."*

The physical challenges for some older adults in LTC was reiterated by staff during the staff focus group discussion; they highlighted the importance of accommodations for those with physical limitations.

> *"I would say probably 80% of the residents here use a wheelchair or a power chair but, I think whatever technology you're looking at would have to be accessible from like a seating position."*

And a physiotherapist assistant explained the varying needs of residents, as an important consideration in LTC and the design of an inclusive physical activity program.

> *"In my exercise class I have some people with Parkinson's, and I have some people who just have dementia so their movements are pretty good whereas for somebody else it could be very different."*

One of the unique distinctions between the results obtained from residents and LTC staff were related to cognitive capacity. As discussed, older adults were much more open to discuss physical ability barriers while cognitive barriers to technology use were not discussed by older adults, but rather by staff. One personal support worker explains the particular challenges in one unit of the center specifically.

> *"Strict for the[name of unit] building since most of the residents don't have the mental understanding of what you are trying to teach, it would be a big challenge because most of them*

they have dementia and for that it needs patience and its time consuming but sometimes can be successful."

Privacy and loss of control

There was a widespread desire to discuss the privacy implications of modern technologies and strategies to ensure personal data remains safe in an increasingly technological world. Residents discussed a general reluctance to trust technology, given personal experiences with fraud and stories heard through family, friends and the news. One resident discussed the need for caution with technology and suggests more control being necessary to protect users.

"More control is necessary in a lot of areas I think now because of that medium is so widespread. So, its great for these characters to get at you so you have to be careful."

Another resident referenced a previous discussion on artificial intelligence and its use in creating smart homes for older adults, where technologies are implanted directly in living spaces. The resident shares his concern with this type of technology as it relates to his privacy.

"When you were in my room the last time you were talking about putting something in the wall so you can see what's going on and I said no I don't want anybody looking at me! So that's probably the answer you would get from a lot of people."

Finally, residents discussed the fear which has evolved from hearing the various negative consequences which can arise with technology, especially when not comfortable with its use. Below a resident shares his concern with "crashing", referencing his individual lack of confidence in using technology.

"What scares me the most on the very onset of learning this kind of stuff is you heard about in those days something crashing. Crashing its gone its in the atmosphere where? And today there are people here who tells me they do all their business in a computer on a computer, everything smartphone, banking whatever it is, I can't do that."

Loss of human contact

LTC is a sector which relies heavily on the person-person component of care. Older adults shared a clear concern that technology can act as a barrier to human interactions, regardless of whether it is between care staff or family and friends. Specifically, technology was perceived as a possible source of isolation by residents. One resident discussed this loss of person-person human contact while touching upon the generational gap associated with technology and attitudes towards its use.

"I got a grandson who is the younger generation they're engaged in this and he spends all his time speaking to people in his on I don't know whatever he's using you know. And I think to some degree it separates people from people."

Below another resident voices his concerns with smart technologies in the context of aging and long-term care, and how these technologies can remove the quality person-person care they are currently receiving.

"But how would technology take the place of the people that come to visit me or remind me that there's a music program on in 10 minutes or exercise, how would you communicate with the resident?"

Generation gap

A common point of discussion was the generational gap which currently exits regarding technology. Older adults often cited this gap as a source of hardship in terms of using technology, as well as a lack of motivation to learn new technologies. Participants were quite aware of their individual capacities and uncertain how they can sometimes be expected to learn to use technologies despite their relative lack of exposure to them. One resident offers his point of view on using technology to promote physical activity and activity progress in the context of older adults and LTC.

"That's alright when you are 20-40. But I don't think between 70-95 or 100 its very practical."

Lack of practicality was a recurring theme, where technology was not perceived as adding any additional value. Below a resident highlights the clear distinction between generations as an older adult observing younger generations.

"You go and sit in the waiting room of the doctors place and the first thing you see is a baby down the wait hall with it's iPad."

LTC environmental barriers

In addition to the previously discussed barriers to the use and uptake of technology, some organizational barriers specific to LTC were discussed primarily during the staff focus group meeting.

Staff

One category of LTC barriers, pertained to staff specifically, was that staff were not always in full cooperation regarding resident care, and how these of disagreements can jeopardize the care of a resident.

Technology was seen as a potential point of disagreement between staff where some may or may not prefer this approach.

> *"For me the greatest challenge I think would always be other staff. If I'm working with a team that all flows well everything goes well I can get like 25 people to a concert but if I'm working with just one resistive staff, somebody who will just you know be against what I'm doing it just ruins the whole flow."*

Similarly, a personal support worker adds that this challenge is even greater in residents with special needs, where staff may further dissuade them from participation often from a lack of confidence in the resident.

> *"Also coming to the staff sometimes its a challenge because some [staff] don't understand their [residents] needs, they'll be like « you know he won't understand what to do» so they kind of discourage him to go ahead with what you are planning to do with them."*

In addition to individual staff considerations, staff training and availability was a prominently discussed theme in the staff meeting. Specifically, when asked on solutions to better improve uptake of technology in LTC a recreation specialist answered:

> *"I think it's to work on the scheduling and make sure the staff are trained to work on those new technologies, especially when you think the resident will benefit from it. It is very important the staff to be trained on those technologies".*

<u>*Overambition*</u>

Finally, staff discussed the challenge of the sometimes over ambitious nature of healthcare. There was a general consensus around the staff table that great ideas are often developed and implemented, however with time these ideas can get lost. Often the loss of ideas can be attributed to overambition and unrealistic expectations especially in situations where many other things are going on all at once.

> *"Another thing too is you have to remember that things get lost in ideas so... For instance, I can have a three-year study and I've done it before and I'm all excited about something and everybody's onboard but all of a sudden three weeks later it's gone"*

This issue was not only related to organizational changes but also to previously implemented technologies at the center. A staff member explains the fate of some of the other technologies that were implemented at the center through the years.

"The funny thing about this, in my division is that we get something new and it's exciting and we all fight over it and we all want it so we have Wii's here but nobody uses them we have laptops, we have this, we have that when we first got them everybody had to sign-up when you want to use it it was a big thing because we used to travel to where ever they lived before Google map and go to their place and all that. Now they're sitting underneath half the time they're not plugged."

To overcome this challenge, staff recommended strategies such as following up and being proactive in the implementation of a new program or technology in LTC. The establishment of a continued engagement plan and keeping up with the relevance of the platform were key factors. It was agreed that given the fast-paced dynamic nature of LTC, if given a chance an idea will disappear unless continually followed-up on.

3.4 Facilitators to the Use of Technology

Facilitators to support the use of technology were defined as directly promoting greater usability, uptake and integration of technology in LTC. Similarly, these facilitators occurred at a resident level and at a broader organizational level.

Support

Support was the most discussed facilitator to technology use by residents and staff. The support towards technology was predominantly broken down into 2 major categories according to older adults, in both cases support was provided by family members. Firstly, family members were cited to play an integral role in the encouragement to purchase and to use new technology. In fact, it is family members who would often purchase the technology and explain to the resident how it can be used. One resident explained the role his son has had in the technology he owns and his iPad.

"They certainly encourage at least my son does. In fact, he's the one that bought most of the technology I have. He just bought it and gave it to me told me to use it."

Another participant also discusses the role of his daughter in the use of his iPad.

"I got a lesson from my daughter today on my iPad what I can do with it, she went back to the days of you can have that, you can have that…"

This type of encouragement was expressed by several residents, they were mostly given these devices and encouraged to stay in contact via video-chat or messaging. Another common subtype of support discussed was the troubleshooting role family members played in supporting their older family members.

This role was discussed in great detail as this support would often get the participants out of a difficult situation which could prevent them from using the technology further.

Below, two participants discuss the role of family in supporting their use of technology. The first, explaining the role of his son, while the second participant adds to the discussion with the role of friends and relatives.

> *"Oh yeah and when I get in trouble, he's the one that still gets me out of it."*

> *"One thing I like about technology is I don't know a great deal, but I've got friends and relatives who do, and I know who to go to if I need help."*

Family and friends were greatly appreciated by the participants and the impression was that without the support and influence of these relatives, technology use would be limited. Staff members also discussed the role of LTC staff support to technology use. It was noted that older adults at the center receive significant support with activities in the context of technology usage. This notion built upon the discussions of supporting residents in day-to-day activities as a hallmark of providing quality LTC services. One staff member explained how new technology is approached in a LTC centre, as compared to a personal home.

> *"The difference with here and home is that here you would have a coordinator to you know assist the resident… you know we have somebody that's going to help the person if they can't get it going right."*

Purpose of technology

Technology with a clear purpose was discussed as a facilitator especially in the initial phases of deciding to use technology. The participants felt that for older adults to be interested and motivated to use a new technology, this technology should have clear benefits to the user. This was especially discussed when in terms of current and past technology use, where usage was clear, precise and goal oriented. This method of technology use can differ from younger generations where technology use will be more frequent and less contemplated. One resident explained how the failure for a technology to fulfill an explicit need and to make this need obvious can limit technology use, even for simple technology like a phone.

> *"First thing about technology is, is the individuals like the population has to be educated that this is for them, or for some good. Or just lots of people don't want to try new technology. There's lots of people that won't use a phone yet."*

This motivation to using technology was partly explained by the staff discussion. The staff members discussed the importance of assisting participants to maintain control during the use of a technology. This sense of control was discussed as keeping the resident involved in the process and most importantly the final result. A music therapist explains this notion with the use of a simplified music player which supports autonomy, and residents can take control of their music listening sessions.

> *"The smallest way to give the resident a sense of control, so they are feeling like they push the lid its a simple thing that gives them a result…even like something that they can grab or you know they can turn it or they can hold it."*

Individuality

The unique needs of individual LTC residents was a salient subject of discussion in both resident and staff meetings. It was mentioned that efforts must be made to meet the unique needs of individual residents whether physical, cognitive, emotional, or social. Both staff and residents emphasized the importance of keeping technology accessible, to cater to these differing needs. Individuality and personalized experiences were considered to be a strong facilitator of technology use in LTC. However, both groups remained conscious that accessible technologies would still not be appropriate for all LTC residents at their center. Two residents discussed that even with special efforts, technologies in LTC cannot meet the needs of everyone.

> *"But I was saying, something that that could work for all of us it can't, there's to great an assortment of people in here."*
>
> *"Oh, yeah we're all different, everyone of us."*
>
> *"I don't think you can build a program of that nature that will suit everyone. To meet everybody's needs because we have too many variables here."*

These discussions with LTC residents, highlighted a certain level of self-awareness regarding their individual capacities and understanding their personal limits. Staff similarly discussed this notion in their discussion, notably they were able to reference concrete examples of situations where one resident's success story would not be applicable to another resident. One occupational therapist discusses the importance of staying aware of these differences between residents.

> *"I think really the key is that anything that's developed I think it's cause what everyone on the team does is look at a person as an individual and they all have different interests all have different abilities so sometimes its hard to kind of fit everyone in a box."*

Similar to this analogy, technology must remain far-reaching— to prevent too narrow contours around a technology which would interest only a few residents, rather a technology should provide a larger area of interest allowing for more to benefit from the platform.

One recreation specialist described the importance of identifying the right candidates for different programs and activities. The passage below refers to a VR pilot project occurring at the center in the past months; some residents benefited greatly, while it was not compatible with other residents' needs.

> *"Its true and as P1 was saying if a resident has dementia responsive behaviours and agitation and things like that, it may not be the best approach for them it might be over stimulating or you know might cause, a trigger or harm."*

The message surrounding the individual needs of residents and user-centered design was that one residents' benefit can be a potential source of direct harm to another. This notion also extended to the interests of residents. For example, some residents will gravitate towards different types of programs and activities such as arts, games or physical activity. It is important to provide opportunities that cater to different interests, to promote larger scale use.

Simplicity/familiarity

Simplicity and familiarity were also discussed in the context of facilitating the use of technology. To keep applications simple and similar to commonly used technologies was considered good design practice. From the point of view of older adults, television was seen as a familiar technology.

> *"One thing I learned in here is that television seems to be an important way to use your technology in a positive way."*

To integrate new technologies using familiar technologies was also a suggested practice from the staff meeting, where a music therapist discussed the value of such an approach.

> *"I just think of something that's very simple like we have we don't have that many, but we have a modified player, it's called a simple player. We load the music, the resident can open the lid, music plays...enough music close the lid music is done. Like something very simple but it also its like it fits what they're environment is, not something that's foreign."*

Simple designs and familiarity were important facilitators to promote residents to have a strong first impression with the technology and to more clearly delineate its benefits.

3.5 ***Integration of Augmented Reality in LTC***

This section refers to perceptions about the integration of the demonstrated AR prototype in this particular LTC center. This included discussions on design principles to enable easier integration, as well as challenges with the integration of our platform as it currently stands.

Design principles

The focus group meetings were an opportunity to identify key design principles from both residents and staff — for consideration in future versions of the AR prototype. These recommendations were pragmatic in nature and varied from physical, cognitive and environmental considerations. Generally speaking, both residents and staff highlighted the need to keep things simple, familiar and as "low-tech" as possible.

Staff, in particular, provided input on ways mini games could be modified to maximise the possibility of the technology being used by more residents. These recommendations were concrete, such as an example where a group of staff discussed design strategies to modify one specific game.

> *"P2: Maybe instead of having it drop you could have an option just to drag it but there's no like time"*
>
> *"P1: But it's trying to make them exercise at the same time" yeah but you could still move but not where it's like falling maybe another form.*
>
> *P1: I think having levels like level 1,2,3…*
>
> *P6: I agree you could have a first level with only two categories and then you could increase the speed for like the level 1 and then level 2 and 3 categories and then keep going up from there."*

While an occupational therapist recommended to maximise personalization of the entire platform.

> *"Maybe too, if there was something in the program that could when the person was just starting to use the program, that it somehow registered what their baseline range of motion was."*

This type of recommendation clearly emphasized the need for providing options to modify the prototype moving forward. However, other discussions approached topics not yet considered by the research team. For example, a staff member discussed the particularities of keeping the technology accessible to all residents.

> *"What if the person can't move if they've had a stroke, they can only use one arm or you know or...how sensitive is it for eyes like what if an individual communicates with like the blinks. Can you create something that's accessible for somebody who yes is one blink and no is two blinks?"*

Another recommendation focused on the integration of different content to cater to some of the interests of the LTC residents and their respective fields of expertise. For example, one music therapist recommended new content for a mini game.

> *"Yeah like I was watching the video I was thinking of like often times people still have the ability to play a drum and there's that feedback and the motion this very quick motion its not a huge motion but like that could be interesting."*

One of the clear observations between LTC residents and staff were differences in expressing design principles. Staff were very direct with clear recommendations and suggestions while residents provided more their perceptions of the technology and the impact of this technology on their life. This may have been due to their lower level of comfort with technology in general.

Integration

The integration of our AR prototype at this LTC center was received with mixed attitudes from both residents and staff. Firstly, most participants could see the added value of the technology at the center, even if not for their own personal use. One of the takeaway messages from these conversations was the voluntary nature of such a program, which would act as another outlet made available for residents who are interested. One resident explains their view on the platform's integration.

> *"It would be another outlet…For people to take advantage of, but not something that's forced on them. And if somebody has a physical problem like may benefit from that."*

While two residents explain the need for support with this type of platform

> *"P3: It would have to be organized for us we wouldn't I just couldn't make use of it.*
> *P1: Yeah, we all got our, we've got our routines here you know how that goes and the older you get the more you become routine.*
> *P3: But if the activity people if they got it in hand could do something like they do for smaller little things, but they could do it for that too."*

However, this team did note that not all participants were interested in the prototype and did not always see a clear process for successfully integrating this type of platform at their center. This type of data reaffirmed the importance of our approach and the need for continued efforts to obtain feedback throughout the design process.

Challenges with integration

One of the primary challenges with the prototype was the lack of clarity regarding the benefits of the technology for residents. There was uncertainty regarding whether this is a type of technology a resident would be willing to interact with. Here one resident affirms this point after viewing a demonstration of our minigame promoting physical activity and nutritional knowledge.

> *"So, what's the significance of this? What's that supposed to do for me?"*

This type of comment affirmed that modifications were necessary to make the purpose of the technology clearer to residents if it is to promote favourable intentions to use the technology. Whereas for another resident, the purpose of the technology seemed clear, however using it to replace traditional physical activity or health promotion programs was not as clear. Below a resident expresses his lack of interest in the games, driven by his uncertainty as to why this platform would have added benefit.

> *"I don't see the fun in it personally, the objective of the exercise I mean you know as opposed to doing something like we do in the exercise room here three days a week you know."*

Staff, on the other hand, were able to see the benefit the technology prototype could have in LTC. However, its integration was discussed as an important process which would require the identification of a clear purpose in LTC. Given that LTC is such a vast ecosystem of care, with professionals in several fields and dedicated staff to cater to different unique needs. The placement of this technology in this ecosystem is key if it is to have traction in LTC. One recreation specialist highlights how this type of technology as it currently stands requires refinement to meet the needs in LTC.

> *"I can see this more geared to people in homes or even retirement homes because in a retirement home you're in your own little apartment, right? But less for long-term [care] because they have their needs met here. Personally, like I could call [points to occupational therapist], I can put in a note and she's at their door I'm not joking."*

4 Discussion

The ever increasing need to develop innovative technologies to support active aging has spurred innovative ideas to support older adults. Older adults living in LTC are faced with unique circumstances, which amplify the potential benefit they could receive from technologies to support health. Understanding the current situation and unmet needs of a population are among the preliminary steps to the design of an

innovative technology. In doing so, new tools can be created to fill the missing gaps while harnessing what works. The results from this study revealed the current status of technology use in one LTC center while revealing many important facilitators and barriers to the usability and uptake of technology. Factors identified through this study were (1) the attitudes to technology and the current use and motivations to the use of technology in LTC, (2) barriers to technology use, (3) facilitators to technology use and (4) the integration of AR in LTC.

Attitudes to Technology and Current Use and Motivations

Residents in this study had both favourable and unfavourable perceptions to personal technology use and its role in greater society, aligning with previous research on the topic (Peek et al., 2016; Mitzner et al., 2010). On the one hand, participants were able to appreciate the benefits that technology had to offer at a societal level, often citing the advancement in several domains as highly interesting and beneficial. In fact, previous research has shown that a majority of older adults feel technology has a mostly positive effect on society, with only a slim minority perceiving technology as mostly negative (Anderson & Perrin, 2017). Similarly, our sample had a predominantly optimistic view of technology and its contributions so far and moving forward. However, certain reservations were maintained as to the overexposure of technology in society and its replacement nature. Although none of the residents seemed overtly against technology, they did not always believe it to be the ideal option. In relation to this point, residents gave the impression that technology was sometimes best used in the hands of others, citing the lack of direct need for their personal use. In line with previous findings, most older adults in LTC are part of a generation who still face significant challenges evaluating personal gain from technology and remain more skeptical than middle-aged adults and younger older adults (Smith, 2014). This conquers with findings from Peek et al. (2016) that one of the most common reasons to not adopt technology in older adults is a perceived lack of need. In older adult populations it is sometimes the case that interest can take precedence over needs when it comes to technology use (Peek et al., 2016). Highlighting the need to clearly display the role of a technology and the benefits a technology has to offer.

Older adults in our study provided a wide array of current technological uses in the context of LTC. However, it is technology for communications and information which predominated above all other types and uses of technology. This finding is aligned with previous research showing that communication-based technology can provide support to addressing residents' psychological needs for social connectivity with family and friends (Tak et al., 2010). In our sample, older adults used communication technologies to maintain communication lines with relatives and friends, contributing to a general sense of connectedness, despite physical isolation from relatives. This further builds upon strategies to keep residents socially engaged when facing the greater risk of loneliness associated to the physical separation

of family and friends in LTC (Chapman et al., 2019). In addition, the motivation of older adults to use communication technologies further built upon the influence of social networks proposed by Peek et al. (2016). They suggest older adult's social networks are often co-users of technology, and will encourage technology use by frequently texting, calling or sending e-mails to older adults (Peek et al., 2016). In our study this has expanded to include video-calls and immediate chatting services to send texts, pictures and emojis. The importance of communication technologies in this study and previous literature has sparked interest in developing games which can be played in cooperation with visiting relatives and ideas to communicate gaming experiences with family.

Additionally, residents regularly used technologies as a focussed source of information on topics such as weather and news. This reflected findings from previous research that older adults over 70 years old use fewer applications on their smartphones and tablets, when compared to middle-aged adults (Anderson, 2017). Of the fewer apps used by older adults, weather and news represented 63% and 32% respectively and the majority of their usage (Anderson, 2017). This indicates a focussed and directed interest in certain technologies and functionalities above other. This directed use of technology aligns with research showing that as older adults age, they use less types of different technologies often circling back to the same uses (Keurbis et al., 2017). Besides communications and information technology, other types such as health and entertainment were rarely mentioned in our sample. When technology was used for health purposes it was mostly to accommodate for physiological changes associated with aging such as hearing aids, electric scooters and pacemakers as examples. In addition, technology for entertainment such as games, videos, and music were not discussed at the focus group meetings as an important and regularly used application of technology. These findings on the current usage of technology in LTC uncovered the very purpose-driven nature of technology use by older adults in LTC. Purpose driven use has been previously observed and has identified the need to align the purposes of technology to older adults' objectives to maximize the benefits of technology (Rogers and Fisk, 2010). Communication and information technologies had immediate returns for the residents, and likely part of the reason these technologies were most popular. This aligns with research that communications technologies yield the highest mental health benefits in older adults, while information technologies to learn new information yield the greatest impacts on physical well-being (Sims et al., 2017). In the context of health technologies and assistive technologies the challenge may relate to a lack of perceived need among older adult users (Peek et al., 2016). It highlights the importance of focussing efforts on incorporating aspects of communications and real-time information to our design to increase its appeal and impact in older adult resident populations.

Barriers to Technology Use

This study identified several challenges in LTC which can interfere with the usability of a novel technology. Firstly, both older adults and staff cited physical decline associated with aging as a major hindrance to the uptake and adherence to technology. This aligns with previous findings that age-related physical decline contributes to a physical access barrier to technology (Wang et al., 2019). Our study has added that physical limitations such as decreased hearing, vision and manual dexterity influence resident's confidence to use technology. This diminished confidence can directly relate to technological uptake, as confidence and familiarity is an important factor in older adult technology acceptance (Peek et al., 2016). In addition to physical limitations, staff discussed the difficulties associated with cognitive decline and its relationship with understanding and using new technologies. This builds upon research that spatial visualization and task overloading can be a challenge in older adults throughout the aging process (Kuerbis et al., 2017). The overarching findings on the variations in physical and cognitive limitations resonated strongly with literature in LTC both expressing the spectrum of ability between residents (Yu-Hi Siu et al., 2016) and the need to adapt LTC to accommodate for this high variability in capacities (Kehyayan et al., 2016). As general design principles, staff favoured simple designs with accommodations for LTC residents with decreased vision, hearing and range of motion to promote greater accessibility and usability.

In addition, older adults expressed some more intrinsic concerns with technology and its implications in everyday life. For example, technology was perceived as a tool to increase communication, but also one which threatens human connections and interactions. This has been previously observed in research where findings have shown there is a need to complement face-to-face interactions with technology rather than replacing them altogether (Hill et al., 2015). Given the amount of person-person care, which was expected from participants in this study, this project has found this risk may be even higher in LTC settings. This finding emphasized the importance to favour designs which foster human interactions in the context of care delivery, focussing on the inclusion of staff and family and friends in the use of technology. In addition, expressed concerns regarding privacy and a loss of control with technology were significant factors to the uptake of technology. Specifically, in the context of healthcare a previously identified barrier to the widespread adoption of products and services has been consumer concerns on privacy and protection of health data (Chapman et al., 2019). Technology privacy concerns among older adults has been researched, highlighting the need for additional and continued control and transparency in data collection and personal privacy (Huber et al., 2011; Wang et al., 2019). Our results add to the literature that the lack of technological knowledge and experience further increases these privacy and safety concerns (Kuerbis et al., 2017). As these considerations play an integral role in forming technology perceptions and attitudes efforts must be mobilized to communicate clear protection of personal information to potential older adult users.

Staff further provided insight into the potential challenges of incorporating technology in LTC, identifying key opportunities to bolster technology acceptance. Firstly, staff iterated the technical challenges of LTC; generally speaking, staff are expected to provide the highest quality of care in a sector where resources are not always abundant. Challenges such as time constraints, staff training and resistive staff were disclosed as potential barriers to new programs and initiatives. This is well aligned with research in the sector showing the difficulties of LTC in delivering effective care programming given limited resources (Benjamin et al., 2009; Resnick et al., 2008), a particular challenge which has been further highlighted during the COVID-19 pandemic (Armstrong et al., 2020). In addition, resistive staff were cited as a challenge in LTC, adding to the literature that technology must consider the needs of staff and have a strong potential to increase staff satisfaction for successful uptake (Tak et al., 2010). This was received with a sense of opportunity to ensure the Magic Mirror platform does not act as a nuisance to care delivery but rather a facilitator to daily LTC activities.

Staff training was a large portion of the discussion given in previous situations services and tools had been underused. The staff emphasized the need to be adequately trained, and for upper management to be shown the benefit to including a new technology. This adds to previous research in LTC where designers must strike a balance between beneficial results and maintaining workflows and staff engagement (Chapman et al., 2019). Our study adds examples of the benefit of including staff in discussions to promote alignment between tech designers and LTC staff. Finally, it was found that given the nature of LTC and its saturation of programs, services and new technologies, good initiatives can sometimes get lost in ideas. Staff suggested that although everyone has good intentions for older adults and LTC, feasibility remains a strong predictive factor towards the success of a technology or program, and the eventual benefits to residents and the center. This further adds to previous research on difficulties with adherence to health promotion programs within LTC (Lima et al., 2017). To remediate this challenge staff suggested to remain conscious of available resources in the development of the platform. In addition, focussed efforts should be placed on giving clear direction on the target or ideal resident for a mini-game and the target health promotion area which the game looks to improve. In doing so the platform can be better integrated in the suite of tools available to staff and help achieve specific goals. With greater specificity on target residents and outcomes, staff felt they could better situate the platform within the center and increase the feasibility of its uptake.

Facilitators to Technology Use

This study also uncovered some important strategies to promote technology use in LTC to further inform the design. Availability of support and the influence of relatives was a contributor to the use of technology by older adults. This once again builds upon the social network of older adults', including

younger relatives supporting the purchase and troubleshooting of technology-related issues as a strong facilitator to the use of technology (Peek et al., 2016). However, unlike community dwelling older adults, LTC residents in this study benefited from an additional source of support from staff, as they often support residents with the use of technology in day-to-day activities. Given the design of our prototype being specific to LTC its design already integrates the scenario where residents would be supported by staff or relatives while using the platform. This is an important consideration in the attitude formation process of older adults as the availability of support promotes greater confidence and a greater likelihood of uptake of technology (Peek et al., 2016; Chen & Chan, 2014). In-line with efforts of increasing human connections and interactions, the importance of family and friends in using technology was noted as an opportunity to create cooperative play to increase positive input from relatives and technology acceptance.

Finally, simplicity and familiarity were important facilitators arising from discussions with residents and staff. Residents discussed very similar types and uses of technology to inform our research team on how to package our interface and content in a similar and familiar manner. Specifically, residents manifested greater comfort with television, communication technologies and computers. Whereas touch-based technologies such as smartphones and tablets were not as easily used by residents. Despite advances in the usability of touch devices, challenges do remain, and the intuitiveness of touch screen technologies are variable with age (Baker et al., 2016). In our study touch-based and gesture-based controls were perceived as a potential challenge by LTC staff. Throughout the discussions staff emphasized the need to keep technology as familiar as possible with strategic integration of common technologies to promote ease of use. These practices align with previous research to promote confidence and greater accessibility (Wang et al., 2019). As a research team this emphasizes the importance of incorporating aspects of familiar technologies such as a remote control similar to television to complement the gesture-based interface of our platform, should these controls be a challenge during use.

The figure below represents the contributions of staff and residents to the design process of our AR platform. While highlighting important facilitators and barrier to technology use in LTC.

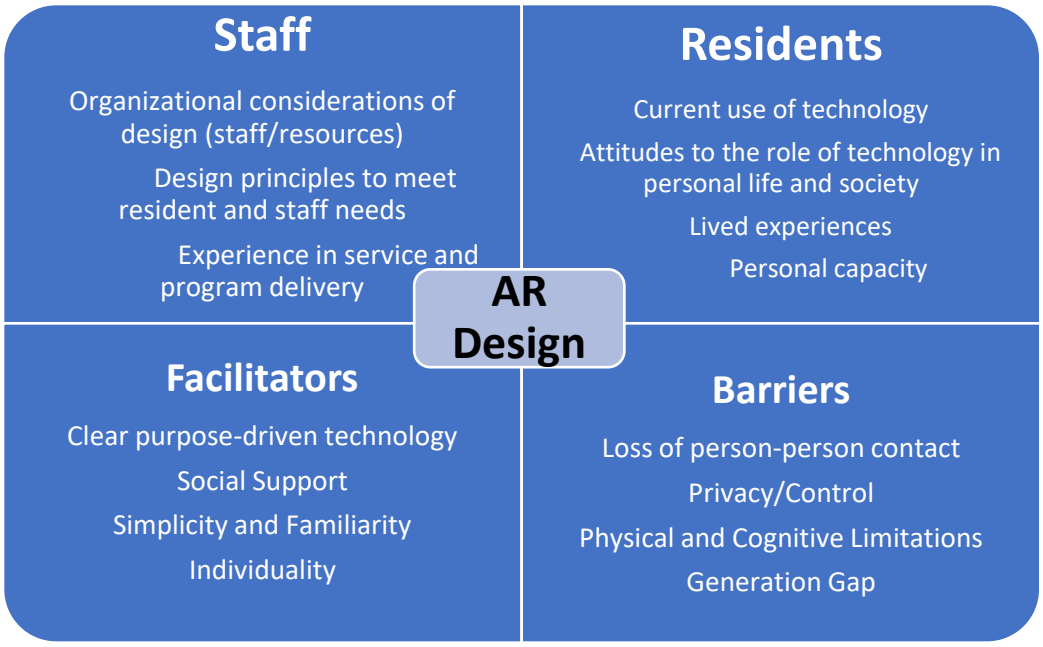

Figure 1: Contributions of stakeholders and findings for the design of *The Magic Mirror* health activity platform.

Integration of AR in LTC

The discussions of integration of the Magic Mirror AR platform in LTC, in its current form, were mixed among LTC residents and staff. Some residents expressed interest in the platform and using it to replace or complement existing health education platforms. However, residents who were generally open to this type of platform highlighted the importance of making this platform available as an option, and never forced upon residents. This not only aligns with the importance of keeping care options open to older adults (Sherwin & Winsby, 2011) but also respecting that not everyone appreciates technology and that technophobia is a true concern especially in older adults (Di Giacomo et al., 2019). This is greatly facilitated by the current structure of LTC where different program options are made available to residents, maintaining resident's autonomy in deciding in what activities to participate. On the other hand, some residents were decisive in sharing that the platform was not something they were interested in trying, usually from a lack of perceived benefit, ability and pleasure using the platform. This further added to the research that the perceived usefulness and perceived ease of use of technology in older adults varies greatly between individuals (Bong et al., 2019) and with younger generations (Peek et al, 2014). This was an immediate indication of the need for further iterations of the technology, allowing for more possibilities to display its potential value in LTC. As the prototype was in an early stage, it is possible the

two demonstrated games and functionalities were not sufficient to spark interest in a majority of residents, reinforcing the need to clearly demonstrate the potential benefit of a technology. Currently, the integration of the platform would be a challenge at this center given the highly variable technology acceptance by residents. This result underpinned the importance of the participatory design process we used, to ensure the day-to-day realities of residents in LTC were accounted for in the design.

Staff on the other hand were receptive to the design and content of the platform, however it was believed the platform required greater direction for success in LTC. Staff discussed the vast diversity of services and programs they offer and the need to localize where our AR platform could be used to complement these services. This was an important finding as the wide-ranging reach of our platform was seen as a challenge, where several departments might want to use it simultaneously for their individual programming. In addition, certain staff discussed their view on how this type of platform could be geared to more dependant older adults either at home or in retirement homes. It was felt that given this platform was designed to incorporate gaming principles to sometimes uninteresting active aging activities, it could be useful for older adults living in more isolated settings as a tool to remain active, engaged and help avoid boredom. It was felt that many of these needs were already met in LTC, limiting the possible impact of the technology. This was an important finding as it became clear that the successful integration of the platform meant finding its unique place in the LTC ecosystem. This aligns with previous findings that the preferred future of technology in LTC, is to embed technology within the environment to enrich the LTC setting (Tak et al., 2010).

By including residents and LTC staff in this research we were able to identify key design requirements to further enhance our current AR prototype. With a better understanding of older adults' use of technology in LTC and the organizational particularities of LTC we can reshape the design approach to best meet these needs. Future work includes continued opportunities for participatory design outreach within LTC to move towards a more finalized prototype for eventual user studies in LTC.

5 Limitations

There are several limitations when interpreting the results of this study. Firstly, the small sample size of older adult LTC residents and staff all from the same LTC center were not a representative sample of older adults residing and working in other centres. Especially as the sample consisted of male residents; no female residents expressed interest to participate in the study. However, despite the small sample size, all residents were actively engaged in the discussions. In addition, the nature of our results remains relative to the needs and circumstances of a single LTC center and these findings are not necessarily

applicable in all long-term care centers for a variety of contextual reasons and variations in resident and staff populations.

6 Conclusion

This study demonstrates some opportunities and challenges of incorporating novel technologies in LTC for the purposes of promoting health activities and active aging. Beyond the design considerations specific to the Magic Mirror platform, the data sheds light on the day-to-day technology needs and interests in this unique sector. Older adult residents are increasingly engaged with a variety of technologies to interact with relatives, stay up-to-date with world events and to perform other daily tasks. While adding technology may be beneficial to older adults, a conscious effort must be made to valorize the benefits of such an approach. Based on feedback provided by LTC staff, technology for health activity promotion in LTC must take a holistic approach, not only considering the needs and interests of residents but also the capacity, organizational constraints and overall benefits to a LTC center. This preliminary participatory design exercise emphasized the need to continue to involve the LTC community in the design of our platform and other novel technologies for LTC. Through strong partnerships with older adults and staff it is possible to create useful technologies throughout the design phase rather than modifying designs after unsuccessful integration.

CHAPTER 5: RESULTS – ARTICLE 2

Reflection on the Participatory Design of an Augmented Reality Tool for Promoting Health Activity in Long-term Care

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Abstract

The integration of technology is a challenge in older adult populations and long-term care (LTC). Older adults have different perspectives regarding technology use and its applications. Participatory design (PD) is a method of eliciting stakeholder perspectives in the design of novel technologies. For a variety of reasons older adults have been historically excluded from PD projects. This article is a reflection after following a qualitative PD framework to gather perspectives on the development of an Augmented Reality gaming platform for use in LTC. Focus group discussions with older adult residents and staff were used to explore technology use, attitudes, barriers and challenges in LTC to inform our prototype design. This reflection highlights the benefits and challenges of employing this type of PD outreach. It explores the complexity of LTC and opportunities to modify PD frameworks to accommodate this unique sector. When carefully conducted, PD with older adults in LTC is an integrated and meaningful process eliciting valuable design information, allowing for greater appropriateness of final technology designs.

Keywords: Participatory design, Older adults, Technology Design, Long-term care, Reflective analysis, Augmented Reality

Introduction

Participatory design (PD) is considered the gold standard methodology for the design of novel technology since the 1990s (Hartson & Pyla, 2019). From its origins in worker-employer relations in Scandinavian countries, the methodology has evolved to designer-user cooperation in tech design (Hartson & Pyla, 2019). PD builds on the simple principle that the input of end-users is equally as important as that of the designer, given their ultimate use of the technology (Rosenzweig, 2015), This shift towards focussing on users of the technology prioritizes the user experience (UX) with hopes to achieve greater end-user uptake, with the design of a useful, appropriate technology that meets the unique needs of end-users.

For a variety of reasons older adults have been historically excluded from PD projects (Iacono et al. 2014). Specifically, physical, and cognitive limitations, as well as limited experience using or understanding technology has led tech designers to perceive older adults as limited in providing valuable information at a design table (Iacono et al., 2014). This belief aligns with the traditional view of older adult care; where it is believed that focus should be placed on treating and managing disease, rather than

optimisation of functionality and independence (de Wit et al., 2017). As a result, design teams may decide to exclusively meet with healthcare staff, friends and support workers to design older adult technologies. Consulting such external stakeholders is of course a valuable approach which uncovers some of the important requirements for the design of technology for older adult use. However, it risks overlooking the most important feedback a designer should be seeking, which is the feedback of the end-user. It is the end-user which will provide the type of consultation which will directly feed into UX and eventual uptake of the technology. This is particularly relevant in older adult populations where most technologies are designed with a youthful body in mind and tend to overlook opinions of the older end-users (Joyce & Loe, 2010). This design failure warrants that designers employ participatory approaches to involve older adult users in technology design. This type of approach is consistent with the paradigm shift of modern aging, which has moved away from the outdated belief that older adults must be dependant on families and the state, toward the view of supporting age-friendly environments. (Zaidi, 2015).

In this article, we reflect on our experience of employing a PD approach in a long-term care center in Ottawa, Ontario for the design of an Augmented Reality (AR) health activity platform. The purpose of the outreach project was to understand perceptions towards technology in LTC and to gather preliminary perspectives on an early prototype of *The Magic Mirror* platform an augmented reality healthy activity platform to promote active aging through physical activity and social interactions in older adults. This article is grounded in the well-established notion that reflection is a very important mental activity be it in private life or in professional matters (Mortari, 2015). In fact, researchers must be able to reflect in a deep way if they are to move away from the role of technicians, to more competent practitioners of research (Mortari, 2015). Reflection acts as an opportunity to process and make meaning of the learning and working experiences we have had, acting as a strategy to support personal growth—and growth as a researcher. Reflection can be particularly important following the conclusion of a research project, in which it may be difficult to fully appreciate the nuances of the project in the midst of implementation. It is intended to question, evaluate and re-think practice in the process of re-construction in research contexts (Barrett & Kajamaa, 2020). Given, the historic exclusions of PD in LTC, and the relative infancy of the field of gerontechnology, this type of reflective exercise is valuable for advancing the field. In this paper we reflect on the process of employing the PD approach, the value the approach has brought to the technology design project, as well as the challenges, limitations and lessons learned throughout the process.

Process

The participatory design phase for The Magic Mirror healthy habits platform began in October 2018 at a large 450-bed long-term care (LTC) center in Ottawa, Ontario. In the early phases of the project

the identification of a partner center and the establishment of a relationship between the research team and the LTC was of paramount importance. These tasks underpinned the long-term success and implementation of the project. Similar to any collaboration, the process began with the need to present the project to the research coordinators at the selected center. This process aligned with what is typically referred to as collaborative negotiation, assuming that two parties have pre-determined goals to be achieved (Adelson, 1999).

In the early discussions with the research coordinators, it was important to uncover what each parties' goals were, as a first step in building a strong collaborative agreement. This phase can be referred to as the opening phase: an opportunity for two parties to make initial contact to discuss individual priorities, shared priorities and the nature of a potential collaboration to meet these priorities (Morse & Stephens, 2012). This in many ways acts as the foundation for the entire PD process. In our case, the LTC center was regionally renowned as a leader in resident quality of care and innovation to achieve better health outcomes for residents. This belief strongly aligned with the objectives of our research team which had a goal to begin the preliminary work of creating an innovative technology capable of improving quality of life and opportunities for active ageing. In our situation, an initial meeting was organized at the LTC center with two research coordinators. At this meeting we had an opportunity to learn more about the center, its mission and values, and were able to give a presentation of our working prototype. Because we required the input of those with lived experiences and staff working in LTC, we planned to incorporate consultation through focus group meetings with residents and staff. The LTC center had a keen interest in innovation and health research to promote resident care at their center; therefore, this project met their internal goal of continued advancement and excellence. When these individual needs were identified and aligned with the shared priority to explore innovative technologies for better resident outcomes, the appropriateness of the collaboration was clear.

The next phase of the process we coined as the bargaining phase. This phase has the purpose of moving closer towards meeting the objectives discussed in the opening phase. In the context of PD, and our experience in this phase, particular attention must be paid to ensuring that the needs and unique considerations of both parties are met. In our case this was an opportunity to discuss how many participants were required, the type of expected participation and other discussions around research delivery and accommodations. In the context of LTC, this entailed respecting the well-established research protocols put in place by the center. As the selected center had a history of academic health research, these experiences translated into established guidelines as to ensure the wellbeing of their residents, staff and larger community throughout the research process. As external collaborators, it was

fundamental to follow protocols to ensure the wellbeing of all participants and the minimal amount of disruption at the center.

From the point of view of the research team, approval from our university centre was a process requiring close collaboration with the research coordinators at the LTC center. This ethics submission in several ways acted as a contract between the team and center regarding how the research would be conducted to meet the needs of both the research team and the center, while meeting all ethical standards. All iterations were shared with research coordinators for input and alignment with internal protocols. In hindsight this process was extremely valuable to create a project capable of working within the realm of a LTC setting. The input and experience of the research coordinators was an asset to ensure the project met these needs. Specifically, simple considerations such as the length of meetings, the time and location of meetings and how to comfortably accommodate participants, were aspects requiring unique expertise with experience working with older adults. This "bargaining" phase lasted several weeks, through several iterations of the ethics document and finalizing the logistics of how many people could participate and in what function this participation could occur. This was a beneficial and enlightening process which built upon the strong opening phase of the collaboration. As a lesson learned, we suggest for research teams entering LTC to keep an open mind and appreciate the advice professionals in the field have to offer. In our particular case, the input of the research coordinators was integral to the long-term success of the project.

We coined the final phase of the relationship with the research coordinators at the LTC center as the maintenance and closing phase. It is in this phase that active efforts from both the research team and the coordinators are made to deliver on the agreements reached during the bargaining process. This is a portion of the experience highlighted by the need to keep communication lines open. As we will discuss in upcoming sections, our project relied on constant support and expertise from the research coordinators. As a result of this needed support, there was value to involving the coordinators in processes such as the recruitment and data collection phases. This proved to be an important component of the project, given the need to adapt our project on a few occasions. Similarly, open-mindedness remained an important element contributing to the success of the collaboration. This was particularly true in light of difficulties encountered during the project, such as recruitment issues and the implications of the COVID-19 pandemic which occurred in the midst of the data collection. The established relationship with the coordinators allowed these situations to be managed in a more open and collaborative fashion.

Recruitment of Older Adults

One of the early challenges for our PD project in LTC was that of recruitment. Despite requiring a small sample of participants in a relatively large LTC center, the recruitment process was challenging. Recruitment efforts were initially supported with the creation of solicitor information sheets which were distributed to all residents and tenants at the center, as well as posted in common areas such as dining areas and activity rooms. Given the eligibility criteria to participate was open, we believed this strategy would identify interested participants requesting further information. However, to our surprise this approach was not effective, requiring refinement to the recruitment process. Once again building upon the importance of building close ties with research coordinators, we were able to defer to their expertise to support the recruitment process. The research coordinators were able to initiate a more active form of participant recruitment, where coordinators and other staff discussed the project with residents and assessed potential interest. Our team met with interested residents to discuss the project and obtain informed consent for residents who wished to participate. This strategy was more efficient, as this process enabled identification of residents willing to meet one-on-one to discuss participation. However, it is important to note that the challenges in recruitment did impact the anticipated timelines of the project.

The difficulties encountered in the recruitment process highlight some of the challenges of involving older adults in PD focussed on technology. It is well known that older adults tend to have diminished confidence in the use of new technologies (Peek, 2014). In hindsight flyers were likely perceived as an obscure request to design a novel technology for which older adults would have limited experience. It is possible this type of solicitation was perceived as more intimidating than anticipated.

The lack of confidence was realized in the one-on-one meetings with interested participants following the active recruitment efforts. All potential participants, without exception, questioned their eligibility and value of their participation in the project. Questions along the lines of “why me?” and “I know nothing about technology how could I help?” were common. The project did not require any technology experience, knowledge or interest. However, the discussions with potential participants highlighted the need to make this point clear, to attract older adults toward technology focussed projects. Once, we were able to have this conversation with the residents, their confidence and willingness to participate changed in nearly all cases. As a lesson learned, a research team looking to involve older adults in a PD process should emphasize interest in their experiences and attitudes, with no prerequisite to being technology savvy; this was something we found easier to express with in-person conversations.

Recruitment of Staff

Recruitment of staff was a different experience, which also required support from research coordinators at the center. An important consideration in our project was to involve staff who were

actively involved in the delivery of programs and care services to residents, as they would have the greatest knowledge of the needs and capabilities of the residents. For this reason, research coordinators at the center were integral in identifying members of their staff in the streams of personal support workers, recreational activity coordinators, physiotherapy assistants, occupational therapists and other staff areas with direct resident care experience. Given the vast expertise in a LTC center and the desire to hear from different perspectives, individual recruitment of each of these specialists would have been a difficult task to undertake individually. The support of internal communication and knowledge of staff teams and supervisors were important to the project. In addition, another important consideration in the involvement of staff in this project was to ensure that their participation would not cause service disruptions at the center and would allow staff to participate during regular enumerated hours. It is the coordinators who did the initial outreach to the appropriate branch managers in the different units which aligned with our project. Once again, the staff recruitment process was greatly facilitated by the close relationship between the research team and the center's research coordinators.

Older Adult Focus Groups

Our focus groups with residents allowed us to understand their previous experiences with technologies and their prioritization process in choosing to use a new technology. These intrinsic data allowed our research team to rethink and refocus efforts towards a more refined and appropriate product for their particular needs and interests. These discussions were invaluable, as some inaccurate assumptions were highlighted. This realization is something we may not have identified until much later in the design process and had the added risk of perpetuating ageist designs by not understanding the unique circumstances of older adults in LTC.

Participatory design is time consuming and requires adequate resources. To fully invest in a design endeavour fueled by optimism and ambition only to have it fail to meet expectations is a significant risk which can be mitigated with PD and other outreach activities. Even though the process did not provide all the design answers for the creation of perfect technology, it did guide the team into a direction only PD could have facilitated. The results obtained focussed on the importance of involving relevant stakeholders throughout the innovation and design phases of technology development. This falls in line with Merkel and Kucharski's (2019) recommendation for thorough and long-term implication of the population during PD. The preliminary data provided insights to a refined prototype which will require further engagement and validation prior to a user-study. In following such an iterative design approach, the input of stakeholders is valued, rather than a symbolic process; however, realizing the long-term nature of this type of engagement, it is an important consideration.

Regrading the actual participation experience of older adults in this type of project, it was an interesting component of the PD approach which evolved over time. As previously mentioned, the initial reluctance to participate in the project seemed to translate towards a sense of satisfaction and a feeling of "happy to have helped" in most participants. The general conclusion we drew from this apparent shift from surprise to satisfaction, is that clearly this type of input on such a topic is something that had never been asked of these older adults before. Although, as expected, the explicit knowledge of technology in older adults was limited, it was important to identify and understand as technology designers that with older adults it is not necessarily the technological specifications you seek to understand. Rather qualitative PD with older adults in LTC is to understand their reality in LTC and find concrete examples and opportunities for the design to complement their daily lives in a positive way. Even though discussions were not always directly on technology and our AR prototype, the discussions were constructive and provided an opportunity to capture the realities of living in LTC. The type of discussions we had with residents uncovered lived experiences that would be impossible to understand without this type of qualitative outreach. From the standpoint of investigators, this type of outreach seemed to be well received by participants. Whether residents were discussing their childhood using early farming technology on the family farm, or their new tablet, they seemed happy to be sharing their experiences. The sense we received as a team was that the opinion of an older adult on technology is rarely sought after; as a result, our interest fuelled collaborative and productive discussions.

Organization of Focus Group Discussions

Certain preparations had been taken as a research team as to ensure the most enjoyable experience for the participants. Firstly, and perhaps most importantly, the conscious decision to create small focus groups was beneficial. This decision proved to be a large contributor the success and experience of our resident discussions. The small group accommodated for some of the potential challenges older adults may have had participating in a larger focus group, notably being heard by everyone at the table and being able to hear everyone else as well. The smaller groups enabled participants to more actively participate in the discussion and removed the possible perceived pressure of speaking fast or concisely. In an effort to keep participants comfortable, the smaller group size contributed to a comfortable atmosphere conducive to conversation. Another unanticipated benefit to the smaller group sizes was a more welcoming environment for participants. As participants entered the room, the small number of people allowed for residents to immediately engage and become comfortable, even prior to discussions officially starting. This was an important element in our data collection process, with older adults having organic conversations from the start of the meetings. We recommend researchers encourage early interactions and other icebreaker activities or questions to create a comfortable

atmosphere. Once in the room, efforts were made to ensure everyone was comfortable for the meeting and snacks and refreshments were available to help create a friendly and open environment. In addition, the research team made themselves available to help residents find the meeting room and return back to their individual homes after the meetings. These small, yet simple logistical considerations ensured the meetings could take place comfortably and efficiently.

Staff Focus Group

The staff meeting acted as a strong complement to the data collected with the older adult residents. In the context of LTC, older adults would not be expected to interact with a novel technology in isolation. In fact, either staff or volunteers would be involved in the process of moderating activities with any new technology. Given this unique circumstance the staff provided insightful and beneficial feedback, particularly with respect to logistical and organizational information. Specifically, LTC staffing and time allocation were cited as a challenge by staff. As a result, staff are key stakeholders to ensure technology meets criteria to accommodate the staffing and resource availability capacity of an individual long-term care center. Some key findings from the staff meeting included ensuring adequate staff training, a clear purpose for the technology, ensuring it is adequately placed within the LTC center and awareness of previous challenges trying to implement overly ambitious projects. Although, these considerations were anticipated by the research team, the meeting highlighted a need to prioritize them.

A LTC center is a large operation with a wealth of expertise in different areas of resident care. In situating our technology in this ecosystem of care, it was important to ensure the right staff and professionals would be involved in the design process. Our prototype aimed to promote physical activity, social interaction and other health topics such as nutrition through interactive games. To gather information from two distinct standpoints, we felt a mix between care delivery professionals and recreation specialists was ideal. In the end, the staff meeting was represented by personal support workers, a physiotherapist assistant, a music therapist, an occupational therapist, an arts and recreation specialist, a family liaison officer and a gardening therapist. This combination of varied staff allowed for interesting conversations and ideas contributing to more than one aspect of technology design. The care professionals such as the personal support workers, physiotherapist assistant and occupational therapist provided a functional lens on the design, discussing primarily older adults' physical, motor and cognitive capacities. While the recreation specialists were able to provide feedback on the content of the technology in relation with the personal interests of older adults. Also, recreation workers were able to apply the technology to their individual fields of recreation such as gardening and music and suggested the addition of content in these areas as possible opportunities. Whereas all participants were able to discuss the organizational and logistical nature of long-term care and implementing and delivering this type of

technology programming at their center. The staff meeting was an important asset to the project and moved away from unidirectional meetings failing to address a variety of topics. Once again, the implication of research coordinators was important to ensure this wealth of diverse expertise could be localised in such a large health and wellness ecosystem.

On another level, the staff were able to provide objective information on the capacity and ability of most residents to perform certain tasks. Being professionals with significant experience in the domain of LTC, the staff remained an important source of information regarding the physical and cognitive abilities of residents. As a matter of fact, and noted by staff, family members are not always aware or accepting of their loved one's physical or cognitive ability when in LTC. It is often the case that family will be overly confident a resident can individually perform certain tasks or use certain technologies, even if this is not the case. Similarly, residents may not always be fully aware of their own capacities or willing to openly disclose this type of information. As a result, the staff focus groups were increasingly important regarding the gathering of baseline physical and cognitive capacity data which did not always match what was heard in the older adults focus groups. Learning that nearly 90% of residents required mobility assistive devices as a wheelchair, walker or electric scooter in this particular center, was critical information for the platform design. Although the design of the technology had already considered accommodations for older adults who are not able to use it standing up, this highlighted the need to emphasize this particular aspect of the design. With the hindsight of our experience, this was an important fact which could have easily been missed and neglected without proper consultation from resident end-users and staff members.

Adaptability and COVID-19

One of the lessons learned from conducting research in LTC has been the somewhat unpredictable nature of the process. Be it with recruitment, participants attending meetings, considering the unique needs of older adults or other factors, flexibility is required once a project has started. For example, and under the recommendations of the research coordinators it was a good idea to recruit 2-3 extra older adult participants than required to hold the meetings. This was to accommodate the fact that in LTC there are factors which may prevent participants from participating on the day of a meeting compared to other populations. Examples include the motivation and mood of a participant on a particular day, unforeseen appointments and conflicts with other activities at the center. This was the case on the days of the older adult meetings, where some participants cancelled for unforeseen reasons. Given this fact it is favourable to accommodate a slightly larger group if all participants can attend, than to cancel altogether if cancellations create too small of a group.

Without a doubt, the greatest challenge faced by our research team were the restrictions related to the COVID-19 pandemic. On March 11, 2020 the WHO declared the novel coronavirus (COVID-19) a pandemic (WHO, 2020). At that time, our project was in the midst of its data collection in LTC. Older adults had met for the first of two planned waves of PD focus group discussions, while staff had met once. As the focus shifted towards protecting the health and wellbeing of LTC residents and staff, an immediate moratorium for research was placed by the LTC facility days after the WHO announcement. Shortly thereafter the University where our team is based also placed a moratorium on non COVID-19 research. The acute and unprecedented nature of the COVID-19 pandemic led to an abrupt stop to data collection for this project. This unexpected context made it impossible to host any additional sessions with the residents and the focus group we had planned with family and friends of the residents.

Given the disproportionate impact of the pandemic on older adults and LTC it meant that no reasonable timeframe could be placed on when this type of research could resume in LTC. As a matter of fact in Canada as of June 25, 2020 with data provided by the Canadian Institute of Health Information (CIHI, 2020) it was shown that 81% of COVID-19 cases in Canada were in LTC settings and that in LTC homes the case mortality rate was approximately 35% (CIHI, 2020). Given this disproportionate risk it became clear that even as research activities would resume, LTC would remain a separate area with heightened precautions and restrictions to prevent COVID-19 outbreaks. We concluded it was not feasible to assume focus group meetings, grouping several people in close quarters including external investigators would be a safe for a foreseeable amount of time. As a result, we decided to analyze the data that had already been generated with the residents and staff. The COVID-19 pandemic reaffirmed the somewhat unpredictable nature of conducting research in a LTC setting. While teams may approach a project with a predetermined strategy and goal, flexibility is necessary to adapt to the changing context.

Most importantly the COVID-19 pandemic shed light on the fragility of the LTC system. In a mere few weeks, we progressed from conducting hands on research in LTC to watching the nightly news announcements covering the new outbreaks of COVID-19 in LTC centers across the country. The experience of living this transition remains an important lesson from the PD process. This project enabled us to appreciate the challenges of such an event and the direct and indirect health impacts of COVID-19 in the center we conducted our research. This pandemic culminating all of its impacts in LTC remains a surreal moment in time which has clearly brought to the forefront the importance of conducting research in Canadian LTC and to refocus efforts on resident-driven care and initiatives.

Conclusion

Our experience conducting PD with older adults in LTC was a challenging, yet rewarding, experience. Through our experiences, we believe there are opportunities to engage the LTC sector in a meaningful and integrated way in PD. Our proposed outline provided us with valuable design data all while keeping the process feasible for the constraints of LTC and enjoyable for participating staff and residents. It is our hope this reflection on the process will entice future design teams to seek stakeholder perspectives to design appropriate user-centered designs.

CHAPTER 6: DISCUSSION

The overall purpose of this research was to explore the usage of technology in LTC, and further understand the principles for the design of a health activity technology to promote active aging of older adults residing in LTC. To address this the following objectives were presented:

1) Explore the current attitudes, usage, benefits and challenges regarding the use of technology in LTC;
2) Gather preliminary data on the attitudes of older adults and LTC staff on the inclusion of an augmented reality health activity platform in a LTC setting;
3) Reflect on the process of employing a participatory design approach with older adults and other relevant stakeholders in the context of long-term care.

6.1 ATTITUDES, USAGE, BENEFITS AND CHALLENGES OF TECHNOLOGY USE

Older adults express varied opinions to the use of technology in the context of LTC and in society as a whole (Mitzner et al., 2010; Peek et al., 2016). In our research, technology was perceived positively with great contributions to society and as a societal step back warranting great caution. Among older adults, one of the key findings of this research was the easier appreciation for technology when used by others. Technology was commonly described as having evolved through the years and having impacted society on several levels and domains. From improving the fields of accounting, farming and medical life-saving technology, it was viewed with an awe-like appreciation. However, the notion of the personal use of technology was met with certain reservations. Regarding personal use, sentiments shifted from the benefits of technology to the challenges of technology. The expectation confirmation theory which highlights the discrepancy between the actual performance and the desired performance of technology, and determines satisfaction or dissatisfaction was relevant in our findings (Jarvis et al., 2019). For our participants, with the divide between expectations and reality, technology did not always seem to meet the level expected by the older adults. This included the difficulty discerning the benefit of technology over the non-technological ways of doing things, especially given the added difficulty of learning and using technology. These findings align with previous research demonstrating the clash in ideologies among older adults; that is the replacement of traditional methods by technological innovations (Currie et al., 2015). In our study, barriers such as lack of familiarity, previous experiences, unclear purpose and fear were discussed in great detail as inhibiting personal technology use. Indeed, older adults disclosed difficulties with the use of technologies, which is not a new finding in research; in fact, usability

factors are a major predictor of technology use and are often unfavourable in this population (Peek et al., 2014).

Given, the setting of our study in LTC, the participants comprised the oldes-old category of older adults (85+), which is most common in LTC settings. The older adults were expected to exhibit different perceptions of technology use when compared to younger groups of older adults. This is in accordance with the literature where one ethnographic study of technology use found higher prevalence of technology use in younger older adults (55-65 years) (Gell et al., 2015), and another sample of young old (65-75 years) older adults, expressed great interest and enthusiasm to the personal use of technology (Vaporitz et al., 2017). It is expected that these younger groups of older adults and future generations will enter LTC with more technology experience, bolstering their technology acceptance and appreciation (Currie et al., 2015). This was one of the challenges of technology design that we encountered in the LTC setting; given the older age of residents, novel technologies remain difficult to present as beneficial and seemingly interesting platforms for the current oldest age group. This also adds to the literature on the importance of conducting PD in LTC, as perspectives in LTC differ significantly from community-dwelling older adults (Tak et al., 2010). As a result of the discussed challenges, technology use in our sample of older adults did remain limited and interest fluctuated significantly between different types of technologies. In the context of health promotion technologies, the challenge seems even more daunting. The benefits of technologies promoting active aging do not always seem immediate and direct. This aligns with the previously identified challenges of technological innovations for healthy aging, which have been establishing themselves for long-term use in LTC settings (Sixsmith & Gutman, 2013). In addition, a consequence to this challenge is that most current innovations for LTC are currently in the concept-for-test, prototype and development phases with few projects moving passed these phases (Tak et al., 2010). Given our experience with this study, and the perceptions of older adults regarding technology, the challenge for the successful integration of health technology in LTC remains. This reality has however affirmed the importance and value of the PD approach in moving past some of the early challenges the field of gerontechnology has faced.

With regards to the use of personal technology it was clear that the technology attitude formation process is increasingly purpose-driven throughout the aging process. This supports with research that the perceived need for a technology in older adults remains one of the greatest predictors to its uptake (Jarvis et al., 2019; Peek et al., 2014; Wang et al., 2019). The technologies we discussed with the participants had clear and nearly immediate benefits to the user, making this an important consideration for technology use in our sample. This finding has been previously observed in research, where there has been an identified need to align the purposes of technology to older adults' objectives, maximizing the benefits of the

technology (Rogers and Fisk, 2010). This is increasingly important with older adults as the decreased technological literacy and experience they possess can complicate their understanding of the benefits and outcomes of a technology (Wang et al., 2019). In the context of this project, this underscored the need to highlight the benefits of technology for older adults. This includes making clear connections between the AR platform and purposeful results such as social interaction, physical well-being, and enjoyable games. Without a clear sequential process in understanding the purpose of a novel technology there is a risk of it being poorly received by older adults in LTC.

As a result of the purpose-driven attitude to technology, participants viewed technology as a great tool for communications and promoting interconnection with family and relatives. The importance and need for connectedness were reported to have intensified upon entering LTC. Incorporating communication technologies in LTC is in accordance with the mitigation of the risk of distanced living between older adults and their relatives; as older adults enter LTC physical separation from family and friends are a contributing factor to loneliness (Chapman et al., 2019). In the event of acute emergencies such as COVID-19, established communications, using technology, can maintain social well-being and healthy aging despite the significant challenge that is a pandemic. Since the onset of COVID-19 the importance of social supports and networks has been heightened, and family has been seen as an important resilience factor, even without physical interactions in LTC (CFHI, 2020). In fact, technologies such as iPads and computers have been cited as incredibly effective strategies to enable older adults to continue to have deep personal connections with family and friends, while respecting public health regulations (Simard & Volicer, 2020). This was highlighted in our sample of participants where the need to communicate with loved ones remained a daily priority facilitated by technology, even prior to the pandemic. Whether participants engaged in video-calls with family across the world, or received pictures from family living in Ottawa, the immediate connection and engagement was appreciated by residents.

Connection was further highlighted with the use of technology as a great tool to gather information and staying connected on topics such as the world news and weather while residing in LTC. This fit nicely with the notion of connectedness and purpose-driven technology use. Also, through the lens of the COVID-19 pandemic, these technologies can play a vital role in keeping older adults informed and engaged in LTC. While our data was generated before the pandemic, residents approached the topic with humour stating, “we may be in here, but we have to know what goes on out there”. Finally, support and encouragement from family was a strong predictor in the process of buying and using a new technology. These findings aligned with Peek et al.’s (2016) proposed social network where relatives and friends promote technology use. This is typically through recommendations to use technology, support acquiring and using technology, and co-usage of technology. Residents in our sample discussed all three

domains of this social network, with relatives fulfilling all three support roles highlighted by Peek et al. The reliance on social networks for the adoption of technology in our study further built upon the concept that technology use in older generations is heavily influenced by relatives, and there is pressure to adopt technology (Heinz et al., 2013). This finding heightened the importance to involve relatives in discussions of healthy aging technology development.

The findings on communications, information and social support have clearly shown connectedness as an important theme to technology design in LTC. These findings relate to previous research, which has shown that residents in LTC can benefit when using technology with others (Chapman et al., 2019). Whether participants were using technology to communicate with family and friends, keeping informed on the world news, or if they received support from family or staff in the use of technology, the common theme was interaction. This shows the extent to which technology usage in older adults is much more of a social process than a technical one; iterating social influence as a hallmark of technology acceptance (Peek et al., 2016). This component of technology acceptance and use aligns well with the active aging pillar of participation, and capitalizes on opportunities to launch active aging initiatives, which harness the value of social interaction and support (WHO, 2002). This has informed the design of our AR platform by providing this research team with a clear motivation to make connectedness a core value of our platform. This includes opportunities for family, friends and peers to be involved in the gaming component of the game through cooperative gameplay and opportunities for users to share progress and experiences using the technology with family and friends. In addition to bolstering technology acceptance, this strategy can also tackle the issue of social isolation in LTC, where residents continue to face unparalleled loneliness and depression, greatly limiting their overall wellbeing (Jansson et al., 2017; Simard & Volicier, 2020; Theurer et al., 2015)

Our study has also added to literature regarding concerns of older adults as they relate to technology at large. There were specific discussions about the overuse of technology in modern society and the generation gap accompanied to the different uses of technology. This relates to older generations considering themselves part of the non-technological generation and forming their identity based on this fact (Bailey & Ngwenyama, 2010). This gap became quite clear as participants in our study did not understand the level to which younger generations appreciate and use technologies. Nominet et al. (2017) provide an explanation of this phenomenon, as the early exposure to technology in younger generations is likely to support their level of savviness and interest. Of course, in younger generations identities are built on significant technological use and interactions (Bailey & Ngwenyama, 2010). This seemed to explain in part why participants in our study could not understand why technology was being used to replace day-to-day activities such as paying bills, banking, social interactions and health education. From a technology

design standpoint, this reinforces a need to close this generation gap, and design novel technologies which do not seem out-of-reach for older adults' in terms of their ideologies and beliefs.

The apparent technological gap was further compounded with other challenges in residents of this study. Firstly, and in contradiction to the findings of technology as source of connectedness, technology was perceived as a barrier to promoting deep person-person interactions. This has been previously observed, as older adults continuously consider technology as a subordinate method to achieving the benefits of proper human interaction through traditional human contact (Andrews et al., 2019). In the context of health technologies, research has shown that greater acceptance is directly linked to the perception that a technology is not replacing person-person care (Currie et al., 2015). In our sample, the concern of replacement of person-centered care was even more present. It was felt that a technological alternative to traditional health education and promotion activities such as physical activity, may not meet the high expectations of care and services currently received at this center. This came as no surprise as the LTC sector remains deeply invested in the delivery of person-person care and services, and the importance of good caregiver-resident fits (Kane & Kane, 2001). This focussed the need to consider connectedness in the design of our AR platform and include LTC staff and relatives in an integrated way to avoid a false sense of connection. This can be greatly facilitated in the context of LTC, as the rolling out of such a platform would require the support of LTC staff. With efforts to keep staff engaged in an active role, it may mitigate this risk and prevent isolation and loss of person-person contact and care.

Our study provides evidence of concerns regarding privacy and control of technology by older adults. Specifically, issues related to fraud, scams, hacks and crashing were common fears. These were used interchangeably by participants not always fully understanding what these truly represent, but rather being aware that they were all real dangers of using technology. Combined with the over reliance of technology in society, these security issues led to negative perceptions regarding technology in participants. These findings build upon the proposed privacy policy framework for older adult technologies focussing on the right to seclusion, autonomy, control of property, spatial boundaries and ability to see and modify personal data (Huber et al., 2011). This concern related most directly to older adult's limited experience with technology and a self-disclosed lack of confidence. Given the inability to reliably identify security breaches, caution was expressed toward accessing certain technologies, especially as technologies shifted into the realm of personal data such as banking information or health information. This has been previously seen in health research where 60% of a sample of older adults participating in a smart home technology survey disclosed concerns related to security and privacy (Boise et al., 2013). In the context of this project, privacy of personal information was not as relevant, given the technology does not anticipate storing confidential or sensitive data. However, the saturation of

discussion on this topic highlighted the need to properly convey the safety of the Magic Mirror AR platform, to avoid misconceptions regarding personal security breaches.

6.2 DESIGN AND INCLUSION OF THE AUGMENTED REALITY ACTIVITY PLATFORM

The design of the Magic Mirror AR health activity platform benefited from the input of older adult residents and LTC staff. However, the integration of the platform at the Perley-Rideau Veterans' Health Centre was received with mixed reactions. Though LTC staff and residents alike were able to appreciate the value such a platform could offer in a LTC setting, some hesitations were maintained as to everyone's interest in the platform. In fact, diminished interest in the platform was flagged as a challenge among some residents in our study. Previous work has found interest in technology to be mostly related to previous experiences as technologically-minded or a nontechnological person (Peek et al., 2016). Our sample was comprised of both technologically-minded and nontechnological participants, possibly contributing to the dichotomy in opinions. These findings highlighted the importance to clearly emphasize the purpose, benefits and outcomes of our technology to bolster interest among the residents. Furthemore, the proposed and demonstrated technology was lacking in certain important domains for older adults. This built upon literature demonstrating technology acceptance in older adults is often rooted in the fact that current devices are not designed with the needs of older adults in mind (Hakobyan et al.,2019), and the need to move away from *technology-push* design paradigms (Sixsmith & Gutman, 2013). The inclusion of a PD approach in our study allowed to avoid the integration of a technology lacking key design considerations, impeding its successful integration.

In the matter of integration of health activity technology in LTC our study has identified some key principles. Firstly, our results have added to the need for support in the implementation and use of our AR platform. To residents, this entails involving LTC staff members such as activity specialists in the organization and delivery of our platform. This underpinned the importance and value of involving staff in the PD process, to not only meet the needs of older adults, but also for staff (Tak et al., 2010). The value of staff providing support with technology-driven programming was further mentioned by staff as an important facilitator in LTC, compared to community dwelling older adults. In LTC there are opportunities to create supportive environments and routines which can be reinforced by staff at a level which cannot be achieved in individual older adult's homes (Chow, 2003). This acts as a strong motivator to emphasize collective efforts to integrate LTC professionals in this PD process for continued day-to-day contributions to health activity programming. This study also built upon the importance of maintaining older adult autonomy. Interest in the platform was discussed with the important caveat that such a technology must at all times remain an option to residents, and no point be forced upon them. This resonated strongly with this research team and the need to create active aging initiatives which ensure

decisions being made uphold older persons' rights to maintain independence and autonomy (WHO, 2002, p.g 53). In technology design, the goal is for a product to be used on its merit, rather than obligation. This is highly interrelated with the increasing importance of keeping the autonomy of care decisions in the hands of older adults, especially as we shift in the right direction of increasingly independent older adults with stronger opinions on personal care decisions (OLTCA, 2011).

Important design principles were extracted from all three focus group discussions. Firstly, LTC staff provided pragmatic design recommendations. This experience has been encountered by other research teams performing PD, emphasizing the need to educate designers on the realities of older adults and increasing "aging literacy" as an important step to successfully integrate technology in older adult's lives (Wang et al., 2019). With recommendations on accessibility, usability and content, our design team was left with important design discussions to explore new functionalities and content. Notably, details on the physical and cognitive capacity of residents were integral to ensure games would consider the difficulty of certain gaming tasks such as body movements and procedural processes like grabbing a falling object. Recommendations from staff involved options to adjust the speed of games, difficulty and types of movements, content and opportunities for games to accommodate physical and cognitive challenges. As the experts in this field, staff were well positioned to provided insight into structural implications of design, such as staff training, management directives and resource considerations. These discussions revealed strategies to position our platform to provide a clear benefit to residents and staff.

Secondly, discussions on the usage and attitudes of technology by residents provided concrete design principles to abide by, which would promote greater technology acceptance. Our study has built upon the importance of individuality and person-centered individualized healthy aging activities (Lima et al., 2017; Frost et al., 2017; Golinowska et al., 2016). When discussing health activity, personalized content was front and center in both staff and older adult discussions. There was an explicitly stated need to maintain a high level of accessibility in the usability and content of our platform to expect successful integration into LTC. This aligns with previous research highlighting the need in gerontechnology to increasingly adopt user-driven approaches rather than technology-driven approaches in technology for active aging (Sixsmith & Gutman, 2013). Through user-driven approaches assessing everyday lives of the end-user allow for greater alignment with unique needs and situations, promoting technology uptake. This is directly related to the previously discussed variability in the care needs of older adults in LTC, where most centers serve mixed populations with only some overlapping characteristics (Wunderlich & Kohler, 2001).

Despite the recommendations to keep the design inclusive and wide-reaching, residents and staff emphasized the importance to realize no single technology can meet the needs and interests of all LTC

residents. This finding however is not solely applicable to novel technology in LTC, as it coincides with previously identified challenges of general health promotion and active aging activities in LTC (Frost et al., 2017). This explains our findings related to how to keep staff highly dedicated to identifying solutions which work for individual residents, even when this means providing a variety of services through different tools and strategies. These discussions demonstrated the devotion of LTC staff in offering highly personalized care to residents always pushing for active aging activities which work for individual older adults. This was an important consideration in the integration of our platform, and situating it not as a replacement to typical services but a complement to the vast ecosystem of care. This aligns with previous findings that the preferred future of technology in LTC, is to embed technology within the environment to enrich the LTC setting (Tak et al., 2010). From a theoretical environmental standpoint this calls for technology to have a favourable person-environment fit, all while considering the fit within the actual LTC center (Sixsmith, 2013). This is particularly relevant as research has shown that a poor device fit for a user's environment is a major factor for technology discontinuance in older adults (Czaja et al., 2013).

Finally, our study has added to the literature on constraints within the LTC sector. Notably, staff recommended to remain vigilant regarding the ambition of a project and to consider a gradual and continued approach to technology integration. Staff recommended focussing on staff training and education, while remaining active and engaged to prevent a platform from becoming obsolete. In fact, the lack of knowledge among staff regarding how to use and implement new technological interventions remains a challenge to the implementation of technology in LTC (Freedman, 2005). Our study has uncovered the importance of staff training to help overcome the challenge of poor training and lack of awareness. Staff also highlighted the over-ambitious nature of previous active aging projects and its contribution to unachievable expectations. This finding further reinforced the challenges within gerontechnology, where despite considerable research and development the long-term uptake of projects remains low (Sixsmith, 2013). Staff in this study discussed challenges with time, staffing, resource allocation and resistive staff, further building upon the need for tech designers to create viable context specific business models and innovations for LTC (Sixsmith, 2013). This resonates with findings in active aging research showing that program delivery in LTC continues to be inhibited by low staffing levels, limited time and scarce resources (Benjamin et al., 2009). Sensitivity to this fact was heightened during the COVID-19 pandemic— and to this team, successful integration of our AR platform meant not only improving outcomes for residents but also LTC staff. Our findings also corroborated previous recommendations that health education in LTC should consider the unique needs of a specific LTC center and aim for minimal resource investments to promote greater program uptake (Shakeel et al., 2015). These findings on technology integration provided this research team with renewed priorities on ensuring

our active aging platform not only considers individual resident needs but also the needs of staff and the overarching needs of the LTC center.

6.3 PARTICIPATORY DESIGN IN LONG-TERM CARE

In line with previous research, our experience conducting PD in LTC was a challenging yet rewarding experience. This study demonstrated how the benefits outweighed the challenges, and how PD in LTC can be conducted in a feasible and meaningful way (Hakobyan et al., 2015; Jackson et al., 2012). The most beneficial outcome of this approach was the ability to gather insight directly from the experiences and realities of older adults living in LTC. This finding has been previously reported as a hallmark of the PD approach in LTC, where it is the insights into the lives of older adults' which enable designers to alter their thinking about this domain (Jackson et al., 2012). This process shed light on a more pronounced appreciation of daily and organizational considerations to the design of *The Magic Mirror* prototype. A key takeaway of this experience has been the undeniable enthusiasm and willingness to contribute within the LTC setting. As previous work has shown the process should always consider the importance of involving older users in an integrated and meaningful way (Merkel & Kucharski, 2019). Historically, older adults have been perceived as a population who can contribute little in the area of technology design given their limited experiences with technologies (Iacono et al., 2014). The current study clearly demonstrated this was not the case, as our older adult sample contributed significantly to the design and ideation of our technology. This has also been the case for research teams willing to invest the necessary efforts to involve the LTC sector in PD projects (Hakobyan et al., 2015; Jackson et al., 2012; Jia et al., 2015; Wilkinson & Cornish, 2018).

Some of the older adults in our study lacked explicit technology knowledge, such as technological terms and functionalities, domains in which other generations are more comfortable. This has also been true in other research teams where the engagement of older adults has been challenged by their lower familiarity with technology and disadvantaging them in models of interactions, they can use to make inferences (Wang et al., 2019; Wilkinson & Cornish, 2018). This was also realized in this study where the lack of technological literacy and previous experience limited the quantity of functional data older adults could provide. However, our strategy to provide contextual examples of our platform in action enabled residents to create a stronger understanding of the technology enabling for greater opportunities for discussion. This reinforced previous findings that video-prompting and interactive design activities are strategies to provoke interest and discussion in participants with less technology experience (Jackson et al., 2012; Merkel & Kucharski, 2019). In addition, what older adults lacked in technology experience and familiarity was compensated with a wealth of lived experiences and enthusiasm in their contributions. Older adults in this study expressed genuine appreciation for their

involvement in the process, even in spite of their self-disclosed limited knowledge and experience with technology. This further reinforces the need to avoid token PD projects which focus on the tick-in-the-box tech design process. Rather active efforts must be made to involve older adults in a meaningful way to both benefit the design team and maintain the process as an enjoyable experience for older adults (Merkel & Kucharski, 2019). In our case, the involvement of older adults fueled honest discussions which have led to important processes of re-evaluating and re-thinking the AR platform and its role in the context of LTC.

The inclusion of staff in our PD approach contributed to the diversity of data collected. This strategy has remained popular in PD in LTC with several projects choosing to involve secondary users such as staff and relatives (Merkel & Khukarski, 2019; Panek et al., 2018). Older adults provided important perceptions, attitudes and experiences with technology, whereas staff provided input through the differing lens of organizational and delivery type data. The overall impression of involving the staff group was their deep understanding of LTC and the delivery of services in a LTC setting. The complexity of such an ecosystem of care makes it that without the contributions of professional staff in the sector important considerations could have been easily overlooked and technology uptake impacted. This is particularly important as technology in LTC will depend on residents and staff alike knowing how to operate it (Merkel & Khukarski, 2019). The considerations of our research team in involving staff in the discussions included ensuring a broad representation from professionals. The inclusion of healthcare professionals in the fields of occupational therapy, physiotherapy and personal support— paired with recreation and program delivery specialists— made for diverse and productive conversations considering unique perspectives to technology use and our AR platform. Similar to older adults, staff demonstrated appreciation for their inclusion in this process. Staff highlighted several challenges with program delivery, design and technology in LTC, which they felt can be mitigated with the type of outreach our team had decided to do.

However, the PD process in LTC was met with certain challenges. Most importantly recruitment of older adults was a significant challenge, as previously encountered by other research teams (Hakobyan et al., 2015). This notion was a possible indication of the diminished interest and confidence that older adults can have with regards to novel technologies. Our sample also aligned with two previously observed attitudes during the recruitment process of older adults for a technology PD project; the lack of belief to have something to contribute and fear of digital illiteracy (Malmborg et al., 2015). Upon one-on-one discussions with interested participants, it was the lack of confidence and lack of technological knowledge which predominated in the uncertainty to participate. The fear of being incapable to contribute greatly impacted the perceptions of potential participants with regards to the project. This was despite our

attempts to emphasize that technology experience was not required to participate; a point we found easier to express in-person when given the opportunity. This builds upon previous research showing the need to educate stakeholders in the design process to overcome misconceptions and barriers (Wilkinson & Cornish, 2018). Finally, adaptations to the PD process were made to enable target users to effectively participate in the project considering some of the organizational challenges of LTC. In our situation, strong collaboration with the center in which PD activities took place alleviated recruitment challenges and their expertise influenced important decisions to avoid logistical barriers during the process.

6.4 STUDY LIMITATIONS

This study has several limitations that must be acknowledged. Firstly, this study had a small sample size of older adults (*n*=7) and staff (*n*=7). Although the rationale for the smaller sample sizes has been provided the study data is drawn from a small pool of participants. In addition, the sample of older adult participants were all male. This was a challenge with the nature of the purposive sampling technique with only male participants interested in participating in this study. One female participant expressed interest in participating, however she withdrew prior to the study commencing. However, participants were all very active in discussions and provided individual input on the questions and conversations. In addition, no demographic data was collected for the staff participants, this represents a limitation as age and years of experience working in LTC may impact on perceptions towards technology.

In addition, given the COVID-19 pandemic, this research project was significantly impacted given the nature and setting of the data collection within a high-risk LTC center. As the priority shifted to ensure the safety of older adults and staff, all research operations were halted at the Perley-Rideau Veterans' Health Centre in March 2020, in the midst of the data collection for this thesis. At this time the first portion of the two older adult cohorts had met, as well as the one staff meeting. This meant a planned second meeting with both older adult groups was cancelled and the family meeting was cancelled. Given the unique and challenging situation along with the moratorium on research imposed by the facility and the University of Ottawa it was decided to procede with analysis using the data collected.

CHAPTER 7: CONCLUSION

Following the data collection and analysis, the following highlights were observed.

- Older adults in LTC have varied opinions to technology use at large. The benefits of technology were most obvious at a societal level, compared to personal use. As a result, the use of technology in LTC does remain limited, focussing on technologies with clear purposes and outcomes. Of note, technologies promoting connectedness and social interactions remain the most commonly used technologies. Privacy issues, the replacement of person-person care and difficult accessibility and usability persist as challenges to the uptake of technology in older adults residing in LTC. These findings were key to re-evaluating opportunities to promote uptake in this population.
- The integration of *The Magic Mirror* AR health activity platform in LTC was received with mixed reactions from staff and residents. The health activity and active aging components were appreciated with certain limitations. Of note, the platform must thrive for maximum accessibility, usability and ease of use for success in LTC. In addition, the platform must consider the organizational capacity of the center for staff uptake and long-term use. Finally, the focus must be placed on residents to ensure our platform is user-driven and respects the autonomy of care decisions in older adults.
- The PD design process in LTC was a challenging yet highly rewarding experience. Our process outlined an effective way of meaningfully involving LTC residents and staff in a resource conscious manner to gather key perspectives to the efficient design of our AR health activity platform.

7.1 CONTRIBUTION OF RESEARCH

This research sought to understand the perceptions and attitudes of technology for use by older adults in LTC from the perspectives of older adult residents and LTC staff, in turn informing an AR gaming platform for health activity. In doing so this research builds upon existing knowledge on PD, motivations to technology use and opportunities, challenges and barriers of technology uptake in LTC. The results of this study should be considered in future projects designing technology for older adult use and engaging in PD within the LTC sector. Enabling older adults to shape and design their own active aging interventions acts as the foundation for beneficial long-term results.

This study highlighted some key design requirements which can influence the motivation of older adults to use technology in LTC. It provided some examples of perceptions about technology and the role of technology in active aging and health activity initiatives, as well as strategies to mitigate poor technology reception and uptake. On a practical level, this study provides insight on the design, implementation and delivery of PD outreach activities with older adults and staff in the context of LTC. Our proposed process can be followed and adapted to meet the unique needs of different LTC centers in achieving integrated and meaningful PD with older adults.

7.2 OPPURTUNITIES FOR FUTURE RESEARCH

Opportunities for future research in the context of the PD for this AR platform include long-term engagement of the LTC center in future stages of the technology design process. Further opportunities include prototype refinement, prototype testing including qualitative feedback and user studies to evaluate a final prototype. Future research could also consider the experiences of older adults and LTC staff in the technology PD process for active aging technologies. This type of research would allow for further refinement of PD methods and key data on maximising the meaningful involvement of this sector in technology design initiatives. Finally, future research should include family and friends in the design of technology for healthy aging, given their significant role in the technology acceptance process of older adults.

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APPENDIX A: ETHICS CERTIFICATE FOR THESIS PROJECT

The document below is a copy of the ethics certificate approved by the Health Sciences Research Ethics Board at the University of Ottawa. The approval was granted in July 2019 and valid for one year until July 2020. It provides assurance that the methods employed by this project were vetted by the University of Ottawa REB and abide by the ethical requirements of the University.

28/07/2019

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

CERTIFICAT D'APPROBATION ÉTHIQUE | CERTIFICATE OF ETHICS APPROVAL

Numéro du dossier / Ethics File Number	H-05-19-2799
Titre du projet / Project Title	Stakeholder Assessment of Augmented Reality for Health Education of Older Adults Living in Long-Term Care: Magic Mirror
Type de projet / Project Type	Thèse de maîtrise / Master's thesis
Statut du projet / Project Status	Approuvé / Approved
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)	28/07/2019
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)	27/07/2020

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
Patrick LEFEBVRE	École interdisciplinaire des sciences de la santé / Interdisciplinary School of Health Sciences	Chercheur Principal / Principal Investigator
Pascal FALLAVOLLITA	École interdisciplinaire des sciences de la santé / Interdisciplinary School of Health Sciences	Superviseur / Supervisor
Tracey O'SULLIVAN	École interdisciplinaire des sciences de la santé / Interdisciplinary School of Health Sciences	Co-superviseur / Co-supervisor

Conditions spéciales ou commentaires / Special conditions or comments

APPENDIX B: CONSENT FORM

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Faculty of Health Sciences

Interdisciplinary School of Health Sciences

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Consent Form – Residents and Tenants

Title of the study: Stakeholder assessment of augmented reality for health education of older adults

Name of the researchers:

(Principal Investigator) *Patrick Lefebvre*
Master's Candidate
University of Ottawa, Faculty of Health Sciences
[redacted]

(Supervisor) *Pascal Fallavollita, PhD*
Associate Professor
University of Ottawa, Faculty of Health Sciences
[redacted]

(Supervisor) *Tracey O'Sullivan, PhD*
Associate Professor
University of Ottawa, Faculty of Health Sciences
[redacted]

Background Information:
Magic Mirror is a framework that has been in development over the past few years to utilize new technologies in the field of augmented and virtual reality. Its purpose is to find novel solutions to old problems in healthcare, rehabilitation, and education. We are now advancing the framework with a focus on enabling fun and safe exercise and physical activity for older adults. Today, we are ready to demo a prototype of this technology, and we invite you to give us feedback.

Purpose of the Study:
The purpose of the study is to continually develop a cost-effective Magic Mirror technology which seamlessly improves the health and wellbeing of older people, enables less-active elderly to be more engaged in social life and more active contributors to a wider society.

Participation:
Your participation in this research is entirely voluntary. We are inviting you to contribute because we feel that your participation in the existing activities and programs of The Perley and Rideau Veterans' Health Centre will allow for a rigorous and comprehensive design of our new Magic Mirror technology.
Participation in the study requires attending two focus group discussion sessions lasting 60 minutes. You will be invited to share your personal experiences and perspectives on technology and our Magic Mirror platform. During these focus groups you will have an opportunity to shape the design of the platform, so it best meets the needs of older adults.

How will my data be collected?
Data will be collected in the from of audio recordings of focus group discussions.

How long will this study take?
The duration of your discussion activity session is approximately 60 minutes per session and will meet twice over a one-year period.

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Risks:
There are no foreseeable risks to participating in this project. You will NOT be asked at any time to risk your physical, mental, or spiritual safety. However, it is not possible to foresee any discomfort you may experience during the discussions. In the event of any such discomfort Joan Olinik from the resident's support team can be contacted at [redacted]

Benefits:
The benefits to this study will be your influence in the development of this novel technology, which may eventually become integral in your daily lives. You will be considered early pioneers of this revolutionizing idea

Compensation:
There will be no reimbursement for participating in this study.

Confidentiality and anonymity:
To protect your identity, your name will not be used on stored recordings and documents. However, given the focus group format, there is interaction between participants, and therefore anonymity cannot be guaranteed. However, we do ask to maintain all discussions private and to not be discussed outside the meeting times. For the interview transcripts, each participant is given an alternate name to protect their identity. There will be no use of personal identifiers in the research reports, and quotations will not contain identifying information. In addition, to ensure confidentiality, the list of participants will be kept in a secure area, separate from the interview and focus group material and will be accessible only to the research team. All hard copy documents will be kept in the locked filing cabinet in Dr. Fallavolita's lab. Electronic files will be password-protected.

Conservation of data:
Data gathered from the discussion groups may be used in the writing of a research publication. The data may be used to compile internal reports of progress, but there will be no link between any data and personal information. Given the nature of a focus group discussion a participant who withdraws will not be able to have his data removed form the discussion however the identity of the person will continue to be protected. Data will be securely kept for 5 years after the project on password

Who can I contact for more information?
If at any time, you have any questions, comments, or concerns, please feel free to contact any of the following people:

Patrick Lefebvre [redacted]
Pascal Fallavollita. [redacted]
Tracey O'Sullivan [redacted]
Enrique Soto. [redacted]

If I have any questions regarding the ethical conduct of this study, you may contact the Protocol Officer for Ethics in Research, University of Ottawa, Tabaret Hall, 550 Cumberland Street, Room 154, Ottawa, ON K1N 6N5
Tel.: (613) 562-5387
Email: ethics@uottawa.ca

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Acceptance:

I _____, undersigned, voluntarily accept to participate in this study. I have had the opportunity to ask any questions or concerns I had, and all questions have been answered to my satisfaction. I understand that I have a right to withdraw form this study at any time without repercussion.

I understand that data will be collected during this study. I authorize the collection of this data

Print Name of Participant _____

Signature of Participant _____

Date _____
Day/Month/Year

Statement by researcher taking consent:
To the best of my ability, I have accurately provided all information that is required by the participant to make an informed consent decision. I confirm that the participant was given an opportunity to ask any questions or raise any concerns they may have, and I answered those questions to the best of my ability. I confirm that the individual has not been deceived or coerced in any way and has given consent freely and voluntarily.
I confirm that a copy of this form has been provided to the participant

Initial _____

Print name of Researcher _____

Signature of Researcher _____

Date _____
Day/Month/Year

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APPENDIX C : OLDER ADULT FOCUS GROUP DISCUSSION GUIDE

FOCUS GROUP: DISCUSSION GUIDE

Perley-Rideau: Older Adults

Introduction: **10 minutes**

- **Welcome statement:** Welcome and thank you for your participation in today's focus group discussion. We truly appreciate your opinions and are very happy you have decided to share them with us today, we realize your time is valuable and thank you once again.
- **Introduction**: Today's discussion will be on the use of technology and the role of technology in the healthy aging process. Specifically, we will be discussing a platform that is currently being designed at the University of Ottawa the "Magic Mirror".
- **Overview of Magic Mirror:** The purpose of the discussion is to gather your experiences and perspectives on technology to help us design the Magic Mirror to complement your range of activities offered here at Perley-Rideau.
- **Anonymity:** Despite being taped, I would like to assure you that the discussion will be anonymous. The tapes will be kept safely in a locked facility until they are transcribed word for word, then they will be destroyed. The transcribed notes of the focus group will contain no information that would allow individual subjects to be linked to specific statements. You should try to answer and comment as accurately and truthfully as possible. I and the other focus group participants would appreciate it if you would refrain from discussing the comments of other group members outside the focus group. If there are any questions or discussions that you do not wish to answer or participate in, you do not have to do so; however please try to answer and be as involved as possible.
- **Rules:**
  There are no right or wrong answers
  Please share anything you would like and do not hesitate to disagree with others, it is best to hear the thoughts of everyone.
  Any Questions? (Provide answers)

  OK let's Begin.

Introductory Question: First let's take a few minutes to go around the table and hear everyone's name.

Question Period: 40 minutes

2 What is technology for you? What does the word bring to mind?

3.1 Probes: telephone, cellphone, tablets, computers, television, electronic games

3 What technology do you use, or have you used before?

4 What role would you say does technology have on your daily life?

5 With your experience using different technologies what do you find most difficult when trying to use a new technology?

3.2 Probes: instructions, support availability, size of text, volume, confusing

6 Is there a specific technology you have used regularly with ease? What makes this technology so easy to use?

7 In the past have you avoided using certain technology? If so, what were the reasons why?

8 Have you ever used or heard of virtual and augmented reality technologies? Any impressions of these technologies?

Moderator to now provide background information on augmented reality AND video demonstration of Magic Mirror prototype

1) General first impressions of the technology?
   Does this look easy/difficult/entertaining/irritating to use?

2) How might this kind of technology have an impact on your daily life here at Perley-Rideau?

Conclusion: 5 minutes

Thank you all again for your participation today.
Your comments today are very valued and will play an integral role in the development of the Magic Mirror based on your opinions.
For any questions or concerns please do not hesitate to speak to me now or to contact me at anytime.

APPENDIX D: STAFF FOCUS GROUP DISCUSSION GUIDE

FOCUS GROUP: DISCUSSION GUIDE

STAFF

Introduction: 15 minutes

- **Welcome statement:** Welcome and thank you for your participation in today's focus group discussion. We truly appreciate your opinions and are very happy you have decided to share them with us today, we realize your time is valuable and thank you once again.
- **Introduction**: Today's discussion will be on the use of technology and the role of technology in the healthy aging process. Specifically, we will be discussing a platform that is currently being designed at the University of Ottawa the "Magic Mirror".
- **Overview of Magic Mirror:** The purpose of the discussion is to gather your experiences and perspectives as staff members here at Perley. We want to understand from an organizational standpoint the requirements for the design the Magic Mirror to complement the range of activities that are offered here at Perley-Rideau.
- **Anonymity:** Despite being taped, I would like to assure you that the discussion will be anonymous. The tapes will be kept safely in a locked facility until they are transcribed word for word, then they will be destroyed. The transcribed notes of the focus group will contain no information that would allow individual subjects to be linked to specific statements. You should try to answer and comment as accurately and truthfully as possible. I and the other focus group participants would appreciate it if you would refrain from discussing the comments of other group members outside the focus group. If there are any questions or discussions that you do not wish to answer or participate in, you do not have to do so; however please try to answer and be as involved as possible.
- **Rules:**
  It is important for one person to speak at a time, if you would like to comment on the thoughts of someone else please do so after they have finished speaking.
  There are no right or wrong answers
  Please share anything you would like and do not hesitate to disagree with others, it is best to hear the thoughts of everyone.
  Any Questions? (Provide answers)

  OK let's Begin.

Introductory Question: First let's take a few minutes to go around the table and hear everyone's name.

Question Period:

1) What do you perceive as the greatest challenge to offering health education activities to the residents/tenants of Perley-Rideau?
2) What are your opinions on the prospect of using technology for the purposes of health education in older adults? What do you perceive as the pros/cons in doing so?

3) Specifically, what are your opinions regarding technologies such as virtual reality or augmented reality for health education?

Demonstration: Magic Mirror explanation and demonstration of early porotype: The Magic Mirror is a mixed reality gaming platform which is designed specifically to promote health education and healthy life habits in older adults. The prototype consists of a Kinect sensor, a television and an original software keeping this a low-cost setup. The Magic Mirror can track body movements in real time and can be controlled with a gesture-controlled interface. The Magic Mirror is going to be designed to be customizable for different users and will allow for tracking and monitoring of progress.

1) What are your first impressions of the technology specifically considering its potential use with residents here at Perley-Rideau?
2) Potential follow-up question: From an interface and content perspective do you believe most older adults to be able to use this technology with minimum help or support?
3) How does this platform and style of mini games measure up to current program activities? Physical exertion wise is this feasible?
4) From an organizational standpoint what kind of resources do you believe are necessary to have this technology implemented and used in a long-term care setting? What facilitators do you think should be in place?
5) Finally, do you see this platform being integrated at Perley-Rideau? Do you see it as a complement to certain activities or a potential replacement option for others?

Conclusion: 5 minutes

Thank you all again for your participation today.
Your comments today are very valued and will play an integral role in the development of the Magic Mirror based on your opinions.
For any questions or concerns please do not hesitate to speak to me now or to contact me at anytime.
Thank you

APPENDIX E: CODING GRID

Stakeholder Assessment of AR in LTC

Attitudes	***The self-disclosed settled way of thinking regarding technology or the potential future use of technology.***
Negative attitude towards technology (General)	A perceived lack of interest, purpose or motivation to the general use and applications of technology.
Positive attitude towards technology (General)	A perceived interest, purpose and motivation to the use and the applications of technology.
Self-disclosed lack of interest	Perceived attitude the technology will not bring a sense of value or purpose to the user causing a lack of interest in using the technology.
Self-disclosed lack of success	Perceived attitude of failure or the perceived inability to use the technology.
Self-disclosed openness	Perceived attitude of trying something new, or option for trying something different. A sense of openness to technology.
Augmented Reality Magic Mirror	***Discussions on the Magic Mirror AR platform and its place and integration in LTC.***
Integration	Data referencing to the potential successful integration of the technology in a LTC setting, may include certain considerations to the integration.
Interest	Self-disclosed interest in the prototype as being applied in older adults or LTC settings.
New Option	Disclosure of the Magic Mirror as a new option to the delivery of services and care with older adults in a LTC setting.
Unclear Purpose	Self-disclosed uncertainty on the purpose of the prototype and its application with older adults or in LTC.
Unclear Success	Self-disclosed uncertainty as to the successful implementation and value of the prototype in older adults and LTC.
Barriers	***Expressed barriers to the uptake, use, acceptance or openness towards technology.***
Access to Technology	Expensive technology (price), changing too quickly (hard to keep up) and general ability to access technology.
Cognitive Changes	Cognitive changes associated to the aging process (can include self-disclosed forgetfulness or inability to learn certain tasks) potentially inhibiting the ability to use certain technologies.
Comfort	Comfort considerations of a technology, specifically physical comfort. (e.g. heavy equipment being uncomfortable).
Generational gap	Self-disclosed reference to the generation gap with younger generations. Perceived feeling technology was not meant to be used by older adults. Too old to bother learning “not made for us”.
Low familiarity	Having a low familiarity with the type of technology or similar technologies.
Motivation	A self-disclosed difficulty finding the motivation to use or learn a technology.

One Size Fits All Model	No customization or personalisation, technology poorly designed by not considering the unique needs of different potential users.
Overambition	The overambition of creating too many technologies or launching too many initiatives running the risk of unachievable or unrealistic benefits.
Past Experiences	Previous negative experiences with technology hindering the future willingness to use technology.
Physical changes	Physical changes associated to the aging process (physical incapacity or changes in ability can be associated to the senses or physical form) potentially inhibiting the ability to use a technology.
Replacement Technology	Technology being applied in an instance to replace a method or task which works adequately without technology. (Replacing everything with technology i.e. online banking).
Staff Differences	Differences in beliefs and priorities of different staff including not willing to support certain health education or care initiatives.
Staff Training	Deficiencies in staff training hindering the ability to the delivery of care and services.
Technology or the Real World	A perceived feeling of a mismatch between technology and reality. (Getting lost in technology or losing connection with the real world).
Time Constraints	A perceived or real lack of time preventing the delivery of care and services.
Unclear Purpose	A technology which does not have a clear sense of purpose to the end-user or potential end-user. No potential benefit or reason to use said technology.
Emotions	***Self-disclosed state of mind deriving from one's circumstances or mood pertaining to the use or potential use of technology.***
Amazement	The state of amazement towards technology and its applications.
Fear of Isolation	Fear of isolation caused by technology, as services, communications and people are being increasingly replaced by technology.
Fear of Technology	The general fear of technology from previous bad experiences or the fear of failure when engaging with a technology.
Frustration	Technology as a source of anger: from a lack of success or difficult experience.
Joy	Technology as a source of pleasure (when used or externally admired), technology as a source of happiness.
Loss of Control	Fear of loss of control/privacy as it relates to the use of technology. (No privacy, being hacked, feeling unsafe).
Environment	The unique considerations of the LTC environment and
Family and Friends Input	The input and value from family or friends of older adults towards the use of technology or delivery of services in LTC.
Physical environmental	Physical environmental changes (technology available at home vs in LTC, different needs arising from the LTC environment.
Physical long-term care environment	The physical characteristics of LTC which determine the need and desire to use a technology.
Social Long-term care environment	The social environment of a long-term care setting and influence on the use of technology (other residents, socialization).
The evolution of technology	The ways in which technology has changed and progressed over the years, evolving nature of technology for the better or not.

Unique Needs	Considering the unique needs of older adults living in LTC which may not apply to other populations or the unique needs between different residents in LTC.
Facilitators	***Expressed facilitators to the successful uptake, use, acceptance or openness towards technology.***
Accessible	Making a service or making care accessible to all regardless of physical/cognitive limitations.
Clear Purpose	Clear perceived usefulness of a technology acting as a source of motivation to use technology. (Knowing exactly what the technology offers in benefits)
Environmental support	Support from family and friends including in the purchase, use and training on technology. Including troubleshooting, coaching and persuasion to use technology.
Exciting	Technology with a clear component of excitement as a factor contributing to its uptake.
Familiarity with Technology	Past experience with technology (a common technology that person is comfortable with and has used extensively). Example someone who was comfortable with the technology previously or still is comfortable.
Simplicity	Technology designed specifically with simplicity in mind as a design attribute.
Staff Support	Support from LTC staff in the care, offering of services or daily support. Example cooperative staff willing to support residents with "extra" activities such as technology use.
User-centered Design	Customized technology to meet personal needs and interests of the end-user. Taking into consideration the older adult population and LTC specifically.
Types/Patterns of Technology Use	***Discussions pertaining to the current and previous uses and applications of technology by older adults in or outside of LTC settings***
Commercial, professional, industrial use	Use of technology as a means to reach an end other than personal gratification (technology at work, technology in a specific field/line of work).
Health Technology	Technology to promote or maintain health including healthy aging technologies and health tracking.
Technology for Communications	Technology used to communicate with friends/family (e-mails, telephone calls, chat, video chat)
Technology for Entertainment	Technology used to fulfill a personal need for entertainment (watching television, listening to music, playing games)
Technology for Information	Technology used to gather or search for information (including weather, news, research)
Technology for Practical Use	Technology used to complete a personal task or facilitate a process or task (online banking, e-mails, online purchases)
Virtual or Augmented Realities	Awareness of Virtual or augmented realities and its applications.