UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

PSYCHOSOCIAL HEURISTIC FACTORS OF AN INTERACTIVE MOBILE DEVICE FOR GERIATRIC PERSONS

BY

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Declaration

I, Ngaruiya, Mary Njeri, declare that this Ph.D. thesis is my original research work, and where there is work or contributions by other scholars, it has been duly acknowledged through citations given. This thesis has not been previously submitted to any other educational institution for examination. Reproduction of any part of this thesis is prohibited unless permission is granted by the author or the University of Nairobi.

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Dedication

To my maternal Grandmother,

Naomi Wangui Kibue (Wakiriri).

Thank you for pointing me to the need of

modern technology for geriatric persons. I

would have loved you to be around to see this

beautiful outcome, but our Good LORD had

better plans!

Koma Thayu Cucu!!

1930 -2018

Acknowledgement

Last, to my beloved, James Ng'ang'a Kamau, who has seen me through the different phases of 'painful' joys as he kept up with a schoolgirl through the years. Thank you for this incredible support!

Abstract

Over the years, the older person population has grown, currently at 9% of the world's total population. This growth is attributed to modern treatment advancements, modern technology, and improved living standards. However, the Kenyan 2019 census shows that 1.7% and 2.2% of its population represent male and female elderly (Kenya National Bureau of Statistics, 2019), respectively, a growing concern of their physical, social, psychological, and psychosocial well-being. Therefore, the older population needs are continuously growing and necessitate a better solution to ensure their comfort, sense of belonging and elevate self-worth.

Over the years, the physical, social and cognitive needs have been enabled by modern interactive mobile technologies commonly referred to as gerontechnology; to assist the elderly in their day-to-day activities, monitoring, exergames, social engagements, etc., encouraging active ageing. However, the interactive mobile interfaces are developed and evaluated technically, neglecting the users' emotional experience in determining the older adults' acceptance and adoption of modern technologies. Moreover, the technical assessments are domiciled in the traditional heuristics such as Nielsen's principles, Norman's heuristics, and Schneiderman's golden rules that have been followed over the years in universal design and not modified to the growing needs of users and evolving technologies.

The inclusive design calls for revision as geriatric persons have unique needs to be considered during design and development. The inclusive design creates a moment with the users, offering a natural interaction that changes how one feels about the system/application/product. Through observations and interviews, this research purposed to investigate the unique needs of geriatric persons and assess if modern technologies incorporate these needs. The researcher achieved this through a design for delight (D4D) methodology that involved eight participants; four were community dwellers, and four were residents of a philanthropic social home. We introduced touch technology; used tablets for ten weeks where games and interactive video and voice calls through a cross-platform experiment.

The researchers uniquely identified the participants' psychosocial features and users' emotions for modern technology usage. Perceived self-worth and subjective norm were the psychosocial factors that directly and indirectly affect the geriatric person's usage behaviour towards technology usage, contributing to Chen and Chan's STAM model (2014). The researcher considered the Psychosocial needs identified in this research for heuristic development to evaluate interactive mobile interfaces. Alrazgan et al. (2014) and Van Biljon et al. (2010) findings of look and feel, interaction, and functionality (as technical evaluation)

were compared to our results and brought out unique features that these scholars did not elaborate on.

This research also brought forth the psychosocial theme of generating psychosocial usability heuristics, which were defensible using the technical features for evaluation, affecting the behavioural attitude that determines usage. This research presents the heuristics guidelines that guide synchronous and non-synchronous activities such as mentorship and storytelling in an interactive mobile interface. The actions influenced the geriatric person's self-worth and sense of belonging as they believe they are a positive contributor to the surrounding societies through modern technology. For further works, the research recommends inclusion on mixed-age related issues to test the applicability of the proposed research model in determining user behaviour towards modern technology

List Abbreviations

AAL - Ambient Assisted Living

ATT - Attitudinal factors

CAQDAS—Computer-assisted (or aided) qualitative data analysis software

CDC- Centers for Disease Control and Prevention

CA - Cognitive Ability

D4D - Design for delight

ESMAC - Extended Senior Mobile Phone Adoption Checklist

FC - Facilitating Conditions

FDG - focus group discussion

G-A - Gerontechnology Anxiety

G-SE - Gerontechnology self-efficacy

HAI - Help Age International

HCI - Human-Computer Interaction

ICT - information communication and technology

ICG - Interactive Computer Games

KARIKA - Kenyan Aged people Require Information, Knowledge & Advancement

KNBS - Kenya National Bureau of Statistics

KNH-UoN ERC - Kenyatta National Hospital- University of Nairobi Ethical Research Committee

MPCU - Model of PC utilisation

PEOU—Perceived Ease of Use4

PSH - Philanthropic Social Home (PSH)

PU - Perceived Use

SMAC - Senior Mobile Phone Adoption Checklist

SNS - Social Network Sites

SR - Social Relationship

STAM - Senior Technology Acceptance Model

SN - Subjective Norm

TAM–Technology Acceptance Model

TA - Thematic Analysis

TPB–Theory of Planned Behaviour

UI–User Interface

UNDESA - United Nations Department of Economic and Social Affairs

UTAUT - Unified Theory of Acceptance and Use of Technology

UX–User Experience

VoIP–Voice over Internet Protocol

WHO - World Health Organization

Glossary of Terms

Community-dwelling old adults: Old adults above 65 years and are living independently *(Steultjens et al., 2004)*

COVID-19: It is microscopic, extremely contagious, clinically unpredictable (killing the fit and the frail, the young, and the old), and poses a significant threat to a modern way of life and health systems *(Aprahamian & Cesari, 2020)*

EMentorship: A form of mentoring relationship which relies primarily on electronic means for communication between a mentor and a mentee. *(Retrieved from https://www.igi-global.com/dictionary/concepts-technology-applications-mentoring/8857, February 2021)*

Geriatric persons: An older adult 65 years and above *(adopted from United Nations and Africa Union)*

Gerontechnology: Gerontechnology is an interdisciplinary field of research and application involving gerontology, the scientific study of aging and technology, the development and distribution of technologically based products, environments, and services. *(Fozard et al., 2000)*

Modern technology: Modern technology is about ensuring face-to-face communication, connecting you to your healthcare provider, and empowering you by giving you more access and control to the care you get and the service you receive. *(retrieved from https://aging.com/what-is-modern-technology-and-how-is-it-changing/, February 2021)*

Psychosocial wellbeing: influence of both psychological and social factors on an individual's mind or behaviour *(Cambridge Dictionary)*

Senior games: Recreation activities aimed at promoting physical, mental, and social activity to facilitate the good health of older adults *(Henderson et al., 2012)*

Successful aging: A multidimensional concept that encompasses domains of physical, functional, social, and psychological health *(Urtamo et al., 2019)*

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CHAPTER ONE: INTRODUCTION

1.1   Background

"Rigid and Dismissive notions of age and aging have no place in today's world."

Kofi Annan, Former Secretary-General, United Nations.

"As we get older, our rights do not change. As we get older, we are no less human and

should not become invisible." Archbishop Desmond Tutu.

Growing older is an experience that we all share (*Global AgeWatch Index 2015*, 2015), considering the increased numbers of older people in our society who are widowed, retired, or are empty nesters. The definition of older persons *(geriatric persons, senior citizens, and older adults used interchangeably)* in this research is adopted from United Nations (UN) and Africa Union (AU) as anyone above 65 years. Compared to the western - developed countries, the tradition in Africa had people living as extended families, which in most times meant living in a three-generation household (Grandparents-Parents- Children) hence it being a bedrock of care (Zimmer & Dayton, 2005). Unfortunately, the traditional support systems are changing and leaving the elderly taking the role of caring and supporting their home with meagre or no support at all, therefore, leaving them destitute and vulnerable to decline in physical, psychological, and social health.

Senior citizens, commonly referred to as *'Wazees'* in Kenya, slowly fade away with immense knowledge as they feel not dignified by society, as was the case years back. On the other hand, help Age International (HAI) states that the more older people are socially involved and physically taken care of, they feel like part of society, safe, and independent. However, the social and physical exclusion is apparent, though not in equal measures, when aging in place (in a familiar environment), in nursing homes (self-financed), and philanthropic social homes (controlled environment).

World Health Organization (WHO) implies that we can now afford to get old if regional and international organizations enact Active Ageing policies and programs. The central question is; are these policies, programs, and even heuristic guidelines for technological products tailored for older adults' needs, and are they also in context to the environment the senior citizens live in?

There is a considerable body of research dealing with the older adults in less developed countries that are showing a significant increase in life expectancy (Zimmer & Dayton, 2005; Beard et al., 2012; Jain, 2017; Jauregui et al., 2011; Ngaruiya et al., 2017; Ong, n.d.; UNDESA,

2017). The greying population's rapid growth is under-explored, hence the need for a radical change in supporting the elderly through their frail years. Income security, Health status, capability, and enabling environment are the metrics used by Help Age International (HAI) in measuring independent living for older adults **(Figure 1.1)**. HAI believes that in having the right balance in providing these services to the elderly, healthy living leads to an increased life expectancy. Various countries rank differently according to the policies and programs put in place by the state. Scandinavian countries (Sweden, Norway) top the list in catering for their senior citizens' well-being. In Africa, Mauritius and South Africa ensure that senior citizens' welfare is well taken care of.

Global Age Watch Index

Income Security	Health Status	Capability	Enabling Environment
Pension Income	Life Expectancy at 60	Employment of older people	Social Connection
Poverty rate in old age	Health life expectancy at 60	Educational status of older people	Physical safety
Relative welfare of older people	Psychological well being		Civic freedom
GNI per Capita			Access to public transport

Figure 1:1 Global Age Watch Index Domains and indicators for older person population: source Global Age Watch Index 2015

Considering the change in the population pyramid, we cannot ignore their growth in Kenya and the need to cater for their evolving needs. The population at the bottom of the pyramid is becoming smaller, while the pyramid's peak is gradually growing to show increased life expectancy in older persons. Unfortunately, with these growing numbers, governments face challenges in designing and implementing national strategies towards elderly care that include social networks and improved health care (Thumé et al., 2011) because of insufficient data. Rivera (2011), in a report for Help Age International, resonates with Thume et al. (2011) on some challenges encountered in health that includes lack of proper identification documents, limited/poor infrastructure hence the isolation for vital services and programmes that are not keen in advocacy to the older generation (HelpAge International, 2011).
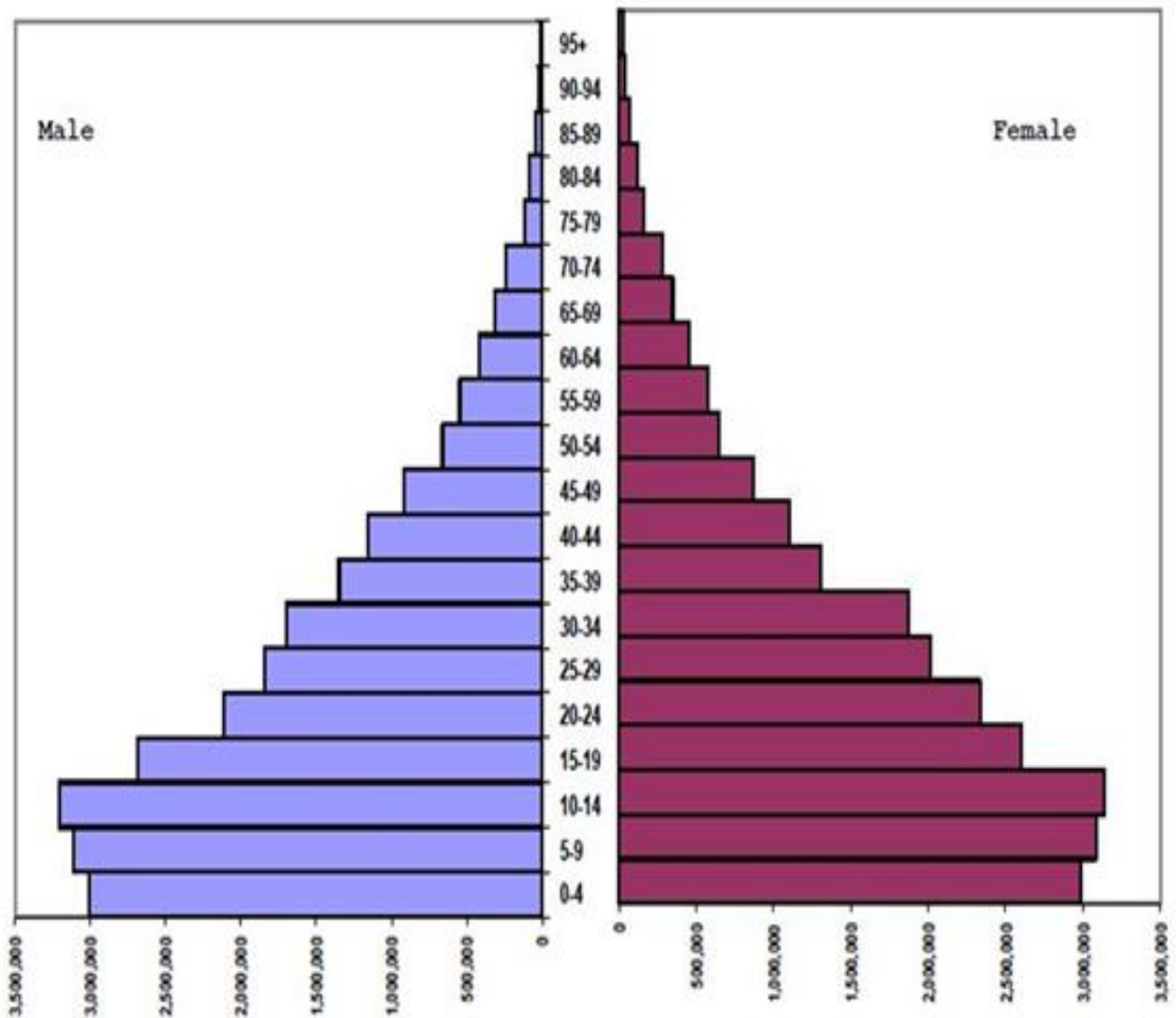
Figure 1:2 Population Pyramid of Kenya: Source (KNBS, 2019)

Looking into the population of geriatric persons, **Table 1.1** shows the aging population is more extensive in Eastern, Northern, and Western Africa than the other countries in Africa. Though there is a significant decline of the population from age sets 15-49 to 50-64, we can still see that these three regions record higher older person populations, and that could pose numerous challenges in developing countries if not looked into.

The older person population in Africa is currently rising compared to some countries such as China (comprising 14% of the world population). According to the 2019 revision of the World Population Prospects, the total population of older people globally was estimated to be 727,606,000 (9% of the total population) compared to 25% of the population aged between 0-14years. UNDESA estimates that in 2030 the older person population will rise to 1,402,000,000

(16.5% of the total population), and in 2050 the aged population will be at 2,092,000,000 (totalling 21.5% of the total world population). UNDESA states that the 42million geriatric persons in Africa will escalate to 212million by 2050, a growth of 19% of the total population

Table 1:1 World Population Prospects; Estimates. Population by age groups–continents and sub-regions and Population Count Census 2019, Kenya.
Source (UNDESA, 2020: KNBS, 2019)
(Values in thousands)

Age	0-14	15-49	50-64	65+	Total Population
World	1,983,649	3,927,780	1,155,764	727,606	7,794,799
Africa	540,830	649,433	103,238	47,096	1,340,598
Eastern Africa	186,199	217,049	29,108	13,050	445,406
Kenya	18,541	18,568	3,296	1,870	47,564
Middle Africa	80,883	82,359	11,392	4,961	179,595
Northern Africa	80,486	124,051	27,483	14,212	246,233
Western Africa	173,334	189,397	27,875	11,255	401,861

The 2019 Population and Housing census by the Kenya National Bureau of Statistics (KNBS) enumerated 47,564,296 people and shows the population grew from 37million in 2009 to 47 million in 2019, where 68.9% live in rural areas, and 31% live in the urban areas. The 2019 census shows that the older population was at 825,373 (1.7%) and 1,044,070 (2.2%) for males and females. There is a significant rise compared to the 2009 census data, which recorded 729,863 and 602,416 for females and males, proving a higher life expectancy.

Most older adults in Kenya prefer a rural settlement (as shown in the population pyramid) once they retire from their active working years. Unfortunately, some geriatric persons may find comfort in a philanthropic social home (PSH), while others will be community dwellers as they live together with their loved ones or caregivers because of various health issues. In either of these dwellings, the older people still need a social circle that engages them to keep physically and psychologically healthy.

In **Figure 1.2**, Kenya's population pyramid depicts a decline in fertility rate and a rise in life expectancy, attributed to modern treatment advancement, modern technology, and improved living standards (Fonta et al., 2017). The older person population is expected to increase by 4.7% annually between 2015 and 2050, reaching 10.6% of the total population (HelpAge International, n.d.). Therefore, this research cannot ignore this growth; hence, the need for attention towards the

older person population, supporting them physically, psychologically, and psychosocially. The growing needs of the older person's and the evolving technologies have to be thought about, especially in areas where they can appreciate technology by being contributors through it rather than being beneficiaries alone. The older persons as beneficiaries of technology are currently being exposed to modern technology, namely; mobile phones (that enable communication and mobile cash transfers such as [1]Mpesa, Airtel money), monitoring systems, social platforms and more, which gained a lot of interest during the pandemic that prohibited physical visits. For these needs to be well addressed, the research, through an inclusive design, proposes psychosocial usability heuristics for modern technologies to allow the older population to nonchalantly use different mobile technologies interfaces to support their physical, psychological, and psychosocial health.

1.2 Problem Statement

The growth of the geriatrics population globally presents a growing challenge in enabling successful independent living. The physical, psychological, and psychosocial health challenges require elaborate plans and strategies that are effective, flexible, cost-effective, and cater to the geriatric persons' needs to address these challenges.

Van Zaalen et al. (2018) states a generational gap exacerbates feelings of loneliness, depression, and anxiety that ultimately contribute to adjustment disorder. These change disorders' have been improved through modern technologies where the geriatric person can be monitored and socialize through the different synchronous and non-synchronous forums. Modern technologies such as Ambient Assisted Living (AAL) provide safety, emergency response mechanisms, and video surveillance systems to monitor daily life activities. The adoption of AAL in developing countries is dependent on different factors that can be compared to developed countries. These factors may include infrastructure, the cost to end-user, literacy levels, which might hinder acceptance and adoption in resource-constrained countries like Kenya. This prompt the question of what available technologies or frugal innovations can benefit older persons. The evolving needs of the older persons in developing countries and the growing technologies are not currently addressing the growing intergenerational gap. Therefore, there is a need for research to front the older persons as primary contributors through technologies. In resource constraint countries, this aspect of understanding and exploring the potential of modern technology in

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[1] Mpesa and Airtel Money are mobile money transfer services in Kenya

enhancing geriatric care (technology acceptance, use, and adoption among geriatric persons, behaviour change among the geriatrics occasioned by use of technology, and the degree to which technology improves geriatrics care) are under-explored, hence the need of this research.

1.3 Research Objectives

This research's general objective was to develop psychosocial usability heuristics to design and develop an interactive mobile interface for geriatric persons to support their psychosocial well-being.

Specific Objectives:

i.   To identify the psychosocial challenges, the older adults face as they age-in-place (Community dwellers) or in an Institution of care (Philanthropic Social Home)

ii. To explore the role of information communication and technology (ICT) application in improving geriatric persons' wellness and well-being.

iii. To identify design factors that define an interactive mobile device's design for psychosocial support of geriatric persons.

iv. To generate psychosocial usability heuristics from the identified factors for evaluation of interactive mobile interface for geriatric persons

1.4 Research Questions

i.   Which challenges do geriatric people face as community dwellers or as residents in an institution of care?

ii. How is modern technology impacting the wellness and well-being of geriatric persons?

iii. Which design factors are key in defining an interactive mobile device for psychosocial support in the geriatric population?

iv. Which heuristic guidelines can improve a geriatric interactive mobile interface design to support a geriatric person's psychosocial needs?

1.5 Scope

The research explored the use of modern technology in supporting the psychosocial health of geriatric persons. The sample population had eight participants drawn from two centres of the aged; a philanthropic social home and a day-care centre in Nairobi and Kiambu county. The research duration was ten (10) weeks, and during this duration, the researcher introduced two interventions that the participants engaged with.

1.6 Significance of the research

This research aimed to establish the emotional experience of geriatric persons as they used modern technology. While modern technologies have addressed geriatric persons' physical and psychological health, limited research has uncovered the psychosocial health brought about by modern technology used for geriatric persons' intrinsic satisfaction. Moreover, the recent Corona Virus pandemic has increasingly shown the dire need to diversify modern technology usage to the fast-growing older population, currently at 9% of the total population.

The existing modern technology is a 'design for all' approach or "a most-fit" for geriatric persons living in developed countries. Yet, in Kenya and Africa, cultural roles (advice, encouragement, sharing their experience, and telling historical events) must be embedded in these modern technologies to enable our elderly population to give back to society.

This research has the potential to impact the following stakeholders;

- Designers (UX), system designers, system developers, and technology solution providers; the heuristics evaluation guidelines will enable the designing and developing of disruptive frugal innovations and interactive mobile interfaces contextualized to the geriatric persons' needs

- Academics and research: According to their needs, the established psychosocial usability heuristic enhances users' profiling. They can expand the psychosocial usability heuristics in the context of the evolving geriatric persons' needs.

- Caregivers (formal and informal); The psychosocial usability heuristics will deliver desirable products to caregivers, enabling them to select appropriate interactive mobile interfaces significantly to improve a geriatric person's psychosocial health.

- Policymakers; the heuristic guidelines will implore them to consider policies that will enhance digital preservation of the different cultures and the historical testaments for the generations to come

1.7 Justification of the research

This research was necessitated by the growing population of the older persons, their growing needs and the evolving technologies. The research discusses the intergenerational gap that has continued to widen, considering the tenets practised in the traditional society vis-a-vis the modern ones. The older generation attests their good morals to their formative years where the old in the society had the mandate of mentoring, storytelling, mediating, teaching etc.; unfortunately, this cannot be said of for in the modern society, therefore raised as a concern by

them. The older person's physical and psychological needs are well catered for by modern technologies hence the advancement of AAL, which primarily takes care of them. This research went beyond technologies that cared for them and discussed how the older person could be a primary contributor through technology, impacting social technologies.

1.8 Research Assumptions

This research made the following assumptions:

- The technology the participants had earlier interacted with will enable them to learn the new touch technology quickly; therefore, transferring knowledge enables the actualization of the set objectives.
- The participants will gain the skills throughout the research period and will be able to genuinely share the strengths and weaknesses to contextualize the heuristics according to the underlying issues.
- The devices' temporal ownership would not demotivate participation; they will only access the devices during training.

1.9 Limitations of the research

- The philanthropic social homes and community centres in Kenya offer essential survival services; therefore, the touch technology introduced during the research still challenged some at the end of the research as technology usage is not necessarily a part of their lives.
- The psychosocial wellness of older people and modern technology is an under-explored topic; therefore, limited scholarly papers addressing the research problem enabled the researchers to understand the variations in different contexts.

1.10 Outline of the thesis

The researcher has organized the thesis as follows;

Chapter 1: This chapter introduces the readers to gerontology and gerontechnology as it shows the greying population's growth and why we need to research more on it. The problem statement is illustrated, and we specify research objectives to achieve this research's overall outcome.

Chapter 2: This chapter reviews previous works that informed the research; detailed introduction to gerontology, how modern technologies (gerontechnology) have tackled the challenges, COVID-19 and older adults, and finally, the influence of Aging and IS theories in developing the theoretical framework

Chapter 3: This chapter describes how the researcher designed the main study; the research design, the researcher's background and belief, the inclusion criteria of the participants, materials, and procedure used in the research, data collection, and analysis approach

Chapter 4: This chapter presents the results from the philanthropic social home, and the community centre coded as RedHouses and gives detailed discussions.

Chapter 5: This chapter presents the conclusions, contributions, thesis evaluation, and suggestions for further works

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction:

This chapter details the relevant literature within the social gerontology domain. First, we discuss geriatrics and modern technology; we explore the different aspects of aging and how modern technology addresses them. Second, we explore the literature on older adults and the COVID-19 pandemic. Third, we expound on psychological theories (theories of aging) and Information Systems theories. The theories are then contextualizing the psychosocial needs of geriatric persons. Finally, we derived the theoretical research framework that influenced the research in defining the factors to be developed in an interactive mobile interface for the psychosocial satisfaction of a geriatric person.

2.1 The Older Generation

According to United Nations and African Union, a working definition of a geriatric person is one whose chronological age is 65 years and above. World Health Organization (WHO) states that the actual definition of a geriatric person in Africa should be 50 or 55 years of age, therefore aligning to the definition of old age by Help Age Kenya; an older adult is anyone who has a blood grandchild; as they refer to them as grandparents, a term viewed by many as an older adult.

The United Nations Department and Social Affairs (2019) observes that the geriatric population has rapidly increased over the past decades, also evident in the population pyramid illustrated in **Figure 1.2**. UNDESA predicts that the geriatric population will outnumber the children's population for the first time in 2045. Jauregui et al. (2011) emphasize that the lower fertility rate and increased life expectancy of geriatric persons (older person population) is the reason for this exponential growth. In emphasizing the above, WHO states that the older population makes up 8% of the world's old age population; 12% in more developed countries and 6% in less developed countries (Prince et al., 2015). The older persons population's longevity is accredited to increased life expectancy (Zimmer & Dayton, 2005; Beard et al., 2012; Jain, 2017; Jauregui et al., 2011; Ngaruiya et al., 2017; Ong, n.d.; UNDESA, 2017). Recently, precisely December 2019, a pandemic (COVID-19) affecting most countries in the world surged geriatric person deaths. The most affected were older adults who were immunocompromised and exhibited existing conditions, therefore, being at high risk of getting infected and later succumbing to it (Abbatecola & Antonelli-Incalzi, 2020; Tay &

Harwood,2020; Lloyd-Sherlock, Ebrahim, Geffen, & McKee, 2020; Digiovanni et al., 2020), consequently thinning the population of the older generation in the world. An example, the Center for Disease Control and Prevention (CDC) states that 8 out of 10 Covid-19 deaths reported in the U. S have been in adults 65 years old and older (CDC, 2020). Goveas & Shear (2020); Shahid et al. (2020); Wells et al. (2020) inform us further of the COVID-19 and related deaths especially in older adults and people with underlying issues

2.2 The plight of the older generation

2.2 1 The burden of the older generation

Gschwind et al. (2014) observe that successful independent living is compromised by health and psychosomatic conditions (psychological distress, loneliness, abandonment, and isolation) as they age; therefore, calling for specialized care for geriatric persons. Literature shows that in both developed and developing countries, the older person population is non-receptive to nursing homes, preferring to spend their last years in familiar environments with the people that care deeply for them (Otieno, n.d.; Trydegård, 2000); therefore, the need for continuous social engagement/participation. As people age, they change various aspects of their lives; their social networks' quality, composition, and social networks frequency. The modification primarily directs to disengagement, which is more pronounced in the oldest-old individuals because of their deteriorating health. For social activities, acute events can hinder older adults' participation, such as hip fractures, cancer, cerebrovascular accidents, etc. The lack of participation often leads to self-isolation or is isolated by others; therefore leading to depression. Conversely, older adults with higher levels of social engagement live a satisfying life.

According to a documentary aired by SBS Dateline (2020), in showing the plight of a low caste of older adults in China, Confucius, the father of Shao (Filial Piety), established 2000 years ago, believed that family would solve everything. This changed with industrialization, where the younger generation went to cities searching for work, leaving their parents behind but found it hard to care for their parents at a distance, therefore abandonment. It became socially acceptable to abandon the elderly to pursue financial goals. This is changing as the Government put in place a law protecting the rights and interests of the elderly. This law provides a framework of how china deals with the aging population, the roles played by family, Government and community. In other countries such as Korea – with high suicides rate as

deaths reported every 33 minutes - older adults are part of the suicide statistics. Elderly people commit suicide because of diseases, loneliness, and economic hardship, as they fail to keep up with the '*Bali Bali*' (fast, fast) culture (Cornish, 2016).

2.2 2 Living Setups of the older populace

Björnsdóttir et al. (2015) state that living in one's own home is one of the significant signs of independence in advanced age. This is not so in most developed countries, where institutionalization or retirement homes seem to be a default choice for most geriatric persons. Without being socially engaged, aging-in-place has difficulties that are profoundly distressful and difficult in situations characterized by hardships such as poverty and loneliness (Portacolone, 2011). In Kenya, the high rates of independent but ostracized and abandoned older adults characterize the growth of these institutions of care, that is, philanthropic social homes (locally referred to as *Nyumba za Wazee.)*

2.2.3 Status quo of geriatric care in Kenya

The strong family interdependencies and community networks in developing countries have degenerated or have stayed damaged because of the fast societal and economic change. The increasing AIDS epidemic in sub-Saharan Africa has left the older adult the sole provider to the orphaned grandchildren, yet they had expected support from their children. Central Intelligence Agency (2021) places the dependency ratio at 69.8%, down from 87% as recorded by the Kenya National Bureau of Statistics & ICF Macro (Kenya National Bureau of Statistics & ICF Macro, 2014) in the year 2014 and also stated that it is 1.6 times more in the rural areas compared to urban areas. The dependency ratio is higher on children than the elderly population; therefore, the priority is educating the children rather than caring for the elderly. HelpAge International reports that the middle generation may not be supportive; thus, when push comes to shove, the elderly must step in (as frail as they are) and take care of their grandchildren. This situation is an emotional toll on them, and it's a financial strain to them too (HelpAge International, 2008), forcing the aging person to engage in subsistence farming to feed on and for sale to settle other needs such as school fees for their grandchildren. These hardships make them ignore their health, which deteriorates till they become immobile.

Older adults may continue living in familiar environments (community dwellers), nursing homes, or philanthropic social homes (PSH). We expound on these forms of settlements a bit to better understand Kenya's seniors' status quo.

PSH in Kenya has a unique setup compared to nursing homes; it is home to many older adults who are lonely, alone and abandoned. The homes are faith-based, privately owned, or managed by a county government. The faith-based homes and the County government (commonly referred to as Nyumba za Wazee in Kenya) heavily rely on well-wishers and are partially donor-funded (if any) therefore having basic care nursing homes. The entry criteria in these homes, older adults from impoverished backgrounds, should show that they cannot afford daily living necessities. In some faith-based homes, terminal illness is a disqualifier for admission, as they cannot afford or sustain such treatments since they depend on well-wishers.

Privately owned nursing homes are residential apartments or cottages designed for older adults. Depending on the type of care, these homes' residents pay about Kshs 200,000 [2](USD 2000) per month for the general care and Kshs. 300,000 (USD 3000) for dedicated care where an elderly has a caregiver round the clock. The elderly in these homes enjoy lavish rooms and are given attentive and comprehensive care by qualified nurses. They also have a shared lounge area where they meet for social activities and meals. For faith-based and county government homes, they cannot think of these luxuries because of cost implications. The caregivers in these homes cannot provide attentive care for each individual, as they are very few and have little experience handling the aged. Unlike the nursing homes where the caregivers are trained, the caregivers in these philanthropic homes have limited or no training and may only take up the job to make ends meet.

On the other hand, we have community-dwelling older persons who have the advantage of daycare centres around where they live. These daycares are venues for meetups, social participation and educational purposes (majorly on awareness of older people's matters.) In addition, day centres like KARIKA (Nairobi County) and MISCOP (in Kiambu county) generate sustenance money through activities such as dressmaking, weaving, beadwork (done by ladies), briquette, and detergent (done by men). Therefore, the impetus encourages social participation, keeping the geriatric person engaged and in a social circle that takes care of them.

Any geriatric person's social aspect is paramount as it keeps them physically and socially active, limiting sedentary lifestyle and subsyndromal depression that disengages them from the larger society. Many are times that the physical interaction is limited because of constraints such as distance, work engagements, etc. Modern technology is easing this by allowing telephone and video communication between older adults and their loved ones.

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[2] Exchange rate of 1 Dollar= Kenya Shillings 101.35 as at year 2019

2.3 Geriatric challenges and modern/digital technology

Geriatric person's significant challenges have been categorized as either physical, psychological, or both (Azeem & Naz, 2015; de Souto Barreto et al., 2016; Jerez-Roig et al., 2016; Teixeira, Raposo, Fernandes, & Brustad, 2013; Yaffe, Barnes, Nevitt, Lui, & Covinsky, 2001). Hence, they need support physically and emotionally, hence the co-residence with close family members (instrumental/tangible and psychological support). According to WHO, aging is taking place alongside other broad social trends that will affect older people's lives. Economies are globalizing, people are more likely to live in cities, and modern technology is developing rapidly. Demographic and family change (evident in the population pyramids across the world) means there will be fewer older people with families to care for them; as people today have fewer children, are less likely to be married, and are less likely to live with older generations (WHO, 2011).

In their late (higher) years, the elderly, aging-in-place, and institutionalized adopt a sedentary lifestyle once left in isolation; this is a marker of either physical or psychological problems. Therefore, we discuss sedentary lifestyles and how modern technology has eased the physical and psychological challenges, especially mental challenges in older adults.

2.3.1 Sedentary Lifestyle in the elderly

From an active lifestyle to a sedentary lifestyle, this change harms the elderly in their later years. An older man who used to work and an older woman who used to take care of the shamba[3] and the household would later have to depend on someone else to carry out these activities as they are no longer independent, mainly because of their health. Some will accept that age has caught up with them, yet the majority will still deny that they can no longer be independent. The latter affects them mentally and may later slip into *subsyndromal depression* (Leask et al., 2015), isolating them from others. The disengagement may lead to illnesses such as; obesity, respiratory impairment, and dyspnea (Vaz Fragoso et al., 2014; Woo, 2015), lack of quality sleep (Holfeld & Ruthig, 2014), and premature deaths as others opt for assisted deaths "euthanasia" as seen legalized in Belgium (SBS Dateline, 2015)

Sedentary behaviour, first noted in the 17th century (Tremblay et al.,2010), has been described as low energy expenditure activities that approximate resting metabolic rate, i.e., body movement is minimal (Dietz, 1996; Tremblay et al., 2010), and it includes activities such

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[3] Shamba: This is a Swahili word for a garden

as sleeping, sitting, lying down, watching TV, (Proper et al., 2011) as illustrated in **Figure 2.1**. Sedentary behaviour is by far the most crucial factor affecting the quality of life in older adults (de Bruin et al., 2008), especially in elderly above 80 years where sitting or lying is the dominant mode of posture; therefore, energy expenditure is low (Leask et al., 2015). Sedentary behaviour is associated with deleterious health outcomes that differ from those attributed to a lack of moderate to vigorous physical activity (Tremblay et al., 2010). Tremblay et al. (2010) though not addressing the elderly population, shows that exposure to a sedentary lifestyle, in this case, exposure to television to infants, decreases the language development scores and is associated with an attention problem.
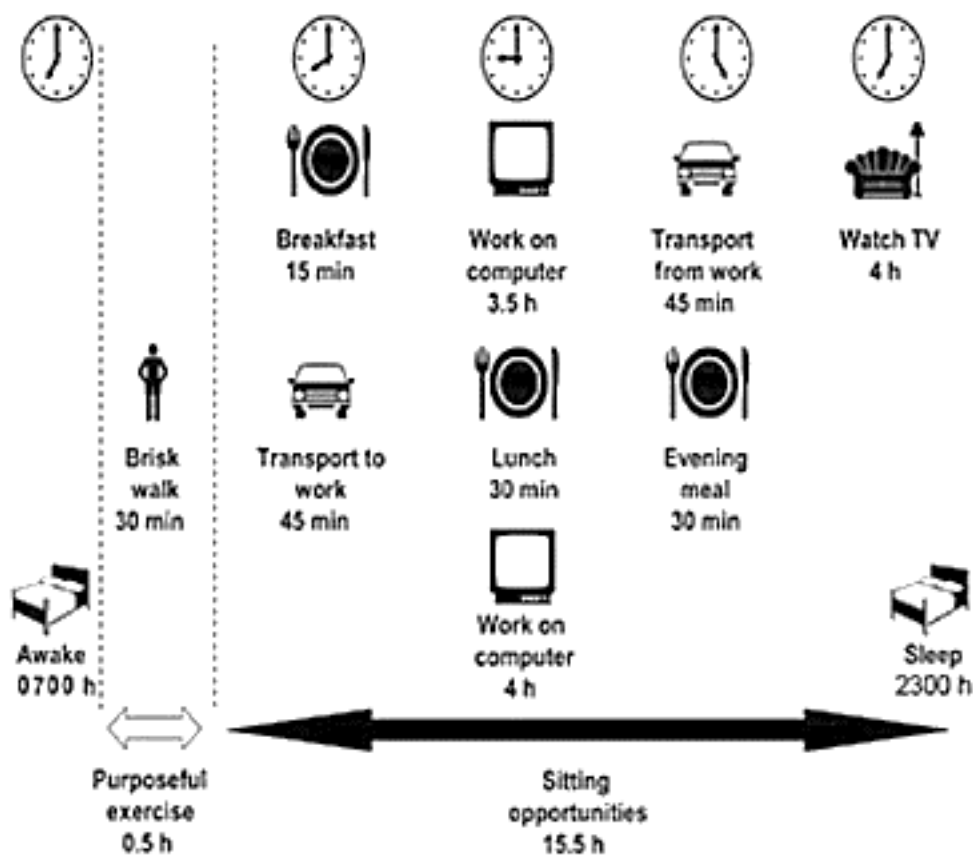
Figure 2:1 Primary contexts for sedentary behaviour and their distribution over a typical adult waking hour. Source: (Tremblay et al., 2010)

In a desktop review, Van Zaalen et al. (2018) found that some studies view technology as a generational gap that exacerbates feelings of loneliness, depression, and anxiety that ultimately contribute to change disorder. Van Zaalen and colleagues show that most studies showed that technology has had a significant favourable influence on them and presented as the only possibility for alleviating psychological conditions (van Zaalen et al., 2018). ICT interventions have also shown a need to improve physical health, especially where an older

person's dexterity is limited, affecting their ability to carry out tasks necessary for daily living (Zimmer & Dayton, 2005).

These modern technologies, not incorporating the growing geriatric person's needs, limits usage by an older adults living in developing countries because of cultural differences, self-efficacy dynamics (knowledge in modern technology use), and limited infrastructure.

2.3.2 Modern technology in the sedentary stage

Disturbance in executive functions (problem-solving, decision making, etc.) reduces dependency, affecting many older adults, leading to depression, hence isolation. This is where digital and modern technology infuses mental solutions, hopefully making these older adults become *technogenarians*. Modern and digital technology works successfully (Báez, Ibarra, Far, Ferron, & Casati, 2016; Haris, Majid, Abdullah, & Osman, 2015; Kucher & Weyns, 2013.; Mainetti, Manco, et al., 2016; Mainetti, Patrono, Secco, & Sergi, 2017, 2016; Manti, Pratesi, Falotico, Cianchetti, & Laschi, 2016; Salmon et al., 2017) in reducing health challenges that are inevitable in the aging society.

Gaming has increasingly promoted fitness training for all ages, considering the multiple platforms available for participation. Interactive Computer Games (ICG) for the elderly have grown over the years but need improvement by knowing their preferences and usage habits (Salmon et al., 2017). IJsselsteijn et al. (2007) and Bleakley et al. (2015) echo the importance of ICG in sedentary life that includes exercise and movements that integrate cognitive processes (e.g., board games, quizzes) for memory stimulation/attention abilities and various motor challenges. This research considered older person types of games that Salmon et al. (2017) describe as easy to learn and play. For example, the Nintendo DS platform, *'Dr. Kawashima's Brain Training: How Old Is Your Brain?'*; this software puts players on a daily regimen of number games, word puzzles, and reading exercises, hence testing the player's intelligence levels (brain age) in quizzes that involve attentional and memory processes. In addition, it saves the results to track and compare progress with others, introducing a social component (Ijsselsteijn et al., 2008). Cognitive activity does not necessarily need physical activity where one moves their limbs; rather, it can also deal with the effect on memory and focused attention (Basak, Boot, Voss, & Kramer, 2008); Peretz et al., 2011; Smith et al., 2009). In another study concerning cognitive improvement, Torres (2011) sampled 43 participants of Portuguese nationality and belonging to a residential home who used video games to test their cognitive abilities; the results showed a positive influence on their health.

Mental engagements using interactive computer games have shown improvement of both cognitive functioning and alleviation from depression. Rosenberg et al. (2010) and Young et al. (2011), using exergames for subsyndromal depression and assessing and training standing balance in older people, respectively, reported good compliance and positive feedback of the intervention and would continue to use it over a more extended period. In a related study by Rosenberg et al., (2010), the scholars observed that the use of exergames, whereby the participants play different sports (golf, tennis, bowling, etc.), using a remote wireless device, had an improvement in cognitive functioning and improved physical wellness.

This, therefore, shows the significant impact of modern technology on the different physical and psychological needs of an older person.

2.4 COVID-19, older adults, and modern technology

The traditional heuristic guidelines vis; Schneiderman golden rules, Nielsen's heuristics, Norman's principles have primarily been used to measure usability and user experience of design products void of the older persons' growing needs and growing technology. The intergenerational, intercultural communication and socialization are the additional needs of geriatric persons, yet guidelines to influence policies and design are void. This then poses a challenge; whereas modern technology is continuously aiding geriatric persons to take care of their health, is the growing technology allowing them to settle in modern society? This section discusses how the pandemic has revolutionized the usual way of carrying out day-to-day activities, especially how geriatric persons consider technology more than before.

Corona Virus, commonly referred to as COVID-19, is a pandemic that distresses public health authorities worldwide. It is described as microscopic, extremely contagious, clinically unpredictable (killing the fit and the frail, the young, and the old), and poses a significant threat to a modern way of life and health systems (Aprahamian & Cesari, 2020). The world was primarily unprepared for this, and it is overwhelming mainly to the most vulnerable population; the older persons (Polidori et al., 2020). The mortality rates are exceptionally high in older people (Tay & Harwood, 2020) as the risk of dying with COVID-19 increases with age (Lloyd-Sherlock et al., 2020). The older person cannot physically socialize (Nagarkar, 2020), cannot take walks outside (Lakicevic et al., 2020), are not physically attended to in a health facility (Lim et al., 2020; Lakicevic et al., 2020), and worse, a negative attitude towards ageism for COVID-19 treatment (Ayalon et al., 2020) where there was favouritism in treatment; youths treated and older adults left to die. Various control measures are in place to reduce infections

in highly susceptible populations. These measures include; physical distancing and vertical isolation, avoiding handshakes (Aprahamian & Cesari, 2020; Berg-Weger & Morley, 2020), and COVID-IAGG-AO guidance (Lim et al., 2020) to ensure physical distance and self-isolation to protect them from the pandemic. Nursing homes, relatives of community-dwelling older persons, and other living setups of older persons are encouraged to minimize in-person visits (Digiovanni et al., 2020) or ban visiting altogether, therefore compelled to develop innovative ways to keep in touch (Berg-Weger & Morley, 2020).

Digital technologies pervade all aspects of our lives, as seen with high-level technologies' digitization of everyday life (Seifert, 2020). Morrow-Howell et al. (2020) urge us to see opportunities to improve older persons' lives despite the challenges brought about by the pandemic. These opportunities pertain to increased connectivity through technology to families and intergenerational relationships that will improve quality of life by reducing social isolation and increasing self-care and management (Morrow-Howell et al., 2020). The older people's motivation and opportunities to learn have grown and created a 'sink and swim' moment for many unskilled and reluctant users (Morrow-Howell et al., 2020), though let us keep in mind that it is not a way for all (Seifert, 2020).

The COVID-19 pandemic has presented a significant opportunity for digital technologies (Doyle & Conboy, 2020) and modern technologies; mobile and web-based platforms for social participation and interaction have reduced physical contact, a high risk for the older population. In Kenya, the pandemic saw a rise in the active mobile subscription at 59.81 million subscribers by the end of September 2020, up from a 55.2million recorded by the end of March 2020; mobile money transfer at 31.79million in September 2020, from 29.1 million in April 2020 and data usage at 43.45million in September 2020, from 39.39million in April 2020 (Communications Authority of Kenya, 2020a, 2020b, 2020c). Berg-Weger & Morley (2020) write how social workers became creative and resourceful in staying virtually connected with older adults through digital devices to allay loneliness, social isolation, and anxiety. These digital and mobile technologies have enabled older generations to stay socially abreast, hence not missing social events such as weddings, religious activities, social activities, and even burials.

The digital platforms have been the link to engage in social isolation and health consultations. Online technologies, regular medical monitoring, psychological therapies, phone calls from/to loved ones, and healthcare personnel (Aprahamian & Cesari, 2020) are some services dominating the pandemic period. Online tools such as Vivifrail for physical activities

(Aprahamian & Cesari, 2020), ALONE for assessing loneliness and social isolation (Berg-Weger & Morley, 2020), telehealth (Digiovanni et al., 2020), *Students to seniors* for virtual conversations, *Zoomers to Boomers*, an intergenerational grocery delivery service (Morrow-Howell et al., 2020) and online group interventions have showed decreased loneliness, social isolation and increased feelings of well-being (Berg-Weger & Morley, 2020; Digiovanni et al., 2020). Retirement homes have been able to keep in touch with the residents' families to update them on their progress through different platforms. In the pandemic, we achieve digital social connection through WhatsApp, Facetime, zoom, and many other videos and teleconferencing platforms.

Taking advantage of this pandemic period, many older adults adopt digital and modern technologies (Conroy et al., 2020; Drouin et al., 2020; von Humboldt et al., 2020), considering the restrictions of physical contact, therefore, reducing social interactions. This aids the research in exploring user-friendly modern technologies for communication to promote mental resilience by increasing social interaction. Intergenerational contact (between the young and old-established) can now be moved to a technological platform instead of a physical discourse, enabling solidarity and relatedness. These modern technologies should motivate and elicit enjoyment in the older population for as long as they can use them, especially in health and psychosocial wellness.

Why this research?

The key lessons from the above sections are;

- The geriatric population is taking an upward trajectory in a majority of countries all over the world. Kenya's recent census data shows that life expectancy has increased while the fertility rate is slowly declining. This population's growth is an alert for keenness in policies, strategies, programs, laws and gerontechnology that meet their needs.
- The geriatric population prefers aging-in-place actively and productively. Unfortunately, this is not the case for older adults, therefore, disengaging from society or leading a sedentary lifestyle as they are cared for by loved ones or in an institution of care. This affects their later years as they slip into subsyndromal depression and loneliness, resulting from or coexisting with social isolation.
- While aging, various modifications affect their physical, psychological, and social life. These modifications have non-technological and technological solutions that have to ease

the surrounding difficulties. For example; physical exercises, exergames, eMonitoring, social network sites, etc

- Gerontechnology is specifically designed by incorporating the needs of the geriatric persons in the developed countries, therefore compelling developing countries to appropriate, yet ignoring the varying context (background, beliefs, technology knowledge, culture, etc.). Contextualization in the design and development of modern technology should ensure that the older person population is a positive consumer of technological products.

- While reporting on disruptive technologies, International Finance Corporation (2020) states that Kenya is one country that experienced the most significant acceleration of technology and digital solutions during COVID-19. In the UK, Center for Ageing Better Evidence Officer Nayyara Tabassum reports increasing internet users in the 65-74 age group, which rose from 52% in 2011 to 83% in 2020 (Tabassum, 2020). In addition, because of physical restrictions and being at high risk of contracting the virus, unenthusiastic geriatric persons have resorted to using these technologies. This creates a positive environment to roll out technology products that can help improve their physical, psychological, and psychosocial wellness, therefore, experiencing low disengagement rates in a society.

These sections have primarily contributed to research objective 2 in understanding through literature the status quo of the Kenyan geriatric persons and exploring the gerontechnology that supports the geriatric persons' wellness and well-being.

Table 2:1 Summary of study characteristics in disease burden and technology

Study	Participants	Intervention	Summary of outcome and results
Wollersheim, Merkes, Shields, & Liamputtong, (2016)	n= 11 Community-dwelling older women aged between 56-84 with limited mobility and were in a planned activity group Investigates: Physical and psychosocial effect of exergaming	**RT3 accelerometers** on their waists to measure intensity and duration of physical activity Baseline: 20 minutes, 12 sessions, 3times, 6-week period Intervention: Wii game, mean duration 51minutes per person, 6 weeks	**Psychologically:** i. Choice of games generated and sustained interest. ii. Interest in playing to establish common interests with their grandchildren iii. Bonding during the intervention period iv. Stimulated their cognitive ability **Physically** i. Keeping active keeps them happy (i.e., arms stronger, can do more steps after the intervention
Chopik (2016)	n=591 American participants aged 50+ Investigating: Association between social technology use and mental and physical health	**email, social networking sites, online video/phone call, online chatting/instant messaging, using a smartphone**	Loneliness mediated the link between technology use and mental and physical health, which predicted better mental and physical health
Studenski et al. (2010)	n= 36 aged 65- 89 years and able to walk a minimum half-mile, recruited from 3 senior living setups	**Interactive video dance games:** played on a dance pad with four arrow panels, which are stepped on by the elderly in response to the arrow being shown on screen	The gain in balance sensorimotor coordination and cognitive skills

	Investigating: to evaluate interest, feasibility, and safety of an interactive video dance game for use by elderly people	30 minutes, 2 times in a week, 24 sessions, 3 months	
Graves et al. (2016)	n=13 old adults aged 45-70 years Study about: evaluate the physiological cost and enjoyment of interactive games versus handheld gaming (sedentary video gaming) in older adults	**Wii fit activities** (yoga, muscle conditioning, balance) and Wii aerobics (brisk treadmill walking and jogging) Fitted with MetaMax 3B (measuring oxygen consumption and heart rate) and performed an ordered routine	Oxygen consumption and heart rate were more significant in Wii activities than in handheld activities. Wii Fit appears to be an enjoyable exergame for the elderly stimulating light to moderate-intensity activity through the modification of typically sedentary leisure behaviour
Rosenberg et al. (2010)	n= 19 community-dwelling older adults aged 63-94 years with subsyndromal depression and fluent in English study: Exergames for subsyndromal depression in older adults	**Nintendo Wii gaming console (Tennis, bowling, baseball, golf, and boxing)** Using the Wii remote- a wireless device with motion-sensing capabilities where the participant uses arms to stimulate actions engaged in playing the actual game 3x35 minutes sessions a week for 24 weeks (12 weeks of study and follow-up study at week 20-24)	Significant improvement in depressive symptoms, mental health, and cognitive functioning
Smith et al. (2009)	N=436 (n=223 as the experimental group and n=213 as the control group) community-dwelling older adults aged 65+ without a diagnosis of clinically significant cognitive impairment	**Brain Plasticity- Based Experimental Treatment vs Active control** It contained six computerized exercises designed to improve the speed and accuracy of auditory information processing.	The training programs had a significant effect on cognitive functioning, showing a more remarkable improvement in the experimental group than in the control group

Study: To investigate the efficacy of a novel brain plasticity-based computerized cognitive training program in older people

Active control involved paper-based exercises like quizzes

2.5 Theoretical development- Description of models and constructs

In theory development, Whetten (1989) writes on essential elements that make a theory complete; (i) What-: The factors considered as part of the explanation of the social or individual phenomena of interest, (ii) How: How are the identified factors related in a causal relationship, (iii) Why: The underlying psychological, economic, or social dynamics that justify the selection of these factors (iv) Who-Where-When: this is the context of a study that determines generalization. We start by discussing the theories of interest: the aging and Information Systems (IS) theories and identifying the factors built into the theoretical framework.

The Aging and IS Theories

The increase in longevity and the rise of aging populations have contributed to concerns and joys and require older individuals, researchers, and policymakers to join forces and develop sustainable solutions (Catrinel Craciun, 2019). This, therefore, brings forth the need to explore the aging models and IS theories that contribute to the growing needs of geriatric persons and relate these needs to the growing modern technologies.

Every domain has a theory that revolves around the characteristics or behaviour of its people. For example, in technology, existing information systems theories such as STAM by Van Biljon and Chen and Chan (Chen & Chan, 2014; Renaud & Van Biljon, 2008) have studied the acceptance and adoption of the geriatric technology environment. Conversely, in psychological aging, there are three theories, as shown in **Figure 2.2** below.

Theories in Aging

Biological Theories
- Cross-Linkage Theory of aging (1941)
- Oxidative Stress theory (1956)
- Theory of Somatic Mutation (1958)
- Immunological Theory of Aging (1964)
- Evolutionary Theory of Aging
- Disposable Soma Theory (1977)

Psychological Theories
- Cognitive Plasticity (Neuro Plasticity (1923)
- Life Span development theory (1959)
- Socio-emotional selectivity theory (1993)
- Positivity Affect Theory

Social Theories
- Disengagement Theory (1960)
- Activity theory (1961)
- Sub-culture of Aging theory (1962)
- Stress theory of Aging (1965
- Continuity Theory (1971)
- Theory of Age stratification (1972)

Figure 2:2 Theories in Aging: Source:

We reviewed the three prominent theories from social gerontology and the IS theories to conceptualize variables derived from this research. The three social theories reviewed were; Disengagement theory, Activity theory, and Continuity theory. These three theories portray the social life of the old life; as guided by the objectives.

2.5.1 Theories in Aging

In defining successful aging (or normal aging, as described by (Atchley 1989)), Havighurst (1961), as quoted by Johnson & Mutchler (2014), identified it as an experience of joy, happiness, and satisfaction in later life. This definition is contributed to by other authors who bring in the status of health of an individual. Rowe & Kahn (1997) position three components in successful aging; the *low probability of disease and disease-related disability, high cognitive and physical functional capacity, and active engagement with life.* Conversely, Johnson & Mutchler (2014), emphasizing Rowe and Kahn's definition, states that successful aging interplays between social engagement with life, health, and functioning. They further state that successful aging, productive aging (participation of older adults in activities), and civic engagement (awareness to involve older adults to further the community) represent essential contributions to the field of gerontology. Despite controversies, these successful aging models (Disengagement, Activity and Continual theories) still dominate social gerontology today as they provide an opportunity to change the opposing views on aging that linked old age with illness and decline (Catrinel, 2019). Bennett (2002) expounds on successful aging to social aspects encompassed in three broad headings: networks, support, and participation. We have considered the three social gerontology theories in our study; disengagement theory, activity theory, and continuity theory, that have driven conceptual transitions in this field and enabled the researcher to think differently about the aging population.

Disengagement Theory.

Following the release of their book "Growing Old," in 1960, E. Cumming, et al. (1960) developed the disengagement theory and defined it as an inevitable process in which many of the relationships between an old person and other members of the society are significantly severed and those remaining as altered in quality (Warren, 1973). Zhou, Liu, & Yu (2018), giving context, says that old age comes with deterioration in knowledge and skills and no longer meets society demands, together with social permission and acceptance; it is rational for an aged individual to disengage from society, and this process contributes to individual's well-

being (Nimrod & Kleiber, 2007). On the other hand, Catrinel Craciun (2019) observes that negative views on aging were associated with ill health and disengagement later in life that enhanced individual disengagement or societal disengagement, leading to depression that predicts mortality (Bennett, 2002). Burbank (1986) states that either the geriatric person or the society can start the disengagement process. Case in point, retirement; society has made withdrawal easier for individuals once they have retired from active work life. The older adult may not have friends to engage with as most of his friends could have moved to their retirement home, which could be a distance off from each other; this means being freed from normative control and disengaged.

Disengagement has tried to be solved by reminiscing theory; an independent nursing intervention where an individual goes through memory selection, immersion, withdrawal then closure with the expectation on the older adult to come to terms with their past, hence helping them cope with stress (Yen-Chun et al., 2003). This has worked for some; Yu, Mathiason, Johnson, Gaugler, & Klassen (2019) used a technology-enabled reminiscence therapy through a game for the demented older adults. The purpose of their study was to evaluate the preliminary efficacy of memory matters in terms of mood and social interaction. Through an experimental design, 80 older adults engaged in a memory game for 30minute a session, twice a week for 12 weeks. The outcome; social interaction in the older adults improved, and they established a slight improvement in mood. Fairhall et al. (2014) found deteriorating social participation while studying community-dwelling older men, as they cannot keep up with their life roles due to age-related issues.

Table 2.2 shows the disengagement concepts, their meaning, and how they are measured

Table 2:2: **Concepts for Disengagement Theory: Source: (E. Cumming, et al., 1960)**

Concept	**Conceptualization**	**Operationalized**
Disengagement	Inevitable, mutual withdrawal resulting in decreased interaction between older adults and the society	Lack of central task (support system) Decreased ego investment
Society	Those concrete cultural groupings to which an individual belongs; actually, or symbolically	Roles in a social group
Successful aging	Having high Morale	Social structure, self-concept, and personal identity, and life events

Exploring disengagement by itself poses a challenge as social engagement is paramount yet reducing the purpose of this research, which is to engage the geriatric persons to optimize social participation as alluded to in the Preliminary findings *(detailed in section 4.2).* Therefore, we have adopted the three concepts in this research to frame our analysis in view of how this theory has been applied in related areas.

Activity Theory.

Havighurst (1968) first propounded the activity theory, which later was a subject of revisions and refinements to formulations by Lemon, Bengtson, & Peterson in 1972 (Knapp, 1977). The theory claims that as one experiences age-related declines, social roles may become unattainable. Therefore, to preserve their self-identity in the face of these deficits, aging adults will replace lost social roles with new ones (Utz et al., 2002), reducing mortality (Bennett, 2002). Also, Zhou et al. (2018) suggest that older adults successfully age by staying active and fully engaging in social interactions. The new social roles (productive roles) include community-based social activities such as volunteering, paid work, and participation in social or religious groups (Pinto & Neri, 2017)

In its evolution, Lemon, Bengtson, & Peterson (1972) states that the essence of adding variables in the original activity theory is to show that there is a positive relationship between activity and life satisfaction and that the greater the role loss, the lower the life satisfaction. While formulating it, the scholars brought in the different activities that enabled them to hypothesize; *"Activity provides various role supports necessary for affirming one self-concept"* (Knapp, 1977). This means that the more intimate and more frequent the activity is, there is an expressed support accorded to an individual by his audience (family, friends, society, etc.) for his roles concerning his role identity (Knapp, 1977; Burbank, 1986).

Zunzunegui, Alvarado, Del Ser, & Otero (2003), in a longitudinal study among community-dwelling Spanish older adults, showed that due to few social ties, poor integration, and social disengagement, they were at risk of cognitive decline. Still, on cognitive skills, Hughes et al. (2013) conducted a study with older adults with mild cognitive impairment who were significantly involved in social activities and, therefore, showed potential benefits for preventing or delaying further cognitive decline. In addition, other studies (Bennett, 2002; Buchman et al., 2009; Knapp, 1977) on activity theory shows positive results when integrating social participation.

Table 2.3 itemizes the factors in activity theory

Table 2:3 Concepts in Activity Theory. Source: Havighurst, 1968; Lemon et al., 1972

Concept	Conceptualization	Operationalization
Activity	Activity is any regularized or patterned action or pursuit or personal maintenance	Informal Activity (social interactions with relatives, friends, and neighbours) Formal Activity (social participation in formal voluntary organizations) Solitary Activity (includes pursuits like watching television, reading, and solitary hobbies)
Life satisfaction	The degree to which one is presently content or pleased with their general life	Positive self-concept
Additions by Lemon, Bengtson, & Peterson (1972) to the original Activity Theory.		
Role supports	Expressed support accorded to an individual by his audience for his roles concerning his role identity	The intimacy of an activity (formal and informal activities)
Self-concept	This is the organization of qualities that an individual attribute to himself	Reaffirming role identities (Interpreting the reactions of others toward self to sustain social self)
Role Change (loss)	This is the alteration in the set of behaviour patterns expected of an individual under the loss of some status position within a given social structure.	Behaviour pattern after retirement, loss of a spouse, as an empty nester

Continuity theories

Robert Atchley was credited with developing this theory as the preferred strategy for aging (Atchley, 1989). The premise of continuity theory is that, in making adaptive choices, middle-aged and older adults attempt to preserve and maintain existing internal and external structures. They prefer to accomplish this objective by using continuity and applying familiar strategies in known life areas (Atchley, 1989). This theory states that successful people carry over their habits, preferences, lifestyles, and relationships into old age (B. Zhou et al., 2018).

Continuity theory still evolved in 1993 as Coleman, Ivani-challan and Robinson established the association between continuity and self-esteem (Nimrod & Kleiber, 2007).

Donnelly & Hinterlong (2010) compared the social participation and volunteer activity among widowed older adults. They found that older adults increase their reliance on other social support sources following the spousal loss and do not change their volunteer activities. This shows that continuity of volunteer engagement and enhanced social participation are essential during widowhood. Similarly, Curl, Stowe, Cooney, & Proulx (2014) found that productive engagement such as paid work, formal and informal volunteering was negatively

affected when the older person stopped driving. Their transition to non-driver status did not immediately compromise the social engagement since they were not limited to their proximal walks, and family and relatives kept in touch through telephone calls.

Table 2.4 itemizes the factors in continuity theory

<p align="center">Table 2:4 Concepts in Continuity theory: Source: Atchley, 1989</p>

Concept	Concept	Conceptualization	Operationalization
Internal Continuity (IC) *Psychological*	Self-concept *(Self-esteem)*	What we think and feel when we focus attention on our specific selves	Preferences, abilities, emotionality, personal goals, level of performance, attitudes, roles
	Identity	Aspects of self-personality that the individual sees as remaining with them regardless of the social situation (Whitbourne, 1986)	Ambition, Feedback from others, life events (such as retirement, widowhood, empty nesters)
External Continuity (EC) *Social Engagement*	Continuity of environment	Adapting to an environment and being able to deal with mundane tasks of everyday living	The movement to unfamiliar communities/centres from their households
	Roles Activity	Life roles such as a parent or even an employee or employer before widowhood and retirement, respectively	Role activity, ego investment, and change in role activity since age of 65years
	Relationships (social connections)	One's social support network comprises people one can count on for mutual aid, an affirmation of one's identity and goal structure, a sense of belonging, and intimate self-disclosure opportunities.	Amount of time spent in social interactions with family, friends, and society
	Life satisfaction	This is the degree one is presently content or pleased with their general life situation	-Taking pleasure in everyday activities -Regarding life as meaningful and accepting that which life has been -A balance between desired and achieved goals -Positive self-concepts -Mood tone (maintains a happy and optimistic attitude and mood)

Significance of theories of Aging

The aging theories are essential to this research as it categorizes the concepts significant in understanding the social aspect of the aging population. The social needs that define the emotional experience enabled the establishment of usability guidelines to be used by stakeholders in developing interactive mobile interfaces for geriatric persons.

The aging theories have significantly impacted sustaining geriatric persons where societies/communities are primarily involved. The underlying result from all these theories

depicts a significant increase or decrease in life satisfaction, impacted by society or self. The times have evolved, and often, the aged will find themselves alone since urbanization/modernization has migrated their children to far-off towns or even countries, inhibiting physical visits. Age-related issues also contribute to social engagement, which would ground many to a life of loneliness since there is no physical network, support, or participation. This has been made worse with the recent pandemic that inhibited physical relations with the aged, and therefore many are turning to modern technologies to make the life of the geriatric person less lonely.

As noted, the theories address normal aging, yet we term most older adults as pathologically aging; this means that they have a physical or mental disease that inhibits normal aging. We have defined normal aging in three categories, that is, network, support, and participation. We agree that these three will be easily achieved in normal ageing while still holding an argument on the same, though not in the same levels, that pathological aging can still achieve the three categories if they are well aided. This is where ICT innovations in gerontechnology should make a difference considering geriatric persons' emerging needs. The theories imbued with modern technologies enable continuity of activities, such as gaming and picking up new roles/activities like mentoring or storytelling through modern technology

Modern technology has addressed the three broad areas of social aspects for normal aging and pathological aging. This is the reason we should not look at the psychological factors in isolation from technology. This, therefore, being the motivation of this research, in line with the definition of active aging-in practice as healthy lifestyles, working longer, and remaining active after retirement (Koch, 2006)- a geriatric person is supposed to accept self and explore ways to experience joy, happiness, and satisfaction of life through modern technologies.

2.5.2 Information Systems (IS) models and Aging
The problems faced by older people in learning to use and engage with interactive technology are not confined to physical and cognitive factors only but also to attitude, perceived relevance of the modern technology to everyday life, usefulness, and usability, perceptions of learning abilities in later life, and the degree of social relationship with the interactive device (Turner et al., 2007). This research details the IS models paramount in understanding a geriatric person's perception of digital/modern technology.

Technology has grown over the few decades and more so in the domain of gerontology (Charness & Boot, 2009; Shore et al., 2018), where innovations such as gaming (De Schutter,

2011; De Schutter & Vandenabeele, 2008; Helbostad et al., 2016; Roberts et al., 2019) introduced to keep them both physically and psychologically fit. Various older adults have widely adopted modern technology such as radio, TV, and mobile phones. Similarly, recent assistive and robotics technologies are gaining traction, mostly in developed countries where social bots and even assistive bots are used in smart homes for aged people. Gerontechnology is the proper term to use; this technology has specifically been built for the aging generation, considering their unique needs. In addition to the definition of gerontechnology, Chen, Hoi, & Chan (2014) state that it increases independent living and social participation, therefore significantly easing aging-related problems, resulting in better health and comfort and assuredly safety continually.

Geriatric persons' acceptance and adoption of modern technologies can be accredited to the alignment of their needs and the promising opportunities of technology. Over the few years, this group's uniqueness has been inclusively designed for and successfully implemented in older people's physical and psychological wellness. As Chan and Chen (2014) put it, technology acceptance models are beneficial. Still, to better understand and predict older people's technology usage behaviour, it is essential to identify the factors influencing their acceptance and usage of technology (Chen & Chan, 2014).

Over the years, several theories and models have been proposed and tested, including Theory of Reasoned Action (TRA) by Fishbein and Alzen, which later was used by Davis, Bagozzi, & Warshaw (1989) to build on the Technology Acceptance Model (TAM) and later Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al., (2003). From these models, Renaud & Van Biljon (2008) and Chen & Chan (2014) added on exclusive characteristics, abilities, and limitations of the older person population to develop the senior technology acceptance models (STAM).

We specifically examined the two models specified to the older person population to accept and adopt the technology. The following section briefly discusses these two STAM models.

Senior Technology Acceptance and Adoption Model (STAM)

Van Biljon, a scholar from South Africa (Renaud & Biljon, 2008; Van Biljon et al., 2010; van Biljon & Renaud, 2016), has studied older adults behave when using mobile phones. In 2008, (Renaud & Biljon, 2008) proposed STAM (in **Figure 2.3**) by stating that it is essential to merge the acceptance and adoption approaches, as adopting an artefact cannot occur if one has not

accepted. This has shifted the markets from acknowledging that designers must understand the underlying issues that the consumers face for acceptance and adoption.
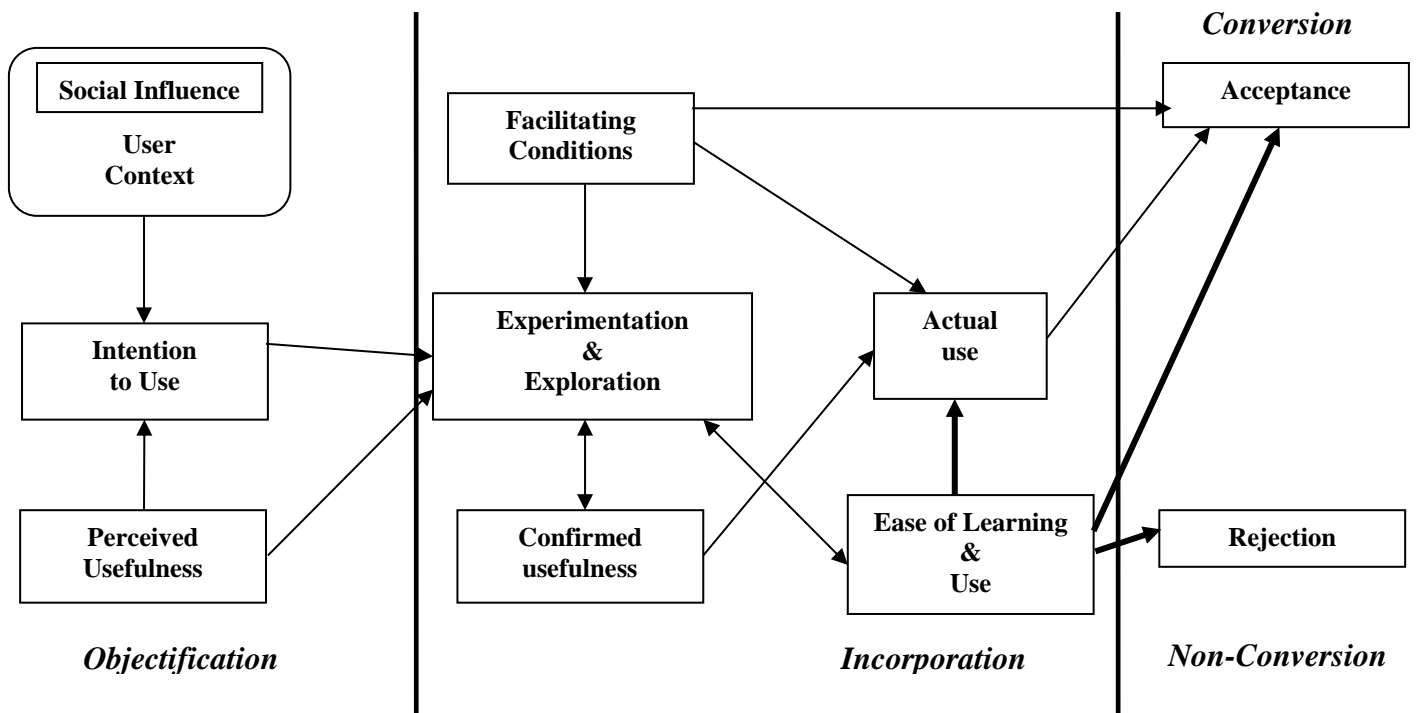
Figure 2:3 Senior Technology Acceptance and Adoption Model (STAM) (Source: van Biljon & Renaud, 2008)

Chen & Chan (2014) later enhanced the STAM, formulated by introducing certain modifications into the original TAM and UTAUT. It practically considered the biophysical and psychosocial characteristics, abilities, and problems experienced by older adults. It shows that acceptance was defined as positive attitudes and usage of technology, predictive factors (such as gerontechnology self-efficacy, anxiety, facilitating factors, PEOU, PU, and attitude), and age-related health and ability constructs (self-reporting health conditions, cognitive abilities, attitudes towards aging and life satisfaction, social relationships, and physical functioning)

Table 2:5 Concepts and meaning of STAM by Biljon and Renaud (2008)

Concept	Conceptualization	Operationalization
Perceived Usefulness	the extent to which a person believes that the proposed system/artefact will enhance their job performance	How technology helps them in their day-to-day activities
Intention of use	influenced by Perceived usefulness and by user context	The people around them supporting and influencing them in using modern/digital technologies?
Facilitating conditions	referring to the mobile infrastructure and cost as determined by the business model of the service providers	Geriatric perception towards the digital technologies
Experimentation and Exploration	is where the user uses the system and forms a first impression of the ease of use	It affords them to use more features of the sampled interventions
Ease of learning and use	Results from perceived ease of use that shows the extent to which a person believes that using the system will be free from effort	It affords them to learn and use without getting frustrated.
Confirmed usefulness	The usefulness of the person's phone to them	How often do they use their mobile phones, for what purpose?
Actual use	The acceptance and adoption of the system in your everyday life	It is part of their day-to-day activities

This version of STAM (Chan and Chen, 2014), as shown in Figure 2.4, has an impressive look, incorporating the cognitive abilities and psychological factors paramount with aging, making technology have the aesthetic view of being a panacea to healthy independent living. This model makes it ideal for the adoption of various variables for this research. Chen and Chan's model was derived after a survey that measured three significant sections: the acceptance of gerontechnology, older people's health and ability characteristics in Hong Kong Chinese, and demographics. The findings show that Usage behaviour, measured as a self-reporting degree of modern technology, was influenced by the attitudinal factors (PU and PEOU), the health and ability characteristics (cognitive ability, physical functioning, and social relationships), and the other predictive factors, vis; gerontechnology self-efficacy and anxiety, facilitating conditions. The concepts are defined and illustrated on how the scholars measured them in **table 2.6** below.
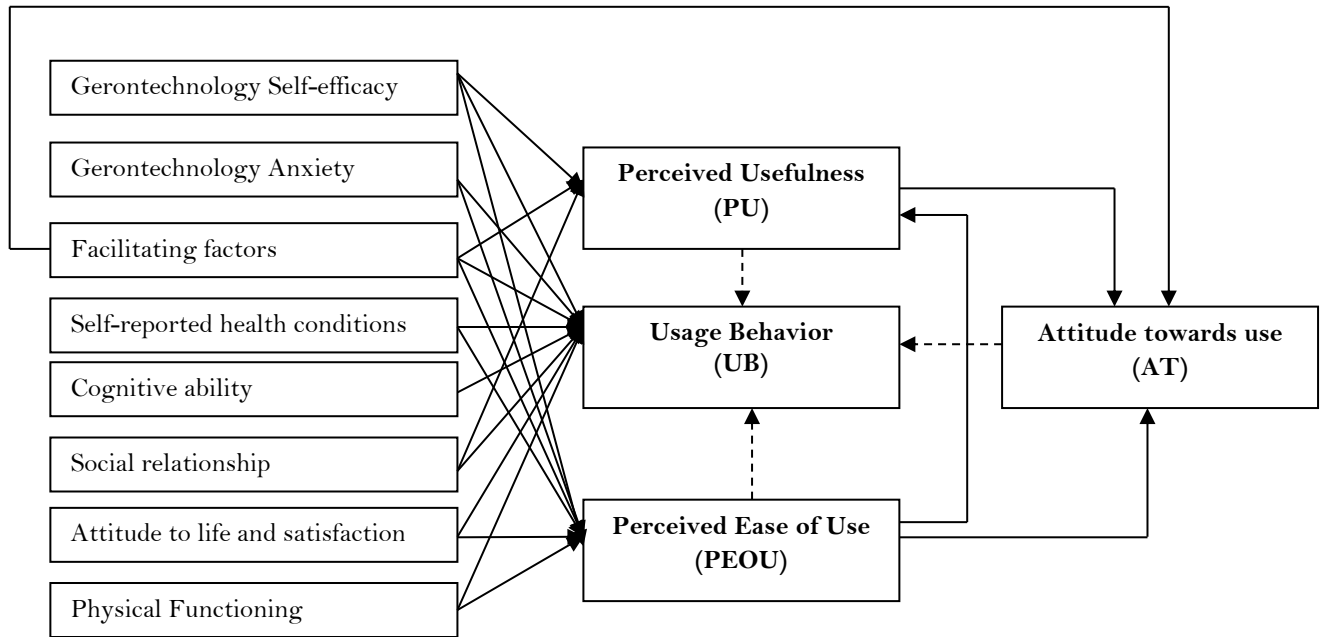
Control Variables: age, gender, education level, and economic status

Figure 2:4 Senior Technology acceptance Model, adopting TAM and UTAUT: Source (Chen & Chan, 2014)

Table 2:6 Concepts and meaning of STAM by Chen and Chan (2008)

Concept	Conceptualization	Operationalization
Perceived Usefulness	the extent to which a person believes that using a particular technology would improve their quality of life	How technology helps them in their day-to-day activities
Usage behaviour	Modern technology usage in their daily life's activities	The self-reporting use of modern technology
Perceived ease of use	The extent to which a person believes that using modern technology is free from effort	Modern technology is easy to learn and use
Attitude towards use	An individual's positive or negative feelings or appraisal about using modern technology	Modern technology is useful in accomplishing their daily activities
Gerontechnology self-efficacy	The extent to which one can use gerontechnology successfully	Easy to use technology repeatedly and successfully
Gerontechnology anxiety	This is the individual's apprehension when they face the possibility of using modern technology	The initial behaviours for technology use
Facilitating conditions	These are conditions associated with the perception of objective factors in the environment that support the usage of gerontechnology	The technological and environmental factors that remove barriers to use
Self-reporting health conditions	The ability to report health status through technology	General health status and health conditions are compared with the same age groups, visual ability, auditory ability, and movement ability.
Cognitive ability	the mental ability on carrying out an activity	think, learn, memorize, and concentrate on an activity
Social relationships	The existing relationship in their circles, family, and friends	Satisfaction with personal relationships and support from family and friends
Attitude to life and satisfaction	The extent to which they feel they live a fulfilled life	Their life roles, current activities
Physical functioning	Ability to perform instrumental activities in their lives independently	How they carry out their daily activities

Significance of IS models and Aging

The STAM models are specific and tailored to the geriatric person's needs, influencing the acceptance and adoption of technology. STAM by Chan and Chen (2014) identified psychosocial factors adopted in this research and elaborated further to establish the emotional experiences later transformed into usability heuristics.

The STAM by Chan and Chen (2014) considered the physical, psychological, and social characteristics that are not clear in STAM by Van Biljon, concluding that biophysical and psychosocial characteristics have not widely been considered. The STAM by Chan and Chen (2014) limits the psychosocial factors contributing to the geriatric person's life and satisfaction attitude. This research adopts the different key factors in Chan and Chen's model to modify it in considering the psychosocial characteristics that bring about the geriatric persons' self-worth and sense of belonging when using modern technology. The models, just like the theories in aging, have the weakness of limited consideration of the additional geriatric needs and the growing modern technology. The models inform this research by identifying some key factors that contribute to influencing psychosocial wellbeing.

In this research, three variables from the STAM by Chan and Chen (2014) were dropped considering the study's context.

i. *Self-reported health conditions*: Self-reporting has been used as a proxy to measure an individual's health state by assessing social, mental, and physical well-being (Fonta et al., 2017). In context to STAM in assessing the geriatric persons in Hong Kong, self-reported health conditions were measured regarding general health status and health conditions compared with the same age groups, visual ability, auditory ability, and movement ability. Unfortunately, these simple self-rated items and modern technology use are under-explored in developing countries like Kenya. Many findings associate the self-reporting of health with measuring the quality of life (Debpuur et al., 2010; Groot & Muthuri, 2017; Kyobutungi et al., 2010) wealth, educational level, functional limitation, lifetime employment, etc. The findings in other regions such as Ghana are not unique to Kenya as during the Initial Research, the participants self-reported ill-health verbally and rarely communicated it to their loved ones through the mobile phone for fear of being a burden to their loved ones.

"When I am ill, I prefer to self-medicate before I alert anyone that I am sick. Calling my son because I am not that well feels like I am burdening him too much, considering he works from morning until evening. I want none of my children to worry much about me."

Grandpa George.

The researcher dropped the self-reporting health conditions through modern technology as the research had no direct involvement with their loved ones. The experiments carried out were between older adults and university students who positively impacted the younger generation.

ii. *Attitude to life and satisfaction*: Chan and Chen (2014) assessed this in terms of satisfaction with personal relationships and support from friends and families. The satisfaction is extrinsic as it is nurtured by improved social support with their families and friends. Digital technologies pervaded all aspects of our lives and were well appreciated during the COVID-19 pandemic, where social supports improved in times of physical distancing (Banskota et al., 2020). This present research sought to understand the intrinsic value to life satisfaction that ultimately led to achieving self-worth and a sense of belonging; perceived self-worth contributes to attitudinal factors.

iii. *Chan and Chen's (2014) physical functioning* assessed on performing instrumental activities in daily living independently. This essentially enabled the geriatric persons to age actively either through non-gerontechnology activities (Nawrocka et al., 2017; Pedroso et al., 2017; Puciato et al., 2017; Salvo et al., 2018; Yoo & Kim, 2017) or through gerontechnology (Khalili-Mahani et al., 2020; Salmon et al., 2017; Bin Eddy Yusuf et al., 2020; Ngaruiya et al., 2019). This present research studied social groups, both physically active and one's living a semi-sedentary lifestyle. The outcome of this research is psychosocial wellness. We excluded the physical functioning to allow any geriatric persons to take part.

2.6 Design Guidelines for a geriatric interface

2.6.1 Introduction

In inclusive design and universal design, researchers or product designers have addressed the importance of understanding a range of capabilities and needs of potential users to ensure that the products, services, or environments are flexible to be used with no limitation (Chen & Chan, 2014). For example, physical limitations (low vision and reduced dexterity and precision) and cognitive limitations (low memory, great difficulties in learning, slower response) can inhibit

the older population's technology use. Similarly, psychosocial factors like self-esteem and self-worth should be transformed into design principles, building modern technology to motivate them to share and enjoy society's usage.

Over the past years, the geriatric domain has emerged as an essential consumer in acquiring digital/modern technology for their psychosocial health. This has made the later years of the geriatric persons more autonomous and socially engaging, despite the heterogeneous characteristics. Advanced technology care and innovations for the aging population have revolutionized gerontology (Lattanzio et al., 2014).

Modern technology advances how humans perform tasks by making them more comfortable, more efficient, safer, or perhaps more pleasurable; unfortunately, this modern technology does the inverse (Rogers & Fisk, 2010); hence, frustration psychological science impacts. Rogers & Fisk (2010) states that psychology has much to offer to the design of technology- from understanding the needs of the people, identifying the preferences for design characteristics, defining their capabilities and limitations that will influence modern technology interactions (Rogers & Fisk, 2010) which unfortunately inhibits the confidence and level of engagement for the interested older adults. The innovative technology that has an incremental growth is Ambient Assisted Living (AAL), which is built mainly for the realities of the developed countries, has minor considerations of the realities in the developing countries like Kenya. Ambient Assisted Living has successfully achieved autonomy where infrastructure is in place (Alsharqi et al., 2014; Baker et al., n.d.; Gschwind et al., 2014; Kucher & Weyns, 2013; Mainetti, Patrono, & Rametta, 2016; Molka-Danielsen et al., 2013) and where developers are seriously thinking of applications and games that are interesting and accessible by the elderly users (Ijsselsteijn et al., 2008).

Since geriatric persons are consumers of this technology, we should understand their needs, concerns, and joys before designing these modern, robotic, and assistive technologies that assist them daily. Johnson & Finn (2017) say that it seems paradoxical that older adults can be susceptible to the ill effects of poorly designed digital devices and user interfaces while yet like any other age group, they need the benefits of staying mentally, psychosocially, and physically active, therefore the reason new recommendations and guidelines need to be developed to serve the older adults (Al-Razgan et al., 2012)

2.6.2 Grey population, modern technology designers and developers

Designing and developing for the elderly population needs a detailed effect that incorporates the age-related impairments and other factors such as intergenerational culture gap and localization (language). This cultural and experiential gap is essential when designing and developing ICT products and other new technologies (Eisma et al., 2003), especially for the geriatric population in developing countries. Over the years, the discussion of modern technology and computer usage for the elderly has grown exponentially in developed countries than in developing countries. The development of technologies for older adults in developed countries are not to be poached to developing countries. This is because it does not accommodate the needs prevalent in developing countries, such as limited infrastructure, limited broadband, limited modern technology knowledge, and diverse cultural differences. Therefore, there is a need to empathize with the older adults to avoid developing products based on an apparent understanding of the old persons' needs, hence having a less ideal and possibly patronizing solution.

In designing opportunities by IJsselsteijn et al. (2007), they argue that besides ensuring the usability of interactive interfaces for seniors, one needs to make sure that there are substantial perceived benefits for elderly users so that they will invest their time and energy in what might be a rich and rewarding experience.

2.6.3 User Interface with a touch of gray

Growing old has a degenerative effect on physical and cognitive capabilities (i.e., diminished vision, varying degrees of hearing loss, psychomotor impairments, reduced attention, memory, and learning abilities) therefore being a great hindrance in the usage of any technology that has a user interface that is not well suited for the elderly users. The universal design, also known as 'Design for All,' is primarily adapted to design for diversity, i.e., people with disabilities, different age groups, and different cultural bases (Dix et al., 2004). Design for all has further been described as the philosophy in design that recognizes values and accommodates the broadest possible range of human abilities, skills, requirements, and preferences in the product and supporting environments to suit the broadest possible end-user population (Zaphiris et al., 2005). Several academic papers(Morris, 1994; Freyhoff et al., 1998; Gregor, Newell, & Zajicek, 2002; Kurniawan & Zaphiris, 2005; Ijsselsteijn, Nap, de Kort, & Poels, 2008; Boustani, 2010; Gerawork, 2016; Rot, Kutera, & Gryncewicz, 2017) have developed guidelines developers have used when designing for the elderly and the physically challenged

population. Social and mental engagement have widely been developed, yet no literature has shown that development entails geriatric persons' self-worthiness.

In designing any User Interface (UI), usability and user experience (UX) are well known as significant contributing factors to any technological product quality, becoming increasingly important in mobile development (Heo et al., 2009) and by extension to the mobile application. Although there is a range of usability definitions, the usability concept specified by ISO/IEC 25010:2011 is the one that is used widely as the *'quality of use model'* for software products. ISO/IEC 25010:2011 defines usability as the *software product's capability to be understood, learned, used, and be attractive to the user when used under specified conditions.* On the other hand, user experience looks at the individual's entire interaction with a product and their thoughts, feelings, and perceptions that result from that interaction (Heo et al., 2009). These two factors will be part of our guiding factors in literature as we explore the design principles and guidelines for products and applications designed for geriatric persons that incorporate psychosocial factors.

Designing an artefact requires a designer to follow specific standards and guidelines to enable the acceptance and adoption of the intervention for the users in mind. To establish the acceptance and adoption of an intervention, usability and user experience (UX) speak volumes, influencing the study on UI guidelines for older adults. The User Interface expresses the user experience as the 'face' of interaction between the technology intervention and the user. A good user experience will make people like the tool, while a bad experience can make people dislike and abandon the tool despite its other benefits (Lee & Coughlin, 2015; Pavlov, 2014). Therefore, this research deeply considers the statement made by Rodrigues et al. (2014); by *captivating the interest of elderly users in technology, we can fight isolation and exclusion and allow the elderly to be more productive, independent, and have a more social and fulfilling life.*

2.6.4 Interaction Guidelines as used in developing countries

Deveza et al. (2014) state that designers and developers from the developed world, when creating products for developing countries, usually face a significant hurdle in accurately understanding these users because of the gap between mental frames of reference and technology experience. Standardized guidelines can help close this gap for cases where users are not available; therefore, the need to design mobile application guidelines unique to an older person from a developing country context by considering their characteristics that lean towards the intergenerational cultural gap.

Human-Computer Interaction (HCI) guidelines for developing countries by Deveza et al. (2014) are general guidelines for designers and developers to consider increasing product acceptance and long-term positive user experience. They classified the guidelines under four major categories **(Table 2.7)**. Though they are generic, this research found it fit to derive some guidelines from it because it has considered the aspects suitable in contextualizing the needs of geriatric persons.

Table 2:7 HCI Guidelines for developing countries (source: Deveza et al., 2014)

Area	Principle	Detailed Guideline
Interface design	Text	• Minimize reliance on text • Complement text with other modalities (Multimodal interface, e.g., Voice I/O • Do not remove all text from the interface
	Graphics	• Use culturally relevant icons • preference of realistic cartoons from representing pictorial content • Use motion to identify actions visually • Captions should accompany the icon
	Voice and Audio	• Voice content should be provided in the local language and accent • Help should always be available • Oral information should be short and simple • Audio feedback should be provided on demand • High speech recognition is crucial
Device manipulation	Complexity	• Avoid complex interaction styles (Multi-function buttons, soft keys, over-cluttered buttons, and double-tap interaction have been shown to cause problems to low-literate users)
Navigation and Information Architecture	Navigation	• Linear structures are quick to understand than branched • Encourage interface exploration • Keep screen simple and limited number of tasks • Avoid scroll bars • Use real-life metaphors to describe foreign concepts
Content		• Use familiar language

Van Biljon & Renaud (2016) describe the challenges that older adults face in developing countries that the researcher should always consider; *illiteracy, low computer literacy, language barriers, social and cultural differences, and economic constraints*. When these context-specific factors are considered, they inform technology design, therefore, acceptance of a product that appeals to the target user's needs; for this case, the geriatric

persons. In 2010, Van Biljon et al. (2010) developed a senior mobile phone adoption checklist (SMAC), which was later revised (Van Dyk et al., 2013) to extended senior mobile phone adoption checklist (ESMAC). The SMAC checklist had the concept of purely feature phones while ESMAC incorporated the smartphone concepts, and this is where this research considers some of these guidelines as we incorporate the psychosocial characteristics in the modern technology's design.

Table 2:8 Extended Senior Mobile Phone Adoption Checklist (ESMAC) Guideline (Source: Van Dyk, Gelderblom, Renaud, & Van Biljon, 2013)

Type	Recommended guideline
Physical Characteristics	
Keypad	• Touch screen (Larger keys and less tactile feedback) • Key buttons provide clear tactile feedback when pressed • Key buttons to provide audible feedback when pressed • Easy key lock function (physical and via software) • Large emergency button in a prominent place
Display	• Screen font should be large • The overall size of the phone should not be too small • The phone must not be heavy
Complexity	
Key buttons	• Each key should preferably control only one function • Recognizable function name on buttons to facilitate recognition rather than recall
Menu	• Simplified menu structures to minimize nesting of functionality • A clear sign of battery charge remaining
Features	
Caretaking	• A big programmable and prominently visible emergency button • Alarm and reminder functions
Communicate	• Support additional languages and English • Voice output of displayed information
Features	• Add camera • Add internet access

Table 2:9 The proposed principles guided by generic guidelines of mobile development and guidelines from a developing country context

Factor	Principle	Detailed guideline	Definition
Interface Factors	*Feedback* ((Rodrigues et al., 2014;Yamagata *et al.*, 2013; van Biljon & Renaud, 2016b)	1. Key Buttons should provide for clear tactile when pressed i.e. Tactile design for mobile apps (*haptic feedback*). 2. Application Sounds 3. Speech output	To alert an elderly person that there is an action selected on the mobile device
	Visibility (Boll & Brune, 2015; Deveza et al., 2014)	1. Minimize reliance on text 2. Use clear fonts, simple and clear 3. Use clear and larger buttons with both icons and text 4. Use simple graphics 5. Reduce number of features available at any given time	Ability of an elderly person to be able to view the mobile device screen comfortably so as to undertake an action
	Complexity (Deveza et al., 2014; van Biljon & Renaud, 2016b)	1. Simplified menu structures to avoid nesting 2. Avoid scrolling bar 3. Keep screen simple and limit number of tasks 4. Avoid complex interaction styles 5. Linear navigation better than branched, hierarchical structures.	Ability of the elderly to successfully carry out a task using the mobile device
	Cultural (localization) (Deveza et al., 2014)	1. Use real life metaphors to explain foreign concepts 2. Use familiar language 3. Use culturally relevant icons 4. Prefer realistic cartoons for representing pictorial content	Ability of the elderly to relate with the features displayed by the mobile device as its their everyday custom
	Recognition (Gregor et al., 2004; Pavlov, 2014; van Biljon & Renaud, 2016b)	1. Design for simplicity and few elements on the mobile device 2. For memory use recognize option other than recall 3. Shorter output messages 4. Establish appropriate level of challenge	Ability of the elderly person to cognitively engage with the mobile device to accomplish a task.
	Exploration (Al-Razgan et al., 2014)	1. Easy reversal of action	Ability of the elderly person to enjoy the intrinsic value of the mobile device through exploration.
	Safety (van Biljon & Renaud, 2016b	1. Large emergency button in a prominent place (programmable function) 2. Alarm and reminder functions (such as wake-up and medication)	Ability of an elderly person to easily seek assistance to do a particular task. The degree to which an elderly person can use technology to interact more efficiently and safely (ergonomics)

Table 2:10 Principles from the Universal design principles; Source: Literature.

Theme	Heuristics Factors	Shneirdermann's	Nielsen's	Norman's	ESMAC
Physical Characteristics	Consistency	√	√	√	×
	Feedback	√	√	√	√
	Use of shortcuts	√	√	×	×
	Simple error handling	√	√	×	×
	Easy reversal of action	√	√	√	×
	Recognition	√	√	√	×
	Localization	×	√	×	√
	Complexity	×	×	×	√
	Visibility	×	√	√	√
	Safety	×	×	×	√
Psychosocial characteristics	Self-worth	×	×	×	×
	Sense of belonging	×	×	×	×

Table 2:11 Proposing Guidelines for an interactive technology for geriatric persons in developing countries

Category	Heuristic factors	Derived from	Justification
Physical Characteristics	Feedback	ESMAC, Shneirdermann's golden rules	Having a clear and simple response that the geriatric persons can understand and be able to carry out an activity with not much strain, directing them on what to do
	Easy reversal of action	Shneirdermann's golden rules, Nielsen's heuristics, Norman's principles	Affording a geriatric person a simplified way to a previous action enables easy exploration of a new technological device and a probable increase in self-efficacy
	Recognition	Shneirdermann's golden rules, Nielsen's heuristics	Enabling the geriatric person to recognize an action to take through icons/widgets instead of recalling a procedure
	Localization	HCI guidelines for developing countries, ESMAC, Norman's principles	Contextualizing the icons, feedback, and language to fit the communication need of a geriatric person
	Complexity	HCI guidelines for developing countries, ESMAC, Norman's principles	A non-nested interface that enables a geriatric person easy access to activities they want to carry out.
	Visibility	HCI guidelines for developing countries, ESMAC, Norman's principles	Large prints and icons for their weak eyesight. Easy resizing of the fonts
	Safety	ESMAC	Modern technology allows the geriatric to ask for help in case of emergency easily
Psychological Characteristics	Self-worth	Preliminary findings	The geriatric person's ability to teach, mentor, correct the younger generation.
	Sense of belonging	Preliminary findings	The intergenerational gap is being reduced by incorporating the older persons to share, mentor, teach, etc. through the modern technology

2.8 Deriving the theoretical framework

We derive the theoretical framework from the social theories of aging, IS aging models, and the initial research. The social theories of aging inspired the psychosocial characteristics which build on the geriatric persons' behaviours. The geriatric persons, having grown in a social environment, had stories being told to them, discipline instilled by the society, and mentored to be responsible young adults, which they have carried to their later years. These different roles that older people played gave them a satisfying identity. The older generation knew their position in society and was respected for that. However, as discovered in the initial research, modern society has ripped them these identities as they have little or no communication with the younger generation, creating an intergenerational gap. Modernization, where rural-urban migration is prime, or parents being empty nesters at their young-old age, has increased the level of loneliness since the physical distance is not possible. In cases where mobile phones are used, there is a time limit. The aging social theories have inspired modern technology where

social engagements are experienced through gamification and social networks, keeping the aged engaged and not lonely.

This is where IS models in aging consider the physical characteristics of an interface to ensure usability and user experience. Modern technology's usability for the aging populace should be easy yet effortless to use, encouraging acceptance and adoption. Age-related issues and other predictive factors have been investigated to ensure the needs of geriatric persons are met. We then investigated these factors for design, and this is where heuristic guidelines consider the different needs of geriatric persons to form the guidelines to be used by designers and developers when developing interactive mobile devices. The researcher developed the heuristics guidelines from the interactive mobile interface's physical and geriatric persons' psychosocial characteristics **(Table 2.12).** The theoretical framework, shown in **Figure 2.5**, later guided the methodological approach, qualitative exploratory research using a case study.

The need for Psychosocial Usability Heuristics

The HCI heuristics and Van Biljon heuristics only address the visual aspects neglecting the psychosocial feature (practical dimension) where the users' emotions are featured. Renaud & van Biljon (2010), quoting Cockton G, state that *designing worth is worth designing*. Therefore, we need to look beyond the visual features and build on worth; worth for the older persons in our communities. Geriatric persons are not all incapable as design for geriatrics has shown to be. Instead, their unique needs must be investigated and build a self-satisfactory interactive mobile interface than generalizing their needs since they all exhibit different emotions. The users' emotions govern the quality of interactions with a product in the user's environment and relate directly to an appraisal of the user's experience (De Lera & Garreta-Domingo, 2007).

A practical dimension sprouting emotions in geriatric persons can relate to the cultural aspects where they had distinct roles and activities that put them at the top of society, gaining respect, which positively influenced their self-worth as they felt they belonged! The guidelines, though, are silent on the factors that bring forth the sense of belonging and self-worth considering the innate nature of the geriatric persons in continual skills like mentoring, storytelling, and teaching while in their later years. Therefore, the design of heuristic guidelines to incorporate these two paramount psychosocial factors will have modern technology more beneficial for the geriatric persons' roles and activities if it's easy to use.

Table 2:12 Factors towards psychosocial experience in the proposed theoretical framework

	Factor	Operationalization	Derived from	Relevance to work
Social Aging Theories	Society	Roles in a social group	Cumming et al., 1960	With social theories, the participants were questioned on their roles in society to understand their social engagements better.
	Successful Aging	Social structure, self-concept, and personal identity, and life events	Cumming et al., 1960	The active and productive activities aided the research to understand the activities they took up or had in their middle years to their aged years.
	Activity	Informal, Formal and Solitary activities	(Havighurst, 1968)	Their social engagement/participation status informed the research on the activities the participants can engage in.
	Life Satisfaction	Positive self-concepts, pleasure in everyday activities, regarding life as meaningful, balance between desire and goals	(Atchley, 1989; Havighurst, 1968)	To establish contentment of the participants' general life regarding contribution to society through the touch technology.
	Role Support	The intimacy of an activity	(Lemon et al., 1972)	This research included other human subjects who supported the participants' to achieve a task using touch technology.
	Self-Concept	Preferences, abilities, emotionality, personal goals, level of performance, attitudes, roles	(Atchley, 1989; Lemon et al., 1972)	The transfer of knowledge gathered through experience being shared through the social networks
	Social Connections	Amount of time spent in social interactions with family, friends, and society	(Atchley, 1989)	To evoke the contribution of the participants to the society as primary contributors through touch technology
IS Aging Theories	Perceived usefulness	How technology helps them in their day-to-day activities	(Biljon & Renaud, 2008; Chen & Chan, 2014a)	In this research, we proposed touch technology to find out if it improves their quality of life; for this case, their social participation using modern technology
	Usage behavior	The self-reporting degree of use of modern technology	(Biljon & Renaud, 2008; Chen & Chan, 2014a)	To show the degree of self-efficacy in touch technology usage for their psychosocial support
	Perceived EOU	Modern technology is easy to learn and use	(Biljon & Renaud, 2008; Chen & Chan, 2014a)	To test the ease of use of the touch technology, especially to novice users.
	Gerontechnology self-efficacy	Easy to use technology repeatedly and successfully	(Chen & Chan, 2014a)	To test how the participants carried out different actions to deal with the prospective situations.
	Gerontechnology Anxiety	The initial behaviours for technology use	(Chen & Chan, 2014a)	To gauge the participants' apprehension when using touch technology to carry out different tasks.
	Facilitating Conditions	The technological and environmental factors that remove barriers to use	(Biljon & Renaud, 2008; Chen & Chan, 2014a)	To establish any external factors that barred the participants from achieving an action through the touch technology.
	Cognitive Ability	think, learn, memorize, and concentrate on an activity	(Chen & Chan, 2014a)	To establish the participants' mental ability in achieving tasks through touch technology

	Social relationship	Satisfaction with personal relationship and support from family and friends	(Chen & Chan, 2014a)	To evoke the contribution of the participants to the society as primary contributors through touch technology
	Attitudinal factors	Modern technology is helpful in accomplishing their daily activities	(Biljon & Renaud, 2008; Chen & Chan, 2014a)	To establish the overall participants' feeling on touch technology usage
Initial Research	Feedback	Having a clear and simple response that the geriatric persons can understand and be able to carry out an activity with no much strain as it directs them on what to do	ESMAC, Shneirdermann's golden rules	To establish if the participants comprehend the language used as they interact with the touch technologies
	Easy reversal of action	Affording a geriatric person a simplified way to a previous action enables easy exploration of a new technological device and a probable increase in self-efficacy	Shneirdermann's golden rules, Nielsen's heuristics, Norman's principles	To observe the participants' exploration experience as they interacted with the different application software.
	Recognition	Enabling the geriatric person to recognize an action to take through icons/widgets instead of recalling a procedure	Shneirdermann's golden rules, Nielsen's heuristics	To test the cognitive ability to either recall or recognize icons or widget
	Localization	Contextualizing the icons, feedback, and language to fit the communication need of a geriatric person	HCI guidelines for developing countries, ESMAC, Norman's principles.	To gain the context according to the participants' needs as they interacted with the touch technology.
	Complexity	A non-nested interface that enables a geriatric person easy access to activities they want to carry out.	HCI guidelines for developing countries, ESMAC, Norman's principles	To test the navigation through the menus and other nested procedures to successfully carry out a task
	Visibility	Large prints and icons for their weak eyesight. Easy resizing of the fonts.	HCI guidelines for developing countries, ESMAC, Norman's principles	To observe the visual manipulation of functionalities such as text resizing
	Self-worth	The geriatric person's ability to teach, mentor, correct the younger generation through technology	Initial Research	To gain an understanding of the participants' emotional experience (psychosocial wellness) as primary contributors to contemporary society through modern technology
	Sense of belonging	The intergenerational gap being reduced by incorporating the older persons to share, mentor, teach, etc. through the modern technology	Initial Research	To show the inclusion of the older populace in contemporary society through modern technology
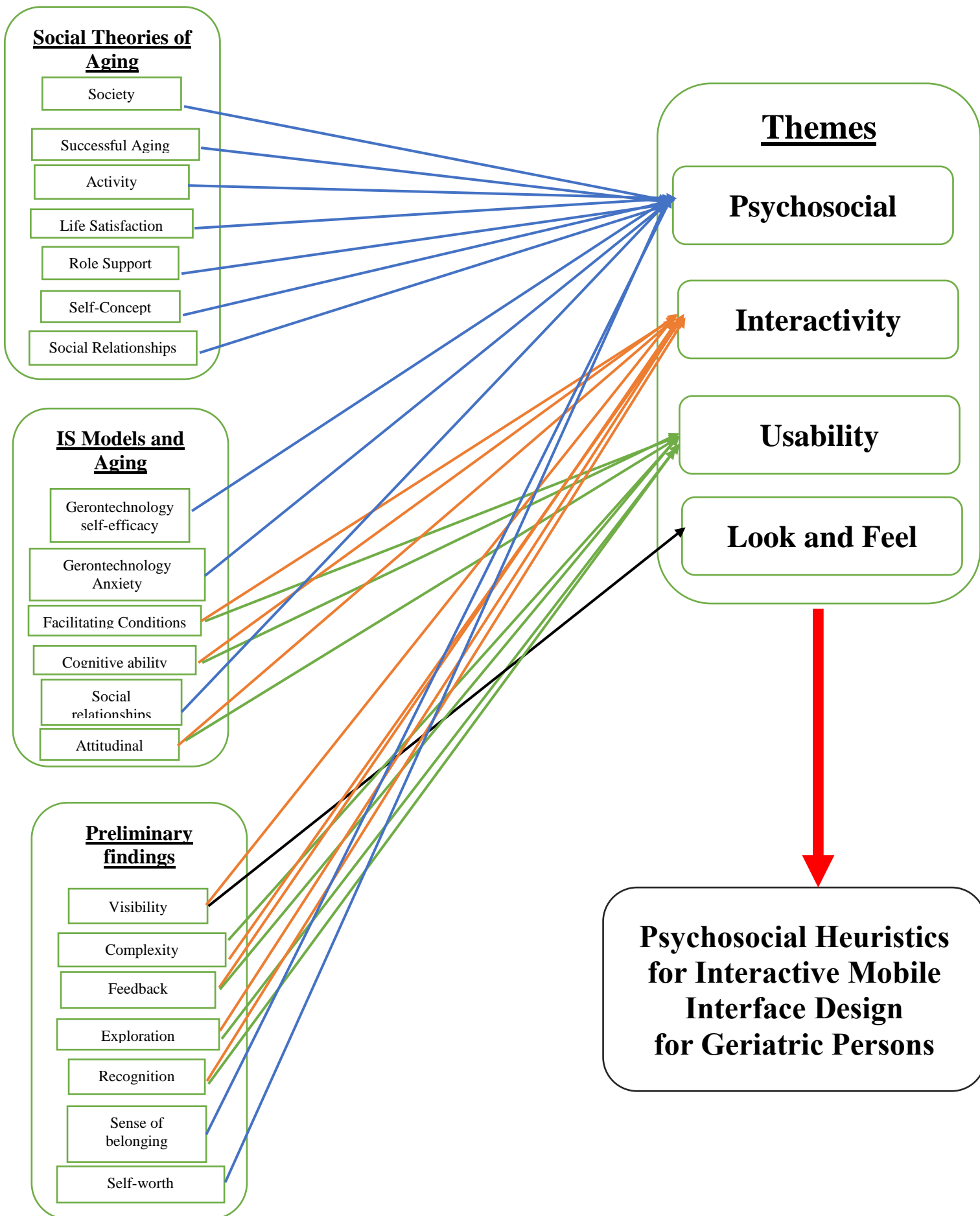
Figure 2:5 *Theoretical framework: Source: Research*

2.9 Chapter Summary

This chapter started with an overview of geriatric persons in developed and developing countries and pointed out their challenges. The research identified the universal heuristics developed for designers' usage to ensure the acceptable technology by distinct groups. Literature showed sufficient work done but not completed in creating heuristics guidelines for using the interactive mobile interface for geriatric persons. This led to initial research that established some needs that have not been incorporated into heuristics used in developing technologies for geriatric persons.

CHAPTER THREE: METHODOLOGY

3.1 Overview

The methodology chapter details the research's effort in producing quality, credible and reliable research findings through a qualitative exploratory approach. The research has its chapters organized as follows: research philosophy/perspective, the design methodology, the researcher's beliefs and background, population, participants, sampling techniques, the methodology for heuristics development, and data collection and analysis approach.

3.2 Research Question

RQ3: **Which factors are key in defining an interactive mobile device for psychosocial support in the geriatric population**?

There is a need to ensure that modern technology meets geriatric persons' needs, as this older person population is exponentially growing. The geriatric persons assume a sedentary lifestyle that wastes them both physically and psychologically when they are not engaged or do not want to engage (inferring to the disengagement theory). With modern technology, older persons carry out their day-to-day activities by staying in contact with loved ones, monitoring at a distance etc. This research expounds on a more inward need where the geriatric persons need to use modern technology to give to society as they did long ago, such as being a source of advice, mentorship, storytelling, etc. Psychosocial factors; self-worth, life satisfaction, and sense of belonging, were incorporated to expound on existing heuristics and senior technology and acceptance model.

3.3 Research Design

3.3.1 Research Philosophical perspective/worldview.

In developing the design guidelines in usage of mobile interactive interface for geriatric care for their psychosocial health, this research considered the approach, strategies, choices, time horizons, tools, and techniques (Saunders et al., 2006) applied to achieve a reliable solution. Saunders et al., (2006) research onion, as shown in **Figure 3.1,** guided this research.
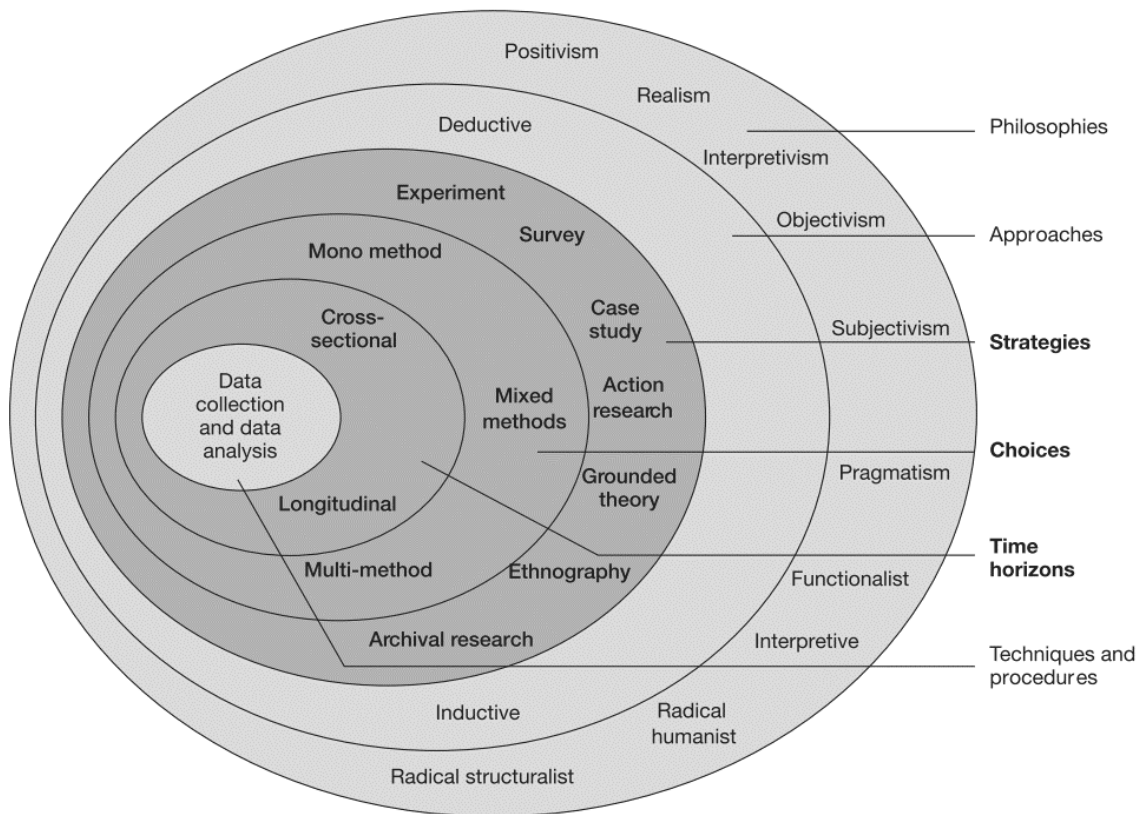
Figure 3:1 The research 'onion.' Source: Saunders et al., (2006)

This research was a qualitative exploratory study guided by the pragmatism philosophy. Pragmatism combines both objectivism and subjectivism (Saunders et al.2006) or social constructivists (Creswell, 2009), where reality is constructed by the participants interacting in their social worlds. In this worldview, actions, situations, and consequences rather than focus on the method are the fundamentals studied as the researcher emphasizes the research problem and uses all approaches available to understand the problem (Creswell, 2009) and give a contextualized solution. Yazan (2015), quoting Merriam, states that the researcher brings reality to the research situation, interacting with other people's constructions or interpretations of the phenomenon under study.

Given the nature of this research, the researcher considered the qualitative research approach. Njie & Asimiran (2014) describes qualitative research as a multi-method, involving an interpretive, naturalistic approach to its subject; research is carried out in a natural setting, attempting to interpret phenomena according to the participants' take. This research explored an array of dimensions of the social worlds through qualitative research, including the understandings, experiences, and imaginings of the research participants and the significance of meanings they generate (Mason, 2002; Njie & Asimiran, 2014). The popular qualitative

research approaches include **(Figure 3:2);** phenomenological, grounded theory, narrative, case study, and ethnography. A qualitative researcher can use one or a combination of these approaches. In this research, we selected the case study approach as it enabled us to work with small groups of older persons. In grounded theory (GT), the researchers aim is to ultimately develop a theory out of the different data that is continuoulsy collected. In case study, just as GT, has an advantage of collecting data continously in order to identify build on meaningful information that depicts the realism of the participants. The difference in GT and Case study is that the prior one ends with a theory which is not the case for a case study.
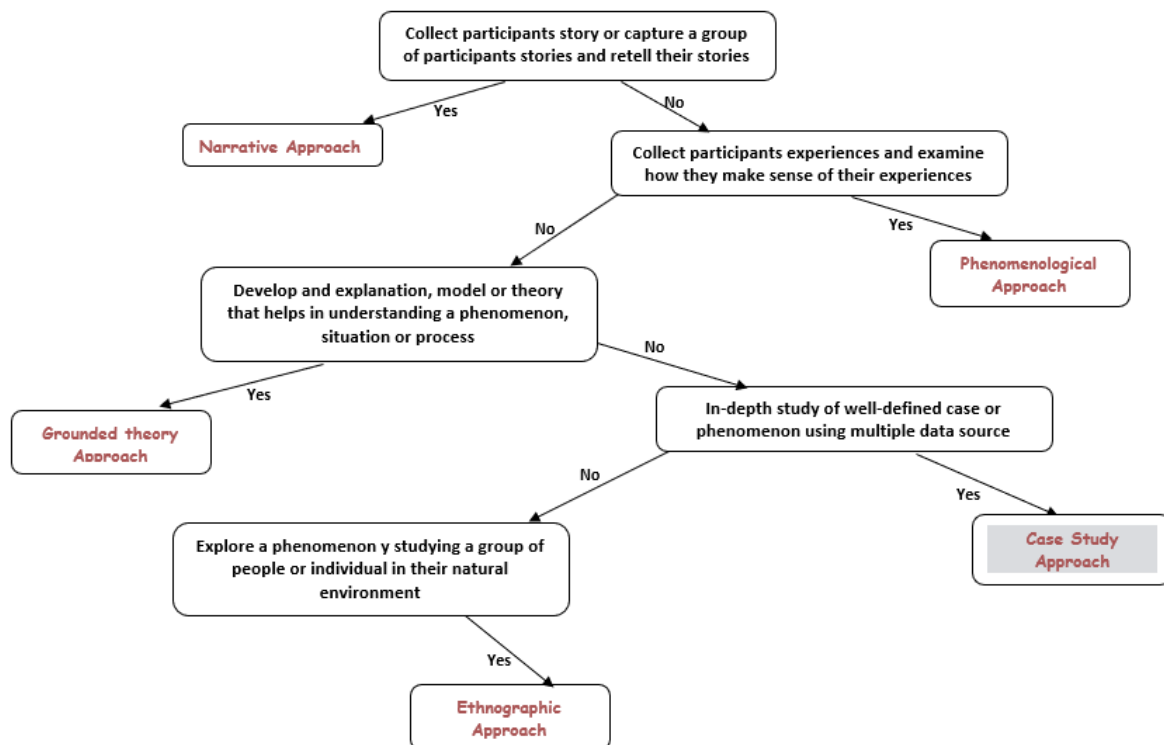
Figure 3:2 Choosing an appropriate Qualitative Approach for study

The pragmatism paradigm, ontology, and epistemology in the research

In choosing the research methodology, Singh (2019), quoting Atieno, states that the paradigms give a researcher a firm understanding of their research's philosophical underpinning considering the underlying assumptions on ontology, epistemology, methodology, methods, and source. This shows the interrelationship between the building blocks of research, as shown in **Figure 3.3**

```
┌──────────┐   ┌──────────────┐   ┌──────────────┐   ┌──────────┐   ┌──────────┐
│ Ontology │   │ Epistemology │   │ Methodology  │   │ Methods  │   │  Source  │
└──────────┘   └──────────────┘   └──────────────┘   └──────────┘   └──────────┘
```

What's out there to know?

.

What and how can we know about it?

How can we go about acquiring that knowledge?

Which precise procedures can we use to acquire it?

Which data can we collect?
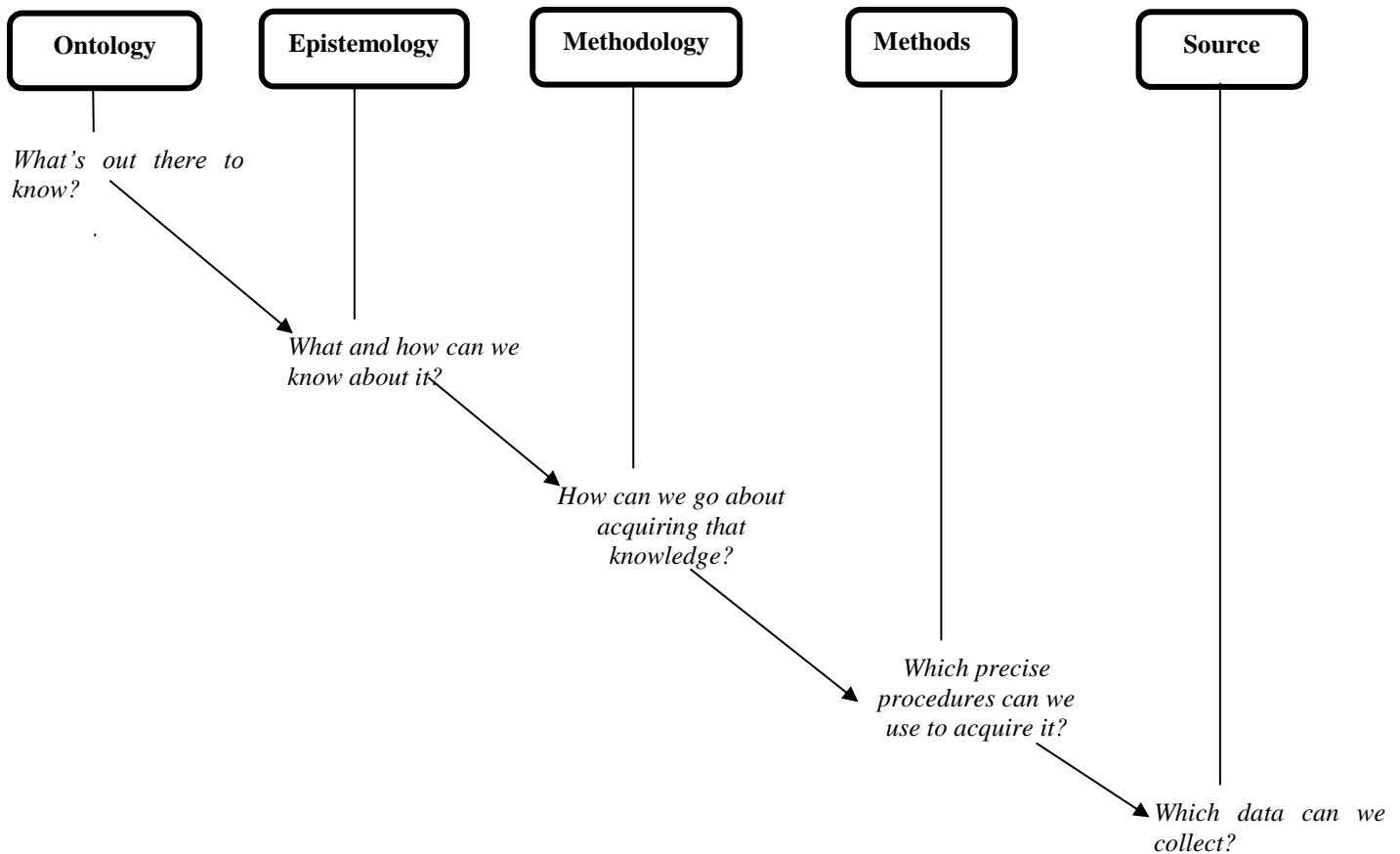
Figure 3:3 Interrelationship between the building blocks of research. Source: (Singh, 2019)

The researchers achieved in-depth knowledge through the pragmatism paradigm that gave knowledge on the user behaviours, shared beliefs, and the human experiences on modern technology and psychosocial well-being. This is in line with the pragmatic ethics stating that the more we understand relevant aspects of the geriatric persons' lives, the better we will predict their needs and ambitions and supply the answering technologies for enhancing their quality of life (Bouma, 2010). However, the pragmatism paradigm's ontological assumption is that the reality is ambiguous based on the subjects' culture, language, and history (Kivunja & Kuyini, 2017), therefore taking up a relativism approach accepting the multiple realities considering the different contexts. Furthermore, it dictates an emic relationship between the researcher and the participants in gaining knowledge of their reality in context to respect culture, language, and related beliefs in a society.

In adopting the empiricism epistemology, through the case study methodology, the researchers immersed into a social group of geriatric persons to have a contextual understanding (the reality) from the subjects' viewpoint. The precise procedure for acquiring this knowledge was through interviews and observations, which yielded qualitative data. The

research used an inclusive design **(as discussed in the 3.3.2 section below)** using the design for delight principles to gain the knowledge shown herein, to ensure that products and services target the geriatric persons' needs.

3.3.2 Design methodology

Design for Delight (D4D) was used when conducting part of the Initial Research and the main study. D4D is a series of three principles that gave the research an in-depth understanding of the research questions. We carried the three principles out as follows;

Principle #1: Deep Empathy

The research went beyond the existing literature to better understand geriatric persons' intrinsic and extrinsic motivation in modern technology usage. The researcher had prior interaction (lasted 2 weeks) by immersing in a community centre and a PSH. The researcher would join the geriatric persons in their groups and help in the day's activities like soap making and hold talks they would start. The talks were informative or random, like historical events and how they took part in events such as the MauMau movement, the trending news in the society, or the political arena. These sessions later grew to current technology usage discussions and how it has affected their day-to-day lives. The outcome of this session was the emotional experience that is not designed in modern technology.

Principle #2: Going Narrow

The empathy stage outcome inspired the thoughts on proposing a design that evokes the geriatric persons' emotional experience on modern technology, using modern technology to inspire, story-telling, eMentoring, etc., for the geriatric person to feel still valued in a highly tech-savvy society. The outcome was selecting two interventions; senior games and synchronous communication between the participants and four students from a local university.

Principle #3: Experiments

We selected two applications; (i) senior games downloaded from the play store: Reasoning games, rolling balls, fruit legend, and balloon shooter (bow and arrow). (ii) The second intervention was an interactive session through a video call to interact with students from a local university.

3.3 Population, Participants and sampling techniques

3.3.1 A targeted Case study.

Peshkin (1993) states that to unravel a well-understood study, a qualitative study should be; *(i) Descriptive* - where research reveals the nature of a situation, setting, or process *(ii) Interpretative*–helps in gaining new insights, concepts, and discover problems that exist in a given situation *(iii) Verification*–helps experiment certain assumptions and finally *(iv) Evaluation*–it helps provide the means of judging the effectiveness of particular practices, innovation, and process. Njie & Asimiran (2014) posits that qualitative research is generic and needs a direction mainly decided by the specific aim and type of study one conducts. A case study is one such direction that is prompted by the need to plunge deep into a specific unit for a greater understanding and is solely anchored on the tact, resilience, and gusto of the researcher during the research process (Njie & Asimiran, 2014) therefore the choice of a case study for this research in a study population that has limited contribution to gerontechnology.

A case study demarcates a group, area, or situation to concentrate intrinsically on understanding and explaining how it lives its case of interest (Njie & Asimiran, 2014). Baxter & Jack (2008) states that once a researcher has considered what the case will be, one is to put parameters/place boundaries on a case to avoid making the scope of research too broad, therefore, enabling one to focus on bringing to light the issues that are to play within the case.

In this research, the case study primarily laid in the quality of information obtained per sampling unit (Sandelowski, 1995) instead of the number of participants; it's case-oriented and not variable-oriented. In elaboration, Njie & Asimiran (2014) states that the key distinguishable attributes include the focus of a unit, in-depth description of a phenomenon anchored on a real-life scenario, and use of multiple data collection tools. In health informatics, as nature of this research, various authors such as Barros et al. (2014); Planinc et al. (2013); Rodrigues et al., 2014; Seraphini (2012), have shown that an event, incidents, and experience are typically the objects of purposeful sampling (Sandelowski, 1995) not the number of participants. With this, we agree people are central in giving information. For our case (qualitative research), the participants enter qualitative studies because they have the information (information representative) fitting the problem in context, affording the researcher to make a naturalistic generalization.

3.3.2 Population, Participants and Sampling technique.

The richness of qualitative research brings in-depth knowledge to research rather than statistical significance. This needs the right participants who are knowledgeable and experienced rather than statistics in bringing value to the research. We achieved this through purposive sampling. The researcher considered a purposive-convenience strategy as the participants were knowledgeable, experienced, and were experts to answer the research question. *Purposive;* geriatric persons conversant with mobile interface usage, giving rich information to address the research question. *Convenience*; Be in Nairobi county's environs and live in social communities like self-help groups or social homes for easy follow-up.

The analysis unit was a social group, identifying a philanthropic social home and a centre coded as Redhouse. We recruited potential participants from an older person's self-help group coded as Redhouse1 in Nairobi county, and a philanthropic social home (PSH) coded as Redhouse 2 in Kiambu county. The research adhered to the Ethical Principles for Scientific Requirements and Research Protocols by World Medical Association (2013)

At the onset, the primary researcher contacted the two homes and discussed the research problem and its objective with the management. With this understanding, the management was able to select the participants who fit the study purposively. As selected by the management personnel, the four participants (3 female and 1 male) in RedHouse_1 had an average age of 75 years and were all independent in physical movement. They live in an urban setting and usually visit the centre once a week for communal activities and have an intense social life outside RedHouse_1, including family, religious activities, and other social events. Their educational level is between high school and tertiary education, therefore, being formally employed and later retired. For the aged in RedHouse_2, the management personnel selected four participants (3 male and 1 female) of an average age of 80. They are residents of the home where they are taken care of by employed personnel. They have experienced rural settings all their lives, having a limited educational background, therefore engaging in informal employment such as farming as their source of income

The inclusion criteria for the participants was that they were 65years and above, had some knowledge of mobile usage and were free from neurological conditions, cognitive and motor impairment. The duration of the research guided this inclusion clause for participation. In total, eight (8) geriatric persons between the ages of 65-85 years agreed to take part in the study where observations and focus group discussions were conducted by researchers in four different time series (Baseline survey as T_0, T_1, T_2, and T_3) that lasted 10 weeks (each time

series taking two weeks), an average of five hours every day of the week from Monday till Friday. At the onset of the main study, this research carried out a baseline survey. The baseline survey detailed their prior knowledge of technology, which was crucial in gaining insight into what is already known by the participants and what types of interventions can be introduced to the research. Secondly, a trial timeline survey was conducted that enabled the research to gather meaningful information on the approximate duration needed for each timeline. Lastly, the primary research was carried out in three subsequent timelines, each taking two weeks. The duration of ten (10) weeks was appropriate for observing the participants' behavioural change as they interacted with the mobile interface. The research assistants recorded the observations, and after two weeks each (total of 10 weeks), the researcher gathered information from the participants through interviews. **Table 3.1** describes the research timelines.

Table 3:1 Research period Time Series

Level	Activities	Duration
Baseline Survey	To gain insights into modern technology and geriatric persons	2 weeks
Trial Timeline	We conducted it to determine the period of each subsequent timeline (T1-T3)	2Weeks
T1	Introduced Senior games	2 Weeks
T2	Introduced social interaction using VoIP	2 Weeks
T3	Combined both interventions	2 Weeks

The Interventions description

The geriatric persons from both RedHouse_1 and RedHouse_2 are introduced to two sets of interventions, as shown in **Table 3.1** above. (i) senior games that we downloaded from the play store included; Reasoning games, rolling balls, fruit legend, and balloon shooter (bow and arrow). (ii) The second intervention was an interactive session through a video call to interact with psychology students from a local university. The purpose of the lessons was as follows; (a) To engage cognitively, (b) To explore the mobile interface to spark curiosity on other features of the touch interface, and (c) To interact through a cross-platform messaging and Voice over IP service by engaging the younger generation

These two applications had broader acceptability and a positive user experience for the geriatric persons in the research, testing psychological and psychosocial fitness. These interventions had an app rating of >4.5 and >3000 reviews in the play store. These apps' uniqueness is that they are user-friendly, simple, and exciting to the different users, as shown in the app reviews. Therefore, the senior games are specifically designed for the older adults,

considering their deteriorating health like poor eyesight, making the icons more prominent, etc. For the social communication platform, the researcher used WhatsApp because of its minimized procedure, and secondly, the participants had seen their close family members interact through it; therefore, we assumed support if they got stuck.

3.4 Research Methodology for heuristics expansion

Fruhling & Siy (2017), Hermawati & Lawson (2015), and Rusu et al. (2011) have developed different methodologies that guide a researcher in heuristics development. In how to expand heuristics (shown in **Figure 3.4**), Hermawati & Lawson (2015) states that heuristics that are solely based on documented usability issues, while providing a solid ground for heuristics expansion, need to ensure that the usability issues are collated from a wide range of application and even people in the domain in the study. The scholars also state that heuristics based solely on design guidelines could quickly increase the number of heuristics with no limit, but warn that a lengthy heuristic can be cumbersome during evaluation. This is emphasized by Fruhling & Siy (2017), where their study demonstrated users' capability to understand heuristics and provide useful input as a factor that increases usage of the developed artefact.

Rusu et al. (2011) propose a six-step method to establish usability heuristics, while Hermawati & Lawson (2015) propose a general methodology encompassing two stages to establish usability heuristics for a specific domain. Fruhling & Siy's (2017) methodology was; (*i) develop a set of domain-specific usability heuristics by usability experts where a qualitative design with two data collection phases is employed. Then, (ii) validation phase with actual users is carried out (this step aims to increase internal validity results by including users' perspective). (iii) Finally, both phases are analyzed to identify the points on which they agree and disagree and then compared to the initial heuristics of the domain where they could determine which heuristics have become irrelevant and which new ones need to be added.*
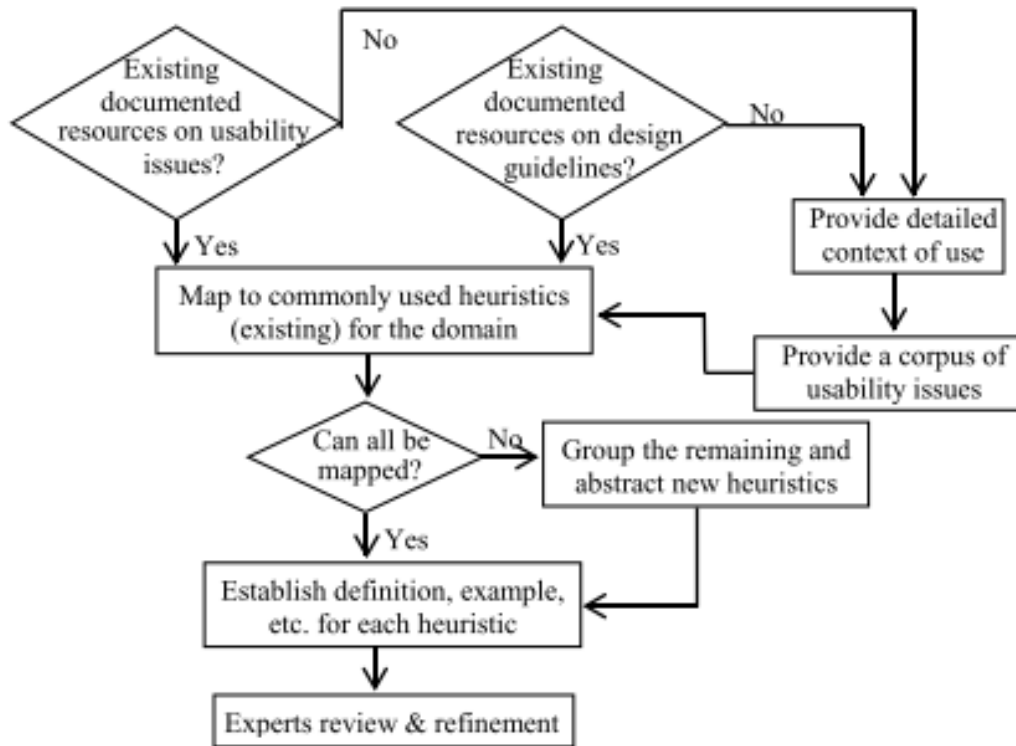
Figure 3:4 *Process to Expand heuristics sets for a specific domain*

Fruhling & Siy (2017) and Hermawati & Lawson (2015) have modified the Rusu et al. (2011) methodology that the researcher further changed, as shown in the steps below. Using a multi-method choice, the researcher proposed a methodology carried out in three phases and tested during the actual fieldwork.

i.   Identified heuristics guidelines through literature and study. *In Literature*: established the existing heuristics guidelines that have been used in developing modern geriatric technology;

ii. Through the case study approach, the researcher, through careful considerations, introduced two interventions to leverage both the interface and interaction design in influencing the psychosocial wellbeing of geriatric persons. While interacting with the mobile interactive interface, the researcher identified different factors contributing to the interface and interaction design for the participants' psychosocial benefits.

iii. Compare the results of (i) and (ii) against the existing heuristics and generate a new heuristic guideline for a mobile interactive interface for the geriatric person in context to psychosocial wellbeing

3.5 Data Collection and Analysis Approach

The newness informed the decision to follow a qualitative approach of psychosocial attributes identified during the Initial Research. The existing heuristics dwell on the visual design (interface design) that helps the geriatric person interact with a mobile device. Throughout the literature review and the preliminary findings, the researcher collected sufficient information to generate the constructs that guided the development of the data collection tools used in the main study.

3.5.1 Data Collection.

A multi-source for data, interviews and observations were used to gain insights from the two cases, which were heterogeneous as the participants' context varied in terms of education, former employment, family set-up, modern technology uses, etc. These variations determined the learning curve of the case groups where the privileged to education and employment were conversant with the touch technology either by using it or have seen someone using it.

3.5.1.1. Data Collection tools

We observed the participants performing tasks using their mobile phones. In addition, we conducted an in-depth interview with the older adults on their mobile technology's usability and user experience.

> *Observation.* A participant observation protocol was used in the study where research assistants were active participants, and the research subjects were aware of their identity. In the undisguised participation observation, the research assistant took notes and engaged them in unstructured interviews, and they were recorded after gaining consent. The research assistant observed the participants as they carried out different tasks to understand user behaviour better. The activities observed were actual usage of mobile phones carrying out tasks such as reading a text message, increasing the font size, distinguishing the different tasks' feedback, recognising icons, and exploring "non-mundane" features like cameras. The notes were taken during the participant observation, and the recordings, which are reported verbatim, are a source of data reliability.

> *Interviews.* The lead researcher conducted one-to-one in-person interviews with the older adults weekly and triangulated with the participatory observation. Through a

semi-structured interview, the research subjects articulated the ease or difficulties of the tasks carried out during the week.

The interview guide was pre-tested for clarity on language simplicity to answer the research questions. In tools testing, two philanthropic homes were identified. The inclusion criteria were some knowledge of mobile usage (feature phone and/or smartphone) and should be above 65 years.

Individual interviews yielded little when testing the instruments until we changed the strategy and had a focus group discussion (FGD) where the participants were more comfortable. The FGD gave detailed narrations, as the participants would add more to what the previous participant said. In the subsequent data points of the three specified time orders, the participants were comfortable to engage in an individual interview as the confidence of using the touch technologies started building up. Geriatric persons are intimidated by modern technology already; therefore, strategies have to be developed to ensure their confidence grows with time. Therefore, the FGD was the first choice, affording us a comfortable, face-to-face interview as they shared what they can and cannot do without being intimidated.

In administering the data instrument, the research followed the considerations by (David & Covert, 2007) to successfully implement the tool. We selected the sites, a sampling strategy identified, and the research assistants trained. The research sites were two centres, a daycare for the community dwellers and a philanthropic social home. The researcher used a convenience strategy to identify these centres as they were conveniently reachable by the researchers and the research assistants, therefore easy follow-up. The sampling strategy was purposive; therefore, the inclusion criteria of anyone above 65 years, free from neurological conditions, cognitive and motor impairment, and having some knowledge of mobile usage. The research duration, constrained by time, guided this inclusion clause for participation. The eight participants were each provided A-Tab A8+ (7", Android) touch technology during the 10 weeks duration.

We carried the research out in subsequent data points indexed in time order T_0-T_3 and took 10 weeks, where eight geriatric persons took part. The duration between the time orders and overall timeline was determined through a trial timeline that enabled the research to gather meaningful information. The duration of ten (10) weeks was appropriate; (i) we could observe the behavioural change of the participants as they interacted with the mobile interface, and (ii) there were no additional issues observed after this period. The research assistants recorded the

observations, and after two weeks each (total of 10 weeks, the researchers gathered information from the participant through interviews. The management and the participants consented to the observation and the interviews. In addition, the participants agreed to audio recording during the interviews, enabling the interviewer (researcher) to observe non-audible gestures.

However, many excellent qualitative studies (Turunen, 2010) have not used strategies that outline the underlying issue. These studies seek to improve the geriatric persons' day-to-day living yet insufficiently deal with their emotional experience, especially modern technology. This is why the strategy/procedure used in this research brings forth a methodological contribution in using a series of time orders, which gave a clear and in-depth understanding of an underlying issue that geriatric persons have on modern technology use.

Step-by-step data collection

Pre- Data Collection

1. This research attained approval for ethical collection of information from the subjects (Research protocol: P219/03/2016) from Kenyatta National Hospital-University of Nairobi (KNH-UoN ERC) **(Appendix H),** which we have used since carrying out the pre-study (in 2017) and approved extension in carrying out the main study (2019-2020).

2. Through purposive sampling, the management selected the participants who gave insights into the research questions. Geriatric persons at RedHouse_1 and RedHouse_2 provided the interactive mobile interface's knowledge, expertise, and experience. Redhouse_1, a centre for the elderly, has older people coming into the centre on different days and engaging in different activities. In Redhouse_2, the participants are residents of the home.

During Data Collection,

1. The researcher introduced themselves and thanked the participants for agreeing to be part of the research. Through the management's help, the researcher identified participants who were briefed on the research's purpose, the research duration, the requirements needed for the research, and how it will benefit them. The researcher answered the participants' queries to remove any doubt or anxiety that limited their participation.

2. The researcher made the participants aware of the recording tools used throughout the research.

3. Once the researcher addressed questions, management in Redhouse_2 gave consent for participation, while in Redhouse_1, we got consent from both management and participants; after that, we included them in the 10-week research.

4. In the FGD, interviews were semi-structured, as the researcher prodded more or the participants gave more than what we questioned and yet relevant to our work. In the FGDs, the researcher was the moderator of a group of geriatric persons eager to inform our research through stories and their life experiences as they enjoyed interventions that engaged their psychological and psychosocial well-being.

5. Once we concluded the interviews and FGDs, the researcher always thanked the participants.

3.5.2 Data Analysis.

A methodological expert, Philip Adu (Adu, n.d.), states that qualitative analysis reduces data without losing its meaning. Thematic Analysis (TA) was used for the qualitative analysis, as illustrated in **Figure 3.5** below. It's a descriptive method that reduces the data flexibly, dovetailing with other methods (Castleberry & Nolen, 2018). The TA's interest in our research was discovering patterns that identified the psychosocial needs that would fulfil the emotional experience of an interactive geriatric interface. The content analysis did not fit this research as it assumed a hypothesis/themes (pre-defined) therefore looking for the theme in the data (Jackson et al., 2007) rather than letting the data speak for itself as grounded theory depicts. Grounded Theory closeness to TA is the process of analysis only that the output in grounded theory leads to forming a theory (Corbin & Strauss, 1990), which was not the case for this qualitative research.

Like any other CAQDAS, the raw recorded data was transcribed in word processor software and fed into Atlas. ti for coding and interpretation of data using the 6 phase steps by Braun and Clarke (Maguire & Delahunt, 2017) shown below;
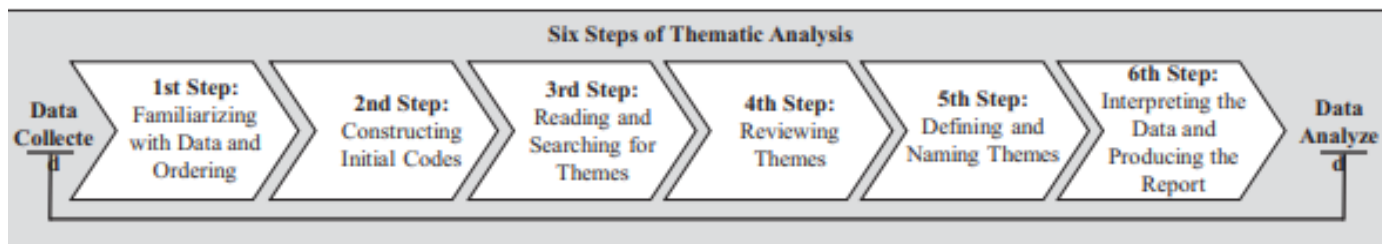
Figure 3:5 Data Analysis Steps of Thematic Analysis. Source(Braun & Clarke, 2006)

Phase 1: Data Familiarization

The researcher could familiarize themselves with the collected data, which was in text data. Reading and re-reading the text and visualization of data was done as the researcher attempted to go beyond the data's surface, meaning to tell a rich and compelling story with the data. The researcher could identify overt patterns and repeating issues in the data that we later identified as themes later in the coding process.

Phase 2: Generating Codes

Once again, going through the text and visual data, the researcher could tag items of interest. The researcher generated the semantic domains and sub-codes, stating the meaning of each through a comment tag. As mentioned earlier, we used emergent coding in identifying factors that defined an interactive mobile interface for psychosocial support for geriatric persons.

Phase 3: Generating Initial themes

In this phase, we did memoing in two levels; textual and conceptual levels. At the textual level (also known as open-ended coding, theoretical and operational), we incorporated memoing to give meaning to the codes and give reminders and critiques to the researcher. After the textual level, we cascaded to the conceptual level, where integrative memoing was used to theorize concepts, categories, properties, themes, and relationships. This later enabled the researcher to form overarching themes through the Gioia methodology, which would later be redefined to bring out the significant concepts that guided the final report's discussions.

Phase 4: Reviewing themes

In this phase, the researcher checked the initial themes against their coded data and entire dataset to ensure no drift from the research question. The essence here was to refine and review themes to ensure coherent patterns that tell the participants' stories through the coded data.

Phase 5: Defining and renaming themes

In this phase, the researcher reconstructed the identified themes to make a complete sense of their importance. This was done by *(i) defining what the current themes comprised and (ii) explaining each theme in a few sentences.*

Phase 6: Producing a report

In this phase, the researcher reported on the themes that contributed to the research question. The researchers exhibit verbatim reporting to support the dependability and credibility of the themes.
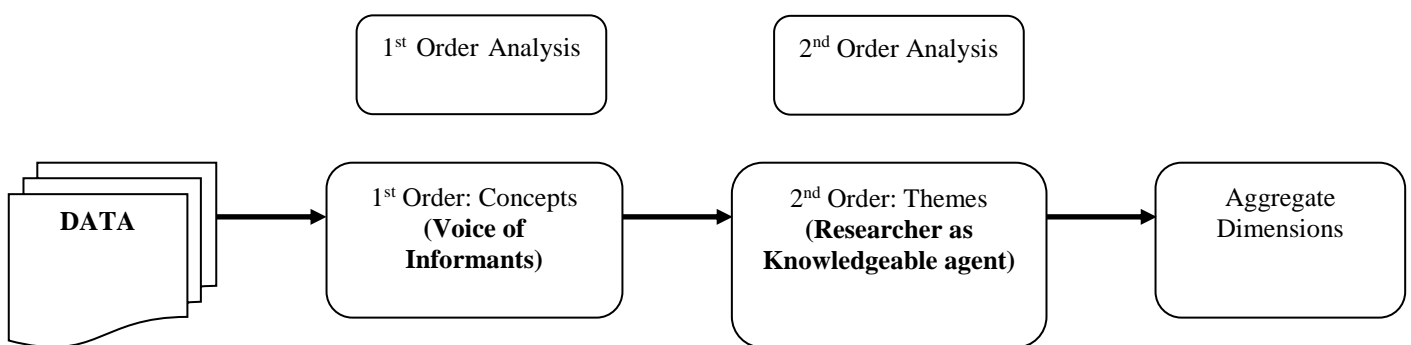
Figure 3:6 Analysis Process (modified)

3.6 Trustworthiness of research findings

Kivunja & Kuyini (2017) elaborate on the different criteria for qualitative studies' valid data and data analysis. In quantitative studies, four validations are; internal validity, external validity, reliability, and objectivity to ensure sound research. Conversely, in qualitative studies, four validations ensure the trustworthiness of research. The validations are; credibility, dependability, confirmability, and transferability.

First, we describe credibility as the researcher's ability to map their findings from the participants' realities. This research's overall outcome identified psychosocial usability heuristics, satisfying the participants' emotional needs when a preliminary study was conducted. Secondly, dependability is defined as observing similar findings under the same circumstances (Kivunja & Kuyini, 2017). While researching two centres, the findings were similar though variations on the learning curve were evident as the participants varied in education, former professions, health, family setup, etc. The research data from the two RedHouses is available for stepwise replication and/or inquiry audit to ascertain the consistency and repeatability of this research. Thirdly, transferability is when researchers

ensure they provide enough contextual data for other researchers to relate those findings in their contexts. This research will provide the Institution of study with the research data (raw data in audio format and transcribed notes), which other researchers can infer for contextualization. Lastly, confirmability ensured that the researcher minimized biases to ensure that outcome represented the participants' experiences. The research reports verbatim quotes from the participants, eliminating subjectivity and ensuring that findings are mapped to the participants' needs' realities.

3.7 Data Management and Analysis

The data collected is stored on a cloud service to mitigate the risks of losing instruments and preserve empirical evidence for this research. Furthermore, the participants' and centres' identities were protected using pseudo names and codes, respectively, achieving anonymity without promising confidentiality since our data was derived from.

3.8 Ethical permissions and Privacy

While dealing with human factors, a researcher should consider ethical permissions from the relevant authorities. A renewed research protocol P219/03/2016 was obtained from Kenyatta National Hospital-University of Nairobi Ethical Research Committee (KNH-UoN ERC) that enabled the research to be carried out in two centres in Nairobi and Kiambu counties in Kenya for pre-research and the main study. The management of these centres further gave consent, and before carrying out the training, the participants gave verbal consent. The researchers ensured anonymity, and therefore pseudonyms were used in reporting their responses. However, the researchers did not assure the participants of data confidentiality because the researchers used the data to report the research findings.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1 Introduction

The purpose of this research was to identify psychosocial factors that UX developers and designers should consider to design an interactive mobile interface for geriatric persons. This is important as mobile devices equipped with touchscreen interfaces enable geriatric persons to improve their physical and psychological well-being, health care, social life, and gaming (Motti et al., 2013).

4.2 Preliminary findings

Deveza et al. (2014), van Biljon & Renaud (2016), Van Biljon et al., 2010) establish the guidelines to be considered in developing modern technology for older adults to bring forth psychosocial wellbeing. However, these guidelines have not modelled the primary factors that bring out the valuable dimensions of the users' emotions, bringing a sense of belonging/self-worth to the older adult.

The importance of understanding the potential benefits of modern technology was illustrated further in a small group of older people in institutionalized care to explore the usage and attitude. The elderly, as seen earlier, was a source of wisdom, dealing with community/family feuds, and gave historical stories and experiences which were keenly listened to and followed by the younger generations. In addition, the older persons' grey hair was a sign of respect and made them feel the importance of society's belonging; this brought out self-worthiness to consider while developing modern technology for geriatric persons.

Through interviews and observations, we identified the underlying issue of modern technology adoption in their higher years in the Initial Research. We identified various existing factors that influence design guidelines in the research. The researcher confirmed physical design factors as per the existing heuristic guidelines.

The researcher performed a thematic analysis on the qualitative data to identify the key issues under the physical and psychological factors affecting older people using modern technology. The researcher obtained the physical and psychosocial factors through interviews and observation, where we interrelated the social factors and the older people's thoughts and behaviours. The output of the initial research yielded as below.

Physical factors

- *Visibility:* Respondents using their phones (a majority are using feature phones) complained that the device was too small; therefore, the font and the icons were not visible. Eyesight was a contributor to this issue.
- *Complexity*: The respondents complained of the nested layering of the mobile services. For example, making a phone call, scrolling down to the phone book to select a name, and making a phone call was an uneasy task for them.
- *Feedback*: The language type was complex for them to comprehend, therefore getting help.
- *Exploration*: There is no motivation for exploring the phone. They only used what they knew. In addition, the keypad feedback was cumbersome to the participants.
- *Recognition:* The participants said the icons were too small, therefore inhibiting selection. Interestingly, they located the money transfer icon since they have a lot of interest compared to other icons.

Psychosocial factors

- *Loneliness*; Respondents in touch with their families said that the thought of distance from their close family and relatives brings about loneliness, and they are mentally disturbed. On the other hand, older people like ourselves live and look forward to bonding with families and friends as this is their pride.
- *Self-worth and Sense of belonging:* Respondents voiced the need to use modern technology actively.

> **Case Description**
> *Mzee John is an octogenarian and currently a resident in an institution of care. While growing up, he acknowledges his grandfather's outstanding efforts in nurturing the young men to be the breadwinners of their families. The grandfather taught them how to live in peace and deal with conflict. Growing up, they could see cases being resolved, especially family and community feuds. He accredits great wisdom to his grandfather and agemates and is proud to have been impacted by them. These formative years had great lessons in them, and he wishes he could impact the younger generation. Before admission to the home, he entertained the youths and nurtured through storytelling, narrating his own experiences: great life lessons. This was cut short when he became a resident of the home since the youths would not visit, especially so because of the distance. He gets in touch with the youths who call him, but they cannot talk much. This saddens him since he cannot enjoy the endless talks he had with the youths who would be keen to follow what he said. He felt appreciated and wanted. This, though since changed when he became a resident in the home.*

Intergenerational gaps and cultural gaps were the primary concern. Self-worth is when the older person can share, and they can be intellectually engaged. This way, they can give either a historical account or even give sound advice on different life stages. They expressed their concern about how the younger generation is not upholding the culture used to honour men and women in society. The participants also stated that they do not

feel a sense of belonging today as they are not involved in matters arising, where they can give wise inputs considering their experiences.

The initial research outcome aided the research in two ways; first, it confirmed the validity of the constructs identified in the literature review where IS models and the researcher expounded on aging theories. Secondly, it identified the psychosocial factors that build on the realities of the root need of our older persons. Therefore, this research blends the psychosocial needs to modern technology where the geriatric persons can use the modern technology in a retro perspective and engage socially and cognitively with society.

4.3 Findings in the baseline survey

In October 2019, the older adults from both Redhouse1 and RedHouse_2 were interviewed. The outcome influenced the subsequent data points indexed in time orderT_1, T_2, and T3, where senior games and standard VoIP experimented over ten weeks.

Table 4:1 Time Series Activities

Time Series	Concepts	Activities
T_0	Personal memoir	To understand the participants' day-to-day routines
	Modern technology	To gauge how they understood modern technology
	Psychological section	This helped us understand their inner desire and the modern world's view compared to the traditional one (the one they grew up in) and how modern technology has intervened.
T_1	Intervention 1: Wow, Senior Games	Engaging their cognitive ability
T_2	Intervention 2: VoIP Interactions	Engaging their psychosocial ability
T_3	Both Interventions	Cognitive and Psychosocial abilities

The baseline survey gave this research an understanding of how older adults viewed modern technology and how they have used it in their day-to-day activities. Using the Gioia methodology, the researcher shows the baseline data in **Figure 4.2.**

The participants stated life satisfaction was achieved by how meaningful life was to them, their achievements over the years, and their life after retirement. We defined the meaningfulness of life as how the participants engaged in different activities for social fulfilment. In their yesteryears, the participants admired the roles of the elderly as they took up initiatives of talking to the younger generations, resolved family/community feuds, socially engaged the younger generation and the society through story-telling and as advisors because of the experience they have gathered over the years. The mood tone of the participants, that is, their physical and psychological health, contributed ultimately to life satisfaction as this shows

the wellness of the geriatric person. Taking part and interacting with others brings out a positive mood tone that counters feelings of loneliness and sickness. The participation and interactions being physical are paramount for us humans since we are social beings. Various factors, including modernization, have inhibited this, causing a physical distance from their loved ones, especially in recent times of the Covid-19 pandemic. *Question: How do we maintain such experiences in such circumstances?*

Figure 4:1 A class session going on facilitated by a research assistant

Though excited about how modern technology has affected their day-to-day lives, older adults have not thoroughly imbued their emotional experience to influence the younger generation positively. Societal variations (traditional vs modern societies) revealed the emotional experience, which the research later considered for heuristic development as detailed in **section 4.5**. Traditional society is where the participants grew up, and modern society's where they currently live, as they continuously age. In the traditional society, older adults took up different roles/responsibilities that nurtured the younger generation's lives. Contrary, in modern society, this has been loosened, if not wholly lost, in some communities. Moral decay,

indiscipline, and disrespect top the tenets that have been adopted in modern society, as stated by the participants in our research. This is an eyesore to older adults who know the importance of growing up in a community. The roles that were key in shaping young life are slowly taking a nosedive compared to the traditional society where a child belonged to a community and where discipline was a communal role *(It takes a village to raise a child ~ Africa Proverb)*

We aggregated Life satisfaction and society as psychological principles since they affect the older adults' psychological wellness, therefore directly impacting other areas of their lives such as physical and mental health.

The widely held definition of modern technology among participants was expertise, or just a term they have heard and unsure of its meaning. The RedHouse_1 participants, having worked, retired, and settled in the urban area, have had higher exposure to modern technology, unlike their counterparts in RedHouse_2, who have lived entirely in a rural setup. Further discussions revealed that they have benefitted in technology usage as most of them owned a device which could be a mobile phone, radio, tv, and even a refrigerator! The participants majorly mentioned the mobile phone (self-acquired or inherited) as it aids in social engagements, mobile money, and security call. On mobile phone usage, the participants complained of small fonts, and when asked if they could customize to make the words larger, the answer was a resounding No! They had to consult someone to increase their font, therefore not knowing how to go about it. We trained them; we present the results in **Section 4.4 below.** For radio and TV, the vibrant media landscape has made vernacular stations thrive by broadcasting in indigenous languages where the elderly are educators to the younger generation to teach cultural preservation and local language.

Older adults' usage of modern technology reveals its usefulness in a geriatric person and could influence the acceptance and adoption of modern/digital technologies over a significant period. This informed our progression in the subsequent data points in different time orders, as we could merge the psychosocial principles with modern technology to detail its relationship further. The baseline findings helped determine the interventions we used for experiments and exploration in the subsequent data points indexed in time order. We considered senior games and synchronous connections through a standard VoIP, as choices seen in extensive literature to remedy social connection and improve mental engagement.
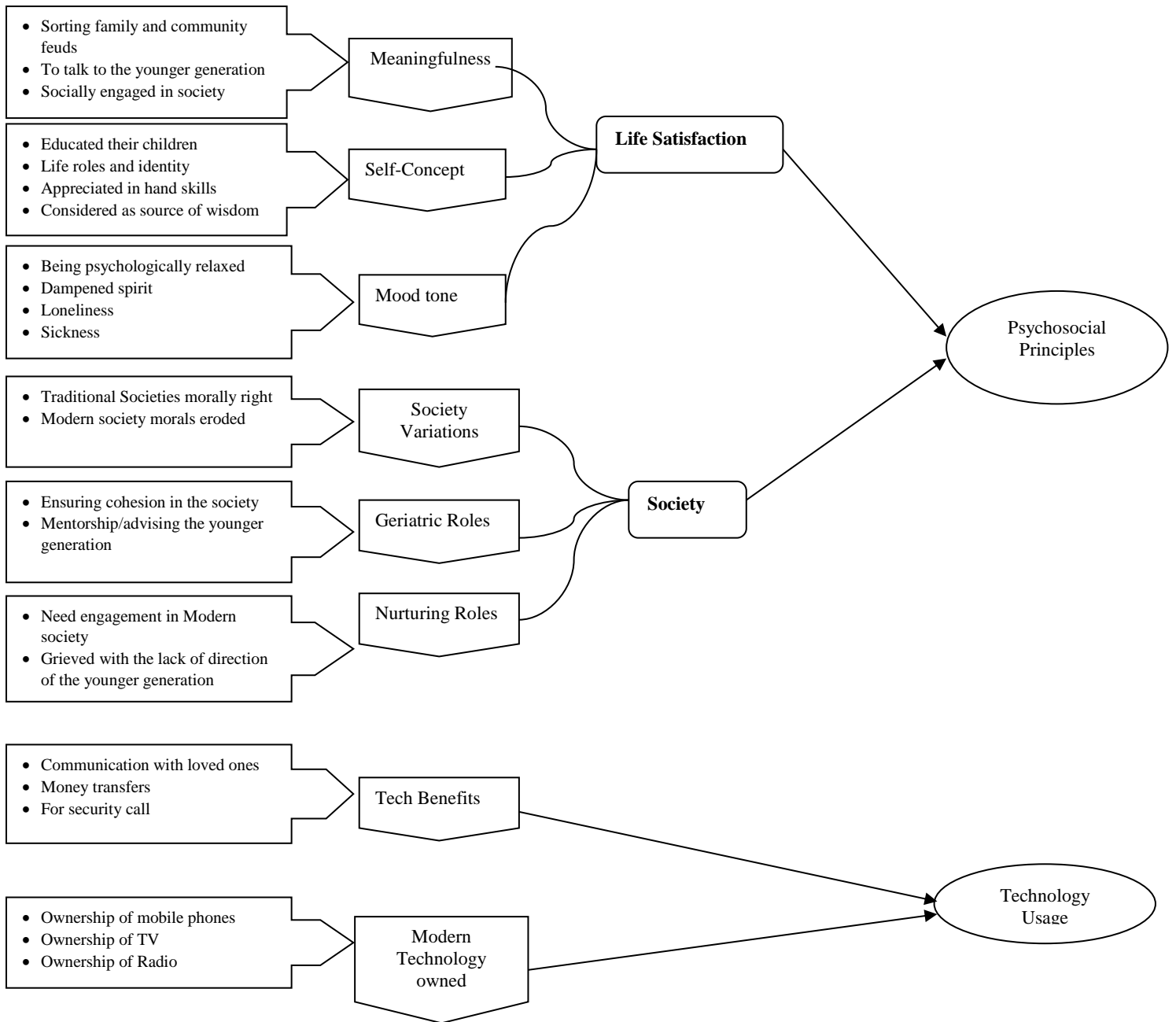
Figure 4:2 Gioia representation of the baseline study

In line with research objective 3, the interventions revealed the psychosocial characteristics that the participants exhibited as they engaged with the interactive mobile interface.

The baseline data is the premise of our subsequent data points, where we introduced the different interventions to expound on the baseline findings. The subsequent section presents the codes, sub-codes, and themes as they emerged [T_1-T_3] by illustrating them through relationships and presenting the themes through the Gioia methodology.

4.4 Relationships in data

The researcher examined the progression through the different time sessions. The touch technology, tablets, was used because of its large screen interface for better visibility by the participants. During the baseline survey, the favourably mentioned mobile phone usage was for social connections and money transfer during the first interview. In subsequent timelines, the research introduces two interventions that further the social connections and engage cognitively. First, adopting Alrazgan's (Al-Razgan et al., 2014) guidelines, the research exposed the participants to detailed questions to better understand the tablets' usage. We, therefore, present findings depending on the above-listed categories.

4.4.1 Functionalities and learning curve relationship.

In functionalities (usability), we tested the practical ability to operate a touchscreen flat display, a tablet. WhatsApp, a common VoIP platform launched in 2010 and is used by billions of people worldwide (Fernández-Ardèvol & Rosales, 2018), was preferred by the participants after an earlier question in the baseline survey showed they have either used it or have heard of it, therefore demonstrating that they can get support in case of issues arising.

```
WhatsApp. I talk to my daughter who is abroad through WhatsApp call.
I just need to have sufficient data bundles and I can talk to her
as much as I need. She requested one of my relatives to come and
teach me so that we be able to talk cheaply.
                                                    Respondent 2a
```

```
WhatsApp. I have heard it with other women in a chama am in,
but I have not used it yet                    Respondent 4a
```

```
I have only heard my children talk about WhatsApp
                                        Respondent 1a
```

The participants were given time to explore the platform and asked the same questions over 10 weeks as the researchers observed the incremental growth in usage. The initial question in T_1 touched on the 'basic' functions they may have experienced with their mobile phones, as shown in **Table 4.2**.

Voice calls, text messaging, and VoIP

Voice calls and text messaging were standard, though the participants preferred voice calls since they found messaging tedious because of the small fonts. The keypad complexities where they had to press the keys for selecting letters were tedious, as some buttons had multiple letters (for feature phones).

The participants' preference for voice calls varied as we reviewed the responses from these two RedHouses. In RedHouse_1, where participants are identified with the letter [a], they can write the text messages, but they cannot see well and cannot customize it because of its small fonts. In RedHouse_2, participants denoted as [b] are inhibited to text chat because they cannot write considering they are low-literate, their extreme ages, and lived in a rural setting most of their lives lowly exposed to technologies. We perceive the phone call preference as easy to use as it does not strain them compared to text chat. This is depicted as perceived ease of use (PEOU) by Chan and Chen's model (Chen & Chan, 2014b), and in Renaud and Van Biljon (Renaud & Biljon, 2008), they describe it as ease of learning and use. Progress in the different timelines showed impactful enhancement of skills for the older people in RedHouse_1 than in RedHouse_2; Redhouse_2, if granted more time, could improve to be as good as their peers in redhouse_1.

In T_2, respondent 3b lacked interest in picking up a new skill and preferred to settle with what he knows best, emphasizing the level of education and modern tech exposure. The respondents in RedHouse_1 expressed a positive attitude toward text messaging on larger screen sizes (tablets); they insisted on a voice and video calls preference. Ease of use is evident as it affords the participants' voice/video functionality. In T_3, the responses were similar for RedHouse_1, and some improvement was noted from our respondents in RedHouse_2. As depicted in Chen and Chan STAM model (Chen & Chan, 2014), this shows that attitude can be influenced by the ease of using a tech functionality.

The VoIP component was a new practice, as the participants rarely used it. Those who had used it before (participants in Redhouse_1) still learned additional features during the training. This component created a virtual space for mentorship, storytelling, etc., between the aged and the young generations. The researcher also included university students representing the younger generation to communicate with the participants through WhatsApp.

While experimenting with large screen devices, this research had a unique observation of an appropriation of voice call functionality in interactive mobile interfaces for older adults. Voice calls with an enlarged dialler icon have been developed for geriatric launchers for an average screen size like smartphones. A tablet user or screen size larger than 7" lacks the unique affordance to hold it to their ears during a call since it did not fit in their palm well. A loudspeaker icon should be visible for easy identification as they receive a phone call or make a phone call; therefore, there is no need to hold it up to their ears. Though not preferred, messaging is a valuable tool for non-synchronous activities where older adults can leave a text

message that can be responded to later (for non-emergency cases). However, composing a text message can also be problematic for older adults who are low-literate (therefore, the gulf of evaluation and execution cannot be well carried out) and also for the ones who have low visibility on small fonts. Different geriatric launchers have made the icons larger for the latter, yet not all elderly people are okay with 'bigified' icons and text. Instead, a simplified resizing icon should be used for easy use, therefore, reducing cognitive load. For VoIP communication, we observed that the sensory component that combines visual and listening is exciting to older people.

In contrast with passive recordings, the participants commended the video calls. Unfortunately, when the participants wanted to dial the university students, their video calls would go unanswered, yet the university student was not online. The participants later got to know how to check how the university students are available. The fonts denoting online or last seen are too small, and they can only guess what they see because it is blurry. The 'available' button should be visible for anyone with eyesight issues to carry on a task. Just as we record videos or audio, the start and end buttons should be visible, and voice feedback enabled to affirm the older person of choice picked. After the recording, two visible buttons marked either send or save should guide the older person to the next step.

Image capture and picture messaging

Picture capture was another enthralling feature that the older people enjoyed. For the older adults in RedHouse_2, this is an endless sight every time they have visitors who "snap away" during their social visit in the home. In T_1, respondent 3b is cognizant of a feature phone not having the ability to take a picture, therefore, knowing what phones can take pictures, considering he sees them being used by the visitors. Respondent 1b seems curious about how it works but has not asked how it is done. In RedHouse_1, we see that the ability to take pictures is common. These responses challenged the typical stereotypes that older people cannot learn new tricks as there was a willingness and desire to learn though the health issues, such as the involuntary movement of hands, may hinder it. Health issues were cited in showing that they cannot hold still the camera, and therefore requests were made on being afforded a stand for the tablets. By the time we interviewed at T_3, there was an easy recognition of the camera icon and its functionalities because they localize it to their visual and physical understanding of a camera.

Literature has not adequately studied camera use by older people, as most authors report on cameras that monitor older people. The participants recognized the camera icon as it maps onto the actual object known to them. Due to involuntary hand movements, some participants took shaky photos and were still excited about it as they had not done it before. Geriatric interfaces such as elder and big launcher have considered using the camera by a geriatric person where a back arrow and flip camera are well elaborated. The feature it lacks is on assessing the gallery where all photos captured are located. The gallery should be easily accessible to allow older adults to share with their loved ones. In elder and big launchers, photos are not displayed in the expected large thumbnail, therefore challenging to select, delete, or even send. This research suggests a galley that displays large thumbnails and where functions like select will display a large tick on the photo and delete and send tabs to be displayed on top for further action.

Table4:2 Functionalities and learning curve relationship

Activity	T1	T2	T3
Voice calls vs Text Messaging.	*"Yes, being able to do a short SMS. I prefer to call though more than SMS. SMS is tedious,"* [1a]	*"It's effortless for me to text and can customize the fonts now. I prefer to still call than text, though."* respondent 1a	*It's easy to text, but I prefer the calls as I will talk much than texting*
	"Yes, being able to do text messages, but I prefer phone calls to text. The fonts are too small; therefore, much of a struggle to use. You cannot say much on a text message compared to a phone call," [4a]	*"Am liking the text chat because now I don't need to struggle with small fonts. I can adjust where I can. I still prefer a phone call or even the video call that we've been learning,"* Respondent 4a.	*It is easy to work with text right now, knowing that I can adjust the font.*
	"I cannot be able to text anyone. I have never done it before." respondent 3b	*"I never do text messages because I cannot write much well. I know my native language and Swahili. I prefer to speak it than write it."* respondent 3b	*"I can write, but not much as I comprehend little of English. I prefer to phone call as we can communicate much in a language that I understand for a shorter period."*
Camera use	*Respondent 3b says, "My small phone cannot take a picture. So, I have never done a picture before,"*	*Respondent 3b "I have taken a photo, though not too clear because my hands cannot be steady; I am shaking a lot.*	*It is easy to take photos though having shaky hands*
	Respondent 3a says, "It's easy to take a picture. I learned this recently,"	*Respondent 1a "I finally can attempt to take a selfie. I am still not proficient, though.*	*"I do this very well. I have taken a selfie, and I have also shown one of my colleagues how to do it because she struggled.*
Key Pad interface (button interface vs touch interface)	*"The touch interface is a bit of a challenge since I am holding too long on some buttons and hence not working. But I am loving the experience and slowly becoming better."* Respondent 3b	*"I can say it's fair. I can see all the letters, but I have no keen interest in using the keypad."* respondent 3b	*"It's fair. I can be able to save people's numbers as the writings are big enough,"* Respondent 3b.
VoIP (Voice Calls)	*I quickly make phone calls. Remember, I was once a secretary before I retired-which was not too long ago. I have not done a video call before, though.*	*I am trying on this. I can see in real-time the person am communicating with—respondent 2a.*	*It is a beautiful way of communication. They can also take me around to see different places when they are outdoor. I have enjoyed this much, mainly when I communicate with my daughter abroad, Respondent 2a.*
	Yes, it is effortless to make a phone call with my feature phone. I am slowly getting how to use the tablet. The touch interface is a bit of a challenge since I am holding too long on some buttons and hence not working. But am loving the experience and slowly becoming better.	*They have shown us this. We have even interacted with the other teacher, where we see each other through the phone with far away people—respondent 3b.*	*This is very interesting. I have never seen this before. This would be nice for interaction Respondent 3b.*

VoIP (voice/video recording)	*I do not know how this is done*	*Not yet done an audio message. It isn't effortless, as I need to hold on to the button as I record Respondent 4a.*	*I will struggle with this because it seems like the process is lengthy and complex*
	I do not know about this	*"I have not recorded myself yet, though the teacher has shown us. The process seemed long. I will attempt this week—respondent 4b.*	*I wouldn't say I liked this feature at all. It demands a lot that is tiresome.*
	No am not. I just do not know how to do it.	*This is complex, but I will learn in a few. Mark has shown us, but I feel it's hard. With more lessons am sure I will grasp it.*	*Even after being demonstrated to, most of us prefer to direct (one-on-one contact than recording ourselves.) I want to see the person am talking to. I do not want to talk to myself Respondent 3a.*
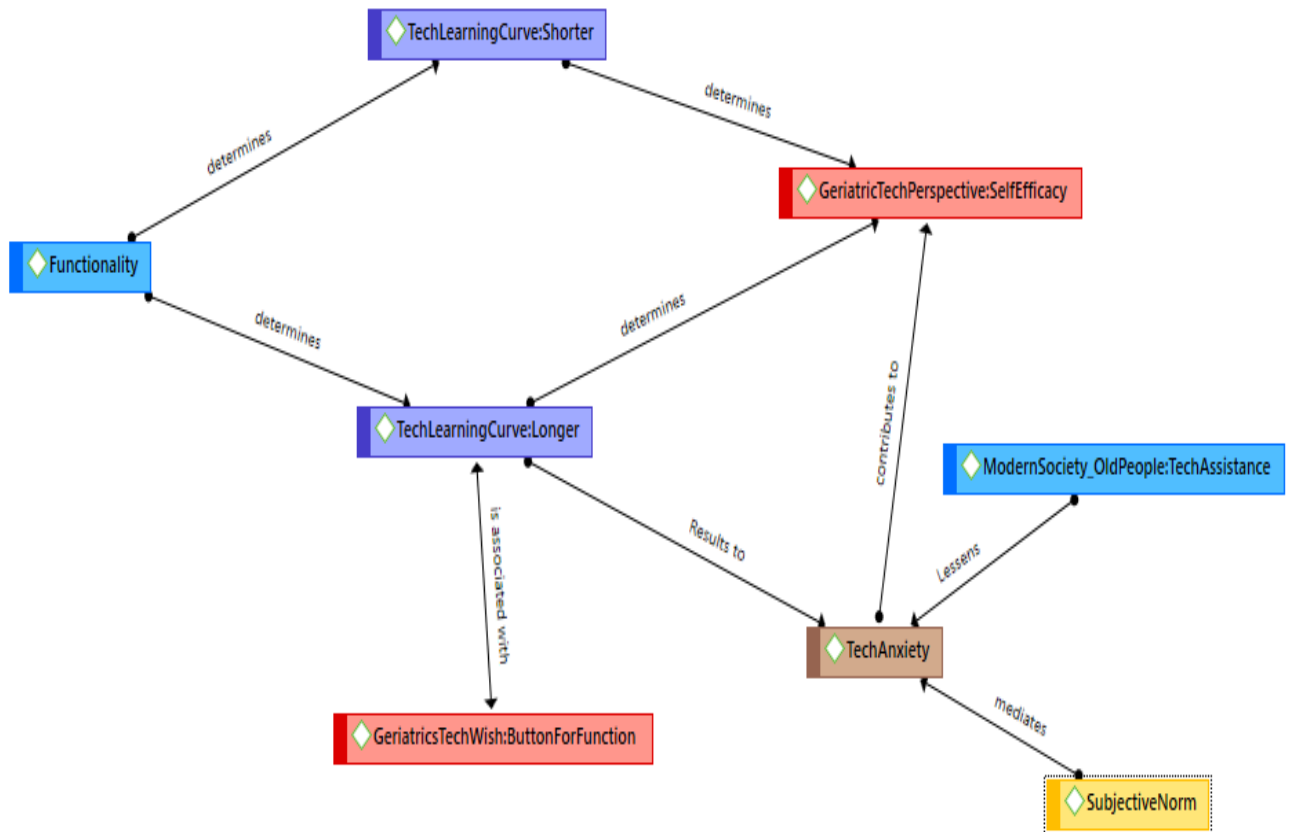
Figure 3:3 Functionalities and learning curve relationship

Figure 3.3 depicts the observed behaviour of exploring the functionalities of a device by older adults. The functionalities complexities or easiness; perceived ease of use or ease of learning and use (Chen & Chan, 2014; van Biljon & Renaud, 2008), as depicted in both models of STAM, will determine the learning curve of the technology that will bring about rejection or acceptance of technology use. The participants in RedHouse_1 took a shorter learning curve because they were earlier highly exposed to technology, as seen in Section **4.4.2 discussed below**. RedHouse_2 had a longer learning curve due to their background that had less exposure to technology and other factors such as age and their living setup for most of their lives. Mobile use anxiety, a predictive factor in technology usage behaviour in STAM (Chen & Chan, 2014b), was noted from the participants in RedHouse_2, especially where there is cognitive overload resulting from the longer tech learning curve. The management and staff (represented as social influence in Van Biljon's STAM) encouraged them, requiring more patience from the research assistance during the research period. According to the older adults ' pace, they can achieve self-efficacy if this is done over an extended period. By the end of the research, the participants in RedHouse_2, though still dependent on the training research assistance, they could accomplish some tasks therefore having some sense of self-efficacy. Geriatric persons

were categorical in their wish of a button to perform a function rather than a nested procedure; therefore, a preference for recognition than recall)

Wildenbos, Jaspers, Schijven have partially supported this section's results, where design perception, cognition, and physical ability barriers are considered.

| Verbatim quotes | sub-theme | Theme |

- *I can say I have learnt a lot. This is still abit challenging and I hope with time I will be able to do all these without fear of messing the working of the tablet (anxiety)*
- *Am making good progress and am loving it. I am now able to use my phone for more functions other than just calls and texting.*

Self-Efficacy

- *Not yet managed to do an audio message. It's abit complex, as I need to hold on the button as I record*
- *With some assistance am able to do it. I have not mastered yet as I either make it too large or make it too small*
- *Unfortunately, this too am not able to do. If only they can make it abit easier for us without those long procedures that I need to remember*

Perceived Ease of Use

- *I have been shown but I cannot remember right now*
- *It was demonstrated but I have not mastered it yet. Introducing us to such will take a longer time because we take time to learn*
- *I have managed to do this too. Though I have to be reminded most of the time*
- *I am able to do this with the assistance of the teacher. I always forget what he tells me because I find it hard*

Technology Support

Usability

Figure 4:4 Summary of usability as a theme

4.4.2 Design (look and feel), Geriatric perspective, and learning curve.

The look and feel in design are composed of how a geriatric is satisfied with the colour, the layouts (the "look") and how a geriatric person relates to buttons and menus in an interactive mobile device. In this section, exploration is determined and perceived as either high or low.

In the "look" category, all the geriatric persons in T_1, compared their phones to the tablet with a larger screen size where the participants preferred the latter; therefore, defining the mobile device preferred.

```
I can see the icons in this tablet are bigger compared to the ones in my
phone. Therefore, I prefer this big screen     Respondent 2b
```

```
Compared to what I have, this tablet is big and am satisfied
with the screen size                          Respondent 1a
```

As shown in excerpts below, the size did not inhibit the respondents' preference for a bigger size when asked about the tablet's portability (size and weight). Knowing the usefulness of this device (as a phone and a calculator), this respondent is still willing to have it with him even if it does not fit in his pockets.

```
This screen is okay compared to my phone (shows his phone). It has bigger
pictures and words.  It is a bit heavy though than my phone and cannot fit in
my shirt pocket                                            Respondent 2b
```

Though citing its heaviness, they still engaged with the device and held it throughout the research without complaining that it was heavy, except for respondent 1b, who requested a tablet support/holder.

```
"The screen is okay. I find it comfortable to work with. Is it possible
to have it be kept somewhere on a table in a way we can still operate
it to avoid holding it every time?" respondent 1b
```

Background

The response was that the participants applauded the font visibility since the screen was much larger than their feature phones. Due to their deteriorating eyesight, usability is inhibited the smaller the font or icons, especially on a feature phone. The participants praised the larger screens, larger fonts, and larger icons as they were easy to see and, therefore, the willingness and desire to use. Other than smaller font types, other issues such as teary eyes, mild or severe headaches were evident after prolonged use. The researcher advised the participants to take brief breaks in between sessions. In T_2, they expressed cognitive overload because of the nested procedure of customizing the screen's font and brightness. This calls for background lighting to be easily adjustable (possibly a button for it rather than the nested navigation,) which can be a (+) or (-) sign at the top of the launcher to adjust the lighting.

Table4:3 Look and feel, geriatric perspective and learning curve

	T1	T2	T3
Background lighting	*It is clear. But when I use it for long, the light distracts my eyes.* *Respondent 4a*	*"I have since known how to increase the fonts. I am working well with it. However, even if I adjust the brightness, I still cannot use it for a longer time. I think it's just my eyes since they have issues adjusting to such light."*	*My main issue is my eyes. Even if the words are enlarged, I still cannot sustain an extended usage of the tablet. I have known how to increase the font, though, but still request assistance…………*
	Respondent 2b said, "It is clear for me. The tablet has a larger font size. Can it be larger than this, though?".	*Respondent 1b said, "Not too clear. I have not known how to increase the fonts. Unfortunately, I keep forgetting each time being shown."*	*The words are much clearer after they adjusted them for me. But, unfortunately, I keep forgetting the process of adjusting the font size. It's a long process to remember.*
Recognition (Icon Distinction)	*"Yes, they are. They are the same as what we physically use. So, it's easy to know what to do with some of these widgets…………… yes, I can recognize a missed call. (Pointing to it) this thing that looks like a phone always tells me there is a missed call."* Respondent 2a	*This, too, is interesting on this tablet as it shows the number of calls that I have missed on the phone icon*	*Respondent 2a said, "I am well conversant with most of these widgets. The exploration has done me well."*
	Respondent 1a said, "Yes. Like for the phone call and the messages, they are easy because I can relate to what I still used before they introduced mobile phones to the market (phone and envelope icons)."	*Respondent 2b said, "The tablet has a proper way of showing that one has a missed call. The phone icon shows a number that tells me how many calls that one has missed.*	*Respondent 2b said, "Yes, can understand the commonly used widgets like WhatsApp, phone call and also games,"*
Scroll	*Respondent 4a said, "Yes, I can.; It was a big issue, though. It took me time to master. But, with time am improving."*	*I can do this easily. I always get my games from scrolling up and down.*	*It's now easy to do it. I get some applications by scrolling or swiping at the left or right.*
	It's easy when I am using my feature phone. However, for the tablet, I am still learning.	*Respondent 3b acknowledges improvement by saying, "This is can do fairly well. I have interacted with this device only for a few days. Maybe with time, I can be very good with it as long as I remember what to do.".*	*Where respondent 3b said, "This is easy to do now. I can scroll and swipe through the applications,*

Contextualization

In the "feel" category, we add **contextualization** where the geriatric person can recognize an icon by relating it to an actual object they have interacted with before, therefore having a shorter learning curve. The 'new message' icon and the 'missed call icon' were well identified, especially by the participants in RedHouse_2. When asked about icon distinction, the participants' responses show an earlier reference point that helps them identify the icons easily, learning fast as it transfers knowledge to the new interventions. It will be encouraging when customization and localization are incorporated when designing for older people, though this might be a challenge since not all icons are universal. For participants in RedHouse_1, the interest was on the missed call icon than the messaging icon. By the end of T_2, the participants could recognize more icons than the message and phone icon. When participants played the different games, they picked a game they had played before physically. One participant picked bow and arrow as it reminded him of the days he went forest hunting. While playing "ball in a hole," another participant identified the green balls as peas (a type of leguminous plant), a reminder of her farming days. For localization, the senior games need to be contextualized for the geriatric persons to relate to quickly and increase engagement as it reminds them of their earlier, energetic years. In T_3, the participants explored the other icons to understand what they could do with them. At this stage, they were not scared of making mistakes as they could move back and forth. Several participants in both RedHouse_1 and RedHouse_2 significantly achieved this.

Scrolling

The scrolling feature was problematic for the RedHouse_1 participant since all had only had a feature phone experience. The participants in RedHouse_2 had no issue with using the scroll button since they have had a smartphone or have used one before. They would swipe up and down to reveal more applications. The participants never used the alphabetical scroll bar (though redundant) as it was in small prints, therefore not easily visible for guiding purposes. Though the initial issues, participants in redhouse_1 showed a willingness to learn and improved over time as they explored the device. In T_3, significant improvement is noted even in redhouse_2 though it's still a challenge as the finger's pressure is detected as a different command; that is, a long press enables moving but gives one an option delete, rename etc.

The geriatric launchers have minimized scrolling for essential tasks, but the designs have not grouped similar tasks to enable more icon display. Because of geriatric persons'

growing needs, the primary tasks will need to be included as more older people engage through social network sites (SNS), play games, exercise, etc. A conventional launcher will need to incorporate a scroll functionality, but when similar tasks are grouped (without crowding the main icon for visibility), it limits the scroll functionality.

The research assistants and the researcher had to have a lot of patience as we trained the participants who would take a longer time to carry out a task because of psychomotor issues. However, this built their confidence over time, and usage was more frequent as we would find them already in the training room and using the devices as they waited for the training to begin.
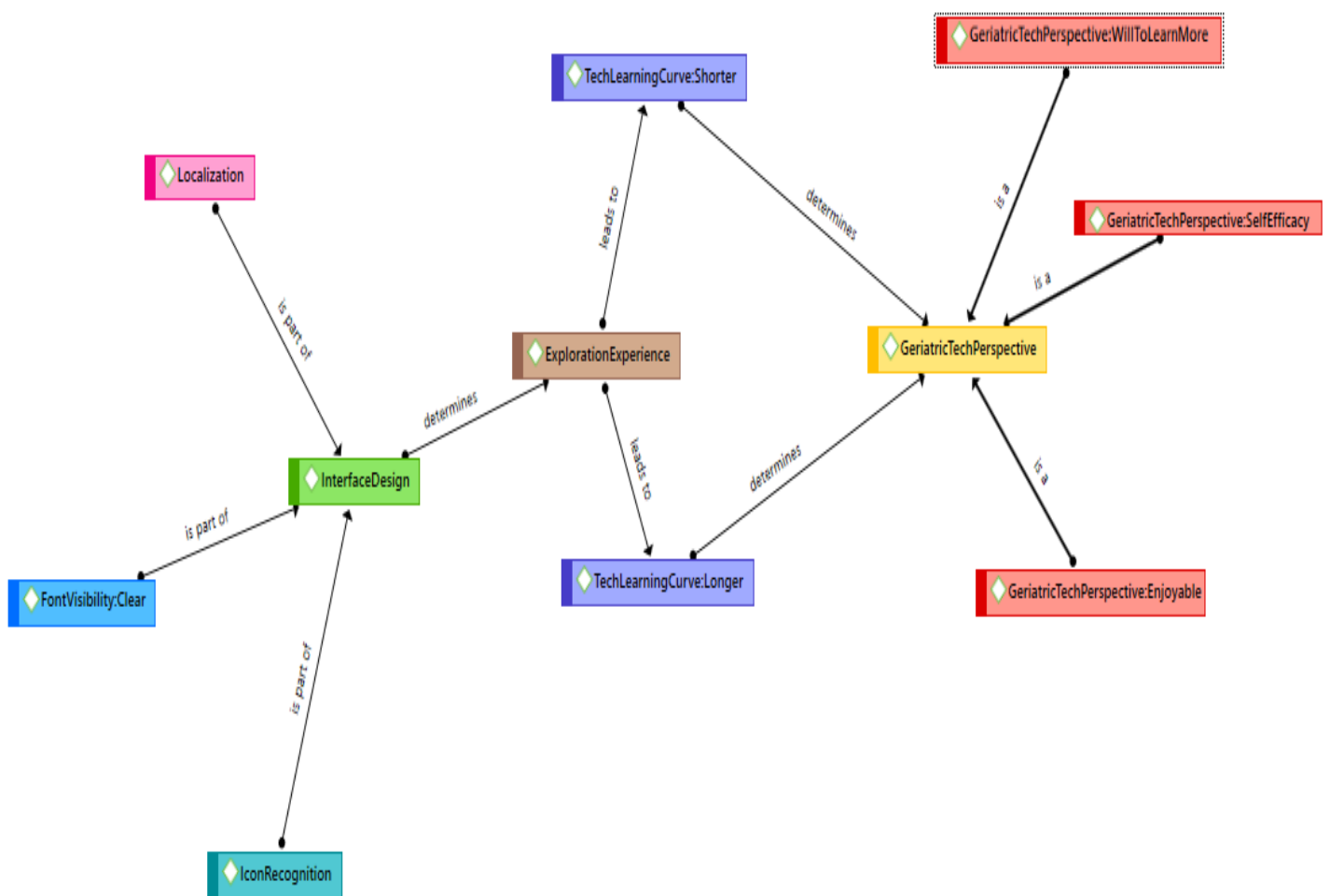
Figure 4:5 Design, Geriatric perspective, and learning curve relationship

Figure 4.5 shows an interface design; the mobile devices' look and feel afforded exploration for the geriatric persons in the research as time progressed through the research timeline. At the initial stage, the participants required tech assistance to grasp buttons and menus' workings. In addition, the participants could explore and customize fonts for better

visibility and recognition of icons they frequently used. There was a variation in Redhouse_1 and Redhouse_2 where the prior took a shorter time mastering the interface than the latter. Nevertheless, technology interest was still high.

- *I am happy I can change notification sounds to my liking. The process though tedious, I would love it to be more direct.*
- *I do my own mobile money transactions, so I know how to follow the steps as directed*
- *I am able to go through the different applications without the fear of messing up the phone because I can easily go back to previous steps or even go back to homepage.*
- *I am slowly familiarizing with the buttons. Am able to explore and this excites me a lot*

Affordance to Exploration

- *Compared to what I have, this tablet is really big and am satisfied with the screen size" (Interface Layout)*
- *Though it abit complex than the feature phone that I had. I have to interact with the screen while the other was an easy touch of a button not caring how hard I hit the button.*
- *...there is a phone icon on top of my screen. This shows that someone called and I missed it*

Interface Design

Look and Feel

Figure 4:6 Summary of Look and feel as a theme

4.4.3 Interactions and learning curve relationship.

In this section, we tested geriatric persons' interaction with the mobile interface; Rather than how the interface looks or feels, can they interact with the interface to their satisfaction? Interaction design is concerned with how the geriatric persons interact with the device's screen, allowing exploration and possibly leading to self-efficacy.

Notifications

In T_1, we tested the participants on understanding the standard notifications and how they responded to them. The researchers tested the phone's previous usage to understand how they interacted with their phones. On asking if the participants understood the notifications returned upon an action executed, their response was affirmative; they could recognize a notification and understand and execute it. However, these were basic notifications that would still appear when using the tablets, as they appeared when using their phones. Transferability of knowledge ensures a shorter learning curve for these basic functionalities, like following up the instructions' mobile money transactions.

We also introduced the participants to senior games that they engaged in and were probed on their navigation experience, such as; going to the next game level, switch to a

different player, and many more prompts. There is a variation in Redhouse_2; the notifications not customized to their language hindered interactions, therefore neglecting an application. During the subsequent training, the participants, while enjoying the new experiences, asked for help, and some also mastered what the researchers told them and would press the shown button every time a notification appeared. This shows a strong will to learn, though it took a longer learning curve, as exhibited in T_3.

The will to learn without customization or localization might be problematic if help is not available. Supporting multiple languages through audio feedback notification is paramount, and visual cues help the geriatric person decide the next step and what button to press.

Exploration

For interactions, as said earlier in this section, exploration determines the geriatric person's learning curve. The initial exploration experienced in T_1 revealed mobile use anxiety. The participants in Redhouse_1 and Redhouse_2 were too careful in T_1, as they only did what they understood as the participants feared to explore; thus, the participants' exploration observed by the researchers was at an adequate level. The design challenge, especially in the VoIP platform, had smaller navigation arrows that missed the participants' eyes. We can remedy this using a sizeable unidirectional arrow or a BACK sign to afford the older person to go to the previous step. Audio feedback for alerting on action taken is also significant.

In T_2, with the continuous help of the research assistants, the participants could appreciate the exploration experience as it relieved them of anxiety and fear of interface interaction. This was the case at Redhouse_2 too. In the last interview at T_3, a button for functionality was requested to avoid the nested (menu navigation) to make learnability easier (a recall vs recognition request), therefore encouraging exploration, which later influences actual tech use.

Touching and gestures

The keypad interface was the norm for the geriatric persons in RedHouse_1, initially explaining the difficulties of interaction with the touch interface. Compared to redhouse_2, the Redhouse_1 participant had difficulty knowing how to press and for how long to press for appropriate action to occur. The longer they pressed on the game icon, the icon would move as the system detects it as a drag command rather than a selection. This brought about mobile use

anxiety as they tried to interact with a new interface. They have mapped the pressing of key buttons to the touch interface, and they realized it is not working the same way. However, this did not demoralize the participants since the learning curve was longer, and there was a willingness and desire to learn. In the subsequent sessions, the participants in redhouse_1 could handle the none complex activities such as selection, but it wasn't easy to group the same items in one group folder through dragging. The participants in redhouse_2 got into their preferred interaction space, gaining self-efficacy levels that shed off fears of any device usage; self-efficacy and anxiety are discussed in Chen and Chan's model (Chen & Chan, 2014) for geriatric persons.

We report on the tap gestures and dragging objects as observed and from interviews with the participants. The initial time series was an introductory change from the keypad to the touchscreen display. This prompted longer press times that would bring no effect; therefore, the application was not opening. Those who could tap and open an application successfully had difficulties repositioning some of these applications—for instance, placing all the games in one folder and naming it. While using the dragging process, the participants had different options specified by the pressure exacted to an object. This was confusing as it gave the participants options to uninstall, share, remove, and apply details instead of dragging the object. Dexterity issues also contributed to the press and dragging as one would release before reaching the destination.

> *"Yes, I can take a picture. I tried recently to flip the camera and do a selfie. My hands are shaky, but I can do it." [2a]*

> *With some help, I can do it. I have not mastered it yet as I either make it too large or make it too small   [3b]*

Different scholars have marked these design problems (Leonardi et al., 2010; Anam & Abid, 2020; Wad-Dirasat, 2020) and implemented them in elderly launchers found in the google play store. The touching interface is elaborated as interaction by Al-Razgan et al. (2014) and as a mode of feedback by Nielsen (1993) for action. Al-Razgan et al. (2014) state that older people prefer tapping but not drag-and-drop actions, voice calls, and a slow-motioned interface for the touching interface. Anan & Abid (2020) and Eichhorn et al. (2020) identified design issues where the elderly got confused on single and multi-touch, small objects leading to finger occlusion and wrong point of the press and small objects being missed and selection done outside. This research recommends putting together the icons that are similar in one widget

(make sure it's visible), and with one tap, the geriatric persons' can select what they need instead of grouping them through drag and drop for easy access.

Table 4:4 Interactions and learning curve relationship

	T1	T2	T3
Understanding Notifications	*Respondent 1a said, "Yes, I can understand. I do my mobile money transactions, so I know how to follow the steps as directed."*	*"Yes, I do. For the games, I can know when a level is finished and when I am prompted to go to the next level.".*	*Very well. I can read the text shown as I perform some actions. Other than the complex ones that I may not understand (I always use the homepage button to exit that page), the others are much easier to understand and clearer to read.*
	Respondent 4b said, "Yes, can understand as long as the text is large enough.".	*"I do not understand all. But my friend assists me in understanding some. My English is not that good, so when my friend reads, he translates it for me in Kikuyu."*	*"I still rely on the teacher to tell me what notification is all about. I do not understand these prompts as I am not good at English. When in school, they taught us to use our mother tongue. I was not privileged to go for higher education."*
Exploration experience	*"Other than what I use most, the other buttons, I do not know what they are for. I do not want to touch things I am not sure of," respondent 2a.*	*"I have familiarized myself with a lot of these buttons, even if I may not be using them much. I can go through the different applications without the fear of messing up the phone because I can easily go back to previous steps or even go back to the homepage."*	*"It has made the experience beautiful. I can go back just in case I feel like I have messed up somewhere. These two buttons (demonstrating using the back and homepage button) have made my fears for exploring disappear."*
	"I can go back and forth with a minor challenge but progressing well. I swipe the screen from down here (demonstrates) and go to the previous task and home page." respondent 2b.	*"I have been able to work with buttons that can make me go back to the previous task and even to the homepage. When I need to play another game, I go back to the homepage, and I select the game."*	*"The buttons are easy to work with as I just need to touch on them, and they change to a different screen or go to the home page."*
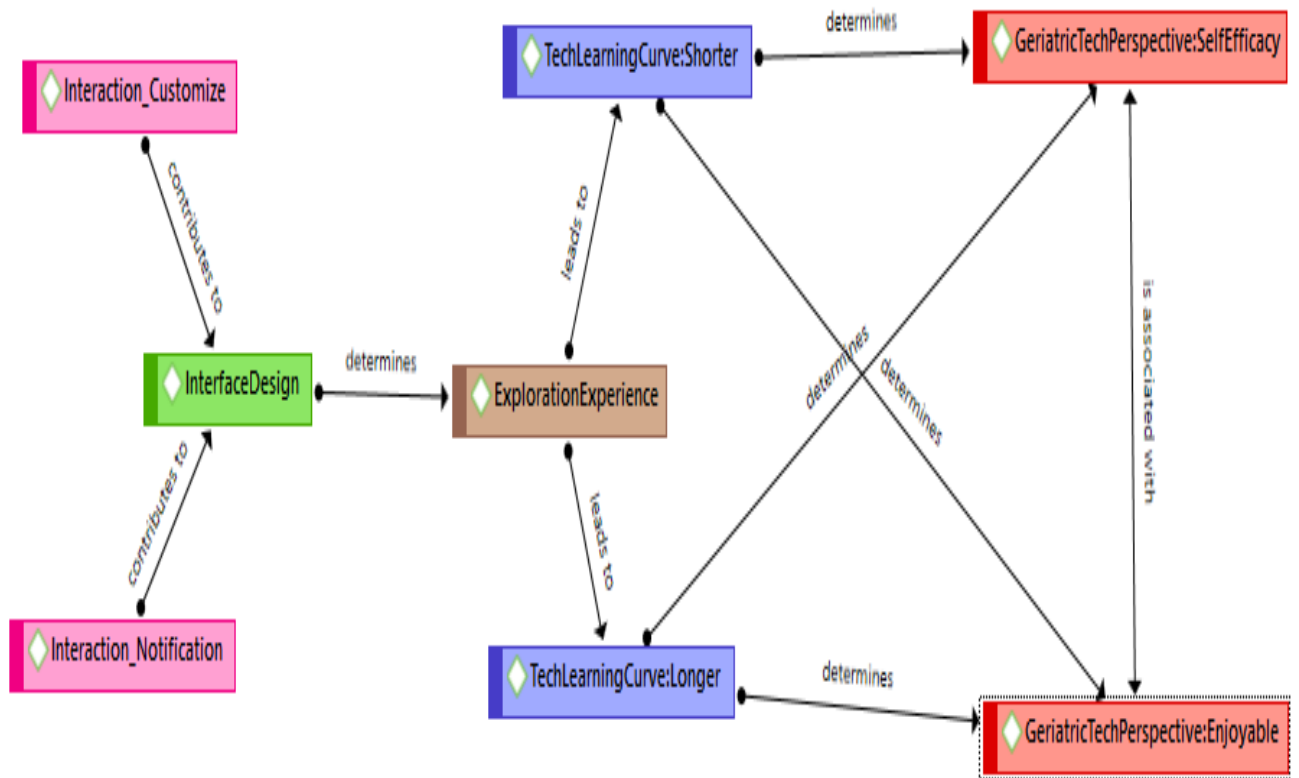
Figure 4:7 The interaction and learning curve relationship

The interaction and learning curve relationship in Figure 4.7 above shows how a geriatric person, through exploration (stated in STAM), confirms ease of learning and use, determining actual use. At the end of T3, the participants had a positive perspective towards the interventions since they enjoyed interacting with the interface and were satisfied with what they would afford to do, hence the self-efficacy.

Motti et al. (2013), citing Caprani et al., 2012, elaborates on the need for touchscreen for older people's interactions. The scholar states that there is evidence of touchscreen interaction reducing movement times and several errors. They state that it is also easy for users without experience to learn the touch interface, reducing older adults' resistance to new technologies. Redhouse_2 had no prior experience of a touch screen, yet they adapted well though experiencing challenges through the research.
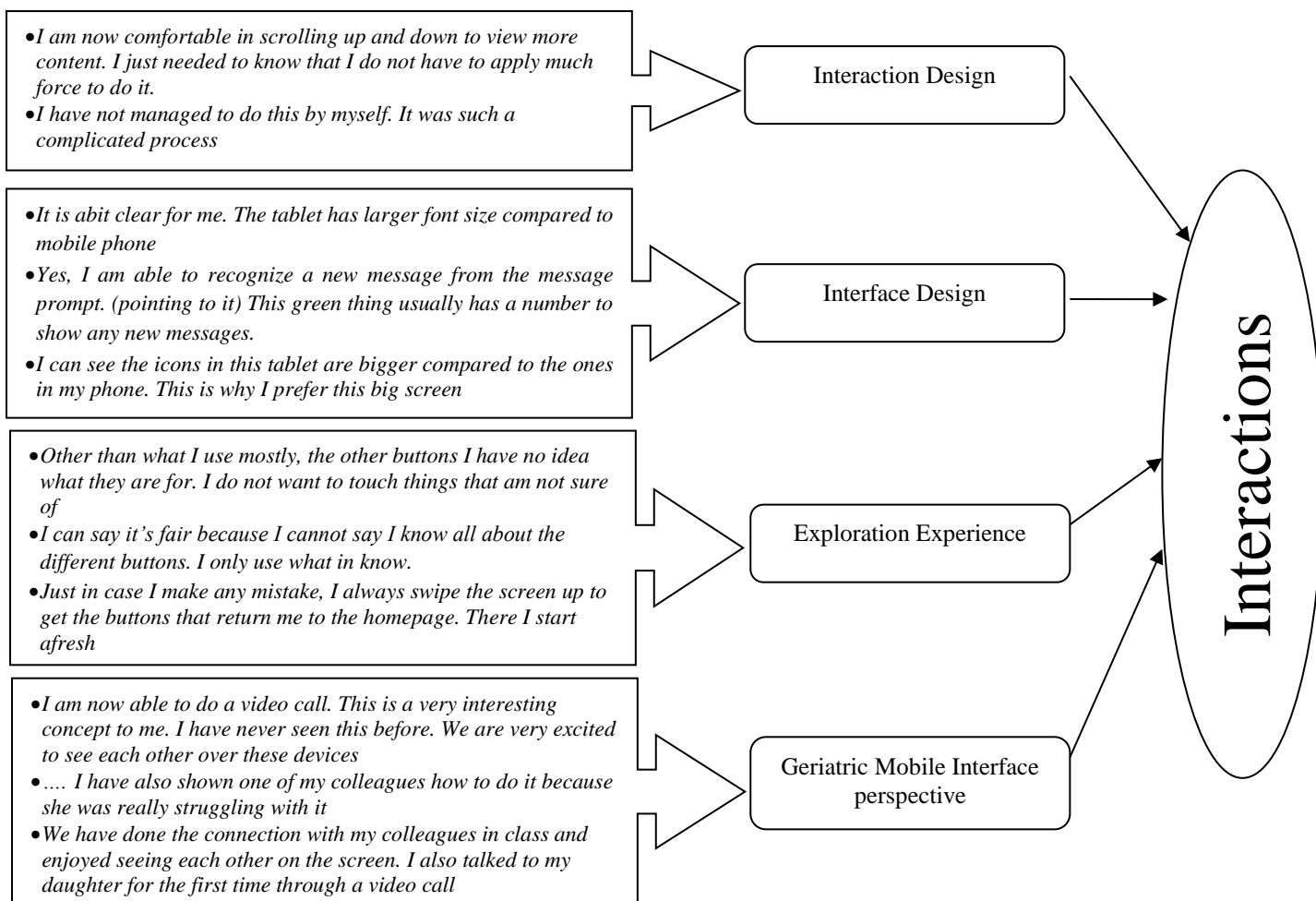
Figure 4:8 Summary of Interactions as a theme

The figure content (boxes) reads:

- •*I am now comfortable in scrolling up and down to view more content. I just needed to know that I do not have to apply much force to do it.*
- •*I have not managed to do this by myself. It was such a complicated process*

→ Interaction Design

- •*It is abit clear for me. The tablet has larger font size compared to mobile phone*
- •*Yes, I am able to recognize a new message from the message prompt. (pointing to it) This green thing usually has a number to show any new messages.*
- •*I can see the icons in this tablet are bigger compared to the ones in my phone. This is why I prefer this big screen*

→ Interface Design

- •*Other than what I use mostly, the other buttons I have no idea what they are for. I do not want to touch things that am not sure of*
- •*I can say it's fair because I cannot say I know all about the different buttons. I only use what in know.*
- •*Just in case I make any mistake, I always swipe the screen up to get the buttons that return me to the homepage. There I start afresh*

→ Exploration Experience

- •*I am now able to do a video call. This is a very interesting concept to me. I have never seen this before. We are very excited to see each other over these devices*
- •*…. I have also shown one of my colleagues how to do it because she was really struggling with it*
- •*We have done the connection with my colleagues in class and enjoyed seeing each other on the screen. I also talked to my daughter for the first time through a video call*

→ Geriatric Mobile Interface perspective

All pointing to: **Interactions**

4.4.4 Psychosocial relationships.

4.4.4.1 Technology exposure and learning curve relationship

Geriatric persons own different modern technology like radio, TV, mobile phones; the predominant one is the mobile phone used for social communication, money transfer, and a security call for emergencies or urgency.

> I own a phone and it has helped me a lot especially when communicating with my nephew and other loved ones. When am sick or I just need to visit my home area, I usually call them, they come for me and later they bring me back [2b]

> I also get medical assistance through the mobile money platform by reaching out to the diocese or friends [4b].

Respondent 2b voices the usefulness of mobile phones as it helps him communicate with loved ones, therefore showing the need of keeping in touch. We see that he also visits his home area, as he misses the young people that used to visit him, therefore, trying to maintain

the physical visit whenever he can, though it was not sustainable because of his deteriorating health. The interaction with his previous environment was psychologically satisfying as it reduced deep thoughts that quickly led to loneliness. While mobile phone calls can quickly solve what respondent 2b is missing, he considers it a costly venture as one must call all of them differently, unlike when they visited and sit beside the fireplace and talk.

In T_2, the respondents had a willingness and desire to learn the technology as it would enable them to be part of a community and go further to mentor, story-tell, and share their own experiences with the younger generation. The willingness to learn depicted interest as various participants prodded the research assistant for clarification or taught or retaught the functionalities. This was so to enable them to reach a level of self-efficacy in modern technology usage.

Self-efficacy was built over time in the different functionalities because of more prolonged exposures to mobile devices. Following the participants in T_2 and T_3, there was a positive response after weeks of training. The confidence was highly significant in RedHouse_1, whereas in RedHouse_2, the research assistants' over-dependency remained clear until the last interview at T_3. The participants in redhouse_2 struggled in building confidence because of the highly nested procedures leading to cognitive overload, therefore, hampering ease of use; ease of use contributed to technology use. If geriatric persons' grievances are not addressed, technology rejection is likely; they clearly state this in STAM by van Biljon & Renaud (2008) and Chen & Chan (2014).

Table 4:5 Modern tech exposure and learning curve

	T₁	T₂	T₃
Willingness to learn	*"I want to know more, not necessarily on the games but the Tablet too. I want to learn" [1a]*	*What I would love to learn is how to send pictures through WhatsApp*	*I can now do a video call; this is an exciting concept to me. I have never seen this before. We are very excited to see each other over these devices.*
	After the teacher adjusted it and showed me how to adjust, I have been able to adjust the light to my preference. It was hard at first, but after some lessons, I could do it well. When I forget a step, I always ask. [2b]	*I have used it, but I cannot connect through it. Hoping I will do it by the time you come back next [2b]*	*I would love to do guidance and counselling through this technology. Unfortunately, I cannot reach the young people physically, but I can reach them from what I have seen with this technology. I am looking forward to having this technology work for us in this way. I am ready.*
Self-efficacy	*"Yes. This is truly exciting as being able to get now a font of my preference without disturbing someone else to do it for me." [1a]*	*Yes, being able to take a photo. Now I can take photos of other people [1a]*	*I can do this no matter where I am in if I am in a room or outside where it's brighter. I have also shown my wife how to do this. [1a]*
	This is too hard for me to do. I ask the teacher to do it for me. Even when being shown, I always forget [2b]	*I can make a phone call. I can also save people's numbers. I saved yours (shows me). [2b]*	*This I have done well. I would love to do this repeatedly. This makes my existence worthwhile [2b]*

(a)

(b)

Figure 4:9 (a) and (b) show the Researcher with participants during interviews

Figure 4.9 shows ownership of modern technology, that is, the touch. The participants acknowledged that mobile use and social network devices' high interest were social connections, money transfers, and security calls. The research introduced a touch interface device for each participant, who tested the two interventions (senior games and VoIP interactions) to understand psychological wellness better. We also observed that residence settings (urban or rural) did not show a variation in mobile use attitude, but a variation was apparent in the learning curve. The geriatric persons initially appreciated the need for help and were afforded knowledge to explore the new touch interface. The urban settlers had a shorter learning curve as they were already exposed to smartphones; therefore, the participants' technological knowledge transfer was not limiting compared to their rural counterparts, who had a low mobile use exposure. This, though, did not deter their interest and will to learn the new interventions. The learning curve for the rural settlers was longer than the urban settlers since they depended wholly on the trainer. The urban settlers, though, had an initial recall issue, but they eventually caught up.

The interest in mobile interface use was initially influenced by exposure to modern technology, modern tech-owned, and geriatric modern tech perspectives. The two houses had some variations, as stated earlier, because of their unique background. Redhouse_1 had an advantage of experiencing the urban setting, and therefore their exposure to modern technology was high, considering that most of them had smartphones already. Conversely, tech interest was also influenced by low exposure to modern tech since the participants saw the usefulness of modern technology regardless of their knowledge. Notwithstanding the issues, they were stoic, had a will to learn, and enjoyed it.

Figure 4:10 Technology Exposure and learning curve relationship as at T3

4.4.4.2 Game benefits and geriatric psychological wellness

Previous research (Chopik, 2016; Wollersheim et al.,2010; Graves et al., 2016; Rosenberg et al., 2010; Studenski et al., 2010) has shown the benefits of games in the aging population. It argues that it increases social interaction and participation, contributing to the geriatric person's physical and psychological well-being. However, to our knowledge, no such research has been conducted in Kenya to generalize these findings, therefore, embarking on this research and evaluating games' effect to confirm other authors' findings.

Figure 4:11 Games session (cognitively engaged in a brain fit game)

The researchers introduced the participants to a set of senior games at T1 (**Figure 4:11**). Then, the researcher downloaded assorted games (both action and brain fit related) from the play store, namely, reasoning games, rolling balls, fruit legend, and balloon shooter (bow and arrow). The purpose of the games was to engage their cognitive skills and realize the fun of playing these games, relaxing them from their deep thoughts and exploring the mobile interface to spark curiosity on other features.

The participants were free to choose the games that they liked. Initially, the participants explored all the games before settling on what they loved most. Then, in a progressive interview, we asked the participants about the benefits they derived from playing games.

Table 4:6 Games benefits to psychological wellbeing

Activity	T₁	T₂	T₃
Playing Games	*Ooh, I don't want to leave it. Even when cooking, the food gets burnt (when playing games at home on the mobile phone). I cannot even remember to call someone that I needed to call. You forget who you are and think you are someone else. Very nice. Respondent 3a.*	*I am enjoying the games; I love the word search game. It is very engaging.*	*I stopped thinking about negative things like being lonely, being a widow, being aged. When I am playing games, I even forget that I am hungry. I play until my eyes pain but nowadays am avoiding too much screen time. I also avoid engaging with other people, which can be addictive, and I might not hear when people are talking to me.*
	We used to have this in primary, so it reminds us of what we used to do; arithmetic's not calculus Respondent 1a	*Playing games, and I am enjoying it. It engages me mentally, and I am happy about it.*	*These games have helped me a lot. They are very engaging, and I want to see that I have moved to the next more challenging level.*

Games gave them a good throwback of their yesteryears and reminded them of the great fun they had without thinking much about what is happening in their lives now. The participants expressed their appreciation for these games as they reduced their deep thoughts, engaging their sensory components and cognitive ability to either solve a mathematical problem, complete a word search, or simply get more points than what they scored previously in a game. Since geriatric people cannot continue carrying out some of the activities, they adopt a sedentary lifestyle that sinks them deep in thoughts and reminisces that they cannot change. The disengagement from society (as stated in the disengagement theory) and living a lonely life is a sure way of deteriorating mental and physical health. The bones become frail because of assuming a sedentary position for too long, and with time diseases associated with nerves will catch up, and one slowly sees their bodies waste away. For the psychological well-being, if one is not cognitively engaged, the mental faction slowly deteriorates, and one slips to loneliness, subsyndromal depression, and into diseases such as Alzheimer's and dementia catching up with them.
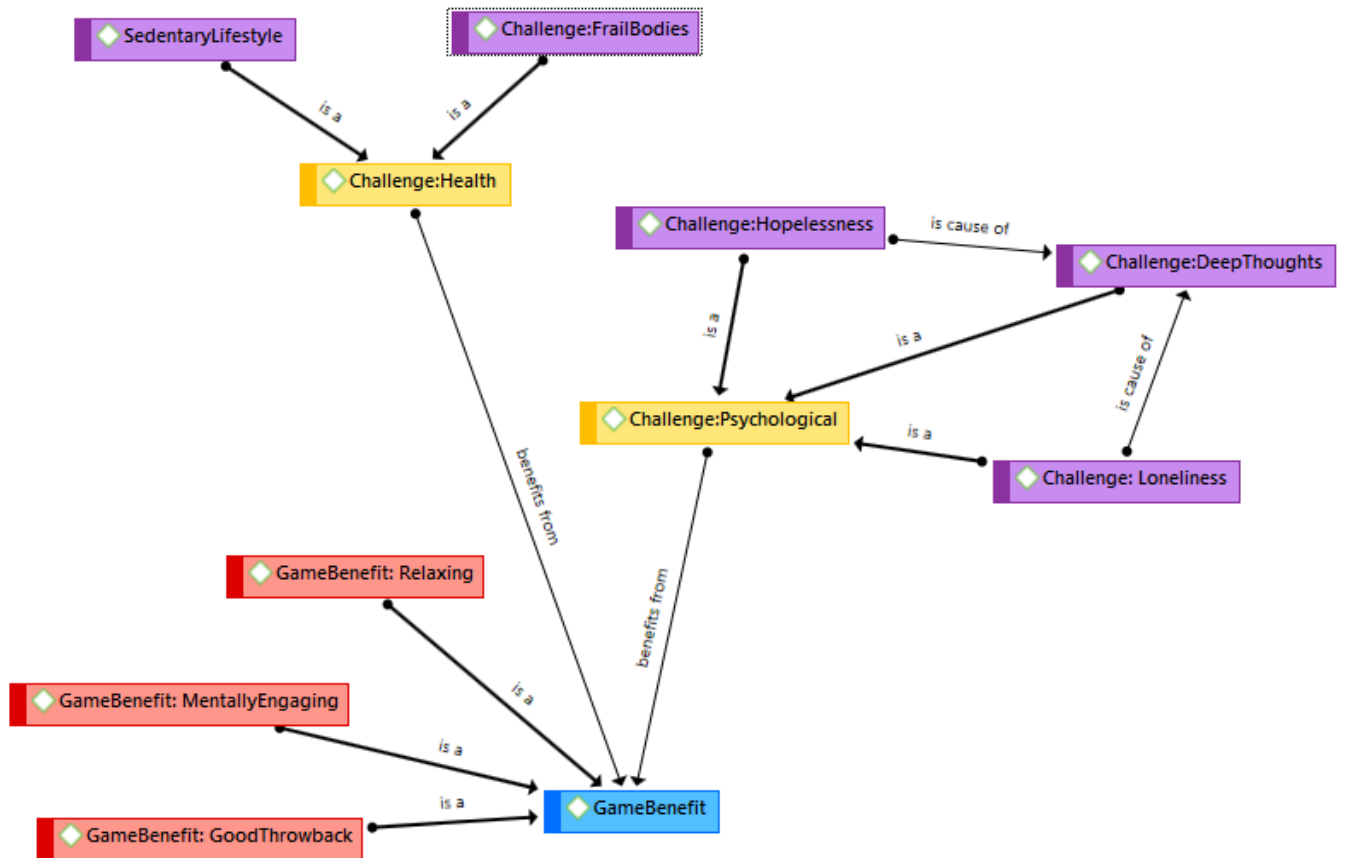
Figure 4:12 Game benefit and psychological well-being relationship

The participants, having engaged in the senior games they expressed feelings of calmness. Redhouse_1 participants requested for games to be installed on their smartphones so that they can engage in them when at home as they rest or during their free time. A random talk with a participant informed the researcher how they engaged their spouse on what they learned in class. They play the games together, and where the spouse gets stuck, the participant is of practical help; this exhibits that an older person can train other older people when they are well-trained.

Considerable research (Chopik, 2016; Studenski et al., 2010; Wollersheim, Merkes, Shields, & Liamputtong, 2010; Graves et al., 2016; Rosenberg et al., 2010) has exhibited the benefits of games to the older person population, physical and psychological. This research proves that we can extend this generalization to Kenyan geriatric people for the basic technological games to interact with a mobile interface.

4.4.4.3 Geriatric activity and psychological relationship

The participants in Redhouse_1 have the advantage of social participation and social activities to talk and share their hardships. The participants lived a quiet life before joining the centre, and after joining, they found comfort where they could relate since loneliness, isolation, and ostracization were common factor at their residential home. Below are some responses on when and why they joined redhouse_1.

> *"I joined in 2011 when a friend mentioned it to me. I got interested and therefore joined. Been here since then and will continue for a very long time until the time am incapacitated."* [1a]

Respondent 1a has experienced the centre's benefit and termed the experience as a "psychological relaxation."

> *"At redhouse_1 you become lively. You meet others and you can interact and talk about different issues and when you head back home you feel relaxed unlike before when you were at home where you may have been alone…………… So, when you come here meet different people, engage in in different issues past and present, you become relaxed"* [2a]

The valuable and therapeutic time through social participation and interaction has seen the participants discredit the disengagement theory as they continue in activities (continuity theory) as they did in their middle age or adopt new activities (activity theory). Social interaction brings about new knowledge and some form of relaxation. This extends to physical and psychological health, as all the sensory components and cognitive ability are highly used. Contrary to this, a sedentary lifestyle is adopted, and in the absence of activities, severe health challenges will emerge that could be physical, psychological, or both; we observe this in Redhouse_2 as respondents 2b and respondent 4b narrates to us how they spend their day.

> *"When I wake, I come to the hall to take tea and come out to the shed to rest. Nothing much goes on around here. I just take my meals and rest. I engage in stories with a few of my friends but unfortunately, we do not have much to talk about unless someone goes outside and gather new stories that he can share with us. Even if there were duties to help around here, I cannot do much as am immobile. I cannot help much because my legs are weak."* Respondent 2b

> *"I wake up early and as my routine, I do my prayers, then I prepare for breakfast. I then take my seat as I wait for visitors like you to interact with. We always get visitors of all types, young and old who asks us different questions and we can answer them. After dinner we at liberty to go and do what we want. For me I read a lot. I have friends who bring me books. Am requesting you to give us some of these devices to work with. You've heard them say that they just idle, this can help them a lot"*
>
> Respondent 4b

From these excerpts, social participation and interaction are minimal since they are in a restricted environment compared to Redhouse_1, who are community dwellers that visit the centre. Redhouse_2 is near a small shopping centre where a few older people (who can walk and of no disease like dementia) can mingle with the traders and the customers and gather some news that they can share with others in Redhouse_2. The participants relish visits to get more stories to talk about in the evening when they go to their halls of residence. Unfortunately, this is limited to the few residents who can take a leisure walk and gather information to share. A sedentary lifestyle is prevalent in redhouse_2; therefore, self-engagement and solitary activities such as reading books are preferred. There is limited psychosocial fitness in redhouse_2, prompting the need to connect the older people in such homes to the active world outside.

Social interactions and participation start from close home, where the participants' children and relatives keep in touch and afford a long conversation either through physical meetings or through a phone call. Of course, the shift from physical meetings to phone calls is not ideal, but it is the reality when current technology brings us close together where physical interactions seem impossible. This is confirmed by the recent unprecedented times of COVID-19, where lockdowns hindered movement, forcing people to use different social platforms to keep in touch.

The geriatric activities need to be thoroughly thought about, enabling them to age gracefully and honourably rather than having their later years in isolation and loneliness. The physical connection has received praise from the participants since they can engage in different activities such as joint talks of interests, laments, and delights of their lives.

> *"I visit a few friends where we engage in social activities in discussing politics and so…"* *[1a]*

> *"I usually talk to my nephew. He comes to visit. At times I go visit them then come back here".* *[2b]*

In T_2 through to T_3, the researcher introduced participants to a cross-platform messaging and voice-over IP service that enabled them to engage four university students recruited for this research. WhatsApp was the preferred platform because of its commonality among the participants since they had prior knowledge or knew someone who uses it; therefore, tech help can be offered whenever they get stuck. In training, the participants picked up the platform's usefulness as they expressed how they have engaged with it for different activities and felt useful, especially when eMentoring the young university students.

> *"I enjoyed this a lot. There is a time you showed us Nairobi town and I was excited on what technology can do. You remember the day we exercised. I was able to follow your cues through the video call. I felt very nice to have someone show me exercise routines from afar."* [3b]

> *"It is a beautiful way of communication. I can see in real time the person am communicating with. They can also take me round to see different places when they are outdoor. I have enjoyed this much especially when I communicate with my daughter who is abroad"* [2a]

> *"This session was very good. I enjoyed every moment with them and shared stories with them. It felt so good and felt useful in sharing and advising these young ladies"* [3a]

> *"Yes, I, managed to share using this platform and it was taken well by the young ones. This made me happy as I felt that they really heard me and learnt a lot. This made me feel worthy in this society."* [3b]

The psychological and psychosocial wellness of geriatric persons was tested during the pandemic. In the unprecedented COVID-19 period, what we previously perceived, as usual, slowly changed, therefore shifting to routines that were to keep us safe to make us adapt to the new normal. Various authorities enforced restrictive measures, which meant social gatherings being banned or, if mandatory, limited to a few who had to observe the social distance. Therefore, the older population was at risk because of comorbidities, being an easy target to COVID-19, causing high mortality in greying populations. Like in any other country, geriatric persons look forward to the sabbath day to go to their worship place in Kenya. They take up different roles that keep them busy in their place of worship as they get spiritually nourished. COVID-19 ceased all these, forcing the geriatric persons to attend services virtually if they can afford it, and if not, they miss out, only hoping for a physical visit from the Priest, Pastor, or an Imam. The GoK heard many Kenyans' pleads, and through the advice of the national security council and national emergency and response committee, the president, on the 6th July 2020, allowed resumption of worship but under strict guidelines. The directives were stringent as they curtailed anyone above 58 years and below 13 years to worship places; the government later reviewed to accommodate everyone but no children below six years. This cut out the geriatric persons who direly needed participation and spiritual nourishment. The 'new normal' is to follow the service online and even use the mobile platform for services such as tithing and offerings. In the Christian faith, the Holy Communion is a sacred practice that saw families directed on preparing the elements (at home), and by following the lead of their pastors through the social network platform, they could commune with their families. Despite the gradual resumption of various activities, such as resumption to religious places, the older generation is still highly vulnerable due to the comorbidities; therefore, the caregivers or even themselves are careful. Modern technology took a prominent role during the pandemic. Social network

services such as televised sermons, live radio broadcasts, and online sermons through YouTube channels, Facebook live feeds, etc., delivered the teachings that cater to everyone's spiritual needs. The rural folks enjoyed the sermons, too, through the radios.

Modern technology revolutionized the whole concept of participation and interactions. The question is, *is it catering to the needs of the geriatric persons wholly or partially?* The geriatric persons' needs are a positive contributor to society through modern technologies; perceived self-worthiness. The participants reminisced about their formative years as they talked of how the older generation in the traditional society took up roles that made their communities better. They wish to replicate this in the modern society that comprises high levels of disrespect and undiscipline among the younger generation. The participants compared the traditional society to the modern society and had much concern towards the younger generation.

> *"The generation right now is highly indiscipline. The kids nowadays can tell you things ((considering the tone, this could be bad talk or use of foul language)) that you left wondering where they got it from. Nowadays, a kid can easily talk rudely to an older person and not be remorseful………... During our time, the society was a parent too ((reminds me of an African proverb; a child belongs to the village)). You misbehave and there and then you will be corrected by anyone close to you even if it's not your parent. Touch a kid nowadays and you get the wrath of the parent. Surely, what are they showing their children? I dread for the coming generation!" [1b]*

Over the years, geriatric persons have gained knowledge and are experienced enough to share with the younger generation. But, unfortunately, these kinds of talks commonly happen in a physical meeting, making it harder to do a follow-up as one expects them to come back later to know how they are faring.

> *"I used to talk a lot to some youth in my area before I came to Redhouse_2, I would get visits from these youths and they would pour out their concerns which we talked about. They enjoyed our talks but unfortunately, I had to leave my area and come to Redhouse_2 and that's how the talks ended. I would love to talk to the younger people."*   *Respondent 2b*

The geriatric persons are likely to be inhibited in movement because of their deteriorating physical health, and others are still stronger in their later years, but they are all retired from active life. However, since these older persons have formally or informally influenced society before, they are still willing and interested in active life through volunteering, mentorship, leadership, or storytelling to the younger generation.

The engagement of the older generation to/with the younger generation is the core of this research. And for this to happen, the research introduced touchscreen flat displays used by the participants who involved the younger generation in different talks. Though the recall (no recognition yet) challenges when interacting through video and voice calls, the sessions gave them a sense of belonging and self-worth. In addition, these sessions had an element of life satisfaction, as they felt that their life was now meaningful and not wasting away without leaving a legacy, even in its most minor form.

In exploring several pieces of literature works (discussed in Chapter 2), modern technology has been accepted and used by geriatric persons to ease their day-to-day activities while also keeping in touch with their loved ones. However, to our knowledge, no empirical research exists that addresses the geriatric person's self-worthiness through modern technology, which expounds on the psychosocial needs of geriatric persons. As shown in the excerpts below, this is paramount, as it meant a lot to the research respondents.

> *"This I have done well. I would love to constantly do this. This makes my existence worthwhile. I cannot walk but I can talk!"   [2b]*

> *"Advising the youth is something that I have ever wanted to do. I used to teach Sunday school and engage with these kids but now since I do not teach, I rarely see them. Some of them have grown up and unfortunately have lost focus. You would talk to them and later you lose them as they disappear for a while. What I experienced using technology was good. I would talk to the young girls and boys you introduced us to and we would engage well. We would talk on different life aspects and it was refreshing. I never thought it was possible to connect this way. I am super happy" [4a]*

The participants in both Redhouse_ 1and 2, through modern technology (for this case, through video chat on WhatsApp), could express their knowledge and impact the lives of the young university students they engaged.

> *"The old people that I managed to interact with advised me on not wasting the days of my youth because old age will come and I will not be able to do anything. I enjoyed the stories especially on the Mau Mau war which is not documented. Some of these old people were detained; like one woman who gave me a story of how she was detained and later after being released, she would have to have a pass to move around. She has even shown me the pass book that was stamped to allow her movement. Things were tough for her!"   University Student*

> *"The old men constantly told me to take care of my children once I get married because in old age, they are the ones who will take care of me. They regret of the life they lived as they did not have a relationship with their children. One of the educated old men stressed on the hard work that is productive which can only be managed through managing my time well. He is now retired, independent and has his 3 children that he talked highly of"   University Student*

This shows that modern technology, in specific the mobile interface interaction, goes beyond its usefulness to showing us that the geriatric person experiences in terms of success, failures, and lessons learned can be shared through such innovative platforms and therefore giving them a sense of belonging as they make an impact in their small ways.
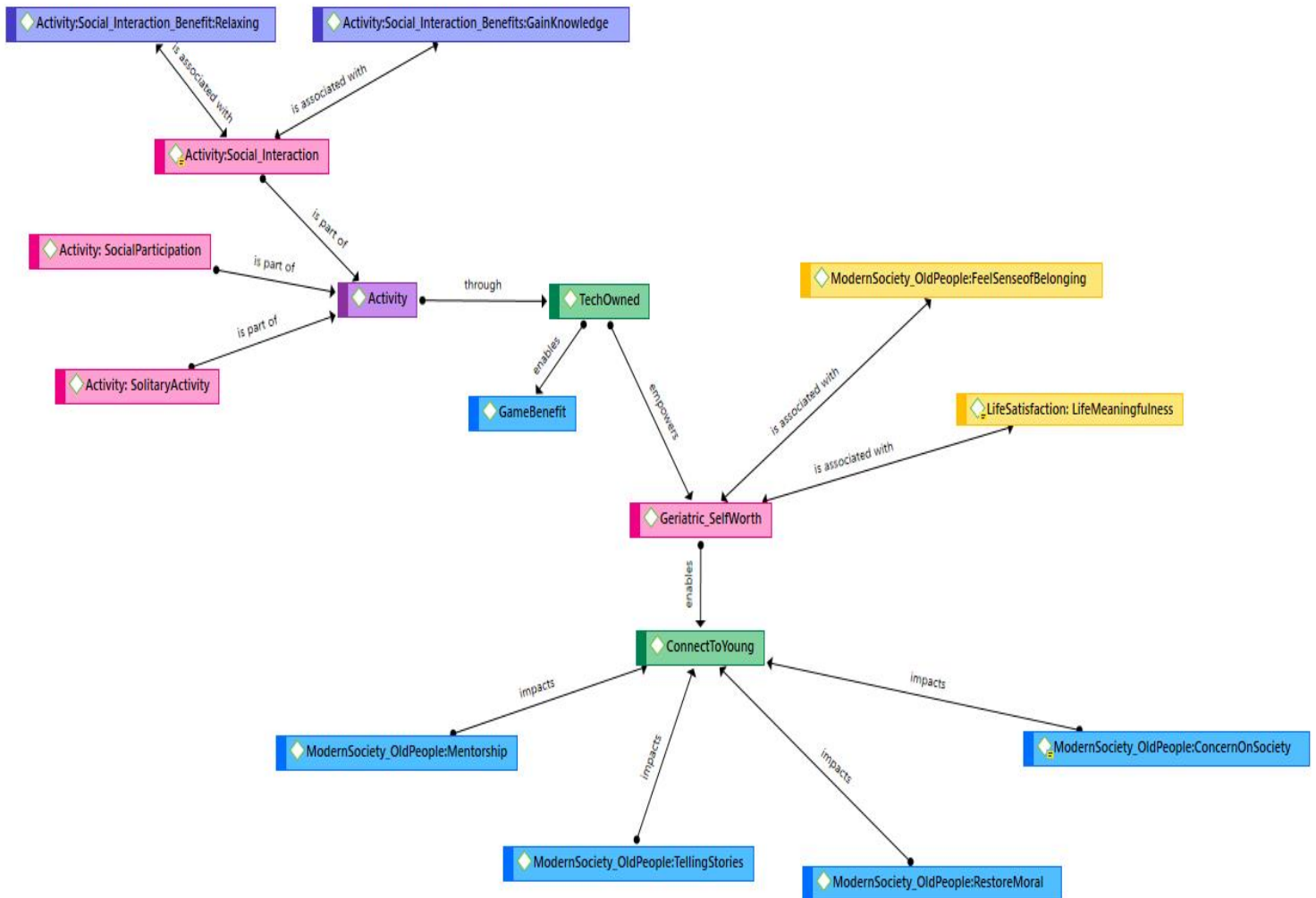
Figure 4:13 Geriatric activity and psychological relationship

The social theories aided in understanding the relationship between geriatric activities and the geriatric person's psychological well-being. As earlier explained, the games were beneficial for cognitive abilities to solve puzzles and enjoy action games that brought about relaxation. The participants achieved emotional experience and self-worth in the research as they felt they were still valuable regardless of the digital divide's modernization shifts. The participants revered the older people's wisdom, stories, and experiences in society, and this research sees modern technology effectively preserving our heritage and culture for generations to come.

4.5 Summary of outcome

For the data relationship, functionalities and learning curve relationship brought fourth variations in the two centres on functionalities such as voice calls and text, camera use and touch interface. This research observed that the participants struggled with the nested procedure and requested a simplified button to carry out a function. The participants preferred phone calls over text messaging since the small fonts were a deterrent to their eyesight. Text messaging was also termed as tedious, especially for the low-literate ones. Various authors have observed the same and have proposed visible, easy-to-read, access and recognizable interfaces (Anam & Abid, 2020) and a virtual autopilot feature to prevent older persons from getting stuck (Eichhorn et al., 2020). The research also observed new findings as shown below;

- The affordance of holding a large screen device to their ears, therefore a need for a large, loud speaker icon once they receive the phone call
- The sensory component that combines visual and listening mode excites the older adults

For the design (look and feel) theme, the researchers observed that the older they get, the low contrast colours become an issue, inhibiting visual sharpness. Finger pressure mapping was also an issue as the icons had multiple functionalities on them, causing confusion, for example, selecting vs moving the icon. Various authors have observed the same and proposed that readability is better on larger screens(Al-Razgan et al., 2014; Renaud & van Biljon, 2010), and the use of 16 point font and distinctive typeface like sans serif fonts is recommended(Eichhorn et al., 2020; Li & Luximon, 2020; Weinschenk, 2014). Further, this research observed a new finding;

- Group similar tasks together to limit the infinity scroll functionality.

For the interaction theme, the researcher observed that the dragging procedure was confusing to the participants as a cause of finger pressure, the assistive navigation buttons rarely used, and language hindered interactions (a gulf of evaluation and execution). Various authors have observed the same and propose tap gestures where the tap is defined carefully and possibly be automatically adapted (Leonardi et al., 2010). Another recommendation is easy to zoom functionality on mobile devices(Williams & Shekhar, 2019). Finally, the researcher made a new observation that visual cues are needed as an assistive tool to help in navigation.

For psychological theme, as the primary research had various observations which later influenced the psychosocial usability heuristics. The findings are as follows;

- The participants were willing to learn new modern technologies if they perceived usefulness and perceived it as a source of self-worth.

- The participants reached the self-efficacy phase when well guided in accomplishing tasks through technology

- The participants engaged more in brain fit–related games than action games as it stimulated their cognitive skills

- The games were psychologically relaxing as they took them away from their thoughts and loneliness

- The participants enjoyed the synchronous activities (ementoring, storytelling) and appreciated the new technologies for this capability

- The elderly appreciated the new technology as it gave them a sense of belonging and self-worth

- My former employer, keeps in touch with me and even sends me some money to buy medicine.
- I am able to communicate with my children over the phone and they are able to respond immediately.
- I am able to connect with loved ones especially when am sick
- Through this mobile phone, am able to keep in touch with my people in Embu. They know how am doing and I also get to know how they are doing.

Perceived Usefulness

- Not yet managed to do an audio message. It's abit complex, as I need to hold on the button as I record
- I can say its clearer after the teacher adjusted it for me
- With some assistance am able to do it. I have not mastered yet as I either make it too large or make it too small

Perceived Ease of Use

- I have been shown but I cannot remember right now
- It was demonstrated but I have not mastered it yet. Introducing us to such will take a longer time because we take time to learn
- I have managed to do this too. Though I have to be reminded most of the time
- I am able to do this with the assistance of the teacher. I always forget what he tells me because I find it hard

Technology Support

- I am happy I can change notification sounds to my liking. The process though tedious, I would love it to be more direct.
- I do my own mobile money transactions, so I know how to follow the steps as directed
- I am able to go through the different applications without the fear of messing up the phone because I can easily go back to previous steps or even go back to homepage.
- I am slowly familiarizing with the buttons. Am able to explore and this excites me a lot

Exploration Experience

- To hava each single button to have one fuctionality
- The nested menu is complex. I forget most of the time
- Visual cues to be localized for easy recognition

Interface Perspective

- ..... I would prefer an audio prompt that will give feedback in either English or swahili
- Visual cues are not clear, not easy to understand
- Use of complex gestures
- Touchscreen technology is complex compared to the feature phone keypad interface

Interaction Experience

- Our bodies may become all frail but our mouths should be instruments of wisdom as we have experience.
- I felt am useful to their lives as they kept asking for advice on different things. Am glad that I was able to impact them positively
- It feels good to be a source of knowledge to them
- ...this made me happy as I felt that they really heard me and learnt a lot. This made me feel worthy in this society

Self-worth

Usability

Look and feel
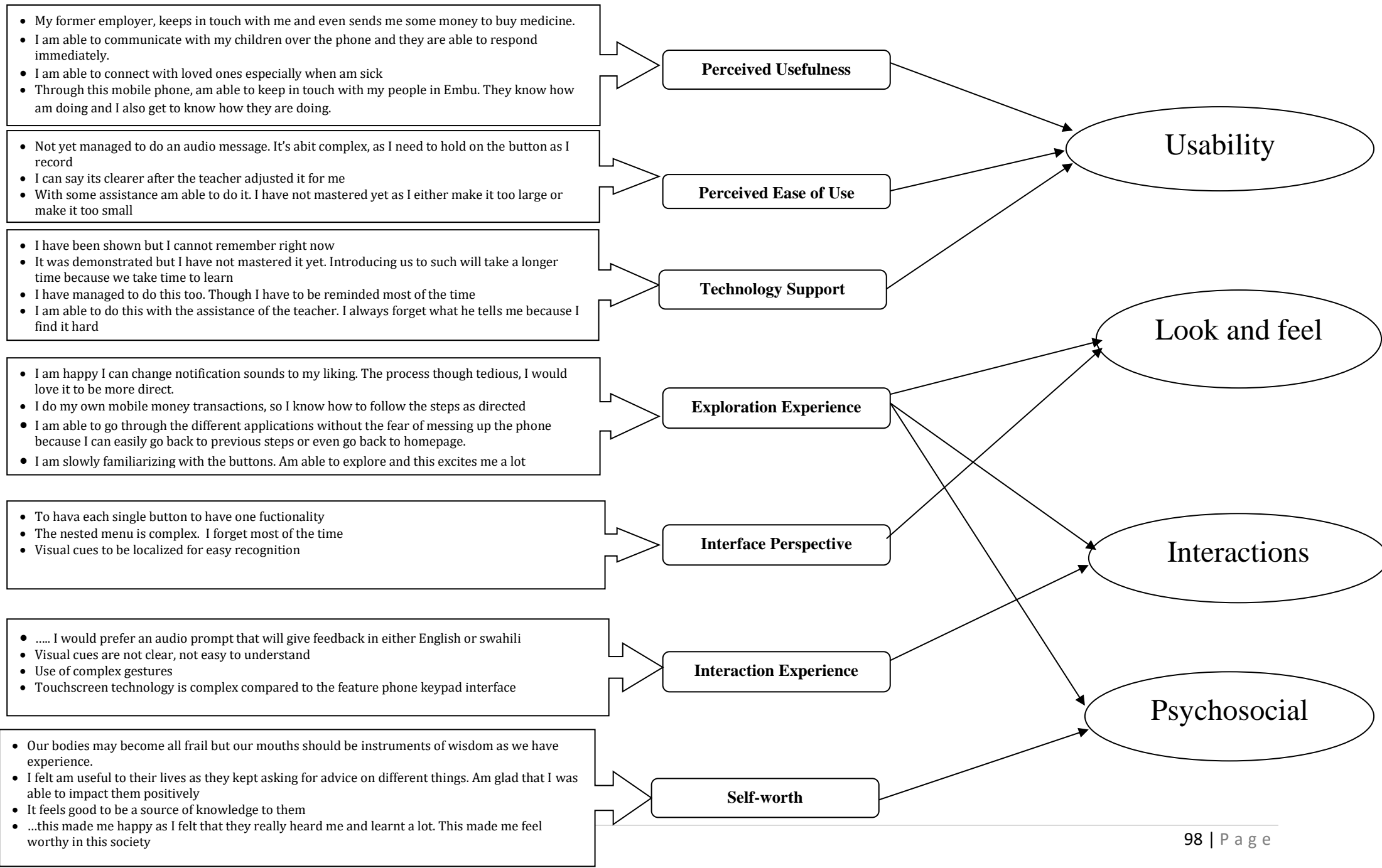
Interactions

Psychosocial

Figure 4:14 Gioia representation of codes, concepts, and themes

4.6 STAM with psychosocial factor

Technology and acceptance models are essentially premised from social theories as they influence users' behaviour. However, being a modified model that combines TAM and UTAUT, STAM still has its constructs identified in the early social models like Social cognitive theory by Bandura (1982).

STAM by Chan and Chen (Chan and Chen, 2014) formed the premise of this research, as it has considered some psychosocial factors such as social relationships present in our research. Chan and Chen (Chan and Chen 2014) related user behaviour by measuring the acceptance of gerontology, the health ability characteristics, and older Hong Kong Chinese demographic characteristics. This research adjusted STAM to consider this research's context, which expounded on tasks performed using interactive mobile interfaces to support psychosocial health. In this section, we define each of the determinants, specifying the moderating factors' role, and provide a theoretical justification that led to the formulation of the research model represented in **Figure 4:15**

i.   *Gerontechnology self-efficacy (G-SE)*

Self-efficacy was defined first by Bandura (1986) as "*judgment of one's ability to use a technology to accomplish a particular task.*" Venkatesh et al. (2003) developed a unified view of technology acceptance and merged self-efficacy and other constructs to form performance expectancy as a variable that affects behavioural intention. In formulating STAM, Chen and Chan adapted UTAUT and TAM and found G-SE's significance as directly affecting PU and PEOU impacting UB on technology use; therefore, they renamed G-SE to be in context. In this research, G-SE was observed after we involved the participants in subsequent training.

Task: Flip Camera:

> "*I do this very well. I have taken a selfie, and I have also shown one of my colleagues how to do it because she was struggling with it,*" [1a]

Task: Adjusting the brightness of the screen:

> "*I can well do this no matter the place am; in a room or outside where it's brighter. I have also shown my wife how to do this,*" [4a]

This shows G-SE having a significant influence between PU/UB and PEOU/UB. The usefulness and usability of the touch technologies to the participants believed that they could use modern technologies to accomplish tasks like eMentorship, storytelling, and playing

games. Experience (through mastery, vicarious or social persuasion) mediated as the participants learned, the more confidence they built in achieving the tasks in question. The participants mastered the process, and also, through vicarious experience, they could use the touch technologies without needing support as long as they had feedback that they were doing it correctly. The process does not need to have a multi-nested menu (complexities); to avoid cognitive overload, which disorients the geriatric person as they wonder if they have accomplished a task. Reed et al. (2005), citing Kelly and Charness, postulated that age mediates G-SE to PEOU. This was contrary to our research, as the participants strived to achieve a task even if it took a more extended learning period. The better they became in performing a task, the more appreciative the participants were. The games and voice chat became part of their lives since they continued with the tasks even after the training sessions and at their homes' comfort. Chen and Chan (Chen & Chan, 2014) showed a G-SE and UB correlation, which was unclear in our research as G-SE moderated both PU and PEOU to show the participants' usage behaviour.

These results are consistent with previous field studies (Kuerbis et al., 2017; Mitzner et al., 2019; Mostaghel & Oghazi, 2017), stating that G-SE remains a predictive factor for perceptions of usefulness and ease of use. To support our findings, Betts, Hill, & Gardner (2019) point out G-SE's significance in enhancing engagement with digital technology and learning.

ii.   *Gerontechnology Anxiety (G-A)*

Anxiety was first described by Bandura (1986) in the social cognitive theory (SCT), a theory known as an influential theory of human behaviour. Bandura defines anxiety as "*Evoking anxious or emotional reactions in performing a behaviour.*" Venkatesh et al. (2003) contextualize the description of technology usage and describe anxiety as "*the individual's apprehension when he/she faces the possibility of using modern technology.*" Özsungur (2019) credits resistance to gerontechnological products to anxiety, level of complexities of technology, and lack of self-sufficiency. This confirms our research findings as usability complexities in a novel technology create anxiety, affecting UB, also supported by Mostaghel & Oghazi (2017). However, this is contrary to STAM by Chan and Chen (2014) and Zhou et al. (2020) findings that show a direct association between G-A and UB, which could be the case if no support training was effectively offered to the participants. G-A was evident when the task seemed difficult for the geriatric persons and could easily lead to resistance to

technology, building a negative attitude towards use if no help is offered. Werner et al. (2020) support our emphasis on the importance of training and guidance, as shown in their studies where the participants' gestural performance and command recognition rate were improved. This was manifest at the beginning of the research, and through support and training, the geriatric persons performed better in the subsequent time series, therefore, encouraged to carry on the tasks rather than rejecting the usage of the modern technology introduced. Mostaghel & Oghazi (2017) also observed a strong relationship between G-A and PU, which was indirectly implied in our research as the participants were more concerned with PEOU, and as they grasped it, they saw the importance of the task, especially in their cognitive health and as a social influence.

Task: recognition of visual cues in T2:

> *"Yes, am slowly learning. It's hard, though. Especially with selecting an icon, I still have difficulties with it. [4]Mwalimu (Research assistant) tells me to touch it lightly (dab it), but I keep on forgetting, and I end up pressing on it, and nothing happens."*

Task: recognition of visual cues in T3:

> *"This is still a bit of a challenge. I can say I have done well over the past weeks as I can interact with it a bit without fear of messing it up."*

This shows that G-A is high on novice technologies and can only reduce by having continual support and training for a considerable period as the geriatric persons learn through.

iii.   Facilitating Conditions (FC)

Facilitating conditions depicts environmental factors that PC utilization (MPCU) describes as *"Objective factors in the environment that observers agree makes an act easy to accomplish." At the same time,* Venkatesh et al. (2003) in UTAUT gives it a managerial description and states it as "the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the systems'(Venkatesh et al., 2003). The FC in our research was training, guidance, and support from the research assistant, therefore influencing behaviour usage; this importance is emphasized by Chen & Chan (2013), outlining FC to include training, assistance, and encouragement. The training, guidance, and support had the

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[4] Mwalimu is a Swahili name for a teacher; for this case the training instructor

participants appreciate the interventions' PU as they progressed in PEOU. This shows a significant influence of FC on PU, PEOU, and UB. The finding is consistent with the one of Chen and Chan (2014).

> *"I do not understand all. But my friend assists me in understanding some. My English is not that good, so when my friend reads, he translates it for me in Kikuyu." [2b]*

> *"I have given it a trial but still needed a lot of guidance from the teacher. I am sure I will do it in time. We thank God for such a patient teacher. He doesn't give up on you," [2a]*

The participants' age mediated PEOU and UB as the older participants took longer to learn the tasks than the others. Though the longer learning curve, their attitude was positive towards usage behaviour. Experience is also mediating between PEOU and UB as FC breaks the complexities of the novel technologies, and transferring knowledge can enable one to carry on a new task. Other studies (Werner et al., 2020) echoed the significance of FC, emphasising the need for support and guided training needed by geriatric persons to enable them to carry out different tasks through varied modern technologies. Peng et al. (2018) show that improved training and guidance will eventually enable any age group to attain self-efficacy. This shows that a novice technology's usefulness and usability should be introduced to the geriatric population through training, guidance, and a lot of support in the initial stages of use.

iv. Cognitive Ability (CA)

In this context, we were establishing the level of alertness in keeping up with a good memory. For cognitive ability, the older generation will not be at par with the younger generation in learning new technologies because of cognitive decay as one progresses towards old age. This research was not different, especially for the participants who had were advanced in age, which showed that their fluid intelligence declined. As observed by Boot et al. (2013), the preferred senior games were brain fitness games (word search, mathematical-related games) compared to action games (rolling balls, bowling). The older generation takes longer to train and make subsequent errors (Broady et al., 2010; Mitzner et al., 2019) as they play these brain fitness games that stimulate their memory.

Task: Benefits of games (in subsequent time series)

> *"I feel relaxed and mentally challenged. We are still a long way off; I would like to know a lot about it."*

> *"These games have helped me a lot. They are very much engaging, and all that I want is to see that I have moved to the next harder level."*

CA moderated PU and PEOU as the usefulness and the non-complex structure of the games played during the research period stimulated the memory and had them engrossed on the screen until they finished the game. The easier the task became, the more appreciative the participants were, improving their cognitive skills. When carrying out a task was simplified (recognition rather than recall), the participants comfortably executed the task. However, this is contrary to Chan and Chen (2014), as they found cognitive ability directly affected user behaviour where the participants either accepted or rejected the gerontechnology. This variation is present because of the context of the research. For this research, we operationalized the cognitive skill through gaming that inspired learning and thinking. This shows that a new intervention will be perceived as valuable and usable if there is no cognitive overload, as it positively stimulates the geriatric's mind, therefore influencing UB.

v. Social relationship (SR)

As Chan and Chen (2014) and Hammerle et al. (2020), this research assessed social relationships in terms of satisfaction with personal relationships, support from friends, social engagements, and social participation. The PU of modern technology creates a social space for communication with loved ones, encouraging synchronous or non-synchronous social relationships (especially during the hard-hit times of covid-19). Synchronous activities encouraged the participants to positively influence society as they took up roles such as eMentoring, enabled through the cross-platform for voice and messaging over the internet. Unlike Chan and Chen (2014), this research found no direct relationship to UB unless moderated with SN if the geriatric person is apprehensive or has a negative attitude towards usage. The negative attitude results from the fear that modern technology will replace physical face-to-face social interaction, which was not the case in this research. Halicka (2019), studying robots used by geriatric persons, confirms that SR directly influences PU, and so does Hammerle et al. (2020) as she studied WhatsApp influence geriatric person's social relationships.

> *"Unfortunately, right now, I do not have a charger as it got spoilt. Now my phone is off. I am trying hard to make sure it works in the next two or three days because someone might ring me and they find me "mteja" {unavailable}" [4b]*

> *"I talk to my daughter, who is abroad through WhatsApp call. I need to have sufficient data bundles, and I can talk to her as much as I need. She requested one of my relatives to come and teach me so that we be able to talk cheaply."* [2a]

Geriatric persons slowly appreciated modern technologies (Morrow-Howell et al., 2020; Seifert, 2020; Berg-Weger & Morley, 2020; Digiovanni et al., 2020) during the Covid-19 pandemic that limited face-to-face social interactions because of the high risks of contracting the virus.

This demonstrates that the usefulness of new technologies is determined by the community's social relationships the geriatric persons are involved in. Continuity and activity social theories illustrate such communities that can use modern technology to keep social life alive.

vi. Attitudinal factors (ATT)

Previous scholars have strengthened the positive significance of PEOU on PU as represented in TAM, and so is in our research. The results show that PEOU and PU have a significant positive influence on ATT, and PU moderated the effects of PEOU on AT. This is contrary to Chan and Chen's (2014) findings as there is no support of PU moderating influence of PEOU to ATT; instead, other factors such as G-SE and FC are predictors of UB. Furthermore, positive ATT was related to enhanced convenience and fulfilment from the tasks, contributing to an individual's UB.

The present research introduces a new predictor to attitude; Perceived self-worthiness (PSW), which we define as *"The degree to which an individual believes that he/she is a positive contributor to his/her surrounding societies."* PEOU and PU moderates the effects of PSW on ATT. The geriatric person who believes that they can contribute to society sees the usefulness of modern technology to affect lives even at a distance and to a larger audience. We adopt PSW through a series of training (to achieve EOU) where the participants could carry out different tasks to enable them to communicate with the younger generation; for this case, university students.

> *"I took my first picture last week. I was so happy. I am struggling though to have a perfect picture without shaking,"* [4b]

> *"I am looking forward to giving the youths some historical stories. This way, I will not be bored as I used to be before this technology came. Now I can engage in games and also talk with the youths," [3b]*

This shows that geriatric persons can achieve worthiness and a sense of belonging in a community if they see the need for the technology and efficiently use it for communication, therefore impacting their audience.

Though not observed in this research, a possible positive relationship between PSW and UB could exist as the geriatric person can transfer the knowledge from one modern technology to some novel technologies if the operations are almost similar.

vii. Subjective Norm (SN)

Geriatric persons are affected by unfamiliar new technologies, causing frustration, apprehension, and anxiety as they form an attitude towards usage. SN can affect these scenarios significantly if an important person to the geriatric person influences the tech usage. The present research, inconsistent with studies such as Lee et al. (2020) and Saare et al. (2019), found that SN reveals a significant influence of ATT on UB. SN has not been represented in the Chan and Chen (2014) model. Lee et al. (2020) and Saare et al. (2019) assessed the acceptance of service bots in Malaysia and adopted mobile health applications among older people, respectively, found that SN was a significant predictor that positively influenced the intention of use. This is a recent confirmation that is consistent with our research as it accredits social norms to attitude towards gerontechnology that positively influences the participants' perception who were reluctant in carrying out a task or could not carry out a task.

> *"I was very encouraged when one of the lady's who does our laundry encouraged me to do some tasks that I did not want to do. I felt they were hard for me, and I would have ignored them and do what I can do" [1b]*

This shows that the close relationships of the geriatric persons can change their perception of modern technology use

Table 4:7 Change of the factors through the subsequent data points

Factor	Activity/Theme	T1	T2	T3
G-SE	Navigation experience/ Interaction	*This is very scary. I fear I might do something wrong permanently; the reason I use what we have only been shown*	*I have been able to work with buttons to make me go back to the previous task and even to the homepage. When I need to play another game, I go back to the homepage and select the game.*	*The buttons are easy to work with as I need to touch on them, and they change to a different screen or go to the home page*
G-A	Video call/ Functionality	*I have not done a video call before [2a]*	*I am trying on this. It is a beautiful way of communication. I can see in real-time the person am communicating with.*	*This is my best right now. I have used this to talk to my daughter and even the young girls you introduced us to.*
FC	Increase font size/Functionality	*For this tablet, I am interested to know how it is done since the wordings are bigger. For my tiny phone, I do this through the help of the interns [4b]*	*With the help of the teacher, yes, I can. I know once I get it, I will do it myself.*	*This I am now good at. I can increase the fonts very well to my preference.*
SR	Connect with the youth using modern tech/ Psychosocial	*I have only talked to my nephew, who is in Meru, through the phone. I have not reached a more comprehensive younger generation through the phone, though.*	*Recently, we were introduced to some youths from the university. We were told that we would interact with them through this technology. We have not started yet, but I look forward to this.*	*I loved this very much. It took my thoughts away as I enjoyed the talk with the young ones. Just having them either through a voice or video chat was good. We discussed a few things, especially the difference between how we grew up to what we have now, and advised them to keep good morals. I was thrilled and looked forward to talking to them.*
SN	(Vicarious experience)	*In T1, a participant in Redhouse 2 was having difficulties capturing a photo. She gave up, but the social worker of the home convinced her back to the sessions.*	*Throughout the sessions, the research assistant (with whom they had created a good rapport) would continually congratulate her and others on the small step they took.*	*during T3, she appreciated the lessons, but unfortunately, she was in a latency stage and was influenced not to attend class by her friend, and this led to her missing out on the last interview*

CA	Changing background/interactions	*No. I heard you say that I can put a picture too. Can you show me?*	*I love that I have my grandson's picture in the background. Unfortunately, I cannot do this by myself. The process is complicated for me to understand*	*I still have an issue with this. The process is too complicated and might take longer to understand.*
ATT	Creating groups /functionality	*I do not know what that is*	*It has been a hustle, but we are trying. It's because it is new, that is the reason it is taking this long.*	*It was demonstrated, and I am yet to master it. Introducing us to such will take a longer time because we take time to learn, but we will go the long haul! We need to know how to use such modern technologies to be part of the ever-growing world.*

From the Chen and Chan (2014) STAM, the researcher dropped self-reported health conditions, attitude to life and satisfaction, and physical functioning because of the research's scope. The health and ability characteristics did not feature in this research, as the participants were not subjected to any self-reporting test and daily instrumental activities. According to the sampling technique (purposive sampling), the management selected the participants. This was per the description given prior by the researcher as an inclusion criterion discussed in Chapter 3.
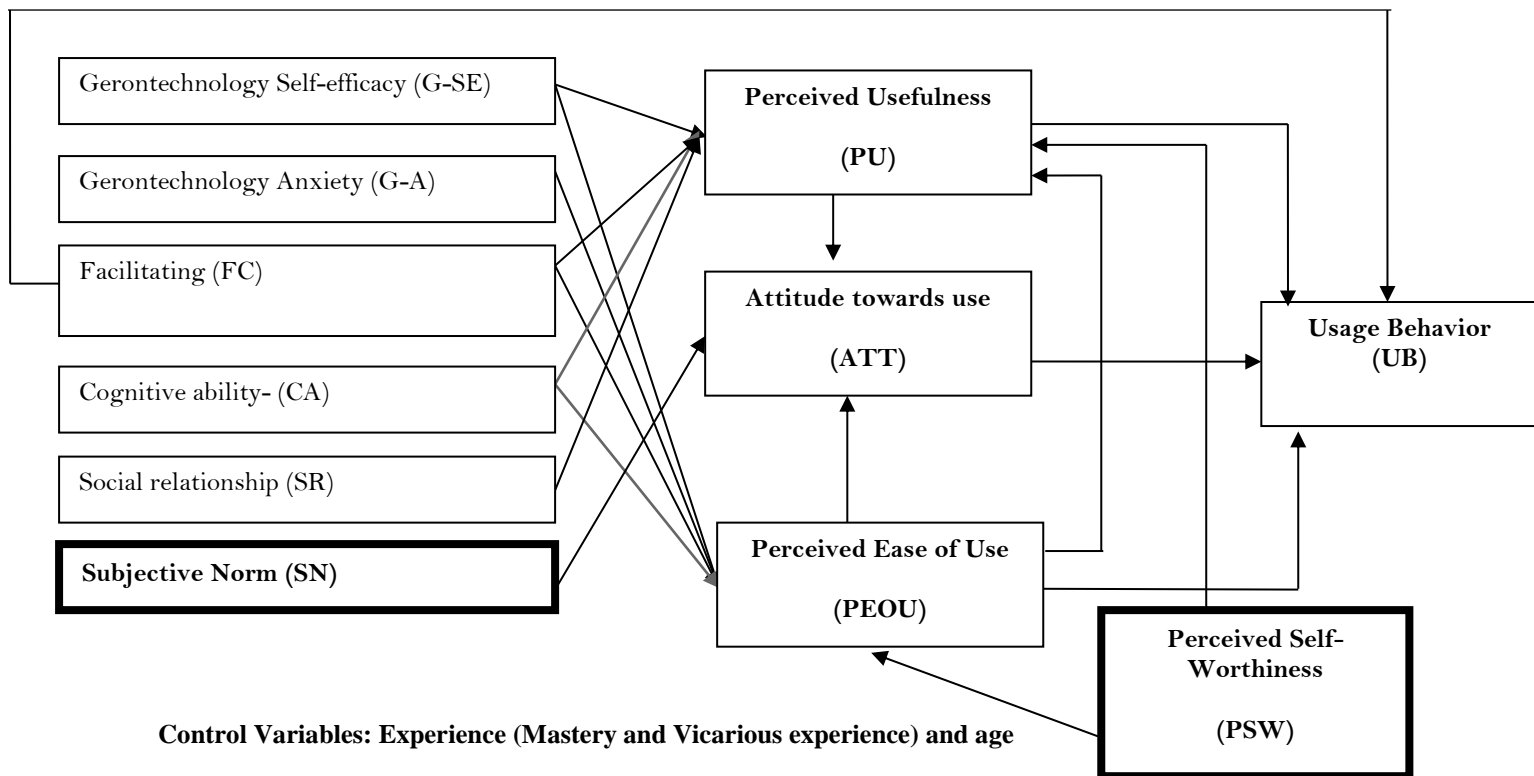

Figure 4:15 Research Model; Source: Research.

4.7 Heuristics guidelines

The geriatric population is increasingly accepting and adopting modern technology use as it aids them in their day-to-day activities. In this research, we embarked on understanding touch phone usage in establishing the cognitive and psychological aspects, which by large are influencing the psychosocial lifestyle of older adults. Though the participants' initial struggles, they accepted the touchscreen technologies during the research period. Following the proposed methodology in Chapter 3, which modifies the Rusu et al. (2011) methodology, this section develops the heuristic guidelines that geriatric persons' psychosocial wellbeing can influence the design of interactive mobile devices.

Usability is based on learnability, efficiency, memorability, and satisfaction (Sajjad, Khan, Saher, & Shahzad, 2016; Anam & Abid, 2020), while heuristic evaluation is a set of usability principles evaluated by an expert and collects a list of usability problems (de Lima Salgado et al., 2017). In context with previous related works, traditional heuristics, namely; Shneirdermann's' golden rules, Nielsen's heuristics, and Norman's principles, are defined for heuristic evaluation geriatric interfaces. Furthermore, specific guidelines for developing countries, namely; HCI guidelines for developing countries Deveza et al., (2014) and Van Biljon and Renaud (van Biljon & Renaud, 2016), are discussed in influencing the design of the geriatric interface and adapted them as we considered the practical dimension that brings out the emotions experienced in the old populace.

The usability heuristics are silent on the factors that bring forth the sense of belonging and self-worth in an interactive mobile device, yet considering the geriatric persons' nature in mentoring, teaching, and storytelling. This research designs additional usability heuristics and sub heuristics by adapting existing heuristics and adding new heuristics/sub-heuristics to evaluate interactive mobile interfaces to support geriatric persons' psychosocial well-being. This means we are looking into the user's experience for effectiveness, efficiency, and satisfaction before, during, and after using the interventions (Quiñones et al.,2018) as introduced in our primary research. The technical factors have been widely covered in Section 4.4 above, where we discussed the unique design problems faced by the participants, shared the lessons learned, how other scholars have designed for such problems and proposed new sub-guidelines in the different categories for heuristics evaluation. We recommend the psychosocial usability heuristics following the expounded discussion in **section 4.4.4** on psychosocial relationships.

The interaction with the touchscreen was a new concept to redhouse_2 participants, while their colleagues in redhouse_1 have used it for a while but had some difficulties that ranged from interactions, look and feel, usability (functionalities)and psychosocial factors on design issues of the touch screen technologies.

4.7.1 Psychosocial usability heuristics

Technical evaluation has explicitly been developed for the evaluation of products, more so systems and applications. However, limited research has considered the emotional experience that psychological usability heuristics are used to evaluate the users' emotions towards using technology and products. Weinschenk (2014), as a psychologist for over three decades, has emphasized consideration of people's behaviour where she guides designers *(through her book; 100 things every designer needs to know about people)* on the psychology of design. The psychosocial attributes considered in this research are self-worth and a sense of belonging. For an interactive mobile interface to embrace the psychosocial attributes, it needs to consider the psychosocial usability heuristics and the technical evaluations, therefore incorporating the behavioural attitude that determines usage.

Psychosocial activities can be experienced as either synchronous or asynchronous; actions are taken together (online activities) and actions not taken together (social media), respectively. Weinschenk (2014) states that asynchronous social activities might fulfil other social needs but do not fulfil our desires and pleasure as experienced through synchronous activities. Therefore, the author suggests we look for opportunities to build synchronous activities in our products (for this case, interactive mobile interface) using live video streaming or video and audio connection. Some of these shared activities, such as mentoring and storytelling, are satisfying to the geriatric person, knowing that they have passed on one's love, skills, and wisdom to others.

> *"I have easily connected with the young girls and boys. They are on my contact list, and we have been able to talk over for a while now. I like this because we do not have to worry about where and when to meet. We need to be both online, and we can have conversations. We have talked about different issues, and it was such a great joy to connect with them from afar as they are through technology. It felt nice to be asked for advice through our video and voice chats via WhatsApp,"* [3a]

> *"I talked to them about how we grew up and the things that I did over until now. Our paths are different as they have the education to propel them, but they still need the discipline to take them further. That Is what we grew up knowing and we have respected throughout our life"* [3b]

> *"We have the experience, and we are grateful to share it with the younger generation. Of course, the only place they beat us on is technology, but all matters, especially on living, we have gained much experience to share with them. This session was excellent. I enjoyed every moment with them and also shared stories with them. It felt so good and also felt useful in sharing and advising these young ladies and gentlemen" [2a]*

This research contributes to the achievement of psychosocial usability heuristics by recommending synchronous and non-synchronous features for social interaction, as follows in **Table 4.8** below. In addition, the researcher technically evaluates the features to ensure that the psychosocial (emotional) experience is achieved by an older person when using modern technology, as shown below.

- An elderly launcher that supports live video and audio connection
- Large icon for a camera, microphone, contacts of people
- Contact list to be large font and have people's image and show availability to chat online
- The contact list should show their active status for the readiness of communication
- For any recording, a simple interface that is not controlled by long-pressing to record
- Send a recording, use a known icon or text (send) in large font to denote the end functionality.
- Use of local language
- Easy reversal of action through a single button showing the interaction direction

The usability heuristics can be written as interrogative sentences to evaluate interfaces for compliance with psychosocial fitness. We show this in **Appendix G** as the researcher integrates the psychosocial usability heuristics to the Al-Razgan et al. (2014) heuristics to evaluate mobile launchers' usability for geriatric persons.

Table 4:8 Psychosocial Usability guidelines operationalization

	Proposed Psychosocial Usability guidelines	Relevance to Psychosocial wellness	Operationalization
1	An elderly launcher that supports live video and audio connection	To support generativity, geriatric persons can contribute to the younger generations' development through live video chats or audio chats. This gives them a live audience and can mentor, share their experiences, story-tell, etc. and answer any arising questions.	• Are the video and audio launchers visible? • Is connecting via video/audio simple?
2	Large icon for a camera, microphone, contacts of people	To ensure that geriatric person achieves self-efficacy levels (mastery experience) by having visible icons that encourage participation.	• Is the camera icon easily recognized? • Is the microphone icon easily recognized? • Is the contact list visible?
3	Contact list to be a large font, have people's image and show availability to chat online	Aids the geriatric person to easily select available persons for synchronous communication	• Is the contact list pictorial visible? • Is it easy to recognize the online presence of a contact?
4	For any recording, a simple interface that is not controlled by long-pressing to record	To encourage geriatric persons to non-synchronously communicate with their contacts by sharing stories, experiences as requested by others.	• Is the recording button easy to use?
5	To send a recording, use a known icon or use text (send) in large font to denote the send functionality	Easy to use, known and visible icons encourage usage and lead to mastery experience that recurs a particular activity.	• Is the send recorded message recognizable? • Is it easy to send a recorded message?
6	Use of local language	This will enable them to share with no limitation of a default language, and therefore, be expressional in a language they are familiar with and comfortable in.	• Is the interface allowing language change? • Is switching between languages easy to use?
7	Easy reversal of action through a single button showing the interaction direction	This encourages exploration and brings about easiness in using an interface, therefore, encouraging participation in either synchronous or non-synchronous activities	• Is the interface allowing easy exploration that encourages synchronous and asynchronous communications?

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

Abraham Lincoln's word "The best way to predict the future is creating it,
The best way to predict the future is to influence the conversation about what it could or
should be (Corley & Gioia, 2011)

5.1 Introduction

In recent years there has been an increased interest in research looking at the use of ICTs and their influence on societal and individual levels (Forsman & Nordmyr, 2015). The younger populace is advantaged in the ICTs related research as they are the predominant users. However, the older population's needs are changing, and older people require these modern technologies termed gerontechnology. This research investigated the factors essential in determining an interactive mobile device's design to support geriatric persons' psychosocial needs. The factors were identified from existing social theories, IS theories of Aging, and Initial Research to develop the theoretical framework, tested in ten weeks to realize the overall objective.

This research is paramount as it merges geriatric persons' evolved needs to the evolving modern technology to support their psychosocial needs. This ensures that we have an active citizen at all-time regardless of age and health-related issues. The research achieved this using exploratory qualitative research where information-rich participants were drawn from a social centre and a PSH. The research used a case study approach, and through purposive sampling, the researchers recruited eight geriatric persons for ten weeks (split into timelines for milestones measurement) and interacted with a touch phone through two interventions; games and a video chat used to engage university students

This chapter presents conclusions by relating the results and the discussions in chapter four to the research objectives and questions. Finally, this chapter delivers the recommendations and highlights interactive mobile devices' methodological and theoretical contributions for psychosocial support in old age.

5.2 Summary of Research Objectives

The problem statement guided the formulation of the research objectives. The researcher achieved the main objective using four specific objectives, realized through four research questions as summarized below;

Objective 1: To identify the challenges the older people face as they age in place or in an Institution of care

RQ: What challenges do the elderly face as community dwellers or residents in an institution of care?

Objective 2: To explore the role of information communication and technology (ICT) application in improving geriatric persons' wellness and well-being.
RQ: How is modern technology impacting the wellness and well-being of geriatric persons?

Objective 3: To identify factors that define the design of an interactive mobile device for psychosocial support of the geriatric persons
RQ: Which factors are key in defining an interactive mobile device design for psychosocial support in the geriatric population?

Objective 4: To generate psychosocial usability heuristics from the identified factors for evaluation of interactive mobile interface for geriatric persons
RQ: Which heuristic guidelines can improve a geriatric interactive mobile interface design to support a geriatric person's psychosocial needs?

5.3 Reviewing Research Objectives

5.3.1 Research Objective 1

The first objective was *"To identify the challenges the older people face as they age in place or in an Institution of care."* The researcher realized this objective by answering the first research question on identifying the different challenges that geriatric persons, either aging in place or a resident in an Institution of care, usually face.

The approach adopted to answer this question through a desktop review and Initial Research also encompassed objective two. First, the research question guided us in establishing the known needs of the geriatric persons aging in place and residents in care institutions. Second, a desktop review shed light on the physical and psychological needs that geriatric people face. Lastly, an Initial Research confirmed some of the stated physical and psychological needs as seen in related work and further identified a unique psychosocial characteristic where the older persons' emotional experiences were expressed.

We carried out an preliminary research to understand the geriatric persons' challenges. Our initial research involved philanthropic social homes in Kiambu and a daycare community centre in Nairobi county. The community-dwelling geriatric person had minimal challenges compared to the resident of a PSH. However, the sedentary challenge was common in the PSH as they live in a controlled environment, unlike their free counterparts, therefore socially engaged. In addition, the community dwellers were physically mobile compared to those in the

PSH who experienced physical immobility and psychological challenges as early as 70years. This outcome shows how volunteering, social engagements, and participation uphold geriatric persons' well-being and wellness.

This objective's outcome is aligned to the desktop review where physical and psychological challenges are common in the geriatric person world; the ways these challenges are tackled, though, it's different considering the policies, the economic well-being, and the family or community roles of taking care of the older person population. In addition, the Initial Research added another fundamental wellness that has not been widely looked into, the psychosocial challenges that bring forth their emotional experience. Therefore, the physical, psychological, and psychosocial challenges identified explained why geriatric care needs more exploration, considering the greying population's growing numbers.

5.3.2 Research Objective 2

The second objective was *"To explore the role of information communication and technology (ICT) application in impacting the geriatric persons' wellness and well-being."* This objective answered how modern technologies are impacting the wellness of geriatric persons. This was a desktop review, where the researcher accessed peer-reviewed journals through google scholar that contains papers from various citation databases.

The wellness of geriatric persons was defined using three categories; Physical wellness, psychological wellness, and psychosocial wellness. This research emphasized the last two, considering the sedentary lifestyle that geriatric persons assume later. Once retired from their active life, the older generation will get to be either socially engaged or disengaged depending on how they spent it. Health tends to deteriorate with time, and therefore, body decreased cognitive ability, etc., are evident. It becomes worse if there is no one to take care of them in their older years. This is how some end in a PSH since they are ostracized, abandoned or isolated.

ICT- related research on older people is now becoming common considering the longer life expectancies they are experiencing. Gerontechnology has evolved as it's being used in monitoring and has gone further to be incorporated in gamification, simplified mobile launchers, pill minders, social robotics, etc., to assist older people in carrying out their day-to-day activities in an autonomous manner. We discussed the modern technology used while in a sedentary lifestyle as we see these technologies fused into mental solutions to make these elderly technogenarians hopeful. For instance, gamification such as exergames (exercise and

gaming) has shown a significant increase in cognitive ability such as alertness, alleviation from subsyndromal depression, and improved physical wellness as they play different activities such as bowling, tennis, golf, etc.

The Covid 19 pandemic created a significant opportunity for modern technologies where the older people's motivation and opportunities significantly increased, creating a 'sink and swim' moment for many unskilled and reluctant users. During this period, the older people were marked as 'very high risk' considering they had pre-existing conditions or comorbidities, therefore, did not survive if they contracted the virus. The physical measures curtailed proximity during the period, forcing people to isolate to reduce the disease's spread. Public places such as malls and worship places were out of bounds for a specific age group. Older people would only get engaged through social network sites or TV and radio.

This objective's outcome gave this research the understanding of the myriad development of modern technologies targeting older people to achieve an independent lifestyle. Moreover, the modern technologies discussed were a major fulfilment of the psychological and part of psychosocial wellness as the latter is well expounded in objective 3.

5.3.3 Research Objective 3

The third objective was *"To identify factors that define the design of an interactive mobile device for psychosocial support of the geriatric persons."* The Senior Acceptance Model by Chan and Chen (2014) evaluated the technology-centred and emotional experience factors to provide a theoretical justification that led to the formulation of the research model that incorporates the psychosocial factors. These factors determined the usage behaviour of the participants. The researcher achieved this objective in two steps; the first was through a baseline survey, then the second was through the main study.

This research is a qualitative exploratory study guided by a pragmatism philosophy that enabled us to explore the gerontechnology domain by understanding, experiencing, and imagining the research participants. The researcher used a case study approach, where the unit of analysis was social groups. The groups were drawn from a daycare community centre in Nairobi county and a PSH in Kiambu county. In this qualitative study, the researcher selected information-rich participants through purposive sampling and was free from neurological conditions and cognitive and motor impairment. Each participant experimented with an A-Tab A8+ (7", Android) for the study duration.

The researcher conducted a baseline survey in RedHouse_1 and RedHouse_2 two weeks before the main study. The three concepts that informed this research are personal memoirs on their day-to-day living, understanding of modern technology, and the psychosocial challenges (transitioning from traditional to modern society). Interviews were the data collection mode, where we recorded and later transcribed to bring out the essential themes. We used Atlas.ti for analysis. The themes evident were (i) psychosocial principles presented in life satisfaction and society variations as elaborated on by the older persons and (ii) modern technology used as the geriatric persons owned mobile phones and talked of the benefits such as social communication, money transfer, etc. The baseline survey findings were the premise of the main research as they influenced the type of interventions to use in line with the research objective 3.

In the main study, the researcher took three data points ten weeks apart. Interviews were established to understand the different tasks they were carrying out. Using Atlas.ti, we analyzed data where sub-codes and codes were established, and themes emerged as briefly discussed herein:

- Functionality: Tested the practical ability to operate the touch technology, where the participants were tested on voice calls, text messaging, VoIP, and camera use. The design challenges addressed were unique, and researchers proposed guidelines to address them. The researcher coded Self-efficacy, Ease of use, and support from the participants' views regarding the tested functionalities. In self-efficacy, the participants' confidence was revealed as they perfected the complex tasks at the initial stage. Self-efficacy was progressive for both houses, yet Redhouse_1 reached self-efficacy earlier than the participants in Redhouse_2 as their knowledge transfer was higher considering they were all using smartphones. Training, guidance, and support are necessary to achieve functionality. The initial data point demanded much as the research assistant would be repetitive before the older person grasped it. In the subsequent data points, Redhouse_1 became more independent and would be seen helping each other at times. The willingness and desire to learn were promising in both homes, and this should be a motivation in developing interactive interfaces by making them easy for users as its regarded as beneficial to achieve an autonomous life.

- Look and feel: this looks at how a geriatric person is satisfied with the colour, the layouts, and related buttons and menus in an interactive mobile interface. The participants explored the affordance of exploration and the interface design, and the researchers recorded views

on background lighting, contextualization, and scrolling. The challenges were mainly caused by their deteriorating eyesight, which would become teary after extended usage or the icons/images being too small to be seen. In addition, the design challenges such as scrolling were problematic for the participants in Redhouse_2 as they were transitioning from a feature phone to a touch technology and, therefore, little transfer of knowledge, which led to a longer learning curve.

- Interactions: this tested how the participants were able to interact with the interface to their satisfaction. Notifications, exploration, touching, and gestures were reviewed where the learning curve in both homes though differing, led to some level of self-efficacy. The interaction design, such as scrolling, was termed as complicated, some of the notifications were unclear, and the drag and drop were confusing. The participants were overwhelmed with the recall process to carry out a task and requested interfaces simplified to ease their cognitive load.

- Psychosocial relationships: The unique factor that was identified during the Initial Research was further explored. Enhanced interpersonal interaction and social inclusion at the society level were the emotional experiences that the participants enjoyed. The participants praised the earlier years as the discipline was high as they upheld moral and cultural values. On the contrary, the geriatric population in modern society are not as highly valued as before. The sense of belonging and self-worth was highly accredited to older people in society as they were highly sorted to give direction, advice, and good storytellers. This, though, is limited and is blamed on the physical distance that modernization has created. With the current modern technologies, the participants could eMentor, story-tell, and share their experiences with the young university students through a VoIP platform.

This research adjusted the STAM by Chan and Chen (2014) to consider this research's context, which expounded on tasks performed using interactive mobile interfaces to support psychosocial health. Two new factors were added: subjective norm was a significant predictor that positively influenced the participants' attitude towards modern technology usage, as PU moderated. The other factor is a new entrant to the attitudinal factors, Perceived Self-worth, which PU and PEOU moderated to determine ATT and after that usage. The researcher dropped some factors in Chen and Chan (2014) as they were not within this research scope were; self-reported health conditions, attitude to life and satisfaction, and physical functioning.

5.3.4 Research Objective 4:

The fourth objective was *"To generate psychosocial usability heuristics from the identified factors for evaluation of interactive mobile interface for geriatric persons."* This was answered by proposing the psychosocial usability heuristics (Appendix G) to improve an interactive mobile interface design to support geriatric persons' psychosocial needs. We considered the unique design challenges in our context, contributing to the technology-centred factors and the psychosocial usability heuristics.

For functionalities, voice calls lack the unique affordance to hold, so a visible loudspeaker icon is recommended for easy communication. For the message as a non-synchronous tool, the nested layer for font size customisation for better visibility is tedious, and therefore we recommend a simplified resizing icon to reduce cognitive load. Participants did not prefer recordings for VoIP interactions because of their complexities regarding holding down the button as you record and how to send the recording. This research recommends a visible start and end button for recording, and once the recording is done, two visible buttons marked either send or save will guide the older person to the next step. The camera use has been simplified by launchers such as elder, but the gallery option was not missing. This research recommends a galley that displays large thumbnails and where functions like select will display a large tick on the photo and delete and send tabs to be displayed on top for further action.

The researcher recommends background lighting to be easily adjustable for look and feel, a (+) or (-) sign at the top of the launcher. Contextualization of the games should resonate with the geriatrics past years, therefore, increasing user engagement. Grouping of similar tasks should be considered to minimize scrolling for the essential services

For interactions, having a sizeable unidirectional arrow will allow the geriatric person to go to the previous step, building the courage to explore the interface. Due to dexterity issues, the touch gestures such as drag and drop should be minimized if not done away completely. A recommendation of grouping similar tasks together will ease this process.

For the psychosocial relationships, there was a fulfilment of the emotional experience of the participants. The connection with the young people (the university students) for eMentorship, story-telling, and sharing experiences rekindled the joys of growing old. The participants acknowledged the growing need for belonging, which gave them value in this modern society that had been digitally divided. Technology-centred factors are still key in designing for psychosocial support of geriatric persons. The synchronous and non-synchronous

activities are simplified to ensure that geriatric persons can carry out these activities autonomously.

5.4 Implication of the research outcome

This research's outcome is an active influence to change modern technology for geriatric persons' intrinsic satisfaction. The psychosocial usability heuristics creates a basis of consideration that will curb the digital divide between the young and the old, as the geriatric's needs cater to the design and development of geriatric interfaces. This is a step forward to the digital preservation of cultural and historical stories from reliable sources.

5.5 Thesis Evaluation

Whetten (1989) recommends a framework that evaluates the theoretical contribution by looking into the building blocks of theory development and the factors considered in judging a well-written thesis.

The building blocks consist of four essential elements; What, How, Why, and Who/Where/When.

- **What;** This is the contribution from the social aging theories, IS theories of aging, and the Initial Research as we constituted the constructs identified in developing a model that institutes technology-centred and psychosocial needs of the geriatric persons.
- **How**; This was answered by illustrating the causal relationships (the theoretical framework) between the constructs by coding using a qualitative tool where we reduced the verbatim quotes to subthemes then themes.
- The **Why** question was answered in detailed arguments elaborating the causal relationships between factors where the emotional experience was established and linked the technology-centred factors to the psychosocial usability heuristics.
- **Who;** These were the geriatric participants who provided in-depth knowledge that impacted this research and the stakeholders in realizing sustainable yet psychosocial features satisfying the older person population.
- The **Where and When** answer the research's contextualization to the geriatric persons' needs in a developing country and the time it took to achieve these outcomes.

In judging a well-written thesis as part of evaluating theoretical contribution, we addressed the seven questions by Whetten (1989).

What is new in your research that contributes to current thinking?

This research has brought into light the psychosocial needs of geriatric people that have not been considered while developing interactive interfaces. The contribution is in two phases *(i)* a model that enhances the current STAM: this new model identifies two new constructs, i.e., perceived self-worth and subjective norm, showing a significant influence on the usage of modern technology by geriatric persons. *(ii)* Psychosocial usability heuristics are elaborated using technology-centred factors to ensure usability that evokes emotional experience in a geriatric person.

So what? Will this research change the practice of gerontechnology?

Gerontechnology, as it is, has some psychosocial features that are extrinsic. This research identified the underlying need for modern technology in satisfying the emotional needs of geriatric persons. The intrinsic needs are essential in bridging the digital divide currently in this modern world, and therefore, the psychosocial usability heuristics recommended will aid in developing interactive mobile interfaces.

Why so? Are the underlying logic and supporting evidence compelling?

This research was qualitative, therefore, having a rich knowledge of the underlying problem. The researcher carried out an extensive and intensive literature review to analyze the existing models for aging and, after that, an exploratory Initial Research that influenced the choice of the constructs. The three principles of design for delight (D4D) by intuit guided the methodology. The researcher justified the choice of data collection tools, and data were analyzed using Atlas.ti to reveal the themes extensively discussed in verbatim quotes from the participants.

Well done? Is the thesis reflecting seasoned thinking, conveying completeness and thoroughness?

The research extensively reviewed the social and IS aging models to understand the social context's emotional experience and the technological factors on improving modern technologies' interfaces. In addition, a situation analysis was carried out through initial

research to define the underlying challenges that the researcher considered in developing the theoretical framework and the social and IS aging models/theories. This has ensured a satisfactory level of completeness and thoroughness as it portrays the current thinking of gerontechnology in the context of a developing country like Kenya.

Is it done well? Does the thesis have a logical flow?

The thesis is well organized with a logical layout of content, addressing the main ideas and arguments in a reader-friendly manner backed up with verbatim quotes from the participants, well-labelled figures, and tables where necessary. The central ideas in all chapters (using headings and sub-headings) are easily accessible and ensure an easy and logical flow of ideas through the thesis. The thesis links the research findings to the title, the introduction, research objectives/questions, the literature review, and methodology. This concludes with the last chapter that shows the contributions of this research and recommends future works.

Why now? Is the topic of interest to scholars in the gerontology domain?

The older person population is continuously growing, considering the better healthcare that has led to high life expectancy. The geriatric needs are also evolving as more and more older adults adopt modern technology for their physical, psychological, and psychosocial well-being. The geriatric persons have an accumulated wealth of knowledge that spews wisdom as they speak from experiences, they have the historical stories that preserve our cultures, and for their wellness, we need to engage the participants in a way they are appreciated socially—what better way than using modern technology to reach more than what a physical meeting can reach. The older persons' wisdom and vast knowledge can be tapped into even after retiring from an active lifestyle.

Who cares? Is this topic of any interest to the academic readers or any other stakeholders?

In Kenya, limited research has been done in gerontology, yet this is an inevitable age group considering the shift in the population pyramid where life expectancy is high. Therefore, this topic is of interest to the academic researchers in health informatics for profiling and addressing their needs; to the UX designers and developers in considering the emotional experience of the geriatric persons when building interactive mobile devices; for geriatric persons, to enjoy

physical and psychological wellness through modern technologies that allow them to be a voice to the younger generation.

5.6 Conclusion

The research developed a theoretical framework that influenced STAM change as this research included two new psychosocial constructs. The technology-centred constructs *Perceived Ease of Use, Perceived Usefulness, Gerontechnology Self Efficacy, Gerontechnology Anxiety, Cognitive Ability, Facilitating Conditions* and psychosocial constructs *Perceived Self Worth and Subjective Norm* significantly influenced usage Behaviour. The researchers used the psychosocial constructs and the technology-centred constructs to further elaborate on the psychosocial usability heuristics.

5.7 Research contribution

For our research to contribute to the ever-growing body of knowledge of the gerontological domain, one needs to review the existing theories and thrive on extending or integrating them to deepen gerontechnology foundations. In this view, this research contributes to the body of knowledge as follows;

1. **Methodological contribution in Health informatics**

   The outcome of this research presents a practical approach in using subsequent data points indexed in time order to identify the key technology-centred and psychosocial factors that were used to enhance STAM and propose the psychosocial usability heuristics for an interactive mobile device for geriatric users.

2. **Theoretical Contribution**

   The model makes a theoretical contribution by identifying two variables that improved the STAM in the context of psychosocial relationships. Subjective norm and Perceived Self-Worth have shown a significant influence on user behaviour in establishing psychosocial relationships.

3. **Contribution to Practice**

   The psychosocial usability heuristics for the design of interactive mobile devices to aid in the psychosocial relationships between geriatric persons and the society

5.8 Recommendation for future work

This research focused on technology-centred and psychosocial heuristic guidelines for touch technologies (specifically tablets). As a result, this research's empirical findings may not be generalizable in the geriatric domain considering the study's inclusion criteria. Therefore, this research recommends further works be conducted with an emphasis on the following;

- Detailed profile of the needs of geriatric persons, the geriatric presentations in both private and public health centres, and how these needs are linked to guide in improved policies for the geriatric domain in Kenya

- A longitudinal study with a mixed age-related issue, namely; cognitive decline, psychomotor challenges, and neurological conditions (to mention just a few), to test the applicability of the proposed research model in determining user behaviour towards modern technology

- Consideration of low-literate geriatric person for tasks such as messaging to enable them to participate in non-synchronous activities

- Considering gerontological models specific to modern technologies, such as holograms for psychosocial activities (language and cultural), helps preserve knowledge even after the older person's death.

In addition, the modified model and the psychosocial usability heuristics were not quantitatively tested due to time and scope limitations, therefore, recommending a further study that will test the model and carry out an expert heuristic evaluation for validation of both.

A further addition to the recommendations is a study that can look into the adversities of modern technologies in older persons' psychological and psychosocial health. This is suggested considering the effects technologies such as social media have some positive and negative effects on usage by the younger generation.

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Appendix A: Research brief (for the management and Respondents in the centers)

Brief of research

These interview sessions are part of Mary Njeri Ngaruiya's (P80/50002/2015) research towards achieving a Ph.D. in Information Systems at the School of Computing and Informatics of the University of Nairobi. We seek to understand how modern technology impacts a geriatric person's psychosocial well-being (senior citizen aged 65 years and above), after that to propose psychosocial heuristics guidelines that UX designers and developers will use in developing interactive mobile interfaces.

Note to participants and the management

This research will be phased into four different series, which will be conducted after every two weeks. Before participating in this research's initial stages, each participant must be briefed on what the research entails and voluntarily agree to participate. The participant will initially be asked questions to understand how conversant they are with modern technology. After that, each of the participants will be issued a touch technology (tablet) to continuously use throughout the research. The participants will respond as guided by the Interview and focus group discussion guide in **Appendix F** below. This research values the responses of each participant and also their privacy. For privacy, we will provide pseudonyms for all the participants for anonymity's sake. This research will not guarantee confidentiality, though, as the information provided is vital in guiding this research's output. The participant is free to disengage at any point through the research period if they feel their privacy has been violated or for any other acceptable reason.

Appendix B: Informed Consent Note

Research Title and Research Question

Title: Psychosocial heuristic factors for an Interactive mobile interface for Geriatric Persons

Research Question: What factors are key in defining the design of an interactive mobile device for psychosocial support in the geriatric population?

Introduction:

I, Mary Njeri Ngaruiya, a Ph.D. student in the School of Computing and Informatics of the University of Nairobi, plan to carry out research that aims in understanding the psychosocial factors that the participants (representation of other geriatric persons) face therefore inhibiting their successful usage of modern technologies such as touch technologies (Smartphones and Tablets/iPads).

Research procedure brief

The research procedure and process involve the initial interaction with the two centers' management (Redhouse_1 and Redhouse_2) to identify the participants and the full involvement with the geriatric persons throughout the research. The data will be gathered through interviews and focus group discussions. The data obtained will give the researchers an in-depth understanding of how psychosocial well-being impacts modern technology usage.

Privacy and Confidentiality issues

Before collecting data from the participants, the research assistants must sign a non-disclosure agreement of what they observe or what the participant confides to them. During the interviews and focus group discussions, the participants, while being recorded, will not disclose their names, therefore, maintaining pseudonyms while writing the thesis. Confidentiality is not guaranteed as this is the information that will give the researchers and the readers of the thesis an in-depth understanding. Anonymity, though, will be observed using pseudonyms.

Respondents Voluntary Participation

Each participant will voluntarily participate in the research after a thorough briefing on what the research entails. The participants are to ask questions for more clarity, and only after that can they be included in the research. Once they all agree, the management will give a consent

form as evidence of voluntary participation and authority to carry on the research. In case of sickness or any unforeseen incident/accident, the participant is allowed to discontinue, and no penalties will be imposed on them by the researcher.

Respondents eligibility to Participate

Respondents for this research should fulfill the following requirements

- Aged 65 years and above
- Have used modern technology either for communication purposes, at work (before retirement), or for other activities.
- Should voluntarily agree to participate in this research

Motivation and drive

This research seeks to contextualize the needs of geriatric persons to encourage the use of modern technology. Physical and psychological wellness has progressively grown and developed as systems and applications, but there is little uptake, especially in developing countries such as Kenya. The discussions built from this research will give the researchers in-depth knowledge to further enrich the heuristic guidelines for developing geriatric interactive interfaces.

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Appendix C: Confidentiality Agreement form for the Research Assistants

I……………………………………………. of ID number………………………. agree that

as a research assistance in this research, I will handle all data with confidentiality, and at no

point during and after research will the data and information be disclosed or even shared with

any other person other than to the primary investigator (Mary Njeri Ngaruiya). By signing

this non-disclosure agreement, I agree to be held accountable for any breach of participants'

confidentiality.

Signature: ………………………….

Date: ……………………………….

Appendix D: Consent form Agreement

Name of Center: …………………………

Research question: What factors are key in defining the design of an interactive mobile device for psychosocial support in the geriatric population?

I confirm that I have read and well understood the requirements of participation as provided in Appendix B.

I confirm that I have had the chance to ask questions, and the researcher has well addressed them to my satisfaction.

I understand that my participation is voluntary, and I can freely withdraw from the research without any consequences.

I also understand that any information recorded will be reported anonymously, therefore, protecting my identity.

I consent to the usage of recorded and observed data for research, publications, and archiving.

I consent to be audio recorded during interviews and focus group discussions as part of this research. **Yes/No**

I agree/do not agree (tick as appropriate) to participant in this research

_____   _____   _____

Name of participant   Date   Signature

_____   _____   _____

Researcher   Date   Signature

Appendix F: Interview Guide in Focus Groups

Welcome, consent process, and Introduction

a. Welcome

Hello and welcome to our discussion group. Thank you for your participation over the two weeks as you engaged with the touch technology. My name is Njeri Ngaruiya, a student at the University of Nairobi. This research aims to understand what geriatric persons' needs are and be proposed for inclusivity in the usability guidelines for interactive mobile interfaces. Today, we would like to talk about the exploration experience, your needs, and preferences short-changed in the two interventions you have been interacting with: senior games and WhatsApp interfaces. We seek your genuine thoughts and ideas to actualize usability guidelines that address the geriatric person's needs.

b. Consent process

In the course of the subsequent FGDs, as a group, we will go over the informed consent form before we start the discussions to be sure that you have all understood why we are carrying out the discussions and be sure that this is a voluntary participation

c. About the group

- Explain what a focus group discussion is: Enables the researcher to gain in-depth knowledge from the users to inform further improvements. For this case, the information that will be shared and will enable the researcher to develop usability guidelines for interactive mobile interfaces according to your needs and preference

- You are the experts in this, and therefore as researchers, we learn both positives and negatives from you. You have essential knowledge as you have worked with a mobile device before and therefore having the particular experience, needs, and perspectives, and we hope to learn more in our discussions

Focus group logistics and ground rules

a. Logistics

- Focus groups will last about two hours at most (120minutes) with intermittent breaks of 10minutes
- Feel free to move around

b. Ground rules

- Participation of everyone is important; therefore, the moderator will select participants to talk but still, yet, more contribution can be made to emphasize the current speakers talk
- Ideas and opinions are fundamental to this research. Please do not feel shy to share them
- All responses are appreciated as these are ideas, experiences, preferences, and opinions that will further this research
- The sessions will be tape recorder (after you have given consent) to help us gather more information that we would miss out on if we were recording it manually
- That's it!! Let us enjoy the discussions

Alert them that the Tape Recorder is being turned on.
(Turn on the Tape Recorder)

c. *Discussion Begins*

Discussions begin in a round-robin manner; give the participants time to express themselves and ask follow-up questions for more clarity.

Guiding questions are as shown in Appendices F(i) and (ii) for baseline survey (denoted as T_0) and the main survey (denoted at T_1, T_2, T_3) in chapter 4

d. *Discussions conclude*

Thank you for sharing your thoughts and opinions with us. Your participation is highly appreciated. This concludes our discussions, and I hope to see you in two weeks for our next discussion. Asante Sana! (Thank you!)

Appendix F: i) Sample for the Baseline Survey

Name   : Respondent XX   Time: XXXX
Gender   : XX   location: XXX
Residence Setting: XX

Purpose of this study.

The purpose of this interview is to gather detailed information that will enable the researchers to learn more about psychosocial and technological factors that you as an elderly person experience.

The Guiding Research Questions for these interviews are;

1. What factors are key in defining the design of an interactive mobile device for psychosocial support of geriatric persons?

2. Which heuristic guidelines can improve an interactive mobile interface design to support a geriatric person's psychosocial need?

PART 1: Personal Daily Activities Living
   i. Before coming to the home, where were you staying and with you?
   ii. How is your communication with your loved ones?
   iii. Where have you stayed the most?
   iv. Have you had any formal employment?
   v. Describe your day from morning till evening
   vi. But you have older people here?
   vii. What would you want to do?
   viii. Do you encounter any hurdles in doing your day-to-day activities?
   ix. How do you spend your free time?

PART 2: Technology
   i. What does the word technology bring to mind?
   ii. Which technologies do you use?
   iii. How has the phone been of assistance to you in your daily life?
   iv. What are the challenges that you had when using your phone?
   v. How did you acquire the phone?
   vi. What else would you want have wished technology would do for older people?
   vii. Have you ever seen tablets before the researcher brought them here?

PART 3: Psychological
   i. What are some of the roles that the older persons used to do?
   ii. What did men and women do?
   iii. How was society then?
   iv. How different is it now?
   v. What roles would you take in nurturing the younger generations now?
   vi. Do you take up these roles with the younger generation now?

Appendix F: ii) Sample for the Main Study

Name   : Respondent XX   Time   : XXXX
Gender   : XX   Location: XX
Residence Setting: XXXX

Purpose of this study.
The purpose of this interview is to gather detailed information that will enable the researchers to learn more about psychosocial and technological factors that you as an elderly person experience.
The guiding research questions for these interviews are;

1. What factors are key in defining the design of an interactive mobile device for psychosocial support of geriatric persons?

2. Which heuristic guidelines can improve an interactive mobile interface design to support a geriatric person's psychosocial need?

{In context to the tablet usage, we can answer the following questions}

1. Look and feel

  i.   How visible is the default font size?
  ii.   Are you able to increase the font size?
  iii.   Do the text and background colors have good contrast?
  iv.   Is the screen good enough (compare phone and tablet)?
  v.   Are you able to recognize a new message prompt?
  vi.   Are you able to recognize a missed call prompt?
  vii.   Ability to recognize the visual cues for more content by scrolling or swiping?
  viii.   When using your phone, what functions do you frequently use?
  ix.   What functions are you frequently using on the tablet?

2. Interactions

  i.   Are you able to understand the notifications returned upon an action executed?
  ii.   Are you able to customize the font size to your preference?
  iii.   Are you able to customize notification sounds?
  iv.   Are you able to customize the background (change theme)?
  v.   Are you able to go back to the homepage?
  vi.   Are you able to use the scrolling gesture to view more content?
  vii.   What is your experience navigating through the available buttons?

3. Functionality

  i.   Before we start in this section, I would like to know if you have heard either of these terms being mentioned before as a communication platform; WhatsApp, Telegram, Viber
  ii.   Ability to make a Voice phone call?
  iii.   Ability to video call?
  iv.   Ability to text chat?
  v.   Ability to Create groups
  vi.   Ability to Group Chat?
  vii.   Ability to see Friends' Status Updates
  viii.   Create own status
  ix.   Are you able to take a picture?
  x.   Are you able to zoom in and out (Picture)?
  xi.   Are you able to flip the camera?

xii.   Are you able to use the speech preference provision in the app?
xiii.   How easy is it to use the keypad?
xiv.   Are you able to record an audio message?
xv.   Are you able to record a video message?
xvi.   Are you able to send what you have recorded?

4. Localization

i.   Is the language used familiar to older people?
ii.   Are the widgets distinct?

5. Psychological

i.   Are you able to connect to the younger generation by advising through technology?
ii.   Are you able to share experiences and wisdom nuggets with the younger generation through technology?
iii.   Are you able to share historical events through technology?

Appendix G: Heuristics for evaluating the psychosocial usability of interactive mobile interfaces for geriatric persons

(An extension of Al-Razgan et al., (2014) heuristics for evaluating the usability of mobile launchers for older people)

Themes	Guideline	Detailed guidelines
Look and feel	Make Elements on the page easy to read	Is the font large enough for older adults?
		Is there any option to enlarge the font size?
		Do the text and background colours have a good contrast?
		Is it possible to customize colours?
		Is the amount of text minimized; is only the necessary information represented?
		Do colour choices allow for easy readability?
	Easy recognition and accessibility	Are the icons clear, understandable, and labelled?
		Re labels described clearly?
		Can the most important or frequently needed functions be accessed directly?
		Is the keypad separated into numbers and letters for entry?
		Is the data entry process easy for the elderly?
		Are there any visual cues in the launcher that help the elderly know more content on a page?
	Make clickable items easy to target and hit	Is it obvious which item is clickable and which is not?
		Are buttons large enough to see the image or text on them?
		Is there enough space between buttons to prevent hitting multiple or incorrect buttons?
		Is button size adequate to finger touch?
		Do buttons and icons enlarge when the rest of the text size is increased?
		Is the image on a button or an icon easy to predict what it does?
	Use the elderly language and culture; minimize technical terms	Does the launcher use terms that most of the older adults are familiar with?
		Does the options/information have a logical sequence?
		Are the icons familiar to the elderly?
Interaction	Provide clear feedback on action	Is there audio/visual/haptic confirmation when tapping?
		Is there an option to enhance them?
		Are error messages descriptive, and are they providing a solution to the elderly for recovery?
		Are confirmation messages clear?
		Does the launcher keep the elderly informed about what is going on through appropriate feedback?
	Providing preferable gestures for the elderly	Does the launcher use tap gestures for most of the actions?
		Does the object have more than one gesture to perform a task? (e.g., tap and drag gestures on the same object)
		Does the launcher use scrolling gestures to view more content?
		Do gestures of launcher work correctly and smoothly?
	Provide the elderly with information on the launcher	Does the elderly know where they are and what they can do next?
		Is the elderly aware when the launcher turns off or gets an error that causes it to stop working?
	Use conventional interaction items	Are the items using the same from section to section within the launcher?
		Does the launcher apply a consistent format?
	Ergonomics design	Are items placed in recognizable positions?
		Do the items in the elderly interface fit the natural posture of the hand and finger?
Functionality	Provide functions that reduce the elderly memory load	Does the launcher support or provide shortcuts for direct access to the most frequent functions or items?
		Does the launcher provide support to remember functions easily?

		Does the function group similar functions in one place?
		Are the essential functions always available?
	The elderly do not feel lost or struck	Does the navigation menu exist consistently on all pages?
		Does clicking the back button take the older person to the previous page they were on?
		Does the launcher provide emergency exits to leave the unwanted state, and is it pointed out?
	Prevent error from occurring	Do the graphical interface design and the organization help prevent errors?
		Is there a confirmation message for critical actions such as deletion?
		Are the essential functions placed at the top of the screen to avoid mistake touches?
	Provide necessary information and settings	Does the launcher show level of the battery, time and date, signal of contact/ WiFi
		Are the default settings of mobile phones available to the elderly in an easy way?
Psychosocial	An elderly launcher that supports live video and audio connection	Are the video and audio launchers visible?
		Is the process of connecting via video/audio simple?
	Large icon for a camera, microphone, contacts of people	Is the camera icon easily recognized?
		Is the microphone icon easily recognized?
		Is the contact list visible?
	Contact list to be a large font, have people's image and show availability to chat online	Is the contact list pictorial visible?
		Is it easy to recognize the online presence of a contact?
	For any recording, a simple interface that is not controlled by long-pressing to record	Is the recording button easy to use?
	To send a recording, use a known icon or use text (send) in large font to denote the send functionality	Is the send recorded message recognizable?
		Is it easy to send a recorded message?
	Use of local language	Is the interface allowing language change?
		Is the process of switching between languages easy to use?
	Easy reversal of action through a single button showing the interaction direction	does the interface allow easy exploration that encourages synchronous and asynchronous communications?

Appendix H: KNH-UoN Ethics Research Committee Approval

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4th July 2017

Mary Njeri Ngaruiya
Reg. No.P80/50002/2015
School of Computing and Informatics
College of Health Sciences
University of Nairobi

Dear Mary

Re: Approval of Annual Renewal – study titled, "Deployment model for effective e-monitoring of geriatrics in developing countries; Case of Rural Kenya (P219/03/2016)

Refer to your communication dated 16th May 2017.

This is to acknowledge receipt of the study progress report and hereby grant annual extension of approval for ethical research protocol P219/03/2016.
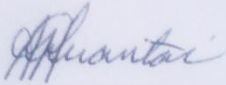
The approval dates are 18th July 2017 – 17th July 2018.

This approval is subject to compliance with the following requirements:

a) Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b) All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH- UoN ERC before implementation.
c) Death and life threatening problems and severe adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH- UoN ERC within 72 hours of notification.
d) Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e) Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
f) Clearance for export of biological specimens must be obtained from KNH- UoN-Ethics & Research Committee for each batch of shipment.
g) Submission of an *executive summary* report within 90 days upon completion of the study
   This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/or plagiarism.

Protect to discover

For more details consult the KNH- UoN ERC website http://www.erc.uonbi.ac.ke

Yours sincerely,

PROF. A.N. GUANTAI
CHAIR, KNH-UON ERC

c.c.   The Principal, College of Health Sciences, UoN
       The Director CS, KNH

Appendix I: Published Articles and a Pre-Print

Journal Papers

Ngaruiya, N., Orwa, D., & Waiganjo, P. (2021a). Psychosocial variables of the interactive mobile interface for geriatric persons in a Kenyan setting : An exploratory study. Journal of Psychology in Africa, 31(4), 375-382 https://doi.org/https://doi.org/10.1080/14330237.2021.1952701

Ngaruiya, N., Orwa, D., & Waiganjo, P. (2021b). The Methodological Approach in Developing Interactive Mobile Devices for Geriatric Persons (Geriatric Person-Centered Methodology) Research design. Africa Journal of Health Sciences, 34(3), 374–383.

Conference Proceedings

Ngaruiya, N., Orwa, D., & Waiganjo, P. (2019). Towards the development of Heuristic Evaluation Guidelines for a Geriatric Interface for mobile interactive devices in Kenya. In N. Mostert & K. Ulrich (Eds.), 12th Health Informatics in Africa Conference (HELINA 2019) (pp. 16–23). Gaborone, Botswana: JHIA

N. Ngaruiya, D. Orwa, and P. Waiganjo, "Situation Analysis and Technology value proposition for geriatric care for philanthropic social homes in Kenya," *2019 IST-Africa Week Conference (IST-Africa)*, Nairobi, Kenya, 2019, pp. 1-9.

N. Ngaruiya, D. Orwa, and P. Waiganjo, "Towards a deployment model for e-monitoring of geriatric persons in rural developing countries: Case of Kenya," *2017 IST-Africa Week Conference (IST-Africa)*, Windhoek, Namibia, 2017, pp. 1-9. doi: 10.23919/ISTAFRICA.2017.8102353

Preprint

Ngaruiya, Njeri; Orwa, Daniel; Wagacha, Peter (2021): Identifying Psychosocial Variables of the Interactive Mobile Interface for Geriatric Persons. Advance. Preprint. https://doi.org/10.31124/advance.14301293.v1